Space the Next Frontier: Opportunities and Challenges for India

Air Marshal Anil Chopra PVSM, AVSM, VM, VSM (Retd)[@]

Abstract

Over 8,000 satellites, or manmade objects, have been launched till date with nearly 5,000, belonging to 50 countries, still in orbit and nearly half of those are actually operational. Spacecraft have done soft or hard landings on or done flybys of many terrestrial bodies within the solar system, including on Asteroids and Comets. American and Chinese private space companies are part of the ultimate goal of enabling people to live on other planets. Space warfare is combat that may take place in outer space. It includes attacking objects in space from the Earth, or from another space platform. Till date, no actual war has ever taken place in space, though a number of tests and demonstrations have been performed. International treaties are in place that regulate conflicts in space and limit the installation of space weapon systems, especially nuclear. Major powers have space warfare organisational structures. Many countries have developed and tested space weapon systems ranging from anti-satellite missiles, Railguns, and very small highly mobile satellites nimble enough to manoeuvre around and interact with other orbiting objects to sabotage, hijack, or simply collide with them. Directed Energy Weapons (DEWs) would include lasers, linear particle accelerators, or plasma based weaponry. With an eye on growing space capabilities of China, India has been slowly building its capabilities in space. India has tested its anti-ballistic missile (ABM) defence systems and achieved many other key milestones pertaining to

---

[@]**Air Marshal Anil Chopra, PVSM, AVSM, VM, VSM (Retd)** is a former Air Officer-in-Charge Personnel. He also served as a member of Armed Forces Tribunal after retirement from Service.

Journal of the United Service Institution of India, Vol. CXLIX, No. 618, October-December 2019.

space, including the demonstration of India's anti-satellite (ASAT) capability and establishment of the new tri-service Defence Space Agency (DSA). The thin line dividing the earth's atmosphere and space is fast shrinking with more platforms transiting between earth and terrestrial locations. Is India prepared and what is its road map ahead is a subject being debated among military and scientific community.

Introduction

The world has come a long way since 'Sputnik 1', when a launch mass of 83.6 kg was put in a Low Earth Orbit (LEO) by Soviet Union on 04 October 1957. The satellite's unanticipated success shocked the Americans and triggered a strategic space race, which was an important component of the Cold War. The launch was the beginning of a new era of political, military, technological, and scientific developments. More than 8,000 satellites or manmade objects have been launched since then. Nearly 5,000, belonging to 50 countries, are still in orbit and nearly half of those are actually operational. As on 26 July 2019, Indian Space Research Organisation (ISRO) has launched 297 satellites belonging to 33 countries. Around 50 Indian satellites are currently in orbit.

Spacecraft have landed on or done flybys of many terrestrial bodies within the solar system. Landings, hard or soft, include on Earth's Moon, Mercury, Venus, Mars, and Moons of Mars and Saturn. Jupiter and Saturn being gas planets have no hard surface to "land", so spacecraft disintegrated on entering the atmosphere. Landings have also been achieved on Asteroids and Comets. Founded in 2002, American private company SpaceX designs, manufactures and launches advanced rockets and spacecraft, with the ultimate goal of enabling people to live on other planets. They have planned a landing mission to Mars with cargo and crew around 2024.

With an eye on growing space capabilities of China, India has been slowly building its capabilities in space. India has tested its ABM defence systems and achieved many other key milestones pertaining to space, including the demonstration of India's ASAT capability and the establishment of the new tri-service Defence

Space Agency (DSA). The first table-top joint war game called "IndSpaceEx" was held in July 2019.[1] Run by the military and the space scientists, it was a logical next step. The moon landing by Chandrayaan 2 was close and should succeed next time. The thin line dividing the earth's atmosphere and space is fast shrinking with more platforms transiting between earth and terrestrial locations.

Space: By Definition

In very simple terms, 'Space' is the vast 3-dimensional region that begins where the earth's atmosphere thins down considerably.[2] 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 kilometres (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.

Space Warfare

Space warfare is combat that takes place in outer space. It includes attacking objects in space from the Earth, or from another space platform. Till date, no actual war has ever taken place in space, though a number of tests and demonstrations have been performed. International treaties are in place that regulate conflicts in space and limit the installation of space weapon systems, especially nuclear. Major powers have space warfare organisational structures, such as US Air Force Space Command, Russian Aerospace Forces, and India's DSA. China's People's Liberation Army Strategic Support Force (PLASSF or SSF) handles cyber, space and electronic warfare.

