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SPACE SECURITY

PKJCSS DIALOGUE REPORT

 THE PANKAJ KUMAR JHA CENTRE FOR SECURITY STUDIES

**SPACE SECURITY**

Pankaj Kumar Jha Centre for Security Studies (PKJCSS) presents dialogue session report on Space Security.Space security has emerged as a significant concern due to the increasing reliance on satellites for communication, navigation, surveillance, and military applications. This dialogue session report serves as a compilation of essays with topics such as rising competition among major spacefaring nations such as Argentina, China, Japan, France, India, Russia, and the United States of America. Our interns explored the strategic motivations behind space policies of these countries, while focusing on nuances like satellite technology, anti-satellite (ASAT) weapons, and space situational awareness (SSA). The role of private companies in advancing commercial space exploration was also highlighted.Furthermore, the dialogue examined the limitations of existing international legal frameworks in addressing modern threats, including space debris, cyber threats to satellite systems, and the lack of binding agreements on military activities in space. Emphasis was placed on the need for enhanced global cooperation to ensure the sustainable use of outer space.This report, divided into 2 parts, offers valuable insights into the evolving landscape of space security and aims to contribute to the ongoing discourse on maintaining stability in the final frontier.

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## ARGENTINA

### Argentina in Space

##### Abhinav Govind Patole

**Introduction**

Argentina, a country in South America, has had one of the most volatile political and economic histories of all time, swinging from democracy and prosperity to military rule and some of the worst cases of inflation in the world. For a country with such a turbulent past and an equally turbulent present, the issue of space security, or a stable space programme, would not be the first thing on the agenda of development. In fact, it is Argentina that has had one of the most impressive growths in the space sector in the entire Latin American region. The country works solely towards the peaceful use of space. Amidst economic issues, Argentina still maintains a presence in the space sector as it is seen as humanity’s heritage, bigger than just the country. This report focuses on the history, the present, and the future of the Argentine space programmeme, along with the implications these developments may have on the country and the larger region it resides.

**Argentine Space History**

Argentina’s first foray into space tech was concerned mainly with furthering the defence and military capabilities of the country. The National Commission for Space Research, or the Comisión Nacional de Investigaciones Espaciales (CNIE-in Spanish), was established under the Argentine Air Force. Together with the Institute of Aeronautics and Space Investigations, the CNIE developed several sounding rockets such as the Orion, making Argentina a space-faring nation.[[1]](#footnote-2)

In 1979, Argentina started to develop a missile programme that would function as deterrence and defence against border troubles that the country was facing in Las Malvinas, or the Falkland Islands. Here, Argentina was in the middle of a conflict with the United Kingdom, who claimed stake on the land alongside the Argentines. The former faced a bitter defeat in the Falkland Islands at the hands of the UK, with the Condor 1 proving to be not of much use after a rushed development cycle following arms embargoes placed on Argentina by France, who were their biggest supplier of missiles.[[2]](#footnote-3) After doing away with the Condor 1 project, Argentina’s development goals shifted towards a longer-ranged ballistic missile that could be launched from the mainland. This kindled the research and development for the Condor 2 missile.

Following the defeat in the Malvinas, the military dictatorship of Argentina came to an end, and democracy was reinstated under President Raúl Alfonsín. This spelt bad news for the Argentine Air Force, which knew that the funds allocated to their Condor project would experience a setback under a democratic government. This led the Air Force to seek foreign investment to fund Condor 2. They found this funding in Egypt and Iraq, who were both quite interested in gaining an insight into the research and development of the Condor Ballistic Missile project, knowing Argentina’s swift strides in the space sector. Deals were made to transfer technology and engines to both these countries once development of the Condor 2 was completed.[[3]](#footnote-4) However, this did not sit right with the United States of America, as it did not want Iraq under then-President Saddam Hussein to make inroads into a country situated in the region the Americans considered their ‘backyard’. USA then pressured Alfonsín to put an end to the Condor programme, and Alfonsín, who did not want to make enemies with its regional hegemon, decided to abide by their demands, and the Condor programme was dismantled by 1993, although The 1990s saw the death of both the Condor Programmeme and the CNIE, created with a view of militarisation that did not fit in with the futuristic plans Argentina had for itself. [[4]](#footnote-5)

**The Present**

Following the death of the CNIE, the Argentine government created the National Space Activities Commission, or the Comisión Nacional de Actividades Espaciales (CONAE in Spanish). The CONAE is a civilian agency that oversees the entire Argentine space programme, with approval from the president, who acts as the head of the commission. The missions of the CONAE, as stated in the official Argentine texts and translated by the ESA’s report on “Emerging Spacefaring Nations”, are as follows:

* Gathering space-based data on the Latin American continent in order to improve the living standards of the population,
* Providing space-based data to economic and industrial sectors to increase productivity competitiveness at the national and international level,
* Driving the development of the national industry through the creation of new companies that develop innovative technologies with the goal of expanding Argentina’s participation in the global high added value supply chain,
* Taking part in international efforts in the field of space exploration and peaceful use of outer space,
* Providing advanced scientific knowledge as well as job and education opportunities in STEM.[[5]](#footnote-6)

The main strategy document that is followed by CONAE is the National Space Plan, or the Plan Espacial Nacional (PEN in Spanish). The PEN is periodically made for a span of ten years, with the first one being active from 1995-2006; the current one started in 2016 and shall be followed till 2027. The current plan has three main objectives:

* Earth observation,
* Peaceful exploration and use of outer space,
* Technological development for space purposes.[[6]](#footnote-7)

These objectives show a clear breakaway from the ideas of a militarisation-centric space programme that existed during the times of CNIE. These objectives are an extremely peaceful evolution of the erstwhile developments made during the government led by a military junta. This shows a clear shift in the ideology of the country from a militaristic state that envisioned every single facet of the earth as an aspect to be militarised to one that takes a more non-aggressive approach, so as to make sure that the country does not find itself in another conflict putting further strain on an already taut economy. It solidifies Argentina’s space programme as one that is based on peaceful exploration for the good of humanity, rather than a field to be exploited for economic gains. This assumption is further proved by Argentina’s signing of the Artemis Accords, headed by the American space agency, NASA.[[7]](#footnote-8) The Artemis Accords do not allow the signatories of the document to militarise space and place a compulsion on them to only use space for peaceful purposes. This details a clear swing of the Argentines towards the Americans, as the Artemis Accords have at times been accused of being too focused around the USA.[[8]](#footnote-9) This democratisation and diversification experienced by the Argentine Space Programmeme as a virtue of not being under the thumb of a military junta has presented it with several opportunities to develop its space-sectors into one of the most impressive and developed programmemes in the LatinAmerican region. The CONAE has developed geostationary orbit (GEO) telecommunication satellites, making it one of the very few countries to have the capabilities to produce their own GEO satellites.[[9]](#footnote-10) It is currently also working on the Tronador project, which aims to create a launch vehicle to launch an Argentine low earth orbit (LEO) satellite from its own territory rather than having to depend on another country. This would make them part of another exclusive group with the capabilities to launch their own LEOs.[[10]](#footnote-11)

All these developments have been made possible through Argentina’s collaboration with INVAP, an Argentine tech company. INVAP has designed all of Argentina’s GEO and LEO satellites.[[11]](#footnote-12) The company has made forays into the nuclear sector, and the information and technology gathered therein give them an upper hand while developing satellites for a country that constantly finds itself in a terrible economic state. The INVAP is the prime contractor for Argentina’s SAOCOM satellites, which have a primary objective of earth observation. Success of this project would provide Argentina, Latin America, and the world in general with vital information in dealing with climate change. Part of the praise for the success of the CONAE can also be given to the erstwhile CNIE, which invested a lot into R&D, although chiefly in the military sector, but the research and the technology created could be further worked on to fit better into the ideas of the newer and peaceful civilian effort.

