WAR IN SPACE: IS INDIA PREPARED?

ANIL CHOPRA

India concluded the first table-top joint war-game called "IndSpaceEx" in the last week of July 2019. Conducted by the military and space scientists, it was a logical next step after India had tested its Anti-Ballistic Missile (ABM) defence systems and achieved many other key milestones pertaining to space, including the recent demonstration of India's Anti-Satellite (ASAT) capability and the establishment of the new tri-Service Defence Space Agency (DSA). The very hopeful successful moon landing by Chandrayaan 2 will give India a ticket to the extra-terrestrial settlements game. India has consistently supported peaceful exploitation of space, but with the erstwhile superpowers, the USA and Russia having made significant advances, and China quickly moving ahead, India had no choice but to accelerate its operational capability in space. Space is also becoming a great economic enabler and is influencing and supporting every activity on planet earth. The thin line dividing the earth's atmosphere and space is fast shrinking, with more platforms transiting between earth and terrestrial locations. It has become all the more necessary to acquire the latest space-based technologies. Greater space presence requires capability to launch heavy satellites, increase the number of launches per year, have the ability to launch satellites at short notice, position high accuracy sensors, have advanced electronic and cyber capabilities, and develop kinetic and non-kinetic means

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to defend India's assets and interests in space. Space-based military, and counter-space operations will allow own use of space while denying the adversary the use of space offensively against Indian space or ground-based assets. 'Space Wars' are no longer in the domain of sci-fi movies or video games, but a reality facing the world. Whether India is prepared and what its roadmap ahead is, is a subject being debated among the military and scientific communities.

SPACE DOMAIN

In very simple terms, 'space' is the vast 3-dimensional region that begins where the earth's atmosphere thins down considerably. Space is usually thought to begin at the lowest altitude at which satellites can maintain orbits for a reasonable time, without falling into the atmosphere. This is approximately 160 km (100 miles) above the surface. The two separate entities are considered as a single-domain for activities of launching, guidance and control of vehicles that travel in both entities. Astronomers may speak of interplanetary space (the space between planets in our solar system), interstellar space (the space between stars in our galaxy), or intergalactic space (the space between galaxies in the universe). Of immediate military interest is the region up to the moon and subsequently the solar system.

EVOLUTION OF SPACE WEAPONS

Vimana: The Ancient Indian Aerospace Craft[1]

India is known to have given to the world most major concepts of mathematics, some as far back as 1200 BC. Reportedly, the concept of zero, the decimal

1. "Ancient Indian Aircraft (Vimana) Technology", https://www.booksfact.com/technology/ancient-technology/ancient-indian-aircraft-vimana-technology.html

system, negative numbers, arithmetic and algebra were Indian contributions. The Sanskrit word '*Vimana*' first appeared in the Vedas, with several meanings ranging from temple to mythological flying machine. There are documents even describing their use in warfare. The *vimana* were said to be able to travel into space and under water. The Sun and Indra and several other Vedic deities were transported by flying wheeled chariots pulled by animals, usually horses, but there were others, like the *agnihotra-vimana* (*agni* means fire), with two engines, and the *gaja-vimana* (elephant powered). The *Rig-Veda* also talks of "mechanical birds". Later texts around 500 BC talk of self-moving aerial cars without animals. As per the *Ramayana,* the *pushpaka* (the flowery chariot) was originally made by Vishwakarma for Brahma, the Hindu god of creation. There is mention of Lord Rama using it, and under the command of the *raghira* (captain), the chariot reportedly rose up into the higher atmosphere. The *Mahabharata* mentions the genius *Yavanas* as the creator (chief designer) of a finite dimensioned *vimana* with four solid wheels owned by the *asura maya*. Jain literature talks of the various *tirthamkaras* flying different types of flying machines. Manuscripts deal with aeronautics, construction of various types of aircraft for civil aviation, and for warfare. Also mentioned are how to make planes motionless (hovering), and invisible (stealth), retrieving photographs of the interior of enemy planes (intelligence), ascertaining the direction of an enemy plane's approach (radar), and means of destroying enemy planes. The propulsion of the *vimana* was by "mercury vortex engines", apparently a concept similar to electric propulsion. There is mention of power sources, pilots and their flying clothing, and the weapons that were kept on these airships. The flight

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manuals of the *vimana* are quite similar to the flight manuals of modern civil and military aircraft. These suggest that the *vimana* were powered by several gyroscopes placed inside a sealed liquid mercury vortex. The *vimana* were kept in a *vimana griha*, a kind of hangar, and were sometimes said to be propelled by combustion engines and even "pulse-jet" engines. Indra's dart was operated using a circular reflector. When switched on, it produced a 'shaft of light' which, when focussed on any target, immediately consumed it with its power (laser weapons). There are references of highly manoeuvrable and powerful *vimana* launching single projectiles charged with 'all the power of the universe' against cities, resulting in huge columns of smoke and fire, equivalent to tens of thousands of suns, which reportedly reduced to ashes the entire race of the *Vrishnis* and *Andhakas*. Were these nuclear weapons? The *Samara Sutradhara* is a scientific treatise dealing with every possible angle of aviation.[2]

