Space the Next Frontier: Opportunities and Challenges for India[@]

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Abstract

Space as the next frontier influences technological and military development, gives a stimulus to the economy and strengthens national will contributing to the coercive and persuasive ability of a nation. It is a medium to gain strategic superiority and has the capability to influence the international balance of power. At the same time it is also an evolving war theatre. The pursuit of security, supremacy, and balance of power in space began with the US and the USSR during the cold war era leading to the present scenario where space is becoming congested, contested, and competitive. India since 1969 has primarily been focused on making use of peaceful applications of space technologies and only recently has started investing to ensure that its assets are protected against advertent and inadvertent disruptions. There is a need for India to focus on having well defined strategic objectives to face the evolving trends on the turfs of outer space. The article analyses the global space economy and the latest trends in the space industry affecting the national security objectives. The compounded annual growth rate required by India's space industry to keep up with the global pace has been analysed. Militarisation trend being followed in the global space domain has been compared with India's counter space capabilities and, finally, a road map has been proposed for the Indian Space Programme to counter

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[@]This is the runners up entry of the USI Gold Medal Essay Competition Group 'B' for the year 2020.

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Journal of the United Service Institution of India, Vol. CLI, No. 625, July-September 2021.

the challenges and exploit the opportunities leading to comprehensive national development.

Introduction

The quest for technological advancements and the desire to explore have changed the way humans look at the night sky. From the time when Sputnik 1 was launched in 1957 to the climax of cold war in 1990, the USA and the USSR were the dominant space powers. 70 per cent of the satellites launched by these two countries were with military intent.[1] In the 1990s, space capabilities began proliferating to other countries and even private entities, resulting in comprehensive development of nations. In today's world, space technology plays a multi-faceted role in all activities ranging from domestic to military. Increased use of space by many nations and development of technology with innovative applications have led to disruptive changes in how space is being utilised. 82 countries with over 200 private investors have contributed to the total satellites in orbit as of 2018.[2] Advancements in space affects "technological, demographic, economic, industrial, military and other factors that contribute to the coercive and persuasive ability of a country to politically influence the actions of other states".[3] In the on-going pursuit of security, supremacy, and balance of power, space is becoming congested, contested, and competitive.

India's foray into outer space started in 1969 with the formation of Indian Space Research Organisation (ISRO).[4] Ever since the launch of India's first satellite Aryabhatta in 1975 to RISAT-2BR1 in 2019, Indian space programme has excelled. On 27 May 2019, post the successful demonstration of Anti-Satellite (ASAT) capability by ISRO, Indian Prime Minister Narendra Modi, while addressing the nation, brought out that "The main objective of India's space programme is to ensure country's security, economic development, and technological progress. India's strategic objective is to preserve peace, not prepare for war".[5] India is presently a well-recognised space-faring country in the global space domain due to its ASAT capabilities and cost-effective launch programmes. With China making huge strides in outer space, the questions that need to be addressed by India are: firstly, whether the growth in space sector is commensurate with the ever-growing global competition? Secondly are the present space capabilities good enough to counter any threat from adversary nations and ensure India's national security?

Global Socio-Economic Trends

The global space industry has grown into a multi-billion-dollar industry, with its assessed value being $366 billion in 2019.[6] The satellite industry contributes 74 per cent to the global space economy (Figure 1 refers). Amongst the various constituents of this share, Remote Sensing Satellites (RSS) have seen an upward global trend in last five years.[7] This may be attributed to the dual usage of RSS for military and domestic applications.

While there is an upward trend in India's space expenditure in last five years (Figure 2), it amounts to only four per cent of the global space economy and 0.06 per cent of Indian economy.[9] A former senior economist, Brian Higginbotham, predicted that global space sector will grow to at least $1.5 trillion by 2040, which would amount to approximately five per cent of US GDP at that time.[10] For India to contribute even up to one per cent of the Indian envisaged GDP of $5 trillion by 2024[11], it needs to have Compounded Annual Growth Rate (CAGR)[12] of at least 24 per cent. The target may sound ambitious but is not impossible. The increasing share of private players in the space domain merits re-evaluation of the traditional measures and policies of Indian space programme. The challenge for India would be to increase the investors in the Indian space economy.

While countries continue their efforts to utilise space, the magnitude of investment and the number of private-sector investors, also called 'Start-ups', have grown significantly over the last decade globally (Figure 3). Start-ups are booming in nations where the government's proclivity is towards forging a sense of security in private firms by implementing various economic reform policies. The Luxembourg Space Agency, formed in 2018, is likely to be the upcoming future hub among European nations in space ventures, such as asteroid mining.[14] Luxembourg has formulated a regulatory and legal framework and an ecosystem for global industries to invest in its space programme through European Space Agency.

