VIF Brief | October 2021

India in Space Domain

Pathbreaking Developments

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Published in 2021 by

Vivekananda International Foundation

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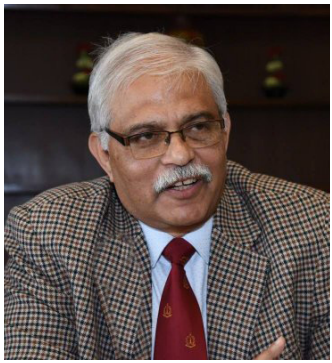
Cover Image Source : ISRO (An artistic rendering of the ISRO's AstroSat satellite)



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India in Space Domain – Pathbreaking Developments

Introduction

India is now a major spacefaring nation. Initially, the Indian space programme was focused primarily on societal and developmental utilities. Today, like many other countries, India is compelled to use space for several military requirements like intelligence, surveillance and reconnaissance. Hence, India is looking to space to gain operational and informational advantages.

India has had its fair share of achievements in the space domain. It includes the launch of the country's heaviest satellite, the GSAT-11 which will boost India's broadband services by enabling 16 Gbps data links across the country, GSAT-7A, the military communication satellite and the launch of the Geo-synchronous Satellite Launch Vehicle GSLV Mk III-D2, the GSAT 29. The Anti-Satellite (ASAT) test is an intrinsic part of today's geopolitics and the national security context.

India's space programme is self-reliant. India has achieved self-reliance in launch vehicles and satellite technology. We have been providing launch services to foreign countries. Space-related assets are extremely useful for military purposes. For example, ballistic missile defence cannot function without space assets providing communications and navigation. Space applications like satellite communications, satellite imagery and surveillance and satellite navigation perform numerous functions. Satellite

imagery helps damage assessment following an airstrike and satellite navigation guides precision missiles to their targets.

Space for military applications is gaining momentum. India is facing a number of national security threats, including two-front war, proxy wars perpetrated by inimical neighbours, insurgencies, left-wing extremism, natural disasters and dangers along the Sea Lines of Communication (SLOCs). Space will play a crucial role in addressing these threats. Space is essential to the Indian Armed Forces for sustaining communications, logistics, missiles launch and guidance, weapons systems and Unmanned Aerial Vehicles (UAVs). INSAT and GSAT satellites for communications, Synthetic Aperture Radar (SAR) satellites, high-resolution panchromatic satellites and Indian Regional Navigation Satellite System (IRNSS) meet a large part of space requirements of the armed forces. However, gaps continue to exist in India's space capabilities.

India is moving towards integrated application of different space technologies by use of satellite communication, navigation, and imaging. These technologies are being used for social welfare purposes such as advancements in tele-medicine, tele-education, disaster management and search and rescue operations. Schemes like village resource centers and e-governance are significant for large populations, providing connection to the most remote places while ensuring transparency. Space assets are also of immense use in disaster management and humanitarian assistance. India is in the process of finalising its space policy. India's space policy should energise private industries to take part in domestic and global markets in launch vehicles and satellite manufacturing segments with increased entrepreneurship. Space assets should be protected for supporting civil space functions and national security objectives.

Commercial uses of space technology are popular. Around 900 television channels are available to viewers through Direct-to-Home (DTH) services. However, in commercial use of space technology, India is lagging

behind. For example, Indian transponders are fulfilling only 40 percent of India's DTH requirements. The Indian Space Research Organisation (ISRO) is trying to reduce this gap through the launch of new satellites to make Digital India a success. GSAT series of will raise the capacity to 75 Gbps of data augmenting the existing bandwidth on ISRO's satellites. Internationally, India is helping other countries boost their space technology and resultant services. In addition to hosting payloads and launching foreign satellites, India is also operating South Asian Satellite for the neighbourhood.

The government of India is taking appropriate measures. On June 24 2020, the Indian Government created a new organisation known as IN-SPACe (Indian National Space Promotion and Authorisation Centre). IN-SPACe is a single window nodal agency that will boost the commercialisation of Indian space activities. In addition, the agency will promote the entry of Non-Governmental Private Entities in the Indian space sector

Characteristics of Indian Space Venture

The government drives Indian space activities to meet national needs with a focus on self-reliance and security. ISRO drove commercial activities through its commercial arm, the *Antrix Corporation* depending on the availability of spare capacity. All commercial space activities were closely regulated and controlled by the Department of Space (DoS). As a result, space commerce has not grown in India as compared to other major space-faring countries. While India has achieved significant feats in space missions and allied activities, Indian space commerce accounts for less than one percent of the global market. The current global space economy is around USD 360 billion. It is split between upstream, midstream and downstream activities. Therefore, there is excellent scope for the commercialisation of the ground operations like mission support, satellite broadband gateways and 5G backhauling.

The Indian space program is totally state-driven. ISRO is around 70–80 percent reliant on private-sector contractors for components and services. A large number of Indian companies provide ISRO with launch and satellite components, the leaders being well known engineering and technology firms like Larsen & Toubro, Godrej, Walchandnagar Industries, and the Tata Aerospace. There are a number of emerging new space actors, mostly start-up companies based in Bangalore. Majority of them are in the small satellite segment.[1]

India has a large base of SMEs for supplying parts and components for satellite and launch vehicle manufacturing. ISRO contracts these suppliers for meeting its demands. There have been initiatives to help private industry build capacity in system-level integration. However, they lack end-to-end manufacturing capabilities ranging from design to testing and launch. Currently, ISRO has adopted public-private partnership (PPP) policies to encourage companies to take up more production activities rather than part/component manufacturers. ISRO has formed a consortium of private industry players for Assembly, Integration and Testing (AIT) of 30–35 satellites. It has built a facility spread over 25 acres in Bengaluru where the amenities have been set up for use by the industry to encourage more private participation. Government entities involved in commercial space activities.