Space Weaponry

Space weapon systems range from simple ground and space-based anti-satellite missiles. Railguns have been developed and orbital mines are contenders. Since most satellites are electronics technology intensive, and are used for surveillance, communications and positioning systems, for tactical advantages, these could be jammed through electronic warfare. The United States (US), and others, are also considering highly mobile satellites called "microsats"[3] (25 cu ft), and "picosats" (1 cubic foot), nimble enough to manoeuvre around and interact with other orbiting objects

to sabotage, hijack, or simply collide with them. The US and Russia had toyed with the idea of kinetic bombardment from orbiting platforms, launching non-explosive projectiles dropped onto hardened targets from LEO. A high velocity direct hit would presumably destroy it. A 'sensor' satellite would identify target and a nearby 'armed' satellite would de-orbit a long needle-like tungsten dart with a small rocket motor.

DEWs would include lasers, linear particle accelerators or plasma based weaponry. Acceleration of charged particles in a stream towards a target at extremely high velocities could cause immense damage. Lasers are already being used in terrestrial warfare. The DEWs are more practical and more effective in a vacuum (i.e. space) than in the Earth's atmosphere. Chemical lasers project missile, killing energy nearly 3,000 kilometres away and could be put into space to intercept Ballistic Missiles.

Complexities of Space Warfare

Space warfare is likely to be conducted at far greater distances and speeds than terrestrial combat. The vast distances involved pose difficult challenges for targeting and tracking, as even light requires a few seconds to traverse ranges measured in hundreds of thousands of kilometres. Geostationary satellites move at a speed of 3.07 km/s, and objects in LEO move at up to 8 km/s. Tracking of military satellites, with inbuilt defensive measures like inclination changes among others, will not be so easy. Error of even a fraction of a degree in the firing solution could result in a miss by thousands of kilometres. The interceptor would have to pre-determine the point of impact while compensating for the satellite's lateral movement and the time for the interceptor to climb and move.

A projectile from a railgun, recently tested by the US Navy[4], took many hours to reach a far off space target. Global Positioning System (GPS) and communication satellites orbit at much higher altitudes of 20,000 to 36,000 km, putting them out of range of solid-fuelled intercontinental ballistic missiles (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. Also, at large distances targets remain relatively small. The International Space Station (ISS), currently the largest artificial

object in Earth orbit, measures slightly over 100 m at its largest span.[5]

Any DEW would require large amount of electric power. Currently the lithium batteries and photovoltaic modules have limitations and may not be practical for powering effective lasers, particle beams, and railguns in space. Anti-satellite attacks, especially those involving kinetic vehicles can add to the space debris and interfere with future space activity. The Chinese ASAT test in January 2007 caused more than 40,000 new chunks of debris[6] with a diameter larger than one centimetre. The PRC is now reportedly developing "soft-kill" techniques such as jamming and vision kills that do not generate much debris. Since 2017, the United States Air Force (USAF) has run an annual military exercise, called "Space Flag", which involves a red team simulating attacks on US satellites.

Ground Based Space Weapons

Use of high altitude nuclear explosions to destroy satellites, through damage caused by electromagnetic pulse (EMP) on electronic equipment, was considered. During tests in 1962[7], 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. Boeing AGM-69 Short Range Attack Missile (SRAM), carried on a modified F-15 Eagle, was successfully tested in September 1985 targeting a satellite orbiting at 555 km. In February 2008, 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 'Sokol Exhelon'.[8] Israel's Arrow 3 (Hetz 3) ABM, with exo-atmospheric interception capability, became operational in January 2017 to intercept 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 SC-19 ASAT missile. The warhead destroyed the satellite in a head-on collision at an extremely high relative velocity. In May 2013, the Chinese government announced the launch of a suborbital rocket carrying a scientific payload to study the upper ionosphere. US government suspects it as the first test of a new ground-based ASAT system. The NASA space plane X-37[9], now with US Department of Defence (DoD) is akin to a space version of

Uninhabited Aerial Vehicle and its employability is evolving. US National Missile Defence (NMD) programme is designed to intercept incoming warheads at a very high altitude where the interceptor travels into space for interception. In June 2019, China became the third country to launch a satellite using Long March 11 rocket that lifted off from a floating launch pad in the Yellow Sea.[10]

Indian ASAT Test

On 27 March 2019, India destroyed a "live satellite" in LEO. The interceptor struck a test satellite at an altitude of 283 km, 168 seconds after launch. The system was developed by 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 1200 km.[11] 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.

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 detonating 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 US and the Soviet Union had performed several high altitude nuclear explosions in space. India had signed and ratified the Outer Space Treaty of 1967. In 1981, United Nations General Assembly (UNGA) proposed a Prevention of an Arms Race in Outer Space (PAROS) Treaty[12], 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. China and the US prevented consensus. The proposed Space Preservation Treaty of 2006 against all space weapons, and 2008 Treaty on Prevention of the Placement of Weapons in Outer Space, was vetoed by USA, despite the Treaty explicitly affirming a State's inherent right of self-defence. In December 2014, UNGA passed two resolutions on preventing an arms race in outer space, both of which were opposed by USA among a few others.