Space Developments During Cold War

Designer Werner von Braun's ethanol fuelled rocket, the A4, launched on October 3, 1942, became the first man-made object to enter space.[3] The 1960s saw humans leap beyond the earth's atmosphere. By the late 1960s, the Soviet Union and USA both had deployed military satellites for communications, imaging, reconnaissance and monitoring ballistic weapons. Ballistic missile transit through space was tested and soon became a capability with many nations. The ultimate desire of a space power is to dominate the use of space and have space-based systems that allow destruction of enemy targets in space and on earth, and deny the enemy full access to space, including preventing the enemy from launching satellites, and destroying or degrading enemy satellites in space. The term 'Space War', however, is restricted to where the target is in space and whether it is attacked from space or from the ground. While

2. "Ancient India: The Samara Sutradhara", http://ultadin.com/2016/01/10/ancient-india-the-samara-sutradhara-is-a-scientific-treatise-dealing-with-every-possible-angle-of-air-travel-in-a-vimana/

3. "German Rocket is 1st to Reach Space, October 3, 1942", https://www.edn.com/electronics-blogs/edn-moments/4397678/German-rocket-is-1st-to-reach-space--October-3--1942.

weapons are still to be officially positioned in space, scientific research is at an advanced stage to act as an enabler. Space is, thus, going to be the force multiplier for military operations.

The United States and Soviet Union began developing Anti-Satellite (ASAT) weapons in the early 1960s. They were in the form of directed-energy lasers to decapitate; *kamikaze* satellites for hard-kill; and possible orbital nuclear weapons. The very long range Inter-Continental Ballistic Missiles (ICBM) spent significant time in sub-orbital flight and were best intercepted in space. The initial US 'Nike-Zeus'[4] programme envisaged firing Nike nuclear missiles against incoming ICBMs. Project 'Defender' was to destroy Soviet ICBMs at launch with satellite weapon platforms that were to orbit over Russia. Both programmes were abandoned later. The 'Sentinel' and 'Safeguard' programmes were to use Anti-Ballistic Missiles (ABMs) to shoot down incoming ICBMs. The initial plan was to use a nuclear-tipped interceptor missile but as accuracy improved, hit-to-kill ABMs evolved. In 1983, US President Reagan proposed a space-based Strategic Defence Initiative (SDI)[5] to protect the United States from attack by strategic nuclear missiles.

In the 1960s, the Soviets developed a "co-orbital" system that would approach the space target using radar guidance, and then explode the shrapnel warhead close enough to kill it. The Soviets evolved a Low-Earth Orbit (LEO) Fractional Orbital Bombardment System (FOBS)[6] for earth targets. It would de-orbit for the attack. The Strategic Arms Limitation Talks (SALT) II agreement of 1979 prohibited the deployment of FOBS systems. The polyus orbital weapon system was an anti-satellite weapon with nuclear space mines and a self-defence cannon. The Soviets also considered the Space Shuttle as a single-orbit weapon that could manoeuvre to avoid existing anti-ballistic missile sites, and then bomb the target, and land. The Soviets experimented with large, ground-based ASAT lasers with a number of US

4. "Nike Zeus Program", http://www.astronautix.com/n/nikezeus.html
5. "Strategic Defense Initiative (SDI)", http://www.coldwar.org/articles/80s/SDI-StarWars.asp
6. "Fractional Orbital Bombardment System (FOBS)", https://www.ausairpower.net/APA-Sov-FOBS-Program.html

spy-satellites reportedly being temporarily 'blinded'. The Soviets also used a modified MiG-31 as an ASAT launch platform.[7] Space weapons can be categorised as those that attack targets in space (anti-satellite); or attack targets on the ground from space; or attack targets transiting through space (anti-ballistic missile). The Russian space station, Salyut-3, was fitted with the 23mm cannon, which was successfully test-fired at target satellites. In the 1960s, the US had envisaged a possible air base with 21 airmen on the moon as part of Project Lunex,[8] a project that was never executed. It is technically possible to position conventional or nuclear missiles in space which could reach targets on the ground, but the same could be expensive and difficult to maintain and service. Also, carrying heavy missiles would be a logistic nightmare and have only a small advantage of saving time vis-à-vis aircraft and submarine launched weapons. Even for the advantage of guaranteed second nuclear strike capability, it would not be worth the complications. The initial US plan was for a space-based constellation of about 40 platforms deploying up to 1,500 kinetic interceptors. The plan was later called off.