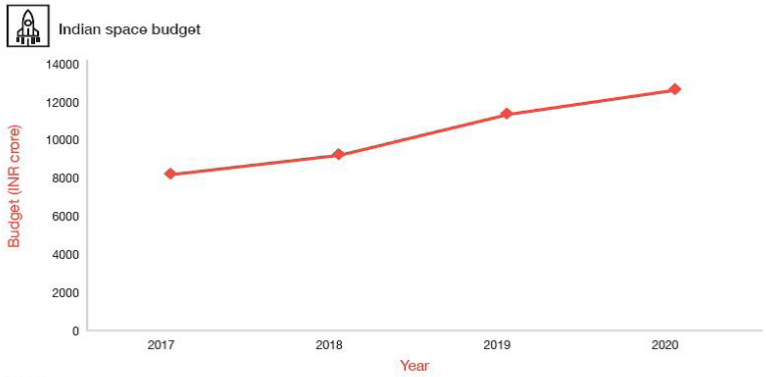


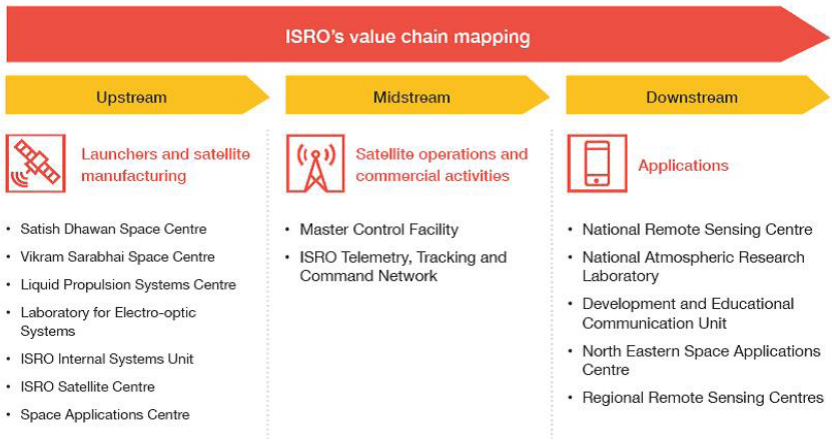
Figure 1

Source: https://www.isro.gov.in/budget-glance, https://www.business-standard.com/budget/article/budget-2019-fm-hikes-dept-of-space-outlay-pushes-for-commercialisation-119070500973_1.html

Size of India's Space Economy

The value of the Indian space economy is around USD 7 billion. It is approximately 2 percent of the global space economy. Of this, upstream activities contribute USD 2.3 billion, and downstream activities contribute USD 4.7 billion.

ISRO's existing space value chain mapping



With the current success of exploratory missions to Moon and Mars, and the government's impetus on promoting space technology-based tools and applications, different avenues are opening up to tap the economic and commercial potential of space technology products and services. With significant advantages like a strong domestic manufacturing base, high demand for services, cost advantage, a large human resource pool and ability to use IT skills, the private space industry should take a more significant role in the space economy.

Space Developments

With the rising space-based needs of security agencies, ISRO will have to continue the normal development of remote sensing and telecommunications missions and deliver for national security

requirements. If the government facilitates development of spacecraft by the private industry, ISRO will be able to focus on the development of the next generation of technologies. The Antrix Corporation has initiated a project of small satellites to boost the New Space Ecosystem in India.

Launchers. ISRO has announced the building of an SSLV that can lift satellites up to 500 kg in Low Earth Orbit (LEO). For the production process, ISRO has been practicing a subcontracting model for all its launch vehicles successfully. However, this model is not adequate to achieve cost optimization and production efficiency. These objectives can be achieved by executing an end-to-end production set-up, with optimum numbers planned and transparently communicated to the industry. India's ability to stay at the forefront in an increasingly competitive space market depends on integrating private players into the ecosystem. There is a scope to commercialise the development of medium and heavy-lift launchers.

Communication. Satellite communication is the largest services market. There is increased interest in optical communication to overcome the constraint of the limited availability of radio frequencies. An Indian start-up plans to build the entire chain of an optical communication system to provide secure communication links at higher data rates with lower form factor and power compared to RF systems. Start-ups are also at developing ultra-high capacity transponders that operate in the millimetre wave frequency range to provide better spectral efficiency and a considerable unused bandwidth. These provide much higher uplink/downlink capacity per satellite. With the implementation of 5G, Internet of Things (IoT) and *BharatNet*, these satellite-based services will be in great demand.[2]

Space Subsystems. India is a major space-faring country, but only a few industries possess the technology to design, manufacture, qualify and supply space subsystems like various sensors, inertial systems, control mechanisms, propellant storage and delivery systems thrusters, power systems and payloads. This can be addressed by a well-defined Transfer of

Technology (ToT) policy.

