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INDIA'S SPACE VISION: NEED FOR A STRATEGIC DIMENSION

GAURAV SONI AND W. SELVAMURTHY

INTRODUCTION

On January 3, 2020, a high altitude drone operating hundreds of kilometres away from its base targeted General Qasem Soleimani, commander of the Iranian Quds Forces. The general was spotted by the surveillance network at Damascus while boarding a flight to Baghdad, where he finally presented himself as a target.[1] Despite being spaced out over large distances, Satellite Communication (SATCOM) enabled linkage between the drone and its decision-makers, thus, resulting in the timely engagement. Five days later, on January 8, 2020, Iran launched 15 missiles targeting the US Army's operational bases in Baghdad and Erbil. With early warning made available by the US Space-Based Infra-Red Sensors (SBIRS), the US bases incurred little losses.[2] In the US-Iran milieu, thus, in a short span of five days, space

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1. Peter Beaumont, "Making of a Martyr: How Qassem Suleimani Was Hunted Down", January 2020, https://www.theguardian.com/world/2020/jan/05/making-of-a-martyr-how-qassem-suleimani -was-hunted-down.
2. Sandra Erwin, "US Early Warning Satellites Helped Avert Casualties from Iran's Missile Attack", https://spacenews.com/u-s-early-warning-satellites-helped-avert-casualties-from-irans-missile-attack. Accessed on February 19, 2020.

reaffirmed its role as a facilitator for strategic manoeuvres in modern-day military conflicts. The omnipresence of space, its reach and its free access captivates users of all kinds and the military is no exception. While many countries are only beginning to utilise space for tactical and operational military purposes, others are already garnering strategic returns. This article emphasises the need for developing a strategic perspective on space in the Indian context.

MILITARY USES OF SPACE

Militarily, space is being utilised by most modern militaries across the world chiefly in three fields, SATCOM, Satellite Navigation (SATNAV) and Intelligence, Surveillance and Reconnaissance (ISR). SATCOM brings connectivity to remote areas and troops conducting mobile operations.[3] SATNAV facilitates navigation during movements and manoeuvre-based operations. ISR, gathered through imagery and Signals Intelligence (SIGINT) satellites, fills the voids of land-based sensors.[4] To develop a perspective on the military utilisation of space, two most vibrant space users, the USA and China, are being discussed here.

The USA remains categorical and unambiguous while relating space with national security. Recognising space as a congested arena which is highly competitive as well as contested, the US National Security Space Strategy, an outcome of its National Security Strategy, lays down three objectives of space security.[5] The rising number of satellites, man-made objects, frequency spectrum and growing space debris cause congestion in space. The first objective which focusses on the safety and stability of space assets can be directly linked to the 'congested' nature of space. The second primary objective assigns a larger role to space, i.e., enhancing

3. Deepak Sharma, *Space Capability and India's Defence Communications Up to 2022 and Beyond* (New Delhi: IDSA), pp. 1-65.
4. USAF 2012, *Global Integrated Intelligence Surveillance & Reconnaissance Operations (AFDD)* pp.1-78.
5. Department of Defence, 2011, National Security Space Strategy Unclassified Summary, pp. 1-21.

strategic national security. At the fundamental level, thus, the USA aims to tap the strategic potential of space. It, therefore, feels that in the near future, space will be highly 'contested' owing to its strategic benefits. The *National Security Space Strategy's* third objective i.e. to boost the industrial base, aims to address the 'competitive' nature of space by giving a governmental push to those industries which work in the domain of space security.[6] It is evident that the USA seeks 'strategic security through space', and, thus, envisages a significantly larger role for space. Therefore, in its approach to using space, the USA adopts a whole-of-US-government approach.[7]

Beginning with the peaceful utilisation of space, China has grown to identify space as the 'new strategic high ground' of future conflicts.[8] The "new historic missions" given out by Hu Jintao in the year 2004, identified space security as one of the key missions of the People's Liberation Army (PLA).[9] As per the White Paper on China's Space Activities in 2006, Chinese efforts in space aim to enhance its national security.[10] The Defence White Paper of 2015, titled China's Military Strategy, designated space as a security domain.[11] In 2016, another White Paper laid down China's space vision wherein its urge to be a space power in all domains emerged categorically.[12] Thus, it can be said that Chinese perspectives on space are rooted in the realisation that space dominance will prove vital to build an edge in