NON-WEAPON SPACE ENABLERS

The end of the Cold War saw new players like China, Japan, the European Union and India create their own space systems. Spy satellites continue to perform Command, Control, Communication, Computer, Intelligence, Surveillance, Reconnaissance (C4ISR) missions. Satellites are also used to provide early warning of missile launches, locate nuclear detonations, and detect preparations for otherwise clandestine or surprise nuclear tests. The Global Positioning Systems (GPS) are an important military application in space. The US GPS, Russian GLONASS, European Galileo, Chinese Beidou and Indian Regional Navigational Satellite System (INRSS) named 'NAVIC' are some such examples. India's is a regional system with seven satellites already in position, and four more planned. The NAVIC will provide two levels of service: the "standard positioning service", which will be open for civilian

7. "MiG-31 as an ASAT Launch Platform", https://www.thedrive.com/the-war-zone/23936/exclusive-russian-mig-31-foxhound-carrying-huge-mystery-missile-emerges-near-moscow

8. "Project Lunex", https://www.revolvy.com/page/Lunex-Project.

use, and a "restricted service" encrypted for authorised users (including by the military). All the others are global initiatives, with between 24 to 36 satellites. They allow precise own location and provide very highly accurate time reference. The GPS system has been in operation since February 1989. It also facilitates accurate targeting by smart bombs and cruise missiles. The military doctrine of network-centric warfare also relies heavily on the use of high speed satellite-enabled communications to improve real-time situational awareness. Satellite imagery of enemy positions with accurate coordinates of the targets can be transferred to bombers and cruise missiles through the military internet connected through satellite communications. Modern military forces, including India's, have such secure information grids. The military requires to use space for C4ISR, for networked warfare.

WEAPONISATION OF SPACE

A 2006 draft of the US National Space Policy clearly formulated the opposition to arms control and the aspiration to dominate in space. "Space superiority is not our birthright, but it is our destiny. Space supremacy is our vision for the future," Gen Lance Lord, then head of the US Air Force Space Command, had said in 2005.[9] Terrestrial geo-politics, with the end of the "unipolar moment" and the reemergence of several powers, including Russia, continues to complicate strategic postures. Russia's "Gerasimov Doctrine"[10] envisions the use of all means available—conventional and social-media campaigns, and cyber and sub-conventional operations—to achieve geo-strategic objectives. The Russian ASAT research has reportedly been resumed under President Putin to counter the renewed US strategic defence efforts post the ABM Treaty. The US also continues working on a number of programmes which could be the basis for a space-based ASAT. International space treaties limit or regulate positioning of weapons or

9. Weaponisation of space has long seemed inevitable and Trump's announcement of the space force diverges from historical conventions that consider space as a global common for peaceful purposes, https://www.downtoearth.org.in/news/science-technology/-the-talk-of-space-wars-colonisation-is-still-in-the-realm-of-fiction--61176

10. "Russia's Gerasimov Doctrine", https://jamestown.org/program/a-new-version-of-the-gerasimov-doctrine/

The USA currently has a space strategy to focus on prevention of nuclear blackmail by major players or rogue states. The US National Missile Defence (NMD) programme has no weapon station in space, but is designed to intercept incoming warheads at a very high altitude where the interceptor travels into space to achieve the intercept. These missiles are both land-based and sea-based.

conflicts in space. To date, there have been no human casualties resulting from conflict in space, nor has any ground target been successfully neutralised from orbit. Control and denial of space-based assets is expected to play a key role in the strategy of the People's Liberation Army (PLA), derived from this doctrine.

GROUND-BASED SPACE WEAPONS

The use of high altitude nuclear explosions to destroy satellites through damage caused by Electro-Magnetic Pulse (EMP) on electronic equipment was considered. During tests in 1962, the EMP from a 1.4 Mt warhead detonated over the Pacific, damaged three satellites and also disrupted power transmission and communications across the Pacific. Another area of research was into directed energy weapons, including a nuclear-explosion powered X-ray laser. The AGM-69 SRAM carried on a modified F-15 Eagle was successfully tested in September 1985, targeting a satellite orbiting at 555 km. In February 2008, the US Navy fired a standard ABM to act as an ASAT weapon to destroy an ageing hydrazine-laden US satellite. Russia has reportedly restarted development of a prototype laser system, the 'Sokol Exhelon'.[11] Israel's Arrow 3 (Hetz 3) anti-ballistic missile, with exo-atmospheric interception capability, became operational in January 2017. It intercepts ballistic missiles during the space flight portion of their trajectory. In January 2007, China successfully destroyed a defunct Chinese weather satellite in polar orbit at an altitude of about 865 km, using a kinetic warhead of the SC-19 ASAT missile. The warhead destroyed the satellite in a

11. "Sokol Exhelon", https://www.defenseworld.net/news/25031/Russia___s_Almaz_Launches_Airborne_Anti_surveillance_Laser_Project#.XTHXCPIzbIU

head-on collision at an extremely high relative velocity. In May 2013, the Chinese government announced the launch of a sub-orbital rocket carrying a scientific payload to study the upper ionosphere. The US government suspects it as the first test of a new ground-based ASAT system. The National Aeronautics Space Administration (NASA) space plane X-37,[12] now with the US Department of Defence, is akin to a space version of the Unmanned Aerial Vehicle (UAV) and its employability is evolving. The USA currently has a space strategy to focus on prevention of nuclear blackmail by major players or rogue states. The US National Missile Defence (NMD) programme has no weapon station in space, but is designed to intercept incoming warheads at a very high altitude where the interceptor travels into space to achieve the intercept. These missiles are both land-based and sea-based. In June 2019, China became the third country to launch a satellite, using the Long March 11 rocket that lifted off from a floating launch pad in the Yellow Sea.