In 2019, Start-ups across the globe contributed $5.7 billion in various space sectors. US private firms such as Elon Musk's SpaceX, Jeff Bezos's Blue Origin, and Richard Branson's Virgin Galactic were forerunners in contributing the maximum to global space sector till 2019 when the mantle was seized by firms like Qianxun Spatial intelligence from China and few from Japan.[16]

The Satellite industry in Context

(2019 revenues worldwide, in billions of U.S. dollars)

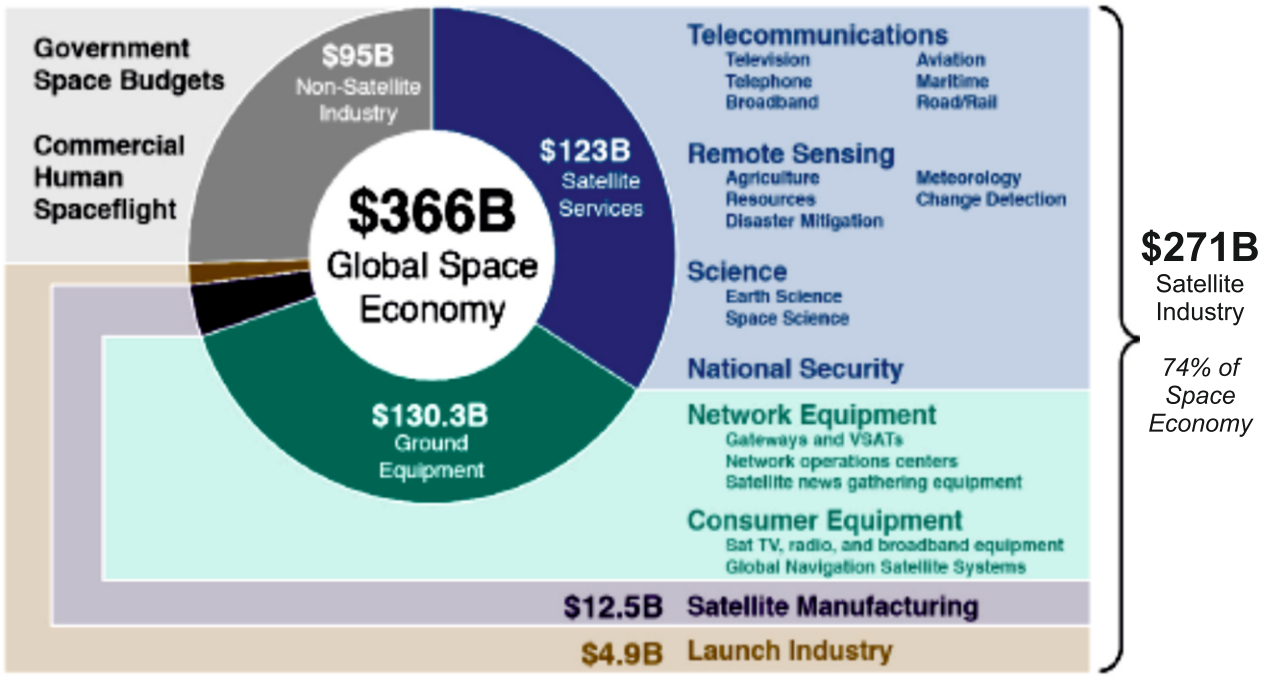

Figure 1: Global Space Economy, 2019, by Bryce Space and Technology

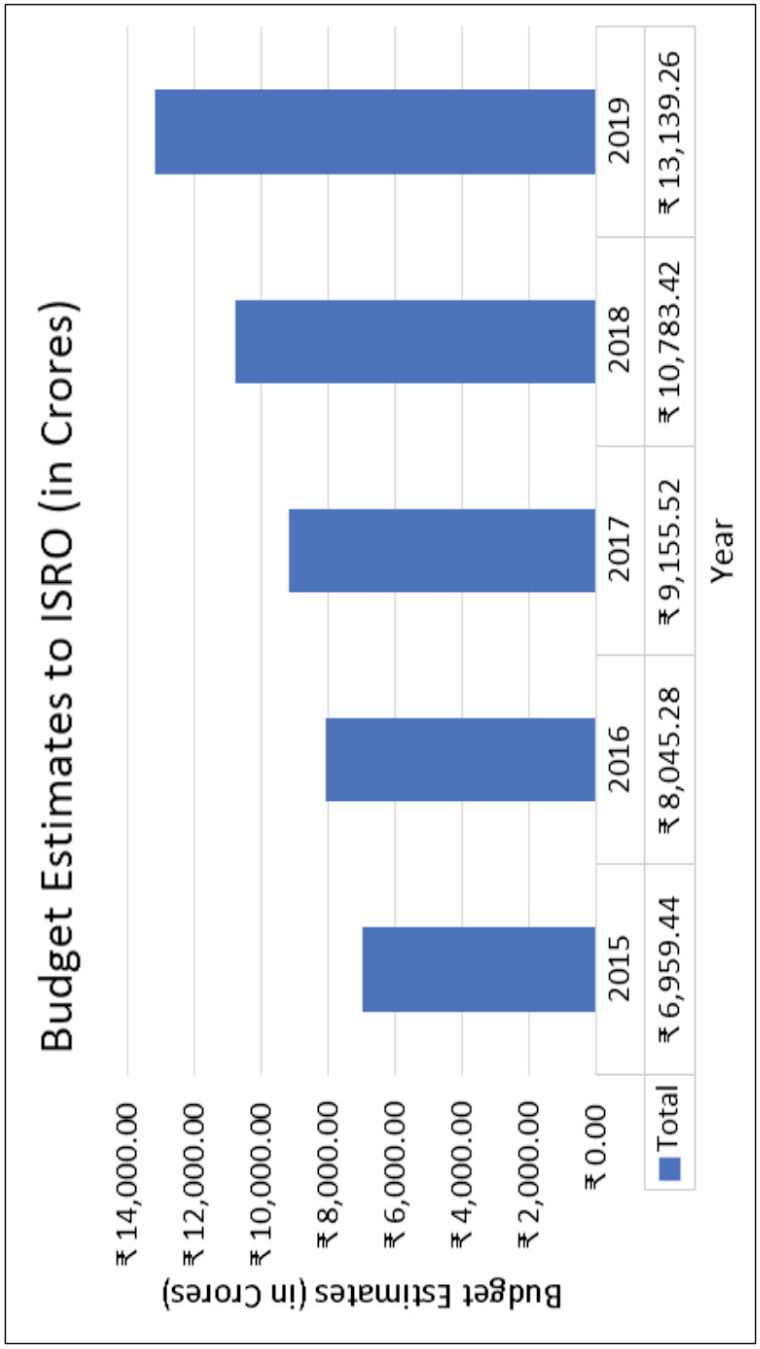

Figure 2 : Budget Estimates to ISRO for last five years[13]

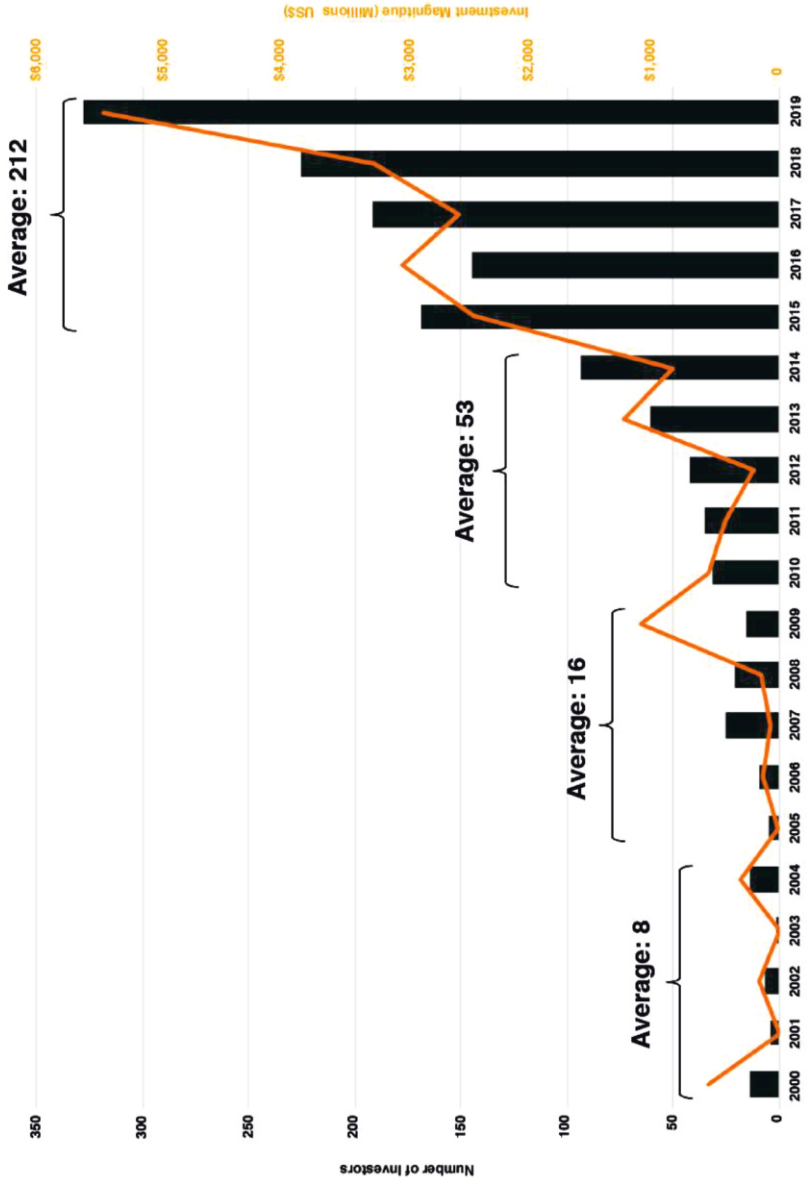

Figure 3 : Private Investors Growth Rate in last five years[15]