6. US Government, National Space Policy, https://www.space.commerce. gov/policy/ national-space-policy. Accessed on January 5, 2020.
7. The White House, "President Donald J Trump Is Unveiling an America First National Space Strategy", https://www.whitehouse.gov/briefings-statements/president-donald-j-trump-unveiling-america-first-national-space-strategy. Accessed on February 11, 2020.
8. Dean Cheng, "China's Military Role in Space", *Strategic Studies Quarterly*, Spring, 2000, pp. 55-77.
9. R Kamphausen, D Lai and T Tanner, *Assessing the People's Liberation Army in the Hu Jintao Era* (Carlisle: US Army War College, 2014), p. 34.
10. "China's Space Activities in 2006", Information Office of the State Council of the People's Republic of China, http://english.cas.cn/newsroom/archive/china_archive/cn2016/201612/t20161227_172932.shtml. Accessed on January 6, 2020.
11. The State Council Information Office of the People's Republic of China 2015, *China's Military Strategy*, Vol. 13.
12. n. 10.

SATCOM in the Indian armed forces is likely to be subsidiary to terrestrial communication. However, in certain remote areas and in inhospitable terrains, it is likely to be the primary mode of communication. Strategic SATCOM, on the other hand, enables global coverage, thus, facilitating strategic operations.

any form of military operations. While China began with tactical and operational utilisation of space, its giant leap in the last 15 years serves as evidence of its new found cognisance of the strategic significance of space. While it made a humble beginning, China began to adopt a strategic approach to space in the early 2000s. A change in approach such as this may have been a result of China's realisation that strategic capabilities are the quintessence of 'contest' and 'competition' in space.

STRATEGIC MILITARY USES OF SPACE: A MINI SCANNER

Strategic SATCOM*:* Military SATCOM is a critical element required to support a broad range of military user applications. It is likely that future conflicts would be highly mobile and intense in nature, hinging heavily on net-centricity and sophisticated communication systems, while supporting the troops on the battlefield. SATCOM in the Indian armed forces is likely to be subsidiary to terrestrial communication. However, in certain remote areas and in inhospitable terrains, it is likely to be the primary mode of communication. Strategic SATCOM, on the other hand, enables global coverage, thus, facilitating strategic operations. Coupled with futuristic 5G data rates, SATCOM can emerge as the backbone of command and control in modern conflicts. Such data rates depend on the type of bands used for communication.

While most space-faring nations currently operate in the conventional Ultra High Frequency (UHF), C, Ku, Ka and S bands, the advanced nations have matured technologies using Extremely High Frequency (EHF) and Super High Frequency (SHF) that give high data rates and high survivability. At the highest level, the US Defence Satellite Communication System (DSCS), now being succeeded by the Wideband Global Satellite Communication

System (WGS),[13] enables highly survivable, secure and jam-resistant communication for a globally distributed military. The global network interlinks the three Services, diplomatic and presidential channels of communication and selected North Atlantic Treaty Organisation (NATO) partners. At the theatre level, the Advanced Extremely High Frequency (AEHF) constellation,[14] replacing the existing Military Strategic and Tactical Relay (MILSTAR), networks the Services as well as provides communication to the president in case of a nuclear attack. In the near future, the Starlink project of SpaceX with a planned 12,000 satellites[15] is expected to provide very high-speed internet, possibly using 5G technology, thus, emerging as the backbone of the new era of data-enabled warfare. In the year 2022-23, during the Russia-Ukraine conflict, it emerged that Starlink satellites played a pivotal role in Ukraine's networking and communication. While the flexibility of SATCOM and its reading to be adopted quickly by any military was a major lesson from this conflict, it also emerged that private SATCOM companies can play a major role in future conflicts.