Military satellites orbit at about 800 km height, move at 7.5 km/s, and are difficult to intercept. Even if an ISR satellite is knocked out, all countries possess an extensive array of manned and unmanned ISR aircraft that could perform the mission.

INDIAN ASAT TEST

On March 27, 2019, India destroyed a "live satellite" in Low Earth Orbit (LEO). The interceptor struck a test satellite at a 283-km altitude, 168 seconds after launch. The system was developed by the Defence Research and Development Organisation (DRDO). With this test, India became the fourth nation with ASAT missile capabilities. As per DRDO, the missile was capable of shooting down enemy targets moving at a speed of 10 km per second at an altitude as high as 1,200 km. However, in order to minimise the threat of debris, the interception was performed against an object moving at 7.4 km per second at an altitude below 300 km. It gave India a great capability for a possible war in space.

12. "NASA Spaceplane X-37", https://www.space.com/x-37b-military-space-plane-otv5-600-days.html

COMPLEXITIES OF SATELLITE INTERCEPTS

The ease of shooting down orbiting satellites and their effects on operations have been questioned by some. Tracking of military satellites with inbuilt defensive measures like inclination changes, among others, will not be so easy. The interceptor would have to pre-determine the point of impact while compensating for the satellite's lateral movement and the time taken for the interceptor to climb and move. Military satellites orbit at about 800 km height, move at 7.5 km/s, and are difficult to intercept. Even if an ISR satellite is knocked out, all countries possess an extensive array of manned and unmanned ISR aircraft that could perform the mission. GPS and communications satellites orbit at much higher altitudes of 20,000 to 36,000 km, putting them out of range of solid-fuelled ICBMs. The constellation of many GPS satellites provides redundancy where at least four satellites can be received in six orbital planes at any one time, so an attacker would need to disable at least six satellites to disrupt the network.

OFFENSIVE COUNTER SPACE CAPABILITIES

Space security and the vulnerability of space capabilities is today an important policy issue. More nations are acquiring offensive counter-space capabilities that could disrupt, deny, degrade, or destroy space systems. Some countries feel the need to prepare for future conflicts on earth that could extend into space, and, thus, need to develop offensive counter-space capabilities and aggressive policy postures. Space is not the sole domain of militaries and intelligence services, and the global society and economy are becoming increasingly dependent on space capabilities: any conflict in space could have serious repercussions. But with the changing nature of geo-politics, competition in outer space is getting more aggressive. Counter-space capabilities are a critical element in the growing relevance of space to national security and conventional military operations. The adversary has to be denied the advantages of the use of space assets. The growth of counter-space capabilities includes the kinetic, non-kinetic, electronic, and cyber. From a purely civil-centric approach, the impetus is gradually

moving towards certain military characteristics. Greater use of space-based assets by militaries around the world, especially for C4ISR, and networked warfare requires counters. ASAT weapons comprise one such capability, but there are other means to disable or degrade satellite-based systems. The counter-space capabilities are of several categories such as direct ascent, co-orbital, directed energy, electronic warfare, and cyber. The Chinese and Americans are pushing ahead with research on directed energy weapons. Rendezvous and Proximity Operations (RPO) are being conducted in the Geosynchronous Earth Orbit (GEO) region by the United States, Russia, and China. The Russians are working on a co-orbital ASAT programme known as Burevestnik.[13] India has already demonstrated its ASAT capability.

ANTI-SPACE WEAPONISATION TREATIES

During the Cold War, to avoid extending the threat of nuclear weapons to space, the Partial Nuclear Test Ban Treaty of 1963 and Outer Space Treaty of 1967 prevented detonation of nuclear devices in space. The moon and other celestial bodies were to be used exclusively for peaceful purposes, and astronauts were to be treated as envoys of mankind. However, by then, both the United States and the Soviet Union had performed several high altitude nuclear explosions in space. The salient features of the treaties were that exploration and use of outer space was for the benefit of all mankind and that outer space was not subject to national appropriation. States were not to place weapons in orbit or on celestial bodies, and would be liable for damage caused by their space objects. India had signed and ratified the Outer Space Treaty of 1967. In 1981, the UN General Assembly proposed a Prevention of an Arms Race in Outer Space (PAROS) Treaty[14] to preserve space for peaceful uses by prohibiting the use of space weapons. The treaty would prevent any nation from gaining a military advantage in outer space, but China and the US prevented a consensus on it. The proposed Space