The CONAE has also collaborated with several other countries to further develop its capabilities. Argentina, along with Mexico, has created the Latin American and Caribbean Space Agency, or the Agencia Latinoamericana y Caribeña del Espacio (ALCE in Spanish). The ALCE, created in 2021, aims to help its members with a shared budget and easier exchange of technologies.[[12]](#footnote-13) CONAE has also developed a partnership with the Indian Space Research Organisation (ISRO), exemplified by a bilateral agreement, codified in 2018. The agreement addresses training in space sciences and technology, development of ground infrastructure, and several other topics.[[13]](#footnote-14) Amongst all partnerships and agreements Argentina has with other countries, those established with the People’s Republic of China (PRC) stand out.

Collaboration with China

China and Argentina have had a lot of interaction on the economic front, with China being Argentina’s second-largest trade partner.[[14]](#footnote-15) Policy banks in China have lent Argentina about $17 billion since 2007, which is more than they have lent to any other country in Latin America.[[15]](#footnote-16) Even in the space sector, China and Argentina have worked closely through the years. One of the first concrete representations of this collaboration came around in 2004 when the then President of PRC visited Argentina. Argentine President Néstor Kirchner, along with President Hu Jintao, signed a joint agreement for peaceful cooperation in outer space.[[16]](#footnote-17)

China also uses Argentine territory as a base for some of its telescopes and radars. The China-Argentina Radio Telescope (CART) is a radio telescope that is to be placed in the San Juan province of Argentina. Upon completion, the CART will be the largest radio telescope in the entirety of the South American continent.[[17]](#footnote-18) In 2014, the Argentine government under President Cristina Fernández received $300 million from the PRC to establish a Deep Space Radar in a remote part of the Neuquén province in Argentina.[[18]](#footnote-19) The objective of the radar lies in data acquisition. The operation of the radar is controversial due to the freedom given to the PRC regarding this facility. The radar station is controlled by the strategic wing of the People’s Liberation Army (PLA), with negligible supervision from the Argentine government, having discontinued their presence at the facility.[[19]](#footnote-20) This is much to the dismay of the USA, who are not too keen on having an almost unsupervised and secretive Chinese data acquisition radar positioned in South America. The radar gives China unprecedented access to the western hemisphere and all objects which may pass over it through space. Due to the lack of supervision displayed by the Argentine government, it is possible for the PLA to use the radar as a site of surveillance and decryption of any messages that may be sent through American satellites. In case of a conflict between the two countries, the radar station can also be used to keep track of all activities being conducted by the US, acting as an early warning system.

As the Americans pressure Argentina to better take care of the Chinese activities on the territory, the country finds itself stuck in a tricky situation. Currently in one of the worst economic states throughout the world, the Argentine economy is experiencing an astonishing inflation rate of 271%.[[20]](#footnote-21) Even the libertarian president Milei of Argentina, does not believe that it would be feasible to limit relations with China,[[21]](#footnote-22) given the fact that they make a large chunk of the Argentine economy. The USA cannot hope for China to end its activities in Argentina till the country finds itself in a better position financially. It is also important to note that the Chinese Argentine space collaborations have led to a lot of development in a space programme that would be severely limited in a country with such economic troubles. It is difficult to imagine Argentina giving up on that due to US demands.

**The Future**

The current economic status of Argentina does not allow the country to be too extravagant with its space programme, but nevertheless there exist a few projects that the CONAE is working on. One among them is the Argentine-Brazilian Satellites for Environmental Information of the Sea, or the SABIA-Mar, a collaboration between the CONAE and the Brazilian Space Agency (AEB). This dual satellite programme has a goal to survey the environmental change in the coastline and the inland water supplies over a period of time.[[22]](#footnote-23)

Javier Milei, the current president of Argentina, has brought about several reforms to create a regime of privatisation with a reduced role of the state in most matters of the country. This, alongside the CONAE’s history of collaborating with companies such as INVAP, creating an environment where the government is not the only body involved in the country’s space programme, would imply that the future of the Argentine space activities lies in the hands of private players. A competitive environment would push companies to innovate further in order to maximise their capital gains. There already exist such startups, with TLON Space being a prime example. Based out of Buenos Aires, TLON Space is developing a cost-efficient and environmentally friendly way to launch small-scale LEO satellites through their project Aventura I.[[23]](#footnote-24) Milei’s excitement on foreign multinational investments is made obvious through his Large Investment Incentive Regime (RIGI). The bill is a radical attempt at increasing private foreign investments through the provision of several perks, such as import and export duty cuts.[[24]](#footnote-25) While the space sector is not outwardly mentioned, this bill encourages private space companies from other countries to invest in and work with Argentine companies to develop space tech.

**Conclusion**

Throughout its history, the Argentine space programme has been an immensely impressive project, both in a vacuum and when looking at the economic cards dealt to it. Through all its brilliance, it is currently facing an issue in balancing between the USA and China, with Argentina having signed NASA’s Artemis Accords and China being one of its earliest and largest space-tech collaborators. In the midst of all of this, President Milei introduces mass privatisation, leading to a possibility of private entities playing a larger role in Argentina’s space policy than ever before. The question that persists now is what an Argentina laden with economic trouble can do to further the most advanced Latin American space programme.

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## CHINA

### China’s Space Agency (CNSA)-Growth, Challenges, and Global Impact

##### Nandhabalan J. K.

#### Introduction

China’s rise as a space heavyweight in recent decades has redefined the global space race, setting new benchmarks in exploration and future-oriented technology. The establishment of the China National Space Administration (CNSA) in 1993 marked the beginning of a relentless push into space, culminating in groundbreaking achievements such as lunar and Mars missions and plans for a permanent low Earth orbit (LEO) presence.[[25]](#footnote-26) These advancements reflect China's long-term strategy of leveraging space exploration for global dominance, national pride, and potential military advantage.

While China’s space ambitions have historical roots, today they are a strategic necessity driven by geopolitical competition. The rapid expansion of the CNSA, which increasingly rivals established agencies like NASA and Roscosmos, underscores Beijing’s ability to transition from relying on foreign technologies to spearheading innovation. This trajectory highlights the growing implications of China's space program for global power dynamics.

This paper will explore the historical development of the CNSA and analyse its significant accomplishments and technological advancements. It will examine China’s shift from dependence on external technologies to becoming a leader in space innovation, alongside its justifications for space exploration as a tool of global influence. Furthermore, the paper will delve into the geopolitical implications of China's LEO ambitions and its rivalries with nations such as the U.S. and India.[[26]](#footnote-27) The role of advanced materials, such as new alloys for satellite construction, in bolstering China’s space capabilities will also be discussed. Finally, the paper will propose strategies for India to counter China’s rapid evolution in space technology.

By tracing China’s meteoric rise in space, this analysis reveals an unsettling landscape of global competition where the balance of power is shifting. As China positions itself as a dominant space power, its advancements carry profound implications for the geopolitical order and the strategies of other space-faring nations.

**Historical Development of CNSA**

China’s space ambitions culminated during the Cold War, but for years it trailed the US and Soviet Union in developing new technology. This largely kept China's efforts in space out of the international spotlight – at least during its early years. The establishment of the China National Space Administration (CNSA) in 1993 was a milestone in the modernisation and consolidation of its space program. The restructuring was part of sweeping changes aimed at kickstarting China's technology and industrial sectors, with space exploration serving as a focal point. China's space program used to be heavily dependent on technology from other countries (mostly Russia and the United States) and still are dependent on external technology as the primary models for its future Long March rocket family (to be the workhorse of China's Space launch), which were heavily influenced by Soviet R-7 Rocket designs.[[27]](#footnote-28)

Starting from the 1990s and early 2000s, there were a lot of questions on how fast China is gaining advancements in space technology. The U.S. and other Western nations accused them of stealing technology, sparking tension between the two countries.[[28]](#footnote-29) Most notable of all was the ten volumes long Cox Report from 1999, charging China with espionage and illicit technology transfers from the U.S.-related to missile and space technology.[[29]](#footnote-30) The controversies that accompanied these feats put a damper on the China Space Program during these years, but they have not quashed its ambitions. Instead, China advanced slowly and built up its indigenous manufacturing capacity based on what it knew about foreign technologies.