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Missile Defence*:* Space assets are fundamental to missile defence. While Infrared (IR) payloads detect missiles in the early phase, communication satellites facilitate space/ground sensor integration with shooters and interceptor missile telemetry. The US Ballistic Missile Defence System (BMDS) relies on the Space-Based Infra Red System (SBIRS), a constellation of IR satellites that provides a layered architecture, giving multiple opportunities

13. "Wideband Global SATCOM (WGS/Wideband) Gapfiller System", https://www.globalsecurity.org/space/systems/wgs.htm. Accessed on December 30, 2019.
14. "Advanced Extremely High Frequency (AEHF) Satellite System", https://www.airforce-technology.com/projects/advanced-extremely-high-frequency-aehf. Accessed on February 22, 2020.
15. Stephen Clarke, "Successful Launch Continues Deployment of SpaceX's Starlink Network", https://spaceflightnow.com/2019/11/11/successful-launch-continues-deployment-of-spacexs-starlink-network. Accessed on April 3, 2020.

to destroy incoming missiles.[16] In the case of China, the Gaofen[17] and Shijian constellations are likely to be performing similar functions.

Anti-Access/Area Denial (A2/AD): The A2/AD strategy of China aims to limit the access of the adversary to strategic locations. Of its eight pillars, four can be directly associated with space, viz., precision strike over long distances, information operations, space/counter-space operations and Ballistic Missile Defence (BMD).[18] Forming the backbone of China's information superiority are its five clusters of Electronic Intelligence (ELINT) satellites specifically tasked to track US carrier groups in the Chinese claimed waters. Once detected, China can engage targets much deeper in the seas, away from the mainland, with its Anti-Ship Ballistic Missiles (ASBMs) like the DF-21D. The success of such missiles requires accurate information of the target and tracking of the missiles made possible by its space assets. The success of A2/AD, thus, largely hinges on space assets.

Targeting the 'Achilles Heel': The Chinese Model*:* The US military relies heavily on its satellites for the conduct of its overseas operations. Its space assets remain the backbone for its Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) structures, accurate targeting over long ranges and operations of its aircraft carrier groups.[19] Critical reliance on such assets may lead to enhanced vulnerabilities in operational scenario.

Space Deterrence: 'Space deterrence' refers to deterring adversarial actions on own space assets by developing means in space or on the ground. Such means can also be categorised under counter-space programmes. Counter-space technologies are typically divided into two categories viz. hard kill and soft kill. Hard kill includes the direct ascent ballistic missiles which are capable of carrying out both exo-atmospheric and endo-atmospheric

16. "Space-Based Infrared System (SBIRS)", https://missilethreat.csis.org/defsys /sbirs. Accessed on April 1, 2020.
17. At www.directory.eoportal.org/web/eoportal/missions/g/gaofen. Accessed on March 10, 2019.
18. Anthony H Cordesman, *Chinese Space Strategy and Developments (CSIS, 2016),* pp. 1–33.
19. Ashley J Tellis, *China's Military Space Strategy: An Exchange Survival* (2008), pp. 1-43.

missions. Such missiles can be utilised for a direct ascent hit on a satellite or for intercepting an incoming missile as part of BMD. Hard kill also entails the usage of orbital space mines which can detonate on coming in contact with the adversary's satellite. Co-orbital kill satellites are especially designed to carry out manoeuvres out of their beaten path to strike an adversary's satellite; and robotic satellites, that have a robotic arm for capturing other smaller satellites or hindering their functioning, are also part of hard kill means. A direct ascent missile is launched from a terrestrial base, while co-orbital Anti-Satellite (ASAT) satellites are pre-placed in their orbits and can be manoeuvred to strike an adversary's satellites at a particular time of choosing. A High-Altitude Nuc Explosion (HANE), conducted in the upper atmosphere will generate a large amount of X-rays along with gamma radiation and neutrons. These X-rays and gamma rays interact with the upper atmosphere of the earth, generating a powerful Electro-Magnetic Pulse (EMP), which can induce voltages that may damage/destroy electronic systems not hardened against these effects. Satellites not specifically hardened for such eventualities may fail quickly in such an enhanced radiation environment. A direct kinetic attack on satellites using ASAT weapons is highly visible and difficult to deny. With the ASAT conducted by China in 2007, 3,000 debris pieces were formed in space, thus, jeopardising the operations of satellites of other countries globally. Hence, countries have now resorted to adopting non-kinetic kill measures for the satellites. Satellite signal jamming and dazzling of satellite sensors are some of the soft kill measures prevelant in the space domain. Directed Energy Weapons (DEWs) can blind sensors and other electronic systems of the satellite and cause damage without making physical contact well beyond the range of hard kill weapon systems. A typical example is the USA's Counter Communications System (CCS) which can effectively interfere with communication satellites in space. The USA's current operational missile defence systems having integral ASAT capabilities include the Ground-Based Interceptor (GBI), as a subset of the Ground-based Midcourse System (GMD) and the Ship-based Standard Missile-3 (SM-3) interceptor. The USA has also test-launched its MiTEx and Prowler co-orbital satellites for