13. "Russian Co-orbital ASAT Program known as Burevestnik", https://breakingdefense.com/2019/04/russia-builds-new-co-orbital-satellite-swf-csis-say/

14. "Prevention of an Arms Race in Outer Space (PAROS) Treaty", http://www.unidir.org/files/publications/pdfs/prevention-of-an-arms-race-in-outer-space-a-guide-to-the-discussions-in-the-cd-en-451.pdf

The major mission of the PLA Strategic Support Force is to give support to the combat operations so that the PLA can gain regional advantages in astronautics, space, network and electromagnetic space wars and ensure smooth operations.

Preservation Treaty of 2006 against all space weapons, and the 2008 Treaty on Prevention of the Placement of Weapons in Outer Space was vetoed by the USA despite the treaty explicitly affirming a state's inherent right of self-defence. In December 2014, the General Assembly of the UN passed two resolutions on preventing an arms race in outer space, both of which were opposed by the USA and a few other countries. The US, Russia and China are the frontrunners in the weaponisation of space, though no weapons have been formally deployed in space yet.

SPACE COMMAND STRUCTURES

The United States Space Command (USSPACECOM) was created as a Unified Combatant Command in 1985 to coordinate the use of outer space by the United States armed forces. After the reorganisation in 2002, it was placed under the US Strategic Command. In December 2011, the Russian Space Forces became the Aerospace Defence Forces, fusing all space and some air defence components into one joint Service. In August 2015, they were merged with the Russian Air Force to form the Russian Aerospace Forces. As part of the reforms in December 2015, the People's Liberation Army Strategic Support Force was created. It is understood that it includes high-tech operations forces such as space, cyber space and electronic warfare. The major mission of the PLA Strategic Support Force is to give support to the combat operations so that the PLA can gain regional advantages in astronautics, space, network and electromagnetic space wars and ensure smooth operations. In 2012, the Indian Armed Forces Chief of Staff Committee had recommended the formation of three Commands for cyber, space and special operations. In April 2019, India set up the Defence Space Agency (DSA) as a step forward to fight the contemporary and new threats. The

creation of India's new tri-Service DSA, based in Bangalore, will help combine key functions performed by the Defence Imagery Processing and Analysis Centre (DIPAC) in Delhi and the Defence Satellite Control Centre (DSCC) in Bhopal. It will also evolve space doctrines and support suitable military action in space. The DSA will have nearly 200 personnel who, in turn, will work closely with the Indian Space Research Organisation (ISRO) and DRDO. The aim is to ensure better utilisation and integration of space resources.

India has launched 115 Indian satellites of various types as on April 2019. ISRO has launched 239 satellites, including for 28 foreign countries. Chandrayaan-2 was successfully launched on July 22, 2019.

INDIA'S SPACE PROGRAMME

Indian Launch and Satellite Capabilities

ISRO has come a long way since its first satellite *Aryabhata* was launched by the Soviet Union in 1975. In 1980, the *Rohini* became the first satellite to be placed in orbit by an Indian-made launch vehicle, the Space Launch Vehicle-3 (SLV-3). ISRO subsequently developed the Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV) for placing satellites into geostationary orbits. The satellite navigation systems GAGAN and IRNSS were deployed. In January 2014, ISRO successfully used an indigenous cryogenic engine in the GSLV-D5 launch of the GSAT-14. ISRO sent the lunar orbiter 'Chandrayaan-1' on October 22, 2008, and a Mars orbiter mission which successfully entered the Mars orbit on September 24, 2014, making India the first nation to succeed on its first attempt. ISRO, thus, became the fourth space agency in the world as well as the first in Asia to successfully reach the Mars orbit. India's space programme, though overtly for peaceful exploitation of space, has military offshoots. These include remote sensing satellites of the IRS series, with some having spatial resolution of one metre or below. There are others

with panchromatic cameras, synthetic aperture radars, satellites providing scene-specific spot imagery for cartographic/military applications. On February 15, 2017, ISRO launched 104 satellites in a single rocket, the PSLV C-37, and created a world record. ISRO launched its heaviest rocket, the Geosynchronous Satellite Launch Vehicle-Mark III (GSLV-Mk III), on June 5, 2017, and placed a communications satellite, the GSAT-19, in orbit. With this launch, ISRO became capable of launching 4-ton heavy satellites. India has launched 115 Indian satellites of various types as on April 2019. ISRO has launched 239 satellites, including for 28 foreign countries. Chandrayaan-2 was successfully launched on July 22, 2019. It is scheduled to land on the moon on September 7, 2019. India will send its first manned mission to space by December 2021, says ISRO Chief Kailasavadivoo Sivan.

