59-70

LEVERAGING 'NEW SPACE' DOMAIN-AN INTELLIGENCE, SURVEILLANCE AND RECONNAISSANCE PERSPECTIVE

Gp Capt Arvind Pandey (Retd)

Abstract

In present times Space has become ultimate high ground for warfare. In past two decades space exploration has seen global outreach and will to conquer. Intelligence is a prerequisite to win a war and ISR plays a crucial role in ensuring precise and timely intelligence. Globally, space faring nations have concluded that without public private partnership timely inclusion of evolving technology is difficult to achieve in this domain. News pace has thus born to commercialise the space and take the applications to new heights. Earth orbit altitudes give an insight into the capabilities of ISR sensors onboard these satellites. LEO has been