International Partnership. India's most important international partner in space is France. It launched most of India's heavy-payload satellites. Besides, India and Israel have cooperated in developing advanced imaging and reconnaissance satellites, most prominently the RISAT-2. Using synthetic aperture radar, it is a day-night and all-weather radar-imaging satellite capable of monitoring India's border areas on a 24/7 basis. Another important partner is NASA, with which India has a long history of cooperation. However, cooperation was restricted because of the export control regimes and sanctions placed on ISRO following the 1974 and 1998 nuclear tests. After the 2005 U.S.-India civil nuclear agreement, things have improved.[3]

The Indian Space Research Organisation (ISRO)

ISRO is now one of the largest space agencies in the world. It maintains a large fleet of communication, (INSAT)/Geo-stationary Satellites (GSAT) remote sensing, navigation and scientific satellites. It provides multiple application-specific products and tools for broadcasting, communication, disaster management, weather forecasting, GIS, cartography, navigation, telemedicine, among many other functions. ISRO has completed 118 spacecraft missions and 78 launch missions till 2019. Presently, there are 18 communication satellites, 21 conservation satellites and eight navigation satellites in orbit. These achievements display the rapid advancements made by the Indian space programme in manufacturing indigenous equipment to fuel its ambitions. ISRO's launch systems proved to be among the most reliable and cost-effective solutions globally and have attracted international customers.

In more recent achievements, ISRO has placed an orbiter around Mars and assisted in confirming the presence of water on the moon. In 2019, the agency tried to land a rover on the moon, but the mission partially

failed when the lander could not achieve a soft landing and crashed.

India has joined the quest to explore other celestial bodies through missions such as:-

- **Gaganyaan**. Sending humans in space and bringing them safely back to earth, planned to be launched in December 2021.
- **Chandrayaan 3**. To land safely on the moon, Chandrayaan-3 is likely to be launched in 2022.
- **Mangalyaan2.** Second Mars mission, this mission is likely to be an orbiter**.** Will be undertaken after the launch of Chandrayaan-3.
- **Aditya.** To study the outermost region of the sun, called corona. It would be placed into a point in space known as the L1 Lagrange point by the end of 2021.
- **Heavy Lift Launcher**. Super heavy-lift launch vehicle, which is planned to have a lifting capacity of over 50-60 tonnes.
- **Geosynchronous Transfer Orbit (GTO)**. Heavy-lift launch vehicle that can carry upto 16-ton payloads to Geostationary Transfer Orbit.

Progress made by the ISRO in outer space technologies has also benefitted other emerging nations. India has signed over 200 cooperation agreements with 51 countries and five international organisations, which provide effective collaborative mechanisms for peaceful use of outer space, data sharing, capacity building, and policy coordination.

Antrix Corporation Limited

The Antrix Corporation Limited was raised in September, 1992 as a company under the administrative control of the Department of Space,

Government of India. Antrix is the commercial arm of ISRO. It promotes and markets the products and services generated by the Indian space programme. Commercially, a total of 328 foreign satellites from 33 countries have been successfully launched onboard the Polar Satellite Launch Vehicle (PSLV). Revenue earned through these launches is $25 million. These launches were done through contracts that were signed with Antrix Corporation Ltd.

Major areas of work of Antrix Corporation are:-

- Obtaining licence from DoS/ISRO for SSLV technology and transfer it to the industry through sub-licencing;
- Providing launch services for customer satellites;
- Manufacture of SSLVs in collaboration with the private sector;
- Production of Polar Satellite Launch Vehicle (PSLV) through industry;
- Production and marketing of space-based services;
- Transfer of Technology to the industry through sub-licensing;
- Market by-product technologies and products or services.

In 2019, the Government of India established the NewSpace India Ltd. (NSIL), whose purposes are almost identical to Antrix. It will be interesting to watch the global role of private players in the space segment.

Role of Private Players

Emergence of private players in the space domain has given a new dimension to the use of space and space security. Big companies like Boeing, Northrop Grumman and Lockheed Martin have been there in

the space domain for some time. But the requirement to make space more accessible and reducing the overall cost of space operations has produced several private launch companies like Space Exploration Technologies (SpaceX), Blue Origin and Rocket Lab. Termed as New Space companies, they have brought about innovations in the space industry. Services such as high-resolution imaging, geolocation and remote sensing are now available through cube and microsatellites. These can be purchased on the commercial market. Earlier, these capabilities were accessible only with large satellites requiring significant investments.

These private players serve both government and non-government organisations. However, their business is largely driven by government contracts. Indigenously-grown private space industries help reduce the launch of assets and provide services that improve the space situational awareness of a country. In addition, they can work as an extended arm in a state's overall national space strategy and space operations.

The rise of commercial rocket and space services companies is not restricted to U.S. and Europe. Many private companies have come up in China and India, which can offer affordable and reliable launch services for small, micro and nano-satellites. Both China and India can lead the micro and small satellite market in the world and become a hub for affordable and reliable launches and space services.

Private players in space bring particular challenges on security. To conduct espionage operations against adversary states or conduct counter-space operations, a country can operate through private players. This will not be easily attributable directly to any state. Access to space becomes easy. This could open doors to non-state actors whose intentions may sabotage a country's satellites and communication networks and create havoc. States will have to deal with the potential threat posed by non-state actors.