Indian Military Application Satellites

India today has 15 operational Indian Remote Sensing (IRS) satellites. All these are placed in the polar sun-synchronous orbit and provide data in a variety of spatial, spectral and temporal resolutions. Though most are civil satellites, some have a spatial resolution of one metre or below which can also be used for military applications. India also commercially offers images with one metre resolution. The Radar Imaging Satellite 2 (RISAT-2) has the Synthetic Aperture Radar (SAR) from Israel Aerospace Industries (IAI). It has a day-night, all-weather monitoring capability, with one metre resolution. The Cartography Satellite, CARTOSAT-2, carries a state-of-the-art panchromatic (PAN) camera that takes black and white pictures of the earth in the visible region of the electromagnetic spectrum. The swath covered by these high resolution PAN cameras is 9.6 km and their spatial resolution is 80 centimetres. The satellite can be steered up to 45 degrees along, as well as across, the track. It is capable of providing scene-specific spot imagery. The data from the satellite is used for detailed mapping and the Geographical Information System (GIS). The CARTOSAT-2A is a dedicated satellite for the Indian armed forces. Due to its high agility, it can be steered to facilitate imaging of any area more frequently. The CARTOSAT-2B offers multiple

spot scene imagery. With the CARTOSAT-2E which was launched in June 2017, India now has 13 satellites with military applications. The GSAT-6 is the second strategic satellite, mainly for use by the armed forces for quality and secure communications. The Indian Navy uses the GSAT-7 for real-time communication among its warships, submarines, aircraft and land systems. The GSAT-7A 'angry bird', an advanced military communications satellite, exclusively for the Indian Air Force (IAF), was launched in December 2018.[15] It will enhance network-centric warfare capabilities by interlinking with the IAF ground radar network and Airborne Early Warning and Control (AEW&C) aircraft. The GSAT-7A will also be used by the Indian Army Aviation Corps.

Indian Space Industry

The Indian space industry is already an acclaimed world player. It is internationally competitive and maintains international quality standards. ISRO was established in 1972 to promote development and application of space science and technology. In the initial years, the space applications were for communication, television broadcasting and remote sensing satellites and to perfect satellite launch vehicles. Today, India has an impressive array of satellites covering the entire spectrum. It has a world record of putting in orbit 104 satellites through a single launch. India has had a mission to Mars and an ongoing mission to the moon. India also has the largest constellation of earth observation satellites called Indian Remote Sensing (IRS) satellites, with better than one metre resolution. The larger INSAT series, besides TV broadcasting, telecommunications and meteorological applications, support societal applications such as tele-education, tele-medicine applications, have been operationalised. The largest Indian space launch vehicle, the GSLV, can launch 2,200 kg satellites into geostationary orbit. The GSLV III will launch up to 5,000 kg satellite payload. Hindustan Aeronautics Limited (HAL) which is a Defence

15. The GSAT-7A 'angry bird' is an advanced military communications satellite exclusively for the Indian Air Force (IAF), https://www.thehindu.com/sci-tech/science/isro-successfully-launches-gsat-7a/article25781226.ece

Public Sector Undertaking (DPSU) manufacturing aircraft, is the premier manufacturing partner of ISRO. It has a dedicated Aerospace Division. The Defence Research Development Organisation (DRDO), with a network of 52 defence laboratories, supports developing critical defence technologies. Other organisations that are active participants in the space programme are Bharat Electronics Limited (BEL) for electronics; Bharat Dynamics Limited (BDL) with missile manufacturing technology; Mishra Dhatu Nigam Limited (MIDHANI) with metallurgical competence in super-alloys and special purpose steels; BrahMos Aerospace with technologies evolved for the supersonic cruise missile; and nearly 40 private sector companies, including Larsen and Toubro (L&T) and Bharat Forge are partners.

SOUTH ASIAN AEROSPACE REALITIES

Elon Musk says he is a big fan of what China is doing in space. Musk is the Chief Executive Officer (CEO) of the space exploration company SpaceX, which faces growing competition from China which is pumping huge amounts of money into space. The first Chinese manned space flight was in 2003. In January 2007, China became the first Asian military-space power to send an anti-satellite missile into orbit, to destroy an aging Chinese weather satellite. Anti-satellite technologies to destroy or disable space-based assets are a critical part of the Chinese space programme. These include land-based missiles, experimental lasers, and signal jammers. China has successfully performed the soft landing of a rover on the moon, including the only one on the dark side. China has long-term ambitions to exploit the earth-moon space for industrial development. It plans to bring a habitable space station the Tiangong2, online by 2022 and put Chinese astronauts on the moon in the mid-2020s. It also has a Mars lander mission coming up. The Chinese space programme is linked to the nation's efforts to develop advanced military technology. China launched the 'DAMPE', the most capable dark matter explorer to date, in 2015, and the world's first quantum communication satellite 'QUESS' in 2016. China is averaging 20 space missions a year. As per estimates, China has over 500 ballistic missiles, including 100 ICBMs, 25 per

cent of which are submarine-based, and some with Multiple, Independent Reentry Vehicle (MIRV) warheads, with ranges beyond 13,000 km.