Indian Launch and Satellite Capabilities

ISRO currently uses the Polar Satellite Launch Vehicle (PSLV) and the Geosynchronous Satellite Launch Vehicle (GSLV). ISRO and Airports Authority of India (AAI) have implemented the GPS Aided Geo Augmented Navigation (GAGAN) project as a Satellite Based Augmentation System (SBAS) for the Indian airspace. Indian Regional Navigation Satellite System (IRNSS), NavIC is an independent regional navigation satellite system being developed by India and will have eleven satellites. It is designed to provide position information service to users in India as well as the region extending up to 1500 km. In January 2014, ISRO successfully used an indigenous cryogenic engine on GSLV-D5 to launch GSAT-14. ISRO sent one lunar orbiter 'Chandrayaan-1' on 22 October 2008, and a Mars orbiter mission which successfully entered Mars orbit on 24 September 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 Mars orbit. On 15 February 2017, ISRO launched 104 satellites using a single rocket, PSLV C-37, and created a world record. ISRO launched its heaviest rocket, GSLV-Mk III, on 5 June 2017 and placed a communications satellite GSAT-19 in orbit. With this launch, ISRO became capable of launching 4 ton heavy satellites. India will send its first manned mission to space by December 2021 says ISRO Chief Kailasavadivoo Sivan. India plans an orbiter to Venus, *'Shukrayaan-1'* in 2023.

Indian Military Application Satellites

Military off-shoots of India's peaceful space programme include remote sensing satellites of Indian Remote Sensing (IRS) series. India today has 15 operational IRS satellites. All these are placed in polar sun-synchronous orbit and provide data in a variety of spatial, spectral and temporal resolutions. India also commercially offers images with one metre resolution. Radar Imaging Satellite 2 (RISAT-2) has synthetic aperture radar (SAR) from Israel Aerospace Industries (IAI). It has a day-night, all-weather monitoring capability with one metre resolution. The 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 data from the satellite is used for detailed mapping and Geographical Information System (GIS). Cartosat-2A is a

dedicated satellite for the Indian Armed Forces. Because of high agility, it can be steered to facilitate imaging of any area more frequently. India now has 13 satellites with military applications. GSAT-6 is the second strategic satellite mainly for use by the armed forces for quality and secure communications. Indian Navy uses GSAT-7 for real-time communications among its warships, submarines, aircraft and land systems. GSAT-7A, 'angry bird', an advanced military communications satellite exclusively for the Indian Air Force (IAF) was launched in December 2018.[13] It can enhance network-centric warfare capabilities by interlinking with IAF ground radar network and Airborne Early Warning and Control (AEW&C) aircraft. GSAT-7A will also be used by Indian Army Aviation Corps.

South Asian Aerospace Realities

Elon Musk says he's a big fan of what China is doing in space. Musk is CEO of space exploration company SpaceX, which faces growing competition from China which is pumping huge money into space. The first Chinese manned spaceflight was in 2003. In January 2007, China became the first Asian military-space power to perform an ASAT test. ASAT technologies are a critical part of the Chinese space programme. China has successfully performed soft landing of a rover on the moon, including the only ones to land on the dark side. China has long term ambitions to exploit Earth-Moon space for industrial development. China plans to bring a habitable space station Tiangong 2 online by 2022 and put Chinese astronauts on the moon in mid-2020s. They also have Mars lander mission coming up. Chinese space programme is linked to the nation's efforts at developing advanced military technology. China launched 'DAMPE'[14], the most capable dark matter explorer to date, in 2015 and world's first quantum communication satellite 'QUESS'[15] in 2016. China is averaging 20 space missions a year. China's BeiDou Global Satellite Navigation System with 26 satellites in orbit started to provide global services on 27 December 2018.

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 Pakistani Armed Forces under control of Pakistan Air Force (PAF). Pakistan's very fledgling space programme has Chinese support and stamp. Pakistan takes

Chinese support for satellite launch. They have also joined the Chinese satellite navigation system Beidou.

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 dynamics will drive the other major powers to act to preserve and enhance their security and national power interests. Space assets will act as the force multipliers and will play a vital role in the formulation and implementation of strategies. The entire National Security Complex would have to be reorganised and restructured keeping in mind this reality. The role of space-based Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) assets, complemented by ground based Space Spatial Awareness (SSA) components, will be critical. India is one among the top six space powers in the world along with USA, Russia, China, European Space Agency (ESA), and Japan.

With space having emerged as the fourth medium for military operations, the IAF had brought out its blueprint titled 'Defence Space Vision 2020'. DSA will work on furthering joint space strategy. The Defence Space Satellite Centre (DSSC) works closely with ISRO. Defence Image Processing and Analysis Centre (DIPAC).and DSSC will report to DSA. A new agency, called the Defence Space Research Agency (DSRO), has been created for evolving space warfare weapon systems and technologies. Greater space presence requires capability to launch heavy satellites, increase number of launches per year, have ability to launch satellites at short notice, position high accuracy sensors, have advanced electronic and cyber capabilities, and develop kinetic and non-kinetic means to defend India's assets and interests in space.