Private space companies extend the capabilities of a country to operate in space. But it also raises the potential non-attributable threats from states and non-state actors.

Availability of Commercial Sector in Crisis Situation

Many countries use satellite communication, remote sensing and global positioning services during normal military operations. As a result, they rely more on these technologies. Due to the dual-use nature of many of the products and services provided by commercial space activities, it is difficult to differentiate between purely military and commercial endeavours and associated systems. There may be shared architectures where military-related communications are enabled by commercial satellites. There are implications of mixing military and commercial activities.

It is understood that commercial companies, especially homegrown, will support states in times of conflict if the applicable agreements are in place before the war starts. Militaries and commercial partners must create trust during peacetime.

Commercial space companies may come under cyber-attacks from individuals, foreign militaries or their surrogates. However, many commercial space capabilities are more robust and resilient than generally understood by policy-makers and the military. Commercial satellite operators deal with various threats like jamming of satellite communications or cyber-attack of networks every day. They have become more resilient. Several medium-to-large commercial space companies do their own research and development to improve operating under jamming or cyber-attack conditions. Governments can benefit by applying the lessons learned from commercial partners.

Private operators and government organisations must understand certain important issues, before any conflict, to incorporate innovative commercial space capabilities. These areas of understanding are:-

- Implications when commercial assets are employed to support military activities.

- Government's considering the ways and means needed to protect commercial space assets when employed to support military operations.

- Companies and their shareholders to consider the implications of commercial space assets becoming targets for kinetic or non-kinetic attack because of the services provided to governments during hostilities.

- For commercial remote sensing companies to understand the potential level of control that licensing nations may exert during hostilities.

- Establishing the most effective and efficient communication structure or architecture between governments and commercial partners enables the unimpeded flow of information during peace and conflict.

- Ensuring commercial partners have access to all necessary data and information so that they can provide the agreed-upon products and services during times of war.

Examples of Commercial Space Enterprises

From the mid-2000s, start-up space companies started coming up. These start-ups entrepreneurs, some with impressive records of success, developed business plans and sought venture capital from investment firms and angel investors. These 'NewSpace' companies are currently taking a leading role in space technological development by building the components, materials, and rockets deploying a new generation of cell-phone-size satellites into space. Many of these companies, including SpaceX, Blue Origin and

Virgin Orbit, are attracting the best and brightest young minds.

The technology of choice for many of these space start-up companies is the *CubeSat*, which is ten cubic centimetres, weighs about two pounds and generally costs less than $100,000 to build. About 60 companies now sell these. This allows governments and companies with relatively little financial resources to put a satellite into orbit for agriculture, oil spill or border monitoring like tasks. Some entrepreneurs envision potentially thousands of satellites being part of a mega-constellation in the decade ahead. A launch market has emerged that caters to the CubeSat market.[4]

SpaceX has become the operator of the world's largest active satellite constellation. As of now, the company has 242 satellites orbiting the planet. It has plans to launch 42,000 over the next decade, part of its ambitious project to provide internet access across the globe. These new satellites can revolutionise many aspects of everyday life, from bringing internet access to remote corners of the world to monitoring the environment and improving global navigation systems.[5]

Starship is different from any rocket that has come before it. After it gets operational, its payload capacity, size, ability to land and fly again and the number of vehicles that will be built, will eclipse anything built over the past 70 years of spaceflight. The dimensions of Starship are mind-boggling. When fully stacked, the 164-foot-tall vehicle is only the second stage of a much larger two-stage rocket. Combined, Starship and the Superheavy booster will stand some 400 feet.[6]

Unmanned orbital flights may commence in 2021 and private manned flights around the Moon as early as 2022. Recently SpaceX won the National Aeronautics and Space Administration contract to provide lunar landing services with a lunar variant of Starship. The company also plans unmanned flight tests to Mars in 2024. When it arrives, a single Starship/ Superheavy will be able to place more mass in orbit during a single launch

than the entire world managed in total in 2020.

There are several technical challenges. First, starship has to demonstrate that it can be reused after surviving landing. Second, it has not yet achieved orbit. Superheavy is still under construction and even when it flies, it will have only three of its planned complement of 37 engines. Finally, core capabilities such as orbital refueling, crucial to advanced manoeuvre above the atmosphere and central to unlocking commercial and military space, still need to be tested. SpaceX is working to overcome these remaining technical obstacles.

Emerging Capabilities and Future Trends

New Launch Vehicles. The commercial sector is now developing multiple new launch vehicles across small to heavy lift payload classes. In addition, many commercial launch providers are investing in innovative technologies and processes to lower launch costs and increase competitiveness. Some of the creative processes include rocket stages and booster reusability, like SpaceX's Falcon Heavy and the use of lower-cost propellants, like the liquefied natural gas used in *Blue Origin's* New Glenn vehicles. While technological innovations and new processes are expected to transform the launch market, the market still has persistent challenges including a highly competitive commercial launch market, historically low profit margins, missile technology proliferation concerns and technology and intellectual property export control risks.

Affordable Launch. Two key trends have enabled reductions in the cost of space launch. First, companies like SpaceX and Blue Origin have pioneered techniques to re-use launch vehicles, potentially saving significant savings. Second, many companies like Rocket Lab have begun introducing small launch vehicles empowered by new technologies such as additive manufacturing. These small vehicles provide lower total cost making them attractive to some users.