One of CNSA's defining moments came in 2003 with the successful launch to space aboard Shenzhou 5 of ASP astronaut Yang Liwei. This milestone marked China as the third country, after only the United States and Russia, to successfully launch humans into orbit. The Shenzhou program was as big a political coup as it represented a technical triumph.[[30]](#footnote-31),[[31]](#footnote-32)

That success paved the way for more ambitious endeavours, most significantly the Tiangong space station program. China started its first space laboratory in low Earth orbit (LEO) by launching Tiangong-1 in 2011. Tiangong-1 was an important part of the process leading to what Beijing hopes will be a permanent space station that is both modular and represents the future of China's presence in space. It allowed CNSA to verify critical technologies necessary for long-duration human spaceflight and multi-asset space operations. The lessons of Tiangong-1 taught China to build the subsequent growth vehicle — the Tiangong space station that will underpin many future Chinese manned (and planetary) projects.[[32]](#footnote-33),[[33]](#footnote-34)

Many claim China is a space power born of technological adaptation strategic planning and long-term investment in research and development. During its formative years, it largely benefited from technological knockoffs of other nations, and then the CNSA matured into a powerhouse space agency. In fact, in the ensuing years, China has gone far beyond catching up with Western and Russian capabilities – and overtaken them in some areas. They have been able to launch humans into space, design more sophisticated spacecraft as well, and link a space station in LEO which is something significant.

The growth of CNSA, historically speaking, is the story of a nation that fought long and hard to move from technology stealing to leading the race into a new frontier. From a space program that flourished on know-how stolen from abroad to a point where it's now its self-sufficient, China's rapidly developing space agency is just one more example of the country's aspiration for technological superiority and geopolitical control.

**Key Achievements of CNSA**

Over the years, CNSA achieved milestones in space exploration such as:

**1. Lunar Exploration: Chang’e Program**

Among some of CNSA's most notorious successes is its Chang'e lunar exploration program, named after the Chinese moon goddess. China became the third country to land a craft on the Moon with its ‘Chang'e 3’ mission in 2013.[[34]](#footnote-35) This was then followed by the ‘Chang'e 4’ mission in 2019, which not only made history as the first spacecraft to land on the far side of the moon but became a feat that no other country had accomplished.[[35]](#footnote-36) Equally groundbreaking was last year's ‘Chang'e 5’ mission, which brought lunar samples back to Earth — the third country after the United States and the Soviet Union to do so.[[36]](#footnote-37)

**2. Mars Exploration: Tianwen-1 and Zhurong Rover**

China already achieved a space milestone in 2021 by landing ‘Zhurong,’[[37]](#footnote-38) their rover that accompanied the Tianwen-1 mission to Mars, which included an orbiter and lander. If successful, the Tianwen-1 will make China only the second nation after the U.S. to land and work a rover on Mars. The mission, which also reinforces China as a major player in the global space race, shows the country's ambitions in "interplanetary exploration" and are beginning to pay off.

**3. Manned Spaceflight: Shenzhou and Tiangong Programs**

The program for manned activities in space programs within China was initiated by Shenzhou missions. This culminated in the space program known as the Tiangong Space Station. In 2021 China sent the core module of the Tiangong that is going to replace the existing space station. Tiangong, which will supposedly be completed by 2023, will be the only operational space station after ISS retires giving China a huge advantage over other nations regarding space exploration and collaboration.

**4. Beidou Satellite Navigation System**

Another striking achievement made by China is the Beidou Navigation System as it can provide its users with global coverage satellite navigation services such as that of GPS. This ‘Beidou-3’ constellation was put to use in 2020, and this brought an end to the construction of the Beidou system. Though with Beidou, Wuhan still reduced its reliance on the US-run GPS and marketed itself as a major player out of China among the navigational satellites buyers’ society.

These accomplishments demonstrate a paradigm shift to the CNSA from rampant ‘borrow-and-imitate’[[38]](#footnote-39)phenomena to coping with the world’s advanced technologies in space areas particularly deep space exploration lunar missions and GNSS systems developments.

**Technological Capabilities and Innovations**

The ability to build Long March rockets remains one of the key components of Chinese technological capability. Long March refers to a family of heavy-lift launch vehicles that form the core of China’s space program. Long March 5, the strongest operational rocket manufactured by China in this period, can put 25 tons in LEO, allowing it to be compared with NASA’s conventional launch capabilities. Suffice to say, the Long March 5 launches are crucial for China’s aspirations concerning space exploration in the future. In addition, work is ongoing on the Long March 9, a picture of the rocket of a new generation with even more lift capacity than its predecessors which will be used for lunar exploration and missions beyond low earth orbit.

Despite China’s assertion, such kinds of sophistication in space technology have not come without a scandal. During the 1990s and early 2000s, China was constantly portrayed as the villain that used espionage to steal space technologies from its rivals, notably the USA and Russia. As noted in the 1999 Cox Report, China was accused of espionage targeting sensitive missile and space technologies.[[39]](#footnote-40) These gave rise to all the accusations as China was then at its unfurling space program that relied on other countries for technologies, especially Soviet Union models on R-7 rockets that were adopted in most of the family of Long March rockets. Still, there is no denying the fact that China has utilised these technologies as a launch pad to attain a new level creating new capabilities in the space arena.

A major focus of China's technological innovation is on the advancement of special materials for Chinese spacecraft and satellites, which include cutting-edge ideas such as new alloys. Such alloys are meant to be able to work in outer space where there is extreme radiation, very high and low temperatures, and micrometeoritic bombardments. A good example is the ‘use of titanium-aluminum alloys’ in the Beidou navigation satellites and other related space systems. These materials are proven to be stronger without any increased weight thus making it possible to launch the satellites more efficiently and enhance their lifetime in orbit.

Last year, China introduced Ibadan, a new alloy that has been touted as a major advance in lightweight and heat-resistant space materials. The alloy Ibadan will be primarily used in lunar missions, specifically in preparing payloads designed for the moon surface exploration. Apart from material science, China has also developed a reputation in ‘quantum communication.’[[40]](#footnote-41)

In 2016 China officially launched the ‘quantum communication satellite,’ ‘Micius’ which broadcasts the quantum key distribution (QKD) between satellite and ground stations. When adopted this technology has the potential of making secure communication almost impossible to hack or intercept. The rapid development of quantum communication technology in the present society places China strategically to lead in the future of quantum security and space communication. [[41]](#footnote-42)

Another important perspective of China’s space control is the increasing capabilities the country possesses in LEO. Several advanced LEO satellites and systems effectively established by China include the ‘Beidou-3 constellation,’ and the deployment of numerous earth observation and communication satellites. This huge satellite network makes it possible for China to conduct real-time monitoring of the world, accurate navigation services, and application of force from space. Such satellite positioning in LEO also advances China’s role in present satellite communication network systems and future space warfare systems, thereby posing a threat to the U.S. and European space research organisations.

Furthermore, China has dumped the ‘International Lunar Research Station (ILRS)’ which shows that it is interested in building a global base in space. In 2024, CNSA entered into partnerships with different global space agencies primarily with Senegal, South Africa, and Egypt for lunar missions. For instance, Egypt has come up with an artificial hyperspectral camera that will be used in the Chang’e-7 Chinese mission in 2026, to look for water ice at the south pole of the moon.[[42]](#footnote-43)

In addition, the feat achieved by the Chang’e missions, which constitute the main line of China’s lunar exploration program, emphasise the international attention paid to China and the significance of the state as a global actor in defining the advancement of space activity. With rising investments into space ventures, new technologies such as quantum communication, new space launch vehicles and materials like alloy are not only for China but also set a new paradigm for space rivalry. Through native development as well as acquiring technologies from other countries, China is on its way to becoming a significant player in the next generation of space programs.