Pakistan's Karachi-based Space and Upper Atmosphere Research Commission (SUPARCO) is more of a bureaucratic agency, with little to show as end products. It is a part of the Strategic Plans Division (SPD) of the Pakistani armed forces under the control of the Pakistan Air Force (PAF). Pakistan's fledgling space programme has the Chinese support and stamp. Pakistan takes Chinese support for satellite launches. It has also joined the Chinese satellite navigation system, the Beidou. The main concentration has been to develop a series of nuclear capable ballistic missiles for the Pakistan Army, with payloads up to 1,200 kg and ranges of 2,500 km. In 2011, it developed the Hatf series of delivery systems for the small tactical nuclear weapon, the Nasr. In January 2017, it tested the Ababeel, a development of the Shaheen-II with MIRV. The intention of the system is to counteract the Indian Ballistic Missile Defence (BMD).

India became the fourth space agency in the world to send a spacecraft to Mars, behind the United States, Russia, and the European Union. India launched its first moon orbiter mission, Chandrayaan-1, and later, in November 2013, its maiden interplanetary mission, the Mars orbiter mission which, in September 2014, entered its intended orbit around Mars. Chandrayaan-2 has been launched for a soft landing on the moon. India plans an orbiter to Venus, the 'Shukrayaan-1 in 2023. The Indian ballistic missile defence programme is a multi-layered system consisting of two interceptor missiles, the Prithvi Air Defence (PAD) missile for the high altitude, and the Advanced Air Defence (AAD) missile for lower altitude interception. It would be able to intercept an incoming missile launched 5,000 km away. The PAD was tested in November 2006, and the AAD in December 2007. India, thus, became the fifth country to have an ABM system, after the United States, Russia, China and Israel. On March 6, 2009, India successfully tested its missile defence shield when an incoming missile was intercepted at an altitude of 75 km. The 'Swordfish' radar for the BMD system currently has an operational range 2,000 km. Two new anti-ballistic missiles to intercept

China has been the single most important factor shaping India's approach to space. As China leaps vigorously forward in counter-space capabilities, India will have to war-game such scenarios. Similar simulations have been done in the past in various military colleges. India must also keep up its efforts to develop global rules and norms about such challenges and threats.

Intermediate Range Ballistic Missiles (IRBMs) are being developed to cover a range of up to 5,000 km. India is also planning a laser-based weapon system to destroy a ballistic missile in its boost phase.

THE FUTURE AND ITS CHALLENGES

ORF SIMEX

The Delhi-based Observer Research Foundation (ORF) Simulation Exercise (SIMEX)[16] was conducted in February 2017 to play out a scenario in which, given the underlying geo-political conflicts, states had already attempted to interfere with outer space assets in an effort to deny certain military the destruction of functions. The exercise simulated that a military communications satellite gets destroyed, albeit accidentally, using an ASAT weapon. The exercise simulated the possibility of a kinetic conflict; the choice of a combination of a multilateralised dispute by approaching the Permanent Court of Arbitration and only modest military punitive steps; and how lack of military heft can be compensated for by using smart diplomatic tactics.

Wargame IndSpaceEx

The "IndSpaceEx" table-top exercise was conducted by the Ministry of Defence on July 25-26, 2019. The exercise assessed threats in space from a military perspective and India's current capability. It took stock of the military space assets of the US, Russia and China. The country's armed

16. Observer Research Foundation (ORF) Simulation Exercise (SIMEX), https://www.orfonline.org/wp-content/uploads/2018/02/ORF_Special_Report_58_Simulation_Exercise.pdf

forces, along with DRDO, ISRO, academia from the Indian Institute of Technology, Mumbai, think-tanks like the Observer Research Foundation (ORF) and private industry were part of the table-top exercise. Within the community of strategic thinkers, Beijing poses a major threat to India's security interest – its satellites and other assets. This first of its kind exercise, at this level, was to help gain a better understanding of security issues related to the space domain. The limited agenda was to give an insight into the vulnerabilities and gaps in India's space security and identify areas for India to develop and strengthen in terms of technological capabilities in order to establish effective deterrence capabilities as the logical next step. Capabilities, capacities, complexity in organisation and the role of ambiguity and escalation risk in war and war deterrence strategies were the parameters along which the game was played out. China has been the single most important factor shaping India's approach to space. As China leaps vigorously forward in counter-space capabilities, India will have to war-game such scenarios. Similar simulations have been done in the past in various military colleges. India must also keep up its efforts to develop global rules and norms about such challenges and threats.

The time has come for India to give due priority to its military needs. Integration of the hard operational aspects created by the SSA and C4ISR assets with the softer strategy and doctrine needs to be worked out. All this is possible and consistent with India's international posture of the "peaceful uses of outer space".