conducting Rendezvous and Proximity Operations (RPO) between satellites. China, as discussed earlier, in 2007, engaged its own weather satellite using the ground-based ballistic missile SC-19, modelled on the DF-21C missile. The test drew much international criticism for the debris created as well as for the blatant attempt at "weaponising space." The history of China's counter-space programme, however, is much older. In 2000, the Chinese Space Technology Research Academy embarked on an ASAT programme including lasers, micro–satellites, Electro-Magnetic (EM) weapon system, and using a ground-based missile system to destroy satellites in space. By 2006, China had carried out its first test of soft kill measures wherein the USA's spy satellite was targeted by a high-power beam. In 2013, China again conducted an ASAT test for higher orbits. China may have also tested technology for close approach operations that can be categorised under co-orbital ASAT capability.[20] Russia is also expected to have developed niche capabilities in this domain. In the ongoing of Russia-Ukraine War, it is widely believed that Russia may have used the 'Wiper Malware Dubbed Acid Rain' to target the KA-SAT responsible for providing internet communication to Ukraine. The attack which was carefully timed just a day prior to the launch of ground operations rendered about 50,000 modems non-functional across the whole Ukraine. There are also newer players which may be working or may have already built counter-space capabilities. In the ongoing Israel-Hamas-Houthi conflict, the UK-based *Telegraph* claims that Israel may have already utilised its Arrow-3 missile to intercept the Houthi-launched Qader missile in outer space. If this is to be believed, such an engagement by Israel is likely to be first ever registered event of combat in the space domain.

Persistent Surveillance and Precise Targeting*:* With an increase in satellites in space and development of a variety of payloads, countries across the world are moving in the direction of persistent surveillance through space. While the USA is already expected to have global persistent surveillance through a combination of its high-altitude drones and satellites,

20. S Chandrashekar, *China's Anti-Access Area Denial (A2AD) Strategy, India's National Security Annual Review 2016-17* (New Delhi: Routledge, Taylor & Francis Group), pp. 381-392.

China is expected to achieve surveillance every 10 minutes through the Jilin series of satellites by 2030.[21] A special mention needs to be made of China's exponential Electronic Intelligence (ELINT) capability. With the South China Sea as its focus, China has developed a large constellation of ELINT satellites. China is expected to be operating approximately 24 ELINT satellites in clusters of three each, thus, having a total of eight functional constellations. This immensely boosts China's ability to generate its own electronic order of battle. All the satellites are expected to be operating closely with the 12th Operational Bureau of the Network System Department (NSD) responsible for space-based Signals Intelligence (SIGINT) collection. This data is likely to be made available to the PLA's Electronic Warfare Regimentts operating under the Electronic Systems Department (ESD). It is likely that the gaps between the passes of all the ELINT satellites range from a minimum of 2-3 minutes to a maximum of 40-60 minutes. This would entail that near-continuous coverage is available to the PLA for monitoring electronic signals. Coalesced with capabilities for precise navigation achieved through centimetric accuracies of their indigenous navigation constellations such as the Global Positioning System (GPS) of the US and Beidou of China, these countries are likely to have matured their capabilities of precision target engagement over long distances.

Regional Power Projection*:* In an attempt to bolster its soft power, China has been utilising its space assets to observe and carry out disaster relief programmes and humanitarian assistance in Pakistan, Nepal, Bangladesh, Antigua, Barbuda and Dominica. The Haiyang and Gaofen series of satellites have also been employed in securing sea lanes of communication and in countering piracy in the Gulf of Aden and other affected areas. Its ambitious Belt and Road Initiative (BRI) is planned to have vehicle tracking and transhipment control facilitated by navigation satellites. China has also patronised the fishing militia in the South China Sea. It gives free satellite navigation devices, communication sets and higher payment in

21. Kevin Pollpeter, "Testimony before the U.S.-China Economic and Security Review Commission Hearing on China's Advanced Weapons", https://www.uscc.gov/sites/default/files/Pollp eter_Testimony_0.pdf. Accessed on April 1, 2020.