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 tactical airspace as an important military asset. Ground/space based lasers to disable enemy satellites or destroy/degrade attacking ICBM as part of ASAT capability. There is also a need to develop DEWs. India, one-day, needs a permanent space station. The space-based systems have enabled dramatic improvement in military and intelligence operations, thus enhancing its capability, accuracy and fire power. In the not so distant future, wars will again be fought like we read in Indian Epics. Space is the future for all action and capabilities, the real force multiplier. India is doing well. Time to invest more and prepare is now.

Endnotes

[1] Rajeshwari Pillai Rajagopalan, India's first simulated space warfare exercise, ORF, June 12, 2019, https://www.orfonline.org/research/india-launch-first-simulated-space-warfare-exercise-51898/

[2] 'Space', WhatIs.com, February 2016, https://whatis.techtarget.com/definition/space

[3] Robert Osiander M. Ann Garrison Darrin John L. Champion, MEMS and Microstructures in Aerospace Applications, 2006, https://doc.lagout.org/science/0_Computer%20Science/8_Electronics%20%26%20Robotics/MEMS%20and%20Microstructures%20in%20Aerospace%20Applications%20-%20Robert%20Osiander%20et%20al.pdf

[4] Ryan Pickrell, The US Navy is talking about finally taking its railgun out to sea for testing aboard a warship, Business Insider, May 28, 2019, https://www.businessinsider.in/defense/the-us-navy-is-talking-about-finally-taking-its-railgun-out-to-sea-for-testing-aboard-a-warship/articleshow/69547676.cms

[5] Bahman Zohuri, Directed Energy Beam Weapons, Page 44, https://books.google.co.in/books?id=fZafDwAAQBAJ&pg=PA44 &lpg=PA44&dq=International+space+station+(ISS),+currently+the+largest+artificial+object+in+Earth+orbit,+measures+slightly+over+100m+ at+its+largest+span.&source=bl&ots=qOaox1oSwn&sig=ACfU3U1cu 3oNE7MFDrfo3t0d58DQaJ_XVg&hl=en&sa=X&ved=2ahUKEwiarcW93drlAhXKIbcAHaFKB1EQ6AEwC3oECAgQAQ#v=onepage&q=International%20space%20station%20(ISS)%2C%20currently%20the%20largest%20artificial%20object%20in%20Earth%20orbit%2C%20measures%20slightly%20over%20100m%20at%20its%20largest%20span.&f=false

[6] Kelly Young, Anti-satellite test generates dangerous space debris, New Scientist, January 20, 2007, https://www.newscientist.com/article/dn10999-anti-satellite-test-generates-dangerous-space-debris/

[7] Richard Hollingham, The Cold War Nuke that Fried Satellites, BBCNews, September 11, 2015 https://www.bbc.com/future/article/20150910-the-nuke-that-fried-satellites-with-terrifying-results

[8] Russia's Almaz Launches Airborne Anti-Surveillance Laser Project, Sokol Exhelon, Defence World Net, June 26, 2019 https://www.defenseworld.net/news/25031/Russia___s_Almaz_Launches_Airborne_Anti_surveillance_Laser_Project#.XTHXCPIzbIU

[9] Mike Wall, X-37B Military Space Plane's Latest Mystery Mission Passes 600 Days, Space.com, April 30, 2019, NASA spaceplane X-37 https://www.space.com/x-37b-military-space-plane-otv5-600-days.html

[10] Hanneke Weitering, China Aces Its 1st Rocket Launch at Sea, Space.com June 05, 2019 https://www.space.com/china-first-sea-rocket-launch-success.html

[11] 2019 Indian anti-satellite missile test. https://en.wikipedia.org/wiki/2019_Indian_anti-satellite_missile_test

[12] Pericles Gasparini Alves, Prevention of an Arms Race in Outer Space (PAROS) treaty, United Nations Institute for Disarmament Research, 1991, 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

[13]Rohit TK, The Hindu, GSAT-7A 'angry bird' an advanced military communications satellite exclusively for the Indian Air Force (IAF), January 25, 2019 https://www.thehindu.com/sci-tech/science/isro-successfully-launches-gsat-7a/article25781226.ece

[14] Charles Q Choi, China's Cosmic 'Monkey King' Satellite Looks for Dark Matter, Space.com, November 29, 2017 https://www.space.com/38937-china-monkey-king-satellite-dark-matter.html

[15] Jacob Aron, China launches world's first quantum communications satellite, New Scientist, August 16, 2016. https://www.newscientist.com/article/2101071-china-launches-worlds-first-quantum-communications-satellite/