India's standing in global space market can be improved by commercialisation of the space industry in India. Over the last decade, an upward trend can be seen in the number of foreign satellites launched by India (Figure 4). Even though India has the capability, it is yet to witness an Indian version of Space X or Blue Origin. Over the last decade, India has launched 319 foreign satellites for 33 countries, US being one of the prominent customers, resulting in a revenue generation of over ₹ 5600 crores.[17]

ISRO, through its nodal agency such as NewSpace India Limited (NSIL) and Public-Private Partnership (PPP) model, has been dependent on various private Small and Medium-sized Enterprises (SMEs) for manufacturing space-subsidiaries such as motor cases, tanks, control equipment, chemicals, electronic packages, etc. An entire ecosystem exists in the Indian market, although at a relatively small scale, for private sectors working for ISRO. To tap the global market, Antrix Corporation Limited (ACL), headed by Department of Space (DoS), is responsible for engaging with international customers on behalf of ISRO. All Indian space activities are controlled and driven by the DoS along with ISRO. Space sector in India seems to lack the competitive and financial drive required for excellence. Impetus on privatisation of space sector with end to end manufacturing capabilities has not yet been legally given by the Indian Government. There is no regulatory framework in India to boost confidence among the existing SMEs to invest more, and expand into larger firms.

The private sector is also shaping the counter-space capabilities of space-faring nations. Private firms are offering low-cost, technologically advanced solutions in the field of Space Situational Awareness (SSA), satellite launching, manufacturing and tracking. In the context of SSA, LeoLabs, a California-based start-up, is operating its own phased array radar and developing the largest constellation of Low Earth Orbit (LEO) satellites without US government support.[19] A less politically controlled, 'bottom-up', innovative approach is trending in the space sector which is working in favour of the US Space programme. However, in Russia and China, a 'top-down' approach is being followed where the programme is governed by political dictate and nationalist agendas. The State Space Corporation of Russia, Roscosmos, appears to be isolated from the growing western global space community. A recent study indicates that Russia imports 75 per cent of its space industry components from US.[20]