Militarily, SSA helps in observing undeclared missions, satellites with parasitic objectives, suspicious in-orbit manoeuvres, malicious experiments, viz., robo-satellites or utilisation of dormant satellites. It may also be used for detection of an adversary's belligerent use of ASAT weapons and to gather SIGINT of the adversary's satellites.

return for them fishing far from mainland.[22] Operations of the PLA Navy (PLAN) once aided by its worldwide satellite navigation and communication can enable presence in deeper seas thus building a global presence.

Space Situational Awareness (SSA): SSA is the surveillance of particles/objects, energies or activities in space. These activities can be naturally occurring or a result of human ventures. Militarily, SSA helps in observing undeclared missions, satellites with parasitic objectives, suspicious in-orbit manoeuvres, malicious experiments, viz., robo-satellites or utilisation of dormant satellites. It may also be used for detection of an adversary's belligerent use of ASAT weapons and to gather SIGINT of the adversary's satellites, thus, proving critical in the continuity of essential services. The USA's SSA is supported by its space segment, comprising SBIRS, Geosynchronous Space Situational Awareness Programme (GSSAP) and Space-Based Space Surveillance (SBSS). Its ground segment, including the 3-km-long space fence and the Falcon Telescope Network (FTN)[23] augments its capability to monitor and control space activities across the globe.

India's Current Perspective and Utilisation of Space: India's envisioned application of the space programme is for societal and economic development.[24] In the early years of India's space programme, Dr Vikram Sarabhai ruled out India's aspirations of competing with the advanced nations in the space

22. Megha Rajagopalan, "China Trains Fishing Militia to Sail into Disputed Waters", www. reuters.com. Accessed on February 22, 2020.
23. "An Overview Space Situational Awareness", https:// www.spaceacademy. net.au/intell/ ssa. htm. Accessed on December 9, 2019.
24. "Vision and Mission Statements", https://www.isro.gov.in/about-isro/vision-and-mission-statements, Accessed on March 3, 2020.

domain.[25] Till date, the word 'security' does not feature in the Indian Space Research Organisation's (ISRO's) or the Department of Space's vision, mission or objectives. Thus, fundamentally designed to meet civilian requirements, India's space programme covers defence and security requirements as mere by-products. India's current utilisation of space is largely expected to be facilitating only the tactical level actions.

In 2014, Xi Jinping announced that "national defence and military reforms are an important part and symbol of China's overall reforms" and to this end, the over-riding goal was to prepare a military that could "fight and win battles".

THE WAY AHEAD FOR INDIA

Instituting Policy and Organisation-Level Changes: Modern armed forces are undertaking organisational overhauls in order to be prepared for future conflicts. The cases of China and the USA are discussed here. In 2014, Xi Jinping announced that "national defence and military reforms are an important part and symbol of China's overall reforms" and to this end, the over-riding goal was to prepare a military that could "fight and win battles". Key reforms were announced by Xi in late 2015 which included the reorganisation of the bureaucratic structure under the Central Military Commission (CMC), creation of a system of five joint Theatre Commands (TCs), upgradation of the artillery into the People's Liberation Army Rocket Force (PLARF) and establishment of two new Services that would support joint operations viz the People's Liberation Army Strategic Support Force (PLASSF) and the Joint Logistics Support Force (JLSF). The above military transformation was further articulated by Xi at the 19th Party Congress in October 2017 wherein it was identified that by 2020, the PLA should achieve mechanisation and make strides in utilising information warfare, thus, developing strategic capabilities. By 2035, national defence modernisation should be completed, and by mid-century, that is 2050,

25. "Dr. Vikram Ambalal Sarabhai (1963-1971)", https://www.isro.gov.in/about-isro/ dr-vikram-ambalal-sarabhai-1963-1971. Accessed on February 10, 2020.