Smallsats. With reduced launch costs and the miniaturisation of computer components, small satellites have shown the way for more diverse uses of space. Countries like Mongolia and Ghana have been able to field satellites, as have universities, high schools and middle schools through programs like NASA's Educational Launch of Nanosatellites (ELaNa). Small satellites like *CubeSats* have also supported many commercial ventures, including Earth-imaging and communications services. However, small satellites and large constellations pose the risk of significantly increasing the quantity of debris in orbit.

Large Constellations. Large constellations have become cheaper as it is easier to launch large numbers of small satellites. As a result, large constellations can be predominantly helpful for lower-latency satellite communications and expand Internet of Things (IoT) applications.

New Space Applications. Commercial companies have offered recently serious proposals to undertake novel activities in space. With plans for private customers on suborbital flights by at least two well-financed companies, space tourism has arrived. Other activities include satellite servicing with specialised spacecraft, which repair or refuel existing satellites to extend their mission lifetimes, and commercial lunar and asteroid missions, which could provide data to space agencies and universities or even prospect for valuable resources.

Activity Type	Example Companies
Satellite manufacturing	Northrop Grumman, Lockheed Martin, Boeing, Maxar
Launch vehicle subsystem manufacturing	Aerojet Rocketdyne
Launch services	Arianespace, SpaceX, ULA, Northrop Grumman, Blue Origin
Telecommunication	Iridium, Intelsat, Eutelsat, DirectTV, Sirius XM
Earth observation	Planet, Maxar
Space tourism	Virgin Galactic, Blue Origin
Satellite servicing	MDA, Northrop Grumman
Space station logistics	SpaceX, Sierra Nevada, Boeing, Northrop Grumman
Space stations	Axiom, NanoRacks, Bigelow Aerospace
Smallsat manifesting	Spaceflight Industries, NanoRacks
Lunar delivery and space resources	Astrobotic, Moon Express, ConsenSys

Examples of Past and Current Commercial Space Activities

Cyber Security

Amid all the pomp, a critical danger has evaded notice. The deficiency of cybersecurity standards and regulations for commercial satellites, along with satellites' complex supply chains management and layers of stakeholders, leaves them highly vulnerable to cyberattacks.

If state-sponsored hackers or non-state actors can take control of these satellites, the consequences could be catastrophic. Hackers can shut down satellites or turn them into weapons, jam or spoof the signals from satellites creating a disaster for critical infrastructures like electric grids, water networks and transportation systems. In addition, some of these new satellites have thrusters that allow them to speed up or slow down and change direction in space. Hackers could change the satellites' orbits and crash them into other satellites or even the International Space Stations. Makers of these satellites, like tiny CubeSats, use commercial off-the-shelf technology to keep costs low. The easy availability of these components means hackers can analyse and find vulnerabilities in them. Most of the elements depend on open-source technology. The hackers can insert back doors and other vulnerabilities into satellites' software.[7]

The highly technical nature of these satellites means multiple manufacturers are involved in making the different components. The process of getting these satellites into space is complicated, involving various companies. Once they are in space, the satellites' owners regularly outsource their day-to-day management to other companies. Additional vendor means, increase in the vulnerabilities as hackers have multiple opportunities to infiltrate the system.

Satellites are normally controlled from ground stations. These stations use computers with software vulnerabilities that hackers can exploit. If hackers infiltrate these computers, they could send malicious commands to the satellites.

While the U.S. Department of Defense and National Security Agency have made some efforts to address space cybersecurity, the pace has been sluggish. Presently there are no cybersecurity standards for satellites and no governing body to regulate and ensure their cybersecurity. Even if common standards are developed, there are no mechanisms in place to enforce them. Responsibility for satellite cybersecurity is with the individual companies that build and operate them.

Market forces work against space cybersecurity. As they compete to be the dominant satellite operator, rival companies are under constant pressure to reduce costs. There is pressure to speed up development and production. This makes it attractive for the companies to cut corners in areas like cybersecurity that are secondary to getting these satellites in space. Even for companies that consider cybersecurity as of high priority, the costs associated with guaranteeing the security of each component could be prohibitive. This problem is more acute for low-cost space missions, where the cost of ensuring cybersecurity could exceed the cost of the satellite itself.

The complex supply chain of these satellites and the several parties involved in their management means it's often unclear who bears responsibility and liability for cyber breaches. Unfortunately, this lack of clarity has bred complacency and hindered efforts to secure these critical systems.

Regulation is Required

Certain experts favour strong government involvement in the development and regulation of cybersecurity standards for satellites and other space assets. There is a need to adopt a comprehensive regulatory framework

for the commercial space sector. Satellite manufacturers may be told to develop a common cybersecurity architecture. Reporting of all cyber breaches involving satellites should be made compulsory. To prioritise cybersecurity efforts, there is a need to clarify which space-based assets are critical. Clear legal guidance on who bears responsibility for cyberattacks on satellites will ensure that the parties concerned take the necessary measures to secure these systems.

A multi-stakeholder approach involving public-private cooperation may be necessary to ensure cybersecurity standards. Whatsoever steps government and industry take, it is imperative to act now.[8]

India's Space Policy

India's space ecosystem has seen significant government involvement, with ISRO spearheading research, manufacturing, launching, operating and maintaining objects in space. ISRO has built a formidable legacy and is among the leading space agencies in the world. However, private sector involvement in space activities was limited to supplying parts and assembling blocks for ISRO.