**Challenges and Failures of CNSA**

However, there have been various difficulties and failures in the development of CNSA on its path to becoming one of the leading space nations. One of the most disastrous accidents took place in July 2017 during the 'Long March 5' rocket launch mission, resulting in the loss of the mission. This setback forced CNSA to conduct comprehensive system reviews and redesigns, leading to delays in several critical projects, including the Mars rover and lunar missions that China had been closely anticipating. The delay highlighted the need for better internal coordination and a reevaluation of technical oversight mechanisms within CNSA. One of the biggest challenges that have been of great concern all over the world is the question of space debris especially due to China’s 2007 ‘anti-satellite (ASAT) test.’ In this test, China shot one of its defunct weather satellites sending thousands of space debris into LEO. This test was greatly criticised worldwide because the debris created by it remains in orbit, posing threats to other space properties and raising the chances of collisions. Residual debris proves the urgency of such tests and has energised people worldwide to want to act more responsibly in space.[[43]](#footnote-44)

Unlike NASA or ESA, which frequently engage in space-related educational programs and international collaborations, CNSA is closely tied to the People’s Liberation Army (PLA), contributing to its perceived obscurity. This close association raises concerns because China develops many of its space technologies with significant support from its military forces. The term 'dual-use' refers to technologies designed for civilian purposes that can also serve military applications, highlighting the blurred lines between peaceful exploration of space and its potential militarisation. This integration of civilian and military goals further underscores the strategic importance of CNSA's advancements for both national pride and defense capabilities. The military aspect of CNSA operations has caused concern in the face of competing nations' fear over what China is likely to develop in terms of ‘space weapons.’ The U.S. and India have expressed suspicion that China’s advancements in LEO and deep space could pave the way for China’s military as the country steps up its space superiority and may result in space-weaponisation. For instance, the many satellites that China has placed in LEO can in principle be redirected for military spy or combat purposes. Due to this fear of militarisation, and because CNSA has not been very transparent about the criteria they use in making decisions, international space community relations are growing increasingly strained.

China’s ASAT (Anti-Satellite) weapon test in 2007 is often cited as an example of the risks posed by China's growing space capabilities. The test demonstrated that China had made significant progress in targeting and destroying satellites, which led to widespread criticism from the international community. The test raised concerns about the potential threats to the space environment and the long-term consequences of space debris. As a result, rival nations now view China’s space ambitions through a dual lens: one perspective acknowledges China's rightful place in the pursuit of space exploration and scientific advancement, while another remains wary of the potential military applications of its space capabilities.[[44]](#footnote-45)

Looking at the future of China pushing forward its space aspirations, CNSA will have to deal with these issues by enhancing openness and positive uses of the space hi-tech. Still, as it is affiliated with the PLA, these challenges are not going to disappear soon and thus add to the intensification of the competitive global space race.

**Geopolitical Implications and Impact on Other Nations**

China has made remarkable progress in the development of space technology and these developments have critical ‘geostrategic implications.’ In 2019, the U.S unveiled the ‘Space Force’ to defend against threats posed by China and Russia, the latter of which has the ability to knock out satellites.

Chinese satellites appear to operate in the Low Earth orbit (LEO), providing it with an opportunity for conducting global surveillance, military monitoring, and improvement of its global navigation services through its Beidou satellites and earth observation systems. This is a direct challenge to the United States’ Global Positioning System GPS and impacts the ‘civilian’ and ‘military’ navigation profoundly.[[45]](#footnote-46)

Regarding India, China’s space plans become both a threat and a possibility. India has its space agency under the ‘Indian Space Research Organisation (ISRO)’ which has progressively developed aggressive policies of its own, but the rapid enhancement by China has provoked unease over a potential ‘strategic asymmetry’ in Asia. India has a test mission called the “Gaganyaan,’ which is to send an astronaut into space by 2024 and is considered as a counter to China’s manned Space capabilities.[[46]](#footnote-47) Besides, India is also procuring and developing ‘Anti-satellite (ASAT) technologies’ and ‘Satellite-based missile defence systems,’ as a reply to China’s gradual growth of its space force.[[47]](#footnote-48)

India is also planning to engage with the U.S., Japan, and European nations to build a stronger apparatus in space tourism. For example, India has signed agreements on cooperation on such topics as ‘lunar exploration’ with NASA and the Earth observation missions with Japan. As India promotes international partnership, it may tighten its position in the space race and may put a leash to check China’s overwhelming dominance in space.

**Future plans of CNSA**

China’s space goals are ever ascending, and the foreign responses appear to be met with reactions as well as anticipation. The CNSA intends to create a permanent lunar base[[48]](#footnote-49) by the 30s of the current century within the framework of cooperation with Russia on the International Lunar Research Station (ILRS).[[49]](#footnote-50) This base is thought to be utilised for science, studying, and resource mining which would strengthen China’s dominance in space.

China also seems to have ambitions towards a human mission to Mars by the 2040s if the ‘Tianwen-1 mission’ proves successful. This would be a big step in mankind’s expedition to the red planet and would put China in an up-front line in space exploration.[[50]](#footnote-51)

Besides its exploration objectives, China is eyeing ‘space-based solar power.’ CNSA is developing technologies for space-based solar power collection and subsequent transfer of energy to Earth that will alter the international energy market and grant China a proprietary advantage in the renewable energy industry.

Last, but not least, China is increasing its commercial space sector by developing more satellites, rockets, and particularly investing in space tourism. Trying to create a competitive environment for the development of the commercial space industry, China wants to fight for a place next to SpaceX and other companies of Western countries in the rapidly growing space economy.

**Conclusion**

China’s space program has transitioned from an early-stage, technology-dependent endeavour into one of the leading and most audacious space ventures on the planet. First of all, today’s China is successfully implementing space exploration projects through the China National Space Administration and boasts significant breakthroughs regarding lunar exploration, manned spaceflight, and asatellite navigation system. Chinese spaceflight has grown its depot in the Low Earth Orbit (LEO); moreover, recent emerging technologies such as quantum communication, and space-based military strength have placed China strategically in the space race.

Yet, CNSA has been escalating questions relating to geopolitics when the continent penetrated meteorically into space. The fast advancement in space power mostly has been viewed as a slippery slope to military power and capability, and more so by China’s space advancements which have both civil and military applications. China’s rising power in space has led nations like the United States and India to step up the pace of their space programs and are developing what is known as ‘military space assets’ and forging what is referred to as ‘International Space Partnerships’ to substantively counter China in space.

As China steadily constructs its ‘Great Wall of Space’ through consistent and ambitious efforts, the world watches closely, speculating on how this rising space superpower will advance in the coming years. The implications of China’s dominance extend beyond scientific and exploration activities; they encompass the geopolitical balance of power. The next phase of the space race will not only focus on who can achieve the most scientifically but also on who can harness the operational advantages of space hegemony. In this evolving context, other space agencies, such as NASA and ISRO, continue to make significant strides. NASA’s recent advancements, like its Artemis program aiming to return humans to the Moon, and ISRO’s successful missions, such as the Chandrayaan-2 lunar mission and the upcoming Gaganyaan crewed mission, reflect their growing capabilities and the dynamic competition in the global space arena. As these agencies strive to maintain their relevance, the geopolitical stakes of space exploration are higher than ever.

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FRANCE

### Space Security of France

##### Vedant Thakkar

**Introduction**

Space Security is a new dimension of National Security that has become increasingly important in the recent global context. France is no exception to this trend; over the past few decades it has developed a remarkable ability to manage its national security in Space. This trend of bolstering one’s security apparatus in Space can be understood through Laetitia Cesari’s commentary for the United Nations Institute for Disarmament Research (UNIDIR),

“The ‘safety’ and ‘security’ of many activities on Earth are underpinned by ‘safety’ and ‘security’ of infrastructure in outer space such as satellites, just as more countries are developing counterspace capabilities.”[[51]](#footnote-52)

The French Space program, like many others, began with these civil-use satellites but as highlighted later in this paper, has come to include the military apparatus as well. This development and the same of its partners and rivals have prompted France to adopt a comprehensive Space Security program. This paper focuses on France’s space security strategy and outlook. The paper will cover a two-dimensional approach to the term ‘space security’. The first has to do with ‘security *in* space,’ the protection of space assets like satellites and their components and building capacity to attack and defend oneself against attacks on these space assets. The second dimension that explores French space security is ‘security *through* space,’ maximising security capabilities on Earth through instruments and assets in space. The paper also briefly covers the history of French Space Security, its multilateral, regional and international partnerships to maximise the two dimensions of space security, the current status of French space security and the potential future pathways of French space security.