the PLA, People's Armed Police Force (PAPF) and militia should become 'world class forces'. Consequently, the PLASSF was created in December 2015 with the status of an independent branch equivalent to a Service. The central idea was to consolidate most of the PLA's Information Warfare (IW) capabilities within one organisation in order to facilitate integrated information support and information operations, enhance coordination and achieve efficient gains. This new organisation has been designed as a force optimised for dominance in space, cyber space and the EM spectrum. The PLASSF is integrating reconnaissance, early warning, communication, command, control and navigation, and will provide strong support for joint operations for each military Service. It constitutes the first step in the development of a cyber force by combining cyber reconnaissance, cyber attack and cyber defence capability into one organisation to reduce bureaucratic hurdles and achieve centralised command and control. It also appears to be in line with the PLA's efforts to support and execute modern IW. Further, it is also on its way to develop key Electronic Warfare (EW) technology in Communication Intelligence (COMINT) as well as Electronic Intelligence (ELINT) based on both satellite and ground-based assets. In the form of the PLASSF, thus, the PLA will have a formidable IW combat potential in the near future.

During the recent times, the USA has been aggressively reviewing its outlook towards the space domain, with a specific focus on organisational reforms. Some of the major steps include revitalisation of the USA's National Space Council in 2017. Headed by Cabinet level secretaries, the council would advise the president of the USA on policy and strategic matters in space with a central idea of synchronising the USA's space security interests with commercial and civil activities. The USA has also been aggressively working to release its Space Policy Directives since 2017. In the milieu of its National Security Strategy, a total of seven such policy level directives have been released which streamline regulations on human space missions, commercial use of space, space traffic management, establishment of a space force, cyber security for space assets, space nuclear power and propulsions, and position

navigation and timings.[26] Such developments in the USA have not been standalone ones and can be said to be concurrent with the military reforms undertaken by the PLA, as discussed earlier, and the Services amalgamation by Russia. It is pertinent to mention that in 2015, Russia raised its 'Aerospace Forces' amalgamating the Áir Force, Air and Missile Defence Forces as well as the Space Force. Amongst these, one of the most foundational efforts has been the announcement and creation of the Space Force on August 10, 2018, as the sixth branch of the USA's armed forces. With the singular mission of securing the USA's interests 'in, from and to space', the Space Force's lines of efforts are primarily oriented towards providing and preserving space superiority.[27] The US government identified that threats from strategic competitors necessitated the creation of the Space Force and that space was imperative to national security. The Space Force manages launch operations for satellites, provides for satellite operators who act as force multipliers for global coverage through space, operates a global sensor network through space, monitors and catalogues space debris, monitors surprise missile attacks and monitors space, air and fleet operations.

It needs to be understood that, at the tactical and operational levels, the advantages accrued by integration of space, to a large extent, can be upset by an adversary by 'alternative terrestrial military capabilities.' However, those accrued by the strategic use of space can be countered only by developing befitting strategic capabilities in space. Hence, the race for space narrows down to a 'race for strategic space' capabilities. India, if it intends to derive meaningful benefits from space, must, therefore, prepare to build its strategic space capabilities. This needs to be seen in conjunction with the burgeoning Chinese space capabilities, which are set to have major implications on the Indian defence and security construct. The delineation into civilian and military components with a clear-cut institutional architecture and better financial allocation will not only meet our security needs but will also serve to promote greater transparency, which could further India's role and

26. *Space Policy Directives* (*SPDS*), Space Foundation Editorial Team, www.Spacefoundation.org. Accessed on September 27, 2023.
27. "About the Space Force", www.spaceforce.mil. Accessed on September 27, 2023.

standing in the international arena. There is a need to incorporate Indian space achievements into our broader political messaging. China's stance took a giant leap when, in 2015 it created the PLASSF, integrating space, cyber and EW, unveiling its strategic interests in space. India's view on space may have to take a similar *leap from being merely 'civil'centric' to also being 'civil centric and security conscious'*. As nations continue to derive strategic advantages from space in the milieu of increased competition, India may have to look towards this newfound military domain *as its own strategic outpost*. This will require a *whole-of-government* approach with the National Security Council Secretariat (NSCS) and the Defence Space Agency at its kernel. The NSCS should work towards the National Space Security Doctrine, from which should also flow the Joint Space Security Framework delegating duties and mandates. As in the case of the USA, a military and civil space programme needs to be *delineated in a tacit yet firm manner*. On December 11, 2023, *The Times of India* has published a report wherein it was believed that the Indian Air Force may have proposed to rename itself as Indian Air and Space Force. A move such as this reinforces the argument that there is a need to view operations in space from the prism of security. ISRO playing the single point exit for all space efforts may not be the best case scenario from the security perspective. A *government-backed private industrial base* and proactive international cooperation can make way for larger and competitive avenues.