ISRO has always punched well above its weight. However, today, the Government space agency, by itself, does not have the capacity in terms of capital, skilled labour, equipment to develop and exploit all benefit single-handedly. This makes a strong case for unlocking the potential of private capital and skills. For example, DTH operators in India use 42 transponders from indigenous satellites and leasing about 67 transponders from foreign satellites. The policy needs to focus on creating a competitive and level playing field where new players can enter, receive mentorship and support from ISRO and flourish.

All these are about to change. In a major policy change, the Union government has permitted for the reforms in the space sector by allowing private players' participation. On November 20, 2020, the Department

of Space unveiled its *Draft SpaceRS Policy-2020* and *SpaceRS NGP-2020* documents and sought comments from the public. ISRO has released the draft of a new *Spacecom Policy 2020*. This is the most significant development in the space sector since the formation of ISRO half a century ago.

The Indian National Space Promotion and Authorization Center (IN-SPACe)

IN-SPACe is an independent nodal agency under the Department of Space to allow space activities and usage of Department of Space owned facilities by non-government private entities (NGPEs) and prioritise the launch manifest. N-SPACe will have a chairman, technical, strategic and legal experts in space activities, safety and from other departments, academia and industries and members of the PMO and Ministry of External Affairs. Decisions of IN-SPACe, shall be final and binding on all stakeholders. The NGPEs will not require to seek separate permission from ISRO for using its facilities.[9] This has invited sharp reactions. Former ISRO chairman G Madhavan Nair said that this is an unwanted disturbance in the functioning of the Indian space programme. Trying to implement an unproven novel concept would result in killing the goose that lays the golden eggs.

Roles and Responsibilities. IN-SPACe will be established as a single-window nodal agency, with its own cadre, which will permit and oversee the following activities of NGPEs:-

- Space activities include building launch vehicles and satellites and providing space-based services as per the definition of space activities.

- Sharing of space infrastructure and premises under the control of ISRO with due considerations to ongoing activities.

- Establishment of temporary facilities within premises under ISRO control based on safety norms and feasibility assessment

- Establishment of new space infrastructure and facilities, by NGPEs, in pursuance of space activities based on safety norms and other statutory guidelines and necessary clearances.

- Initiation of launch campaign and launch, based on readiness of launch vehicle and spacecraft systems, ground and user segment.

- Building, operation and control of spacecraft for registration as Indian Satellite by NGPEs and all the associated infrastructure for the same.

- Usage of spacecraft data and rolling out of space - based services and all the associated infrastructure for the same.

The Chairman of ISRO is also the Secretary of the Department of Space (DOS) and the Chairman of the Space Commission. The New Space Policy 2020 aims to decouple the policy, regulatory and service delivery roles of the ISRO. The incumbent ISRO will be restructured. Its commercial activities hived-off into a government-owned NewSpace India Ltd, leaving the organisation to focus on research and development, scientific missions and exploration.

K. Sivan, ISRO's chairman, categorically stated that "IN-SPACe will be an autonomous body, which won't be influenced by ISRO and it won't influence ISRO's work". However, he is also concurrently the secretary of the department of space (DoS) and chairman of the space commission. Even if IN-SPACe is independent of ISRO, it cannot be truly autonomous to the extent that it is under the DoS. Among the first tasks would be the painful one of severing the roles of chairman of ISRO and secretary of DoS.

In the last two years, IN-SPACe is the second space organisation created by the government. The government, in the 2019 Budget had announced the setting up of a New Space India Limited (NSIL), a public sector company that would serve as a marketing arm of ISRO. Its primary purpose is to market the technologies developed by ISRO and bring more clients that need space-based services. That role was already being performed by the Antrix Corporation, another PSU working under the Department of Space, and which still exists. The government stated that it was redefining the role of NSIL so that it would have a demand-driven approach rather than the current supply-driven strategy. Rather than just marketing what ISRO has to offer, NSIL would listen to the clients' needs and ask ISRO to fulfil those.

In a lecture, Chairman of ISRO Dr K Sivan recently stated that ISRO intends to offload most of its space-related activities to industry and increase focus on advanced research. He said, "Future of space activities is now changing. Earlier all the space activities were done by only ISRO. Now, we are giving equal opportunity to private players also to do it. We want to hand-hold them to our [ISRO's] level so that most activities that ISRO is doing can be offloaded to industry, and we can spend more time on advanced research to take India to the next level (in the space sector)." He was firm in saying that ISRO is not looking at collaboration with NGPEs at this stage. ISRO can only collaborate with partners with equal strength, like international space agencies, since NGPEs in the space sector are still in the growth stage. He added, "That is a process. We are hoping that once they grow to our level, then definitely we will be able to have collaboration."

Spacecom Policy 2020

Key Points of the Spacecom Policy 2020 are:-

- The space policy has been drafted for reforming the Indian space

sector.

- The policy will regulate the commercial use of satellites, orbital slots and ground stations for communication needs.

- The private players in the space communication sector will help India to keep pace with the increasing demand for satellite-based broadcasting, network connectivity and global mobile personal communication.

- The government wants private players to participate in the space sector as a vendor and partner.