**History**

France’s journey in space security began in the context of the Space Race of the Cold War. In 1961, French President Charles de Gaulle founded the Centre National D’Études Spatiales (National Centre for Spatial Studies, CNES) to establish France as an “independent space power.”[[52]](#footnote-53) The first mission adopted by the CNES was the Diamant launcher that launched the first French Asterix satellite in space. The space race of the Cold War had a new European player. In 1975, space agencies from around the continent established the European Space Agency (ESA). France, through CNES, was one of the founding members of the European Space Agency and one of its most significant contributors. This exponentially increased France’s regional and international collaboration in the space domain.[[53]](#footnote-54) The CNES governs and implements French Civil Space policy which has “strategic, economic and scientific” dimensions.[[54]](#footnote-55)

Military Space Security became a major area of cognisance for France after the Libyan invasion of Chad in 1979 and the US intervention in the same. French Prime Minister Laurent Fabius established a high-level working group to assess the possibility of a French military space program.[[55]](#footnote-56) The group produced a report in 1986 which highlighted the importance of space-based intelligence for French national security. This in turn, prompted the French government to launch Helios, a military optical reconnaissance system made in collaboration with Spain and Italy in 1995.[[56]](#footnote-57) Helios was the first move towards security through space adopted by France.

**Current Status of French Space Security**

France operates over a dozen military satellite programs, the majority of which are communications satellites, followed by intelligence, optical reconnaissance, and one early warning satellite.[[57]](#footnote-58) In addition to military systems, France operates a variety of additional satellite systems, including for communication; Earth observation; science, technology, education, and traffic monitoring. The wide variety of military satellites in France’s Space program indicates its strategic redirection towards bolstering its space security. This is in part caused by the regional and global developments in the field of space security and in part by the French government’s ambition to expand its space program to complement its assets, civil and military, on Earth. In recent years, it has also partnered with its ally nations like Germany and Italy to develop joint military capabilities in space. This is reflective of its collaborative yet independent approach to space security.

Fig 1[[58]](#footnote-59)

**The 2017 Defence and National Security Strategy Review**

In his September 2017 speech, French President Macron emphasised the need for an ambitious space policy to strengthen both France and Europe's competitive edge globally. France began openly discussing active defences in space, such as laser systems to disable enemy satellites, positioning itself at the forefront of the global discourse on space weaponisation. Although France didn't formally classify space as a warfighting domain until 2019, a 2017 strategic review identified space as a critical operational environment alongside land, sea, air, and cyberspace, highlighting its importance in national defence and the necessity to monitor low Earth orbit (LEO) and geosynchronous Earth orbit (GEO) threats.[[59]](#footnote-60)

The 2019–2025 Military Planning Law allocated €3.6 Billion (3.6 billion Euros) for space defence, focusing on communication and surveillance. The 2024–2030 Military Planning Law further prioritises space domain awareness and active defence, introducing initiatives like the YODA program for patrolling satellites and the FLAMHE and BLOOMLASE projects for on-orbit and ground-based laser systems, with a total budget of €6 Billion (6 billion Euros).

**The Establishment of the French Space Command**

In 2019, President Macron upgraded the existing Joint Space Command within the French Air Force to form the French Space Command, or Le Commandement de l’Espace (CDE), which officially became operational in September 2020. It was created as a part of the wider French Air Force. The French Air Force was renamed to the French Air and Space Force.[[60]](#footnote-61) This decision came as part of France’s 2019 Space Defence Strategy. France's strategy highlights threats from Russia and China, acknowledging their advanced space capabilities. Although these nations may not categorically prioritise France, the strategy makes it clear on the need for additional investment in the field of space security, more partnerships with allied nations and innovation of comprehensive plans to deal with threats from these countries and other potential rivals.

Alongside the establishment of the CDE, France committed €4.3 billion ($4.6 billion) from its defence budget to enhance space infrastructure from 2019 to 2025.[[61]](#footnote-62) 2025 marks a landmark year for the CDE as it aims to achieve initial operational capabilities by then to protect from any threats in or from space. However, despite its notable success, this target remains difficult, if even possible, to achieve. Since its establishment in 2019, the CDE has expanded in personnel and capability and is expected to reach a size of 500 employees by 2025. The base of CDE’s operations will be in Toulouse, alongside the NATO Centre of Excellence there. The CDE’s mandate, once fully operational, will be ensuring control of military assets and space surveillance, contributing to alerting the population in case of an incoming danger from space, planning and conducting military action in space, ensuring the support of space capabilities and offering space support to operations. The major challenges posed to the CDE’s success and operations were outlined in France’s 2019 Space Defence Strategy. These are to do firstly with the ambitious goal of making CDE operational by 2025, secondly dealing with cyber threats, which are interlinked to the space security apparatus, especially after the occurrence of cyber-attacks in Ukraine and thirdly, threats to civilian data and foreign eavesdropping. The CDE has managed to deal well with the first challenge but lacks significantly in developing capabilities to deal with the other two.[[62]](#footnote-63)

**Multilateral, Regional and International Partnerships**

France has sought to build collaborative and mutually beneficial partnerships with its regional and global allies in the field of space security as well. France distinguishes itself from other European nations with its commitment to strategic autonomy in space and its public ambition to develop active defences for its critical space systems. While countries like Germany, Italy, and the UK prioritise cooperation and the preservation of a peaceful space environment, France seeks independent capabilities to rival historical space powers like Russia and China.

These include its Combined Space Operations Initiative (CSpO) with allies like Germany, the UK, the USA, Canada, Australia and New Zealand (2020) and its bilateral agreements with countries like Norway, India, the UAE, Japan and Italy, among others.[[63]](#footnote-64) France’s efforts towards such strategic partnerships are driven by the threat posed to its space security by rivals like Russia and China, especially in the aforementioned context of the war in Ukraine. The following paragraphs highlight France’s key partnership initiatives with 4 of its closest partners: NATO, Germany, Italy and the USA.

**The North Atlantic Treaty Organisation (NATO)**

France is an active member of NATO; it has been a pioneer in bolstering NATO’s space security strategy. In 2020, NATO approved the French request to create a new Centre of Excellence focused on space in the southern city of Toulouse. This will be NATO’s 27th Centre of Excellence and the second that France hosts, after the Air Operations Centre of Excellence. The centre will host 42 experts in space security, the new centre is expected to be in place by 2025, and its main goals will be to draft policy, improve capabilities and alliance interoperability, and identify lessons learned.[[64]](#footnote-65) French contribution in this domain is especially crucial since NATO’s recognition of Space as one of its operational domains in June 2021, which essentially means that Article 5 of the NATO charter will also apply to space.[[65]](#footnote-66)

**Germany**

Germany’s space security strategy emphasises civil space initiatives through the German Aerospace Center (DLR), focusing on partnerships with the European Space Agency (ESA) and the EU rather than building military space capabilities.[[66]](#footnote-67) Germany’s collaboration with France in space extends back to the 2002 Schwerin Agreement, which facilitates mutual access to military satellite systems. Germany can access a portion of the Helios 2 Earth observation satellites, while France utilises the German SAR-Lupe constellation for military reconnaissance. The partnership underscores Germany’s role as a key ally in space, as emphasised by French officials in recent discussions.[[67]](#footnote-68)

**Italy**

Italy's space strategy is primarily shaped by the Italian Space Agency (ASI), which is the third-largest financial contributor to the European Space Agency (ESA).[[68]](#footnote-69) Italy and France share a longstanding collaboration in space, highlighted by the 2001 agreement on Earth observation, allowing data sharing from Italy’s COSMO-SkyMed and France’s Spot 5 satellites. Both countries have also worked together on military satellites like Athena-Fidus and Sicral 2. Despite differing responses to threats, such as the 2018 targeting of Athena-Fidus by a Russian satellite, their partnership remains strong. In March 2021, France and Italy announced a working group to address challenges in space launch capabilities, advocating for a coordinated European approach to developing launch vehicles. Germany also contributed expertise in liquid propulsion technology.[[69]](#footnote-70)

**The United States of America**

France and the United States have a longstanding partnership in space, formalised by the 2007 Framework Agreement for Cooperative Activities in the Exploration and Use of Outer Space.[[70]](#footnote-71) In addition to civil cooperation, France and the U.S. have emphasised national security in space. A 2016 joint statement by the French defence minister and the U.S. secretary of state highlighted a commitment to enhance military cooperation, particularly in the space domain.[[71]](#footnote-72) This includes joint training exercises, exchanges between military leaders, and the presence of a French liaison officer at the U.S. Combined Space Operations Centre in Colorado. Both nations participate in annual wargames, such as the Schriever Wargame and France's AsterX, fostering confidence and strategic insight among military leaders regarding space threats. These events facilitate dialogue and cooperation on space capabilities and operations.[[72]](#footnote-73)

**Conclusion**

France's space security framework represents an ambitious yet nascent endeavour that balances independent aspirations with collaborative engagement. While its acknowledgement of threats from powers like China and Russia underscores legitimate concerns about global space militarisation, framing these nations as direct adversaries may overstate their prioritisation of France as a rival. This perspective risks diverting focus from more pressing, actionable challenges.