Building Strategic Space Capabilities: India will have to work towards building a capability-based model aligned towards strategic requirements. Formidable space capabilities need to be built up in the following areas:

Strategic SATCOM: In the transformational context of jointmanship and the appointment of the Chief of Defence Staff (CDS), SATCOM can emerge as the first integrating tool between key security agencies. In the near future, the three Services should look to operate on a common space supported network, while in the mid-term, the strategic and paramilitary services including the Intelligence Bureau (IB), Research and Analysis Wing (RAW), NSCS, Aviation Research Centre (ARC), National Technical Research Organisation (NTRO) and Border Security Force (BSF) should be looped in a layered network-centric

theme. Niche technologies like 5G and quantum communication will need a governmental push. Private partners may be encouraged to develop technical expertise for the full utilisation of Super High Frequency (SHF) and Extremely High Frequency (EHF) bands. India must also look to improving its onboard signal processing capabilities to reduce ground-controlled switching, thus, enabling faster communication at the onset of the 5G era. Global communication built on a web of Low Earth Orbit (LEO) constellations, facilitated by satellite relay will thwart ASAT vulnerabilities by graceful degradation.

Strategic Defence: Building India's strategic defence entails strategic capabilities to include detection of missile launch by way of sensors placed in space and development of a ballistic missile defence network for integrating its shooters with the sensors. It will also entail adoption of a cluster-based SIGINT approach for detection of the air traffic network, missile telemetry, aircraft carrier group and the adversary's air defence radars. Augmenting this over the Indian waters should be the Automatic Identification System (AIS) payloads for general maritime surveillance. India needs to create redundancies in space assets in order to ensure continued operations even when targeted. This can be achieved by the creation of networked constellations of satellites with a distributed architecture so that the system continues to function even after destruction of one or more satellites in the constellation. Further, a reserve of satellites can also be created in space which can be activated at a time of our choosing. A reserve can also be created on the ground for surveillance, communication and navigation satellites alongwith compatible launch vehicles for launch at short notice. A multi-tiered constellation of micro-satellites would be less vulnerable to enemy attack and will provide significant redundancy. Low cost small satellite constellations also enable fast revisit periods. Manoeuvrability of our space and ground assets needs to be improved for evasive manoeuvres once a threat has been positively identified. One of the most vulnerable elements of a space system is its command and control link. India must develop and acquire military systems which are capable of withstanding or minimising the effect of adversary EW attacks for both satellites and ground segments. In

While revisit is one factor which entails quick availability of satellite data to the user, the ground segment, its availability and capacity also impact the time matrix.

addition, for satellite-based communication systems, India should develop indigenous jamming resistant ground-based systems. There is also a need to incorporate electronic counter-measures like enhanced encryption of up and down links, agile frequency hopping and signal power boosting in communication systems. Its critical assets in space or on the ground should use indigenous components, especially for networking and power supply systems to avoid resident malwares.

Space Deterrence and SSA: India conducted Mission Shakti on March 27, 2019. Successful launch of ASAT weapons necessitates knowledge of adversarial satellite data (including trajectory component, two-line elements, etc.). When test-launched on own satellite, such data is readily available based on own satellite tracking and telemetry control. However, to acquire such data about an adversary's satellite, robust SSA capability needs to be built. Credible space deterrence, thus, needs a substantial SSA capability. India, therefore, needs to build a network of sensors for populating own SSA data. Further, in the light of the global outcry on the increasing debris in space and given the increased number of satellites in space, kinetic kill measures alone may not be the most suited deterrence measures. Alternative counter-space capabilities to include Directed Energy Weapons (DEWs), jamming and similar soft kill measures, therefore, need to be duly emphasised.