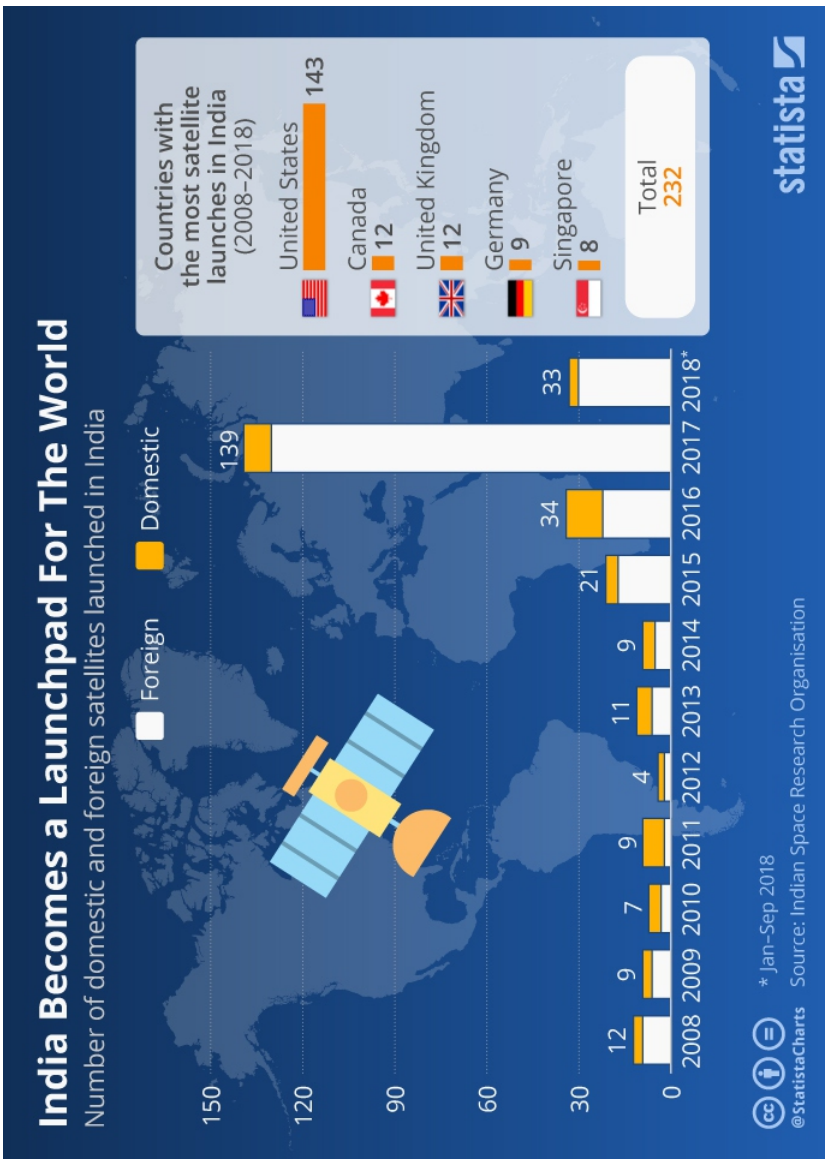

Figure 4: Satellite Launches by India: 2008-2018[18]

Although Chinese space programme follows a top-down approach, it promulgated laws in 2014 for fostering private business and allowed start-ups to emerge in 2015.[21] As on 2018, 60 start-ups have been registered under Chinese space programme.[22] Presently, Chinese private firm SpaceOk is working on putting a constellation of 40 satellites into orbit as part of China's 'One-Belt, One-Road' initiative and China is likely to continue to use its private sector for military purposes.[23]

The correct approach for a nation to adopt, 'top-down' (Russia & China) or 'bottom-up' (US), to promote the growth of its space programme is the challenge that India must resolve. India needs force restructuring in its space sector to meet the challenges that the future is yet to unfold. Private players are playing an evolving role in strengthening military resilience and sustainability across the globe. Thus, to strengthen national security objectives, military must work in confluence with the commercial sector.

Global Militarisation Trends

Militarisation of space is not a recent phenomenon, as since the era of Cold-war USA and Russia has been experimenting and exercising coercion and deterrence through several Space programmes (Table 1).[24]

Table 1 : ASAT weapons tested by the USA and Russia during the Cold War[25]

Country	ASAT Weapon	Treaty Imposed	Timeline
USA	Nuclear Tipped Interceptors	Outer Space Treaty	1950-1960
	Air-Launched ASAT System	US Air Force discontinued Air-Launched miniature Vehicle Programme	1980-1990
Russia	Co-Orbital ASAT weapons	• The Anti-Ballistic Missile Treaty • Accident Measures Agreement	1970-1980

As on date, four nations have demonstrated the possession of Direct-Ascent Anti-Satellite (DA-ASAT) technology for engaging Low Earth Orbit (LEO) satellites[26] (Table 2). With the expanding global space economy and panorama of socio-economic impacts, it is in the national interest of all states to safeguard their space

assets from any attack. Militarisation is perceived as an act of belligerence by a state. Therefore, any overt act in outer space has been disdained by other space-faring nations. Notwithstanding, nations have gone ahead with the development and validation of their anti-satellite capabilities towards space deterrence by denial. With the increased number of global players, the security issues have become more enmeshed and stakes have gone high. With the resultant implications of a direct attack on a satellite, countries are showing preference for covert counter-space capabilities for plausible deniability.

Table 2 : Latest demonstrations by nations having DA_ASAT capabilities[28]

Country	Test Year	Interceptor Missile	Intercept Altitude	Orbital Debris	Life Span of Orbital Debris
China	2007	SC-19	800 kms	3000	Several Decades
United States	2008	SM-3	240 kms	174	18 months
India	2019	PDV-Mk II	280 kms	400	Likely weeks to months
Russia	2020	A-235	Max reported altitude of 1500 kms	Nil	Missile carried a dummy vehicle

In today's scenario, direct satellite attack methods include DA-ASAT missiles and co-orbital systems. The non-direct methods include lasers, microwave, radio-frequency weapons, satellite jamming, and spoofing. Cyber-attacks and SSA are also considered part of counter-space capabilities. The present status of anti-satellite capabilities of few space-faring nations, shown in Table 3, indicates India's standing as a middle-ranking nation in the league. India must keep up the pace of technological advancements with regards to non-direct methods to keep a check on adversaries and ensure Indian national security.