Chief among these challenges is integrating the private sector into France's space security efforts. The country must strike a delicate balance between fostering innovation and safeguarding its national interests. Additionally, the intersection of cyber threats with space security underscores an evolving risk landscape. Recent cyberattacks globally demonstrate vulnerabilities that demand robust, preemptive measures to protect critical space infrastructure.

Finally, France's independent yet collaborative approach to partnerships is both a strength and a limitation. While it has enabled France to emerge as a regional leader in building space security apparatus, this positioning has not translated into leadership in technological development. The nation's multilateral agreements and NATO alignment highlight the benefits of cooperation but also underscore the constraints of pursuing strategic autonomy in an increasingly interconnected domain.

In navigating these challenges, France's success will hinge on balancing ambition with pragmatism, ensuring that its rapidly developing space security apparatus evolves sustainably to meet the multifaceted demands of the future.

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INDIA

##### India’s Space Programme

##### Manjiri Abhay Phansalkar

**Introduction**

The twenty-first century India-that is Bharat, stands at a pivotal point in contemporary world affairs, particularly in the fields of emerging technology, economic prowess and the constant contestation of greater security might. Throughout the years, India has significantly persevered and progressed in major fields of security concerns, whether in the form of arms acquisition, personnel training or integration of technology (artificial intelligence) into the military. However, another crucial sphere of security relevance is observed in the form of the power to establish their proximity to outer space. This further presents complexities characterised by the frequencies at which this proximity is established followed by the ‘collective issue’ of maintaining outer space and nullifying the presence of space debris.

As for India, such practical ideals of proximity and theoretical aspects of collective responsibility rests with the ISRO-Indian Space Research organisation established in 1969 and the genesis of which roots itself to the INCOSPAR-Indian National Committee for Space Research (1962), under the Department of Atomic Energy. The vision of India’s space programme, as established by ISRO addresses the dual intentions of fueling national development through advancements in space technology as well as acquiring ease in space research and strengthening the capacity of India’s space exploration. The objectives and missions of the programme aim at taking incremental steps towards translating the vision to practicality. With reference to these goals and efforts to materialise the space exploration initiatives, this brief advances on the objective of traversing through the nature of India’s space programme initiatives, followed by mapping these effects on her security concerns as well as establishing India’s global ranking.[[73]](#footnote-74)

**Inception of India’s Space Programme**

India’s space exploration initiative and technological developments materialised after the formulation of the Department of Atomic Energy in 1950 spearheaded by Dr. Vikram Sarabhai and Homi Bhabha (secretary of the department of state on inception). This was followed by the establishment of the INCOSPAR in 1962 by Prime Minister Pt. Jawaharlal Nehru and the developments gained a speedy momentum under the leadership of Prime Minister Indira Gandhi when the Department of Space (DOS) was established in 1972 and INCOSPAR was replaced by ISRO (under the DOS). This section first, provides a multi-faceted observation of India’s Space Programme by shedding importance on the past, present and future objectives lined up by ISRO. Next, and in tandem with the objectives, the achievements and failures experienced (initiated missions) are delivered. Lastly, the brief maps these facts with the security concerns as encountered by the World in general and India in particular.

**Historical Milestones**

As history testifies, India’s materialisation of Space technology and exploration came at a time when other powerful nations were experimenting with their scientific expertise and broadcasting sports events through satellites. As the US Embassy and Consulates in Japan claim, “In 1964, the Opening Ceremony of the Olympic Games was broadcast live to the U.S. for the first time via satellite. The Tokyo Games became known as the “TV Olympics.” The Games were a signature event for NHK, which had just begun TV broadcasting in 1960.”[[74]](#footnote-75) It was the founding father of Indian Space Programme Dr. Vikram Sarabhai, who realised the potential advantage of space technologies for India.[[75]](#footnote-76) Considering this, there were four organisations set up which idealised the practices of such technological advancements-inclusive of the Department of Atomic Energy (1950), INCOSPAR (1962), ISRO (1969) and Department of Space (1972)[[76]](#footnote-77). Through these establishments, the Indian Space Programme significantly contributed to various fields, some of which are briefed as follows:

**1967: Experimental Satellite Communication Earth Station (ESCES)**

The ESCES was functionalised in Ahmedabad in 1967 and was essentially utilised as a training center for Indian scientists and engineers as well as international entities. Additionally, as a precursor to operationalising a full-scale satellite system, it was intended to prove the efficiency of television medium for national development. In accordance with this necessity, a TV programme titled ‘Krishi Darshan’ was started to impart information of agricultural importance[[77]](#footnote-78).

**1975-76: Satellite Instructional Television Experiment (SITE)**

Famously known as ‘the largest sociological experiment in the world’ since its inception in 1975, SITE materialised across 2400 villages of 6 states, targeting approximately 2 lakh Indians and disseminated numerous development-related programmes using the American Technology satellite (ATS-6) whereby it successfully trained 50,000 primary school teachers (in science) in one year[[78]](#footnote-79). This was aimed at educational TV in India and was essentially an application satellite programme of the NASA which broadcasted educational programs to television sets present in various rural clusters[[79]](#footnote-80).

**1977-79: Satellite Telecommunication Experiments Project (STEP)**

As a joint project of ISRO-and Post and Telegraphs Department (P&T) and employing the Franco-German Symphonie satellite, STEP was a sequel to SITE-with the objective of conducting experimentation on the field of telecommunications during 1977-79[[80]](#footnote-81). As ISRO claims, “STEP was aimed to provide a system test of using geosynchronous satellites for domestic communications, enhance capabilities and experience in the design, manufacture, installation, operation and maintenance of various ground segment facilities and build up requisite indigenous competence for the proposed operational domestic satellite system, INSAT, for the country.”[[81]](#footnote-82)

**1984: Kheda Communications Project (KCP)**

Following SITE was the KCP in Gujarat-a field laboratory that aimed at the development and local communication in Kheda district of Gujarat[[82]](#footnote-83). The Kheda Project was instrumental in decentralising television broadcasting in India. Further, this project was awarded the UNESCO-IPDC (International Programme for the Development of Communication) award in 1984[[83]](#footnote-84).

**Recent Accomplishments and Future Prospects**

During the phase of 1980s, wherein the Space sector was mainly focused at proving the efficacy of television medium for national development, India’s first spacecraft, ‘Aryabhata’ was launched[[84]](#footnote-85). Further, was the milestone of developing a launch vehicle SLV-3 (with the capacity to reach LEO) and operationalising it in 1980[[85]](#footnote-86). It was this advancement that substantiated the foreground for many space technology elements which were inclusive of vehicle, hardware, avionics and launch operations. Additionally, a significant landmark for India’s Space programme was the development of a multistage rocket system which could successfully orbit a satellite.

Following these, were the Bhaskara-I & II missions which were specialised in remote-sensing areas in contrast to the ‘Ariane Passenger Payload Experiment (APPLE)’ which determined the future of communication systems in India. Continuing the myriads of developments, was the advancements in the sector of launch vehicles, whereby ASLV (Augmented Satellite Launch Vehicle), PSLV (Polar Satellite Launch Vehicle) and GSLV (Geosynchronous Satellite Launch Vehicle) were introduced. The rationale for the induction of these launch vehicles is reasoned by the fact that with every successive launch vehicle, there was an improvement in the payload capacity that could be carried to space, thereby allowing for greater ease of space exploration (by harnessing advanced technology).