Persistent Surveillance and Precise Targeting: Persistence surveillance in-depth as well as forward areas can tremendously boost effectiveness of operations. Such a capability can be fully exploited only if substantiated by precise targeting. This would entail the need to harness the indigenous NavIC constellation with a high degree of military accuracy. Anti-jamming and anti-spoofing techniques must be factored in to provide a very high degree of survivability. In order to build its advanced surveillance capabilities, the security agencies must, first, aim to improve the revisit times by means of increasing the number of satellites in space. While revisit is one factor which

entails quick availability of satellite data to the user, the ground segment, its availability and capacity also impact the time matrix. Ground terminals, if not available, should be planned, at least at the formation levels to ensure early downloading and availability of satellite data. Most of the military satellites across the world are now able to provide resolutions better than 0.5 metre. The endeavours of the planning agencies should be aimed to achieve resolution better than one metre in a near time-frame for most of the civil/military satellites. The hyperspectral imaging concept works on comparison of data with a pre-obtained data matrix of the target body. A library of such targets/locations needs to be created in order to extract the best information from hyperspectral imagery. Continuation of updating and populating hyperspectral data imagery would help best capitalise the hyperspectral surveillance efforts. India must aim to launch an ELINT satellite cluster in order to develop an electronic Order of Battle (ORBAT) of its neighbouring countries.

India's core capabilities in satellite manufacture and launch at a low cost, and humanitarian and disaster relief mechanisms should be bartered with strategic rewards.

Space Diplomacy: Space diplomacy unfolds numerous issues. SSA, for example, needs hand-holding at the global levels, extracting data from multiple agencies/countries. As a start, India signed an SSA Memorandum of Understanding (MoU) with France during the 2018 visit of the French president. India's space prowess should also be used to leverage strategic gains from countries yet devoid of similar capabilities. GSAT-9, launched for the South Asian Association for Regional Cooperation (SAARC) nations at the behest of the Indian government, is one such example. India's core capabilities in satellite manufacture and launch at a low cost, and humanitarian and disaster relief mechanisms should be bartered with strategic rewards.

Science and Human Capital: Comprehensive exploitation of space, concurrent building of capabilities and their operationalisation requires development of human resources. Penetration of space-based capabilities to the lowest level of a soldier necessitates wider user participation. Investment

in Research and Development (R&D), high quality education systems resulting in space capital and skills are a must for any aspiring space power. Along with the requisite space assets and infrastructure, we need to train space professionals who can integrate all security applications and provide technical as well as strategic solutions in the space domain. The space industry has strategic ramifications and, therefore, needs professionals with not only a scientific temper but also a strategic perspective. While the technical expertise does exist, there is a specific need to translate it into projects, applications and procedures to meet the security needs.

CONCLUSION

China's rise in space is set to have major implications on the Indian defence and security construct. China's policy and organisational approach to space demonstrated a visible change in 2015 when it created the PLASSF integrating space, cyber and EW, thus, unveiling its strategic interests in space. Indian planners on space may have to take a similar leap from being 'civil-centric' to being 'security-centric.' India not only needs to prevent its adversaries from deriving strategic advantages from space but may have to look towards this newfound military domain as its own strategic outpost. This will require a whole-of-government approach with the NSCS and the Defence Space Agency at its kernel. First and foremost, India needs to work towards its policy outlook on space. Initial lines of efforts would be to draft and manifest the National Space Security Doctrine from which should also flow the Joint Services Space Security Framework delegating duties, charters and mandates. As in the case of the US, India's military and civil space programmes need to be delineated in a tacit yet firm manner. This may even need an organisational change and may need separate verticles to head both ventures. ISRO playing the single point exit for all civil and military space efforts in India may not result in time-bound and effective solutions for the military. The security agencies may need enhanced representation in the space security domain and, thus, may need to operate their own space security billets. A government-backed private industrial

base and proactive international cooperation can make way for larger and more competitive avenues. However, as laid down in the US Space Force objectives, synchronisation of government and private agencies together with a horizon of security needs to be ensured. As mentioned above, surely there is a clear migration from the abstinent policies of yesteryears, and the policy-makers of today, have, in the recent years, shown a remarkable enthusiasm towards the space domain. Despite India's increased focus in the domain, an ever evolving domain such as space continues to provide adequate room for expressing its own strategic prowess. India needs, first and foremost, to include 'security' as one of the fundamental tenets of its space programme. Having done that, India needs to adopt a non-linear approach with an aim to simultaneously garner tactical, operational and strategic benefits from space.