- The Spacecom Policy - 2020 enables the activities of space-based communications under five major statements. It states that the Government of India shall:- [10]

- Adopt measures to monitor and authorise the use of space assets for communication to or from Indian territory.

- Ensure protection of space assets already put in place and adopt measures to bring in more space assets under the administrative control for enhancing the ability to utilise space-based communication for national needs.

- Promote increased participation of commercial Indian industry to provide space-based communications both within the country and outside.

- Concentrate on realising space-based communication systems to address the requirements that cannot be effectively, affordably and reliably satisfied by the private Indian industry either due to national security concerns or economic factors.

- Provide a timely and responsive regulatory environment for the

commercial Indian industry to establish and operate space-based communication systems.

Salient Features. The new policy will enable India to meet the growing demand for satellite-based broadcasting, network connectivity and global mobile personal communication. It will help India attain a significant position in the worldwide space communication sector. The salient features are:

- Only Indian entities will be allowed to seek authorisation for orbital slots for new satellites, services based on existing satellites, and new ground stations.
- There are no restrictions regarding satellite owning, ground session setup and providing services to ordinary people.
- Private industries are allowed to use the ISRO satellites, and they can have their own satellites.
- Any company sending a communication satellite in space will also be responsible for any damages to other objects in space and the environment.

There are notable issues. For example, taking the satellite industry, each one satellite company requires a frequency allocation license from a national agency that coordinates the frequency allocation with the International Telecommunication Union (ITU).[11] There was no clarity on how a private satellite operator would do that. Agencies involved are the Department of Telecommunications which allocate the frequencies, the Department of Space and some other departments. With the creation of INSPACe and the new draft SATCOM policy, the procedure will become much simpler with IN-SPACe being the nodal agency for this. Regarding the remote sensing policy, it only covered the usage of satellite imagery and not the operations of earth imaging satellites until now. All purchases had to go

through the National Remote Sensing Centre (NRSC). The process adds a time delay. With the setting up of INSPACe and the new draft of the remote sensing policy, the process has become simpler. Anything above 50cm resolution is free to procure and sell, which would be a massive boost to the sector.[12]

What hasn't changed?

Though the new policy has significant clarity compared to the earlier SATCOM Policy and norms, there are areas of concern. The availability and allotment of orbital resources, such as orbital slot, frequency and coverage, have not been deliberated in the new policy. Currently, the wireless planning and coordination wing of the Ministry of Communications is the official body to coordinate with the ITU on behalf of India for securing these resources. The allocation of spectrum is undertaken through the National Frequency Allocation Plan, 2018 and under the Indian Telegraph Act. This process is complicated and time-consuming. The new policy needs the operational licenses to be secured from the ministry of communications or broadcasting.

The new policy falls short of achieving a single-window clearance system for potential applications seeking authorisations for launching and operating SATCOM assets. The new policy and norms do not define the composition of IN-SPACe, the regulatory body for commercial space activities and the extent of the powers of regulation. The Department of Space and IN-SPACe have been given authority to formulate policy guidelines for submiting applications, processing and grant of authorisations without laying down the limits of the powers of each body.[13]

The intent of the new norms and policies is laudable. However, the potential for achieving ease of doing business metrics for the satellite communications industry remains unrealised. Excluding foreign entities altogether from the new policy and norms scheme raises concerns about

whether or not the new policy and norms comply with international obligations under the provisions of relevant Bilateral Investment Treaties. They are corollary to India's membership in the World Trade Organisation. Furthermore, the requirement of bringing non-geostationary non-Indian orbital resources (NIOR) under Indian administrative control curbs the ability of Indian entities to cooperate with foreign satellite service providers to act as aggregators and distributors of their capabilities in India. It is a subject of debate whether the objective of self-reliance should be realised at the expense of facilitating international partnerships.

Supposing that the new policies and norms are to achieve the stated objective of promoting commercial space, in that case, it must first involve the joint and consolidated efforts. Thus the Ministry of Communications, Ministry of Information and Broadcasting, Ministry of Home Affairs, Ministry of Defence, along with the Department of Space have to work out a new and revised policy that consolidates the mandates of the provisions of the Indian Telegraph Act along with security considerations into a single window system for receiving and processing applications for space activities. Authorisation for launching satellites and operational clearances cannot be two independent regulatory streams. This will only lead to uncertainties on timelines and outcomes.[14]

Defence

In June 2018, the U.S. raised a separate branch of the armed forces known as the 'Space Force' to protect U.S. space interests. In 2015, China created the Strategic Support Force to carry out space and cyber operations and information and electronic warfare. Russia has military space command and operational capabilities. Recently, France has announced that it will establish a space command to protect its space assets and interests. The need to save space assets is an inescapable requirement now.

India realises this reality and the need to re-organise and re-structure the entire national security complex. It is the most important task ahead of the Indian nation-state, especially if India wants to become a global power. The role of space-based communications and C4ISR assets complemented by other ground-based Space Situational Awareness (SSA) components will be crucial for waging war to preserve peace through the deterrence of war.