Attention to Capability Building

Dr S. Chandrashekhar of the National Institute of Advanced Studies, Bengaluru, has looked into some of the security-related aspects of utilisation of space in his study "Space, War and Security: A Strategy for India".[17] The major space-based components of this new strategy architecture would be

17. S. Chandrashekar, *Space, War and Security– A Strategy for India* (Bengaluru: National Institute of Advanced Studies, December 2015), http://isssp.in/wp-content/uploads/2016/03/Space-War-and-Security-_A-Strategy-for-India.pdf

a robust Space Situational Awareness (SSA) capability comprising radars, optical and laser tracking facilities complemented by an organisational and human resource base that is able to operationally monitor the space environment: a constellation of advanced communications satellites in Geo-Stationary Orbit (GSO) for carrying out vital Command, Control, Communications, Computers (C4) functions; a constellation of satellites in Low Earth Orbit (LEO) that provide Internet services for the military; clusters of satellites for the Electronic Intelligence (ELINT) function; a constellation of Electro-Optical (EO) and SAR satellites in appropriate Sun-Synchronous Orbits (SSO) for ISR; standby small satellites on hot-standby to be launched at short notice into LEO for ISR needs during crises; adequate Tracking Data Relay Satellite System (TDRSS) satellites in GSO for performing the tracking and data relay functions needed for the C4ISR capability; satellites for meeting operational weather requirements; satellites in geostationary and geosynchronous orbits or Medium Earth Orbit (MEO), for navigation functions. To meet these requirements, India would need 16 PSLV, 7 GSLV and 7 Agni 5-based launchers every year. This would mean creating significant indigenous capacity.

The future requires 'heavy' (4,200–5,400 kg) to very heavy satellites (>5,400 kg). The use of ion propulsion for moving the satellites from Geosynchronous Transfer Orbit (GTO) to GSO is an emerging trend. This approach will allow the GSLV Mark 2 launcher to launch the equivalent of an intermediate class GSO satellite and the GSLV Mark 3 launcher can launch the equivalent of a heavy class satellite. The creation of ELINT and TDRSS capability is an area that needs immediate attention. India's capabilities for performing the surveillance and reconnaissance parts of the ISR function are good and close to the global state-of art ones. Its capabilities for dealing with the infra-red (thermal) part of the spectrum are limited. These need to be strengthened significantly. Apart from ISR, they are used for performing many other military functions and could play an important part in any future BMD system. Antenna technology, used for meeting SSA, SAR and C4 needs is also an area that needs national attention. Reducing the mass of the SAR,

efforts to improve throughputs in data processing, especially for SAR data, are other areas that may require more support. Extending the IRNSS scheme for navigation via a Medium Earth Orbit (MEO) constellation to improve navigation accuracies and eventually providing for a completely indigenous solution to the navigation problem is required. The time has come for India to give due priority to its military needs. Integration of the hard operational aspects created by the SSA and C4ISR assets with the softer strategy and doctrine needs to be worked out. All this is possible and consistent with India's international posture of the "peaceful uses of outer space".

Space Strategy Ahead

Noted strategist Guilio Douhet had said, "Victory smiles upon those who anticipate the changes in the character of war, not upon those who wait to adapt themselves after the changes occur". When Britain dominated the seas, it ruled the world. The Americans have been leaders of the free world ever since they gained superiority in the air. Now the dominating position will belong to those who gain supremacy in outer space. The Sino-US dynamic will drive the other major powers to act to preserve and enhance their security and national interests. Space assets will act as force multipliers and will play a vital role in the formulation and implementation of the strategies. The entire national security complex would have to be reorganised and restructured keeping in mind this reality. The role of space-based C4ISR assets, complemented by other ground-based SSA components will be critical for deciding the new national strategy for waging war and for preserving the peace through the deterrence of war. India is one among the top six space powers in the world: the USA, Russia, China, European Space Agency (ESA), and Japan. The satellites of many countries are used for a variety of military purposes.

With space having emerged as the fourth medium for military operations, the IAF had brought out its blueprint titled "Defence Space Vision 2020". The Integrated Space Cell under the Integrated Defence Staff (IDS) Headquarters in Delhi is working on furthering a joint space strategy. The Defence Space

Satellite Centre works closely with ISRO. Both will now be part of the DSA. India has developed all the building blocks necessary to integrate an anti-satellite weapon to neutralise hostile satellites in low earth and polar orbits. India needs early warning satellites to monitor ICBM launches and even the tactical air space as an important military asset. Ground/space-based lasers to disable enemy satellites or destroy/degrade attacking ICBMs as part of ASAT capability are needed. There is also a need to develop directed energy weapons. India needs a permanent space station. The space-based systems have enabled dramatic improvement in military and intelligence operations, thus, enhancing India's capability, accuracy and firepower. In the not so distant future, wars will again be fought, like we read in the Indian epics. Space is the future for all action and capabilities, the real force multiplier. India is doing well. The time to invest more and prepare for the future is now.