Table 3 : Status-Militarisation of Space, the leading Space-faring nations[29]

Country	Direct Ascent	Co-orbital	Direct Energy	EW	SSA	Cyber Capability
USA	Ops	R&D	Test	Ops	Ops	Ops
Russia	Ops	R&D	Test	Ops	Ops	Ops
China	Ops	R&D	Test	Ops	Ops	Ops
India	Ops	-	-	-	Ops	Ops
Iran	Capable	-	-	Ops	-	Ops
North Korea	Capable	-	-	Ops	-	Ops
Japan	Capable	-	-	Ops	R&D	-
France	-	-	R&D	-	R&D	-

Dual-use satellites are also an emerging trend in the militarisation of space. Satellites with robotic arms meant for repairs, inspection, or debris removal can also grapple an adversary's space asset when required. RSS, communication, and navigation satellites also assist in military domain awareness and network centric operations. After US, China and Russia have the largest RSS fleet. As of 2018, China had a fleet of more than 120 RSS through which China maintains situational awareness in its areas of interest.[30] India presently has 15 RSS to augment the armed force's communication and military operations.[31] With an increasing demand of RSS in the global space industry, India should develop a strategy to upscale RSS production and launch capability, which can be used for both military and economic gains.

Global Strategic Developments

The strategic importance of outer space got emphasised in the global arena when US used it effectively during the First Gulf War. To showcase a resilient posture in the face of growing US space and military capabilities, China successfully demonstrated its kinetic ASAT technology in 2007. While this brought the issue of militarisation of space to fore, it also highlighted the issue of the resultant satellite debris management.

Indian space programme objectives have always been focused on societal co-existence. There is a need for India to focus on having well defined strategic objectives to face the evolving

trends on the turfs of outer space. Some of the global strategic developments in the employment of outer space are as follows:

- Evolving Nature of Space Assets. Nations are exploring higher orbits than LEO for Intelligence, Surveillance, and Reconnaissance (ISR), and communication satellites, as DA-ASAT is limited to LEO as on date. Also, smaller satellites are being preferred for Command, Control, Communication, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) functions currently being performed by larger, more specialised custom-built satellites. Further, options of reusable launch vehicles are being explored for cost and time efficiency during peace and war times. This will also boost the space industry.[32]

- Deterrence through Disintegration. To ensure survivability in case of an attack and quick replacement, when required, without the entire system's breakdown, countries are aiming to spread their satellites in different orbital planes. The disaggregated space assets in multiple orbits would provide redundancy.[33]

- Deterrence through Threat of Retaliation. This strategy supports development of dual-use satellites and soft-kill counter-space capabilities. DA-ASAT will always have a 'No First Use' policy in case of conflict, as a lot is at stake in the arena of space due to congestion. Therefore, all space-faring nations are concentrating on soft-kill technology development. The awareness quotient of hard-kill weapons is exceptionally high. However, it is difficult to assess the arsenal of weapons available with other nations with soft-kill technology. The element of surprise during an emerging conflict scenario will always be maintained. Threat characteristics of various counter-space capabilities are shown in Table 4.

Table 4 : Threat characteristics of various counter-space capabilities[34]

	Kinetic Physical		Non-Kinetic Physical		Electronic		Cyber	
Types of	**DA-ASAT**	**Co-Orbital**	**High Powered Microwave/ Laser**	**Laser Blinding**	**Jamming**	**Spoofing**	**Data Monitoring/ Corruption**	**Seizure of Control**
Reversibility	Irreversible	Irreversible/ Reversible depending on capabilities	Irreversible	Irreversible/ Reversible; attacker may not be able to control	Reversible	Reversible	Reversible	Reversible
Awareness	Known to all	May or may not be known	Satellite Operator will be aware	Satellite Operator will be aware	Satellite Operator will be aware	May or may not be known	May or may not be known	Satellite Operator will be aware
Collateral Damage	Orbital debris could affect other satellites	May or May not produce debris	Could leave target disabled/ uncontrollable	None	Only disrupts signals and frequencies	Only corrupts specific RF signals	None	Could leave target disabled/ uncontrollable

- Multinational Efforts. The US has 50 SSA agreements with nations, international organisations, and commercial entities. This has come to be known as the Combined Space Operations (CSpO) concept, essentially a "multinational effort focused on co-operation, collaboration, and the integration of military space activities across the participating countries".[35]

India's stand in Global Space Domain

Out of 5806[36] active satellites in outer space as on 2019, the Indian share was only 105[37], out of which 68 per cent amounted to communication and earth observation and meteorological satellites (Figure 5).

While other countries are making huge progress in space technology, India is yet to exploit its potential fully. India established its Defence Space Agency (DSA), to coordinate the armed forces space requirements, in Nov 2019. The Defence Space Research Organisation (DSRO) has also been created to provide technical support to DSA. In Sep 2019, India launched Network for Space Objects, Tracking, and Analysis System (NETRA) to improve its SSA capability. India has primarily been focused on making use of peaceful applications of space technologies and only recently started investing to ensure that its assets are protected against advertent and inadvertent disruptions.