Indian armed forces had been aware of the importance of space in today's warfare. Therefore, the first integrated space cell within the Headquarters of the Integrated Defence Staff was created in 2008. This cell was formed to create synergy between the Department of Space, ISRO, a civilian space agency and the Ministry of Defence and the military. These different institutions interact with each other about requirements, capabilities, and relevant policies.[15]

In 2019, the Union Government announced the creation of a new agency called the Defence Space Agency (DSA), comprising members from the Army, Navy and Air Force, and supported by a new research organisation, the Defence Space Research Organization (DSRO). Defence Space Agency (DSA) comprises members from the Army, Navy and Air Force. The DSRO is a research organisation to facilitate the development of space technology for military purposes. DSA may be a precursor to something like that of a space command in the U.S., integrating space assets from the army, navy and air force and formulating strategy. The DSA, commanded by an air force two-star rank officer, began with a staff of about 200 officers taken from the three services and took over the duties of some existing military organs, including the Defense Imagery Processing and Analysis Center (DIPAC) and the Defense Satellite Control Center (DSSC). The DSRO and DSA will form the pillars of India's military space operations.

On March 27, 2019, Prime Minister Narendra Modi addressed the nation, announcing that India had successfully tested an ASAT (anti-satellite) weapon, becoming the fourth nation to acquire this capability after China,

the United States and Russia.

India had about 25 satellites, of which four were dual-use. The armed forces were relying on those four satellites. However, they did not have a dedicated military satellite till August 2013, when the first satellite was launched for the Indian Navy for maritime communications. Before that, India was relying on *Inmarsat*, a British commercial satellite communication provider. This had obvious security implications. The next military satellite will serve the Indian Air Force. Indian Army and will likely have a delayed launch.

Some of the major space-based components required for India's fledgling space capabilities are:- [16]

- A robust SSA capability comprising radar, optical and laser tracking facilities complemented by an organizational and human resource base that is able to operationally monitor the space environment.

- A four-satellite constellation of advanced communications satellites in Geo Synchronous Orbit (GSO) that use ion propulsion for carrying out vital C4 functions.

- A constellation of 40 satellites in LEO that provide Internet services for the military.

- Three clusters of 3 satellites each for performing the Electronic Intelligence (ELINT) function.

- A constellation of 12 Earth Orbit (EO) and SAR satellites in appropriate Sun Synchronous Orbits (SSO) for meeting ISR needs.

- A constellation of 24 small satellites in LEO for meeting ISR needs during times of crises.

- Three Tracking Data Relay Satellite System (TDRSS) satellites in GSO for performing the tracking and data relay functions needed for a C4ISR capability.

- Two operational satellites in GSO along with 3 orbiting satellites in an 800 Km SSO for meeting operational weather requirements.

- Seven satellites in Geo-stationary and GSO for meeting core navigation functions.

- A 24 satellite constellation in Medium Earth Orbit (MEO), established over ten years, for providing an indigenous navigation solution.

To translate the above needs into an operational capability, India may have to launch 17 satellites into various orbits every year. Moreover, 28 smaller satellites may also have to be launched as part of constellations that cater to diverse C4ISR needs. The 'Small Satellite Initiative' needed to build small satellite capacity in the country may also require the launching of 100 small satellites in the five to 100 Kg class. India needs 16 PSLV, seven GSLV and seven Agni-5 based launchers in every year to meet this requirement.

Apart from the requirements for satellites and launchers, many technology areas require urgent action for development to meet operational needs. Some of these critical areas are: - [17]

- Antenna Technology used for meeting SSA, SAR and C4.

- ELINT Technology Development.

- Infrared Technologies and Imaging Sensors.

- Improved Integrated Optics for Imaging sensors.

- SAR weight reduction initiatives.
- Small satellites related developments.
- Data Processing especially SAR data processing.
- Use of commercial open source data for strategic work.
- TDRSS compatibility related developments.

India should have a space doctrine for armed forces (Takshashila Institution, Bangalore, Discussion Document on Space Doctrine for India-2021 (https://takshashila.org.in/wp-content/uploads/2021/03/A-Space-Doctrine-for-India.pdf) may be looked into. India is taking baby steps to develop space warfare capabilities. There is a need for a fast, aggressive approach as we are already considerably behind the space powers. Some feel India should take a leapfrog approach to catch up with lost time. The creation of Space Forces by the U.S. is an example. This would facilitate the defence of India's growing satellite networks and lay the foundation for coercive action against adversary networks. It would require substantial financial support.[18]

Conclusion

Space plays a significant role in meeting national security needs. It is also used extensively in India's social and development sector, with at least 60 departments using space services to pursue its developmental agenda. However, there has to be a balance between national security challenges and societal needs.

India has been committed to the peaceful use of outer space. She believes that space technology can provide innovative solutions to developing countries for meeting their Sustainable Development Goals (SDGs). India has concluded space cooperation programmes with 51 countries and

five multilateral organisations. India has helped improve capacity building by training nearly 3,000 officials from about 109 countries.

India needs to augment and reorganise its space organisational structure so that the armed forces can take full advantage of the country's space assets. Integrating the various SSA and C4ISR capabilities into a seamless network to facilitate real-time action will be the key. In addition, training personnel for the military application of space technology will need major emphasis.

With the present state of global politics, a new arms race in the form of military-oriented applications for space is becoming dominant.[19] India should secure its territory, address threats and have unhindered use of the outer space. The capability to use space for commercial, scientific and military purposes has become a critical factor of national power. India's growing use of space could make its space assets attractive targets for adversaries. Some critical technological developments make this threat a reality. This threat is aggravated as many space-denial capabilities can be employed covertly or with deniability in peacetime or situations short of war.[20]

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