In the next decade, India's space programme aimed at addressing the dual sectors of communication, broadcasting and meteorology by operationalising INSAT (Indian National Satellite system) which was followed by materialising the IRS System (Indian Remote Sensing Satellite)[[86]](#footnote-87).

In the twenty-first century context, India’s space programme has been significantly employed and has served sectors of climate and environment communication, Disaster Management, Earth observation, Planetary observation, Navigation, Student Satellite, and X-Ray Astronomy. In accordance with these sectoral advancements, the following projects are noteworthy:

**CHANDRAYAAN-1**

* Application: Remote Sensing, Planetary Science
* Launch: October 22, 2008; SDSC SHAR, Sriharikota
* Culmination: August 29, 2009 (Communication lost)

As the nomenclature identifies, Chandrayaan-1 was India’s first mission to the Moon wherein the spacecraft would orbit the Moon at a height of 100 km for chemical, mineralogical and photo-geologic mapping of the Moon. The satellite performed more than 3400 orbits around the moon before the mission was concluded[[87]](#footnote-88).

**CHANDRAYAAN-2**

* Application: Planetary Observation (expand the lunar scientific knowledge through detailed study of topography, seismography, mineral identification and distribution, surface chemical composition, thermo-physical characteristics of topsoil and composition of the atmosphere, leading to a renewed understanding of the origin of the Moon.)
* Launch: July 22, 2019; Sriharikota

This was a highly complex mission, as it comprised an Orbiter, Lander and Rover to explore the unexplored South Pole of the Moon. The orbiter was successfully attached to its target in the lunar orbit on August 20, 2019. On September 02, 2019, the Vikram Lander was separated from the Orbiter in order to land on the Moon. However, communication with the lander to the ground stations was eventually lost. The camera in the orbiter has a resolution of 0.3 m and is capable of providing high resolution images of the Moon thereby fulfilling the intended application of this mission[[88]](#footnote-89).

**CHANDRAYAAN-3**

* Mission objectives :
	+ To demonstrate Safe and Soft Landing on Lunar Surface[[89]](#footnote-90)
	+ To demonstrate Rover roving on the moon[[90]](#footnote-91) and
	+ To conduct in-situ scientific experiments.[[91]](#footnote-92)
* Launch: July 14, 2023; SDSC SHAR, Sriharikota

As a follow-up to Chandrayaan-2, this mission aims to represent the advancements in safe and ‘soft’ landing as well as roving on the lunar surface.[[92]](#footnote-93) Further, it consists of a Lander and Rover Configuration - which is known to be a collaborative effort of ISRO (Indian Space Research Organisation) and NASA (National Aeronautics and Space Administration).[[93]](#footnote-94)

**ADITYA L-1**

* Application: dedicated to the comprehensive study of the Sun.
* Launch: September 2, 2023; SDSC SHAR, Sriharikota

The system was intended to be placed at the L1 (Lagrange Point 1) of the Sun-Earth system, which is a location in space where the gravitational forces of two celestial bodies, such as the Sun and Earth, are equal.

The strategic implications of deploying Aditya L1 at its location are to maintain a constant monitoring of the Sun.[[94]](#footnote-95) Further, this also allows for the satellite to contact the solar radiation and magnetic storms (and study their properties) before they gain access to Earth’s magnetic field and atmosphere. The equilibrium provided by L1 maximises the operationality of the satellite.[[95]](#footnote-96)

**XPoSat (X-ray Polarimeter Satellite)**

* Application: dedicated polarimetry mission to study various dynamics of bright astronomical X-ray sources in extreme conditions.
* Launch: January 1, 2024; SDSC SHAR, Sriharikota

Developed in collaboration with JAXA (Japanese Aerospace Exploration Agency) and ISRO, the XPoSat aims to counter the challenge of studying and understanding the exact nature of the emissions mechanisms from various astronomical sources inclusive of stars, nebulae and the black hole. Through the employment of the Polarimetry (the measurement of optical rotation of substances by using a polarimeter), the scientists can implement the dual aspects of ‘degree’ of polarisation and ‘angle’ of polarisation to adequately diagnose the emission processes.[[96]](#footnote-97)

Having examined the intermediate missions launched by ISRO, it is a necessity to also examine the missions that have been lined-up for launch in the coming years and are briefed as follows:

**NISAR [NASA-ISRO-SAR (synthetic aperture radar)]**

* Application**:** Tracking changes in the Earth’s surface, identifying signs of volcanic eruptions, identifying groundwater supplies and predicting melting of ice sheets.
* Launch**:** early 2025

The satellite is a part of a joint observation mission between India and the USA to monitor the surface of the Earth and identify evolving changes.[[97]](#footnote-98) This research partnership between NASA and ISRO began in September 2014, whereby NASA is developing one radar, a communication subsystem, GPS receivers and a payload data subsystem, while ISRO is developing a spacecraft bus, the second radar (called the S-band radar), and the launch vehicle.

SAR is essentially a mechanism for obtaining high-resolution images supported by the largest reflector antenna affixed in NISAR.

**Benefits of NISAR:**

1. Images will show local changes and will produce measures of regional trends.
2. The collected data will ensure better collaboration of the causes and consequences of surface changes.
3. The images captured will show changes on the surface of the globe.

**GAGANYAAN**

* Application**:** Human spaceflight capability
* Launch**:** December 2024

Gaganyaan envisions the exhibition of human spaceflight capability by launching a crew of 3 members to an orbit of 400 km for a 3-day mission and bringing them back to Earth, by landing in Indian waters[[98]](#footnote-99).

The project will be accomplished by employing an optimal strategy via consideration of expertise which are inclusive of inhouse facilities, experience of historical space-related activities, intellect of Indian academia & research along with technologies available with international agencies.

The requirements for Gaganyaan mission include development of many technologies including human rated launch vehicle, Life Support System, crew emergency escape provision and evolving crew management aspects[[99]](#footnote-100).

The Gaganyaan Mission would be carried out by four Indian Air Force (IAF) Pilots- Group Captain Prasanth Balakrishnan Nair, Group Captain Ajit Krishnan, Group Captain Angad Pratap, and Wing Commander Shubhanshu Shukla.

**International Cooperation**

Aiming for strategic bilateral and multilateral partnerships with space stations and agencies of nations abroad, ISRO is taking up novel scientific and technological challenges, weaving new space policies and refining international cooperation mechanisms to avail maximum usage of the outer space for peaceful purposes[[100]](#footnote-101). Further, India being a developing nation is also viewed as an emerging nation with the potential to fulfil its goals and aspirations in the most cost-effective and time-efficient manner. Subsequently, owing to such a characteristic, other developing nations bank on India for technological and scientific assistance in enhancing their space exploration capabilities. Considering these prerogatives, India’s scope to international cooperation has significantly diversified. The following are testimonies to India’s International Cooperation in the space technology and exploration sector:

**Chandrayaan-1**

As a maiden attempt to reach the Moon, this mission set an exemplary illustration of international cooperation in terms of international payloads[[101]](#footnote-102). This was particularly significant, as the ISRO-NASA collaboration led to the novel discovery of water molecules on the surface of the Moon.

**Megha-Tropiques**

With the aim to study the tropical atmosphere and climate of the Earth, this was a joint satellite mission by the Indian and French space organisations in the year 2011[[102]](#footnote-103). Further, the information acquired from this mission was also shared with the International Scientific community.

**Saral**

In February 2013, and in collaboration with the French space station, ISRO launched SARAL-Satellite for ALTIKA and ARGOS- with the aim to understand and study the oceans from space and using the technology of altimetry for studying the height of water and ice surfaces in hydrology and glaciology[[103]](#footnote-104).