In terms of manufacturing capabilities, due impetus is needed on 100 per cent indigenisation of spacecraft components. Presently, India imports 10 per cent of critical materials and electronic components for launch vehicles and 55 per cent for satellites manufacturing.[39] One of the latest reports vetted by ACL brings out a lack of awareness in the general masses about the international space industry's demands.[40] India needs to develop its end to end space system capabilities to cater for global needs. A new kind of partnership between ISRO, the established private sector, and the new space entrepreneurs promoting due participation of all stakeholders in development of indigenous space sector is the need of the hour.

To ensure safe, secure, and sustainable use of space, India will have to follow a multi-pronged approach. Opportunities available

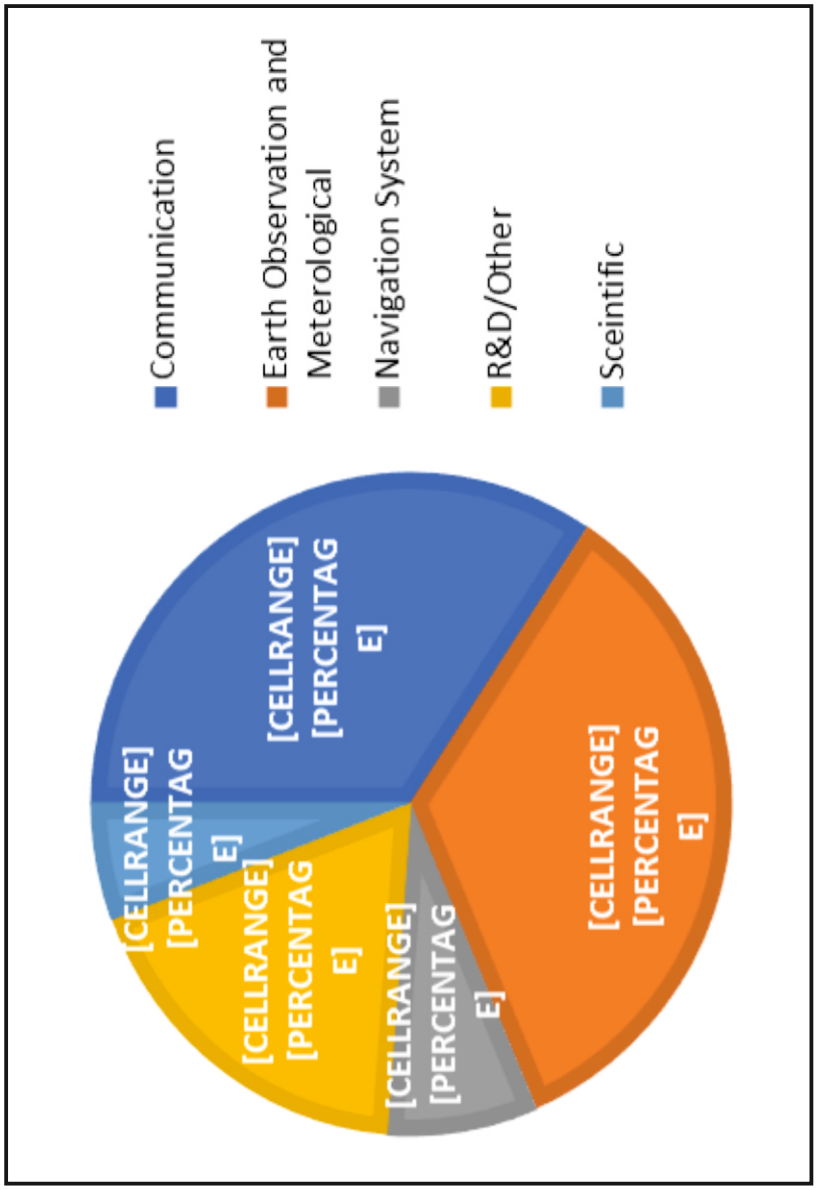

Figure 5 : Percentage share of active Indian Satellites in Outer Space, 2019[38]

with India to overcome various challenges highlighted above are as follows:

- Supportive Governance. With the present majority government having supported various ventures of ISRO such as the ASAT programme, Mangalyaan and Chandrayaan, changes in space organisational structure and a conducive regulatory framework can be promulgated to develop a business-friendly ecosystem for ancillaries – encouraging smaller component manufacturers to participate and existing firms (such as Exceed Space, Dhruva Space, and Bellatrix) to expand in the space sector. The scaffolding is already in place; there is a need to push start the process.
- Globalisation. NSIL was commissioned in 2019, as a commercial arm of ISRO, to globally market space technologies emanating from the Indian space sector. With many start-ups ready to align with the government's aim of comprehensive national development and 'Make-in-India' drive, it is time to annex a sizable amount of $366 billion global economy. The global market for small satellites is predicted to increase from $12.6 billion in 2009-18 to $ 42.8 billion in 2019-28.[41] According to a recent market study by Euroconsult, only 700 small satellites were launched by 2015. This number could grow up to 10,000 small satellites by 2026.[42] There is a massive potential in India to tap this global market.
- Demographic Dividend. Since 2018, India has entered a phase in which she will have a working population for the next 37 years, i.e. people between age group 15 and 60 years will be higher than the dependant population. This phase should be utilised to increase the production capacity and capability of space sector to achieve the CAGR of 24 per cent in the space economy.
- Diplomatic Partnerships. India should utilise its diplomatic relations with Japan, France, and Europe for collaborative ventures in space technology and exploration to raise collective deterrence. This can also leverage indigenous expertise in niche areas.
- Enhanced SSA and Impetus on Network Centric Operations. As the country advances on the path of socio-economic growth, India cannot afford to be complacent about the