**TRISHNA**

In yet another collaboration with the French space organisation, ISRO launched a satellite comprising a thermal infrared imager named TRISHNA intended for feasible Earth observation.[[104]](#footnote-105)

**UNNATI (UN space Nanosatellite Assembly & Training)**

In 2019, ISRO launched an 8-week programme on nano satellite development for scientists, as an initiative of UNISPACE+50 (an event hosted by The United Nations Conference on the Exploration and Peaceful Uses of Outer Space).[[105]](#footnote-106) Held at UR Rao Satellite Centre (URSC) of ISRO in Bengaluru for three years, this initiative trained scientists in two batches in the year 2019.[[106]](#footnote-107)

Furthermore, India is one of the forty-eight signatories to the Artemis Accords, making it a crucial power in its space technological prowess[[107]](#footnote-108). These Accords in symbiosis with the Outer Space Treaty of 1967 (OST) provide a set of guiding principles for space exploration by civilian entities in the 21st century. India’s participation in furthering the goals of these Accords, by means of adhering to usage of space technology for peaceful purposes, ensuring transparency, promoting interoperability, assisting in cases of emergency, registering space objects, releasing scientific data, preserving heritage, using space resources ethically, disengaging from harmful activities and assisting in mitigating orbital debris provide for strengthening her space collaborations with other international actors. It is hereby that The Artemis Accords bring forth the tenets of multilateral engagement and leadership in space explorations and positively bind nations that share a vision of peaceful space cooperation.

**Security Concerns**

In addition to the cooperation at the global level, India is also a signatory to the Outer Space Treaty of 1967. While this treaty explicitly mentions the use of outer space for and only ‘peaceful means’, it does not strictly define the prohibitions levied on the launch of ballistic missiles in/through space, making it the most contestable aspect of security concerning the globe. Further is yet another pivotal doubt of counteracting China’s increasing threat to India’s space programme. Void of a concrete response, India is evidently far from an at-par scenario with China in almost all aspects of space exploration and would need to compare every attribute of space technology with that of China to successfully and rightly perceive their capabilities and usages.

**Emerging Technologies in Space Sector**

In the current day and age of space exploration, the role of technology and regulated developments in the field are of prime importance to realise the prowess of a nation’s space programme. In the context of India, there are several verticals under the ISRO that have undergone various levels of research and development, and certain technological advancements have been noticed in the thrust areas of Reusable Launch Vehicles, Stage Recovery and Reuse, Vertical Take-off Vertical landing (VTVL), LoX- Methane engine, Air breathing/ Hybrid Propulsion, cost effectiveness and many other facets of space exploration. As far as the aspect of developing technologies for low-cost access to space and space travel is concerned, ISRO instrumentalised a Reusable Launch Vehicle (RLV) programme to develop space planes and shuttles that can reach the orbit, re-enter the orbit, and descend onto a runway like an airplane. A second feature of technological advancement is known in the form of Air breathing propulsion with reusable capability, offering a cost-effective futuristic space transportation system. On a tertiary consideration, is the feature of developing a free-space Quantum Communication over a distance of 300 m using the Prepare & Measure Protocol and Quantum entanglement protocols. Further, ISRO has innovatively used the spent 4th stage of PSLV for conducting scientific experiments under a name called PoeM (PSLV orbital experimental Module), whereby it provides a microgravity platform for conducting various scientific experiments in space[[108]](#footnote-109). Finally, ISRO has also been engaged in pursuing several R&D programmes related to Space Robotics such as the *Vyommitra* (Humanoid robot), Lander and Rover for Chandrayaan-3 mission, on-orbit Satellite Refueling, Planetary Rock Sampler, Space-based robotic manipulator, Robotic arm-based umbilical systems, 3D printing in Space, to name a few.[[109]](#footnote-110)

While most technological advancements are made evident considering a nation’s economical and innovative prowess, it is necessary to also consider the aspect of disruptive technology, which is essentially the evolution of technology that disturbs the status-quo of both, dominant technology platforms as well as competitive market layouts[[110]](#footnote-111). In the field of space, which is a high technology intensive sector, it is often noticed that innovation in space is more frequently incremental upon the dominant technology and provides small improvements in the performance of a technology[[111]](#footnote-112). Building on this consideration, is the realisation that the sector of space is one that is not only hard to reach, but also difficult to maintain. In view of this, there have been certain drastic innovations not only in the field of technology in space, but also the aspect of global recognition. One notable example is the development of technology as far as addressing orbital debris is concerned. This aspect of suspended orbital debris is reasoned by the efforts taken up by a China-based space mining start-up which has invented a satellite named NEO-01 and has the responsibility to trap the debris (left by other spacecrafts) in a large net and then burn them using an electric propulsion system[[112]](#footnote-113). Even though the Chinese efforts seem to be extraordinary, the efforts taken by Indian space organisations include features such as Project Netra (Network for Space Object Tracking and Analysis), Collision Avoidance Maneuvers and Space Situational Awareness-which primarily aim at avoiding collision with any suspended debris in space.[[113]](#footnote-114)

**Rise of Private Players -The New Paradigm**

Following the national efforts towards space exploration and technological advancement, there have been initiatives taken up by private actors to indulge and enhance the capacities-which are otherwise set goals by the public stakeholders. To iterate a few, there are five private start-ups that actively participate in facets of space exploration and technological innovations[[114]](#footnote-115).

First, is Aadhya Aerospace which aims to instrumentalise computer vision, communication, and motion control through the integration of AI. Further, its central aim lies in manufacturing cutting-edge electro-mechanical actuators, control actuation systems, and electro-optic systems for missiles and launch vehicles.

Second is Agnikul, which was founded in 2017 and has achieved a milestone by constructing its own launchpad and mission control center at the Satish Dhawan Space Centre in Sriharikota. Additionally, through means of this, it has secured a significant achievement as one of the first Indian private enterprises to establish partnerships with both ISRO and IN-SPACe.

Next, is Astrogate Labs, which has been instrumental in enabling high-speed communications for small satellites including the managing of a network of optical ground stations and in-space relays which support requirements of satellite downlink operations.

The fourth entity is Bellatrix Aerospace, which primarily focuses on the development of advanced in-space propulsion systems and rocket propulsion technologies and is dedicated to making space more accessible and affordable for various applications.

Lastly, Blue Sky Analytics-a geospatial data intelligence company that leverages cloud and AI to build an API-based catalogue of environmental datasets[[115]](#footnote-116). Using these, the start-up analyses data for various environmental indicators such as greenhouse gas emissions, climate risks (floods, droughts, wildfires, and extreme heat), and environmental monitoring, among others.

These start-ups are pioneering stakeholders in leveraging the various features of space exploration and innovation, utilising to the benefit of the ordinary citizen in aspects of AI, communication and weather conditions, thereby contrasting the features of a centralised retrieval of information by public entities.

**Conclusion**

In the backdrop of the various international cooperation initiatives, there are certain poignant challenges that India faces in the sector of space. While India experiences assistance and partnership from various nations in space-related initiatives, whether in the form of launch vehicles (initial phases of exploration), or contributing elements of the project in equilibrium (NISAR, XPoSat and SARAL), China-an ever-evolving global power, on the other hand proves to be a worrying challenge. To enlist a few, the first, is the counter-space capacities possessed by China which are extensive, diverse, and are lethal and reversible. Secondly, are the evolving counter-space threats which pose clear and potent danger to India’s space programme. Lastly, is the challenge of the Indian Space Programme to deter the denial of space activities carried out by China, owing to the disparity between the capacities of India’s and China’s space capabilities, (latter possesses lethal and non-lethal counter-space weapons).

India’s Space Programme has indeed shown significant increment in its operationalism, materialising its goals, aims and objectives as well as diversifying the typologies of satellites, projects and missions across the years-since its inception. In the context of this brief, the writer has intended to address the history of India’s space visions, followed by the programmes that were planned and accomplished as well as inclusive of those missions that are scheduled to be launched. There is also an attempt to bring forth the challenges and security concerns faced by the World as well as India. While certain nations prove to be significant players in the instrumentalisation of India’s space initiatives, China poses significant threats in terms of counter-space capacities and points at India’s incompetency at being able to deter the former’s denial of conducting space activities as well as owning lethal counter-space weapons. In its entirety, India’s space programme identifies with the dual aspects of enhancement in its space capacities, as well as the ever-evolving nature of expanding its global recognition through advancements in space technology and exploration.

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