emerging security environment, particularly in the Indian Ocean Region (IOR) and in its extended neighbourhood. DSA in 2019 conducted the first series of space war game simulation exercises like IndSpace Ex to measure the Indian space security's strengths and weaknesses. The gaps emerging from these exercises in the upkeep of domain awareness and C4ISR should be documented and addressed on priority.

Way Ahead

In an arena that is evolving rapidly, the only strategy that is guaranteed not to fail is to make the most out of the available opportunities. With a view to enhanced utilisation of the outer space, India could consider realisation of the following options:

- Privatisation. The Government of India should formulate a dedicated 'Space Policy' as the first step to commence the privatisation process. Various legal and administrative aspects like intellectual property rights, insurance, transfer of technology, if warranted, liability clause etc. are to be considered and should be laid out in the open for the motivation of private players to commence their relay run.
- Restructuring. Presently, ISRO is a single vertical hierarchy under DoS with various subunits to assist in its functioning. DoS has a divided focus on the multiple roles it is currently playing with subsequent budgetary constraints. Three parallel verticals should be created under DoS. ISRO should purely concentrate on R&D and advancements of space technology. An Integrated Defence Space cell with DSA should be commissioned as a second vertical, headed by the CDS, and responsible for the military security of space assets. A fourth war dimension, called 'Space Force', can eventually be created in addition to Army, Navy, and Air Force. The third vertical should be the private sector, which will be possible only after achieving the short-term goals regarding the regulatory framework and privatisation. All three verticals should work in synergy through a regulatory framework to achieve national security objectives.
- Human Resource Employment. To reap the benefits of demographic dividends, more jobs in space sectors to be

created for improved productivity. Data received from communication, earth observation, and meteorological satellites have a vast scope for data application tools like artificial-intelligence and machine-learning. Thus, there is a scope for commercialisation and increasing human resources employed in the nation.

- Global Support Services. NSIL should show presence in various international forums related to space industry and promote an Indian comprehensive satellite strategy with respect to communication and earth observation satellites. India should offer a cost-effective end to end service for building, launching, operations, ground support maintenance, and mission support services.
- Space Co-operation. It is essential to have diplomatic engagements to address space security concerns and be part of Combined Space Operations (CSpO) like US and other ally nations, like France, Europe, and Japan, as this would deny an aggressor the opportunity to take up a fight on a one to one basis, given the networking of systems of many countries.
- Counter-space Capabilities. India is required to increase its counter-space capabilities. To start with, the government and ISRO should focus on the following:
  - 100 per cent indigenisation in satellite manufacturing sector.
  - Production of cost-effective smaller RSS.
  - Technological advancement to put remote sensing satellites into higher orbits than LEO.
  - Feasibility study for disaggregation of the space architecture as a response mechanism to deal with the perceived threats.
  - Invest in Direct Energy Weapons, Electronic Warfare, and Cyber Technologies.
- C4ISR. To strengthen national security, technology for introducing more robust and redundant space systems would have to be developed emphasising on space-based ISR and

communications. A potential solution could be a fleet of small satellites described as an 'Operationally Responsive Space' launch capability that can be looked into to provide a distributed but integrated multi-sensor, multi-domain approach to ISR data collection and analysis. India also needs to deploy a large number of Electronic Intelligence (ELINT) and Imagery Intelligence (IMINT) satellites to match the advanced space fairing adversaries and increased SSA.

Conclusion

The known unknowns[43] of space is a 'Gray Rhino' event. National security is the ultimate end for which space is an emerging means. India has excelled in its journey of space programme but has a long way to go compared with the US, China, and Russia. The space sector plays a dual role in the national security strategy. Space as the final frontier is vital from the strategic autonomy perspective and is also an enabler for the country's socio-economic development. India needs to develop its regulatory framework, space policy, and a law defining state and private players' role. Sharing of burden with the private industry is a critical enabler in achieving the Indian space programme's vision. It is also essential to focus on space applications of strategic significance and use diplomatic means to ensure space remains a medium to foster technological developments to achieve national security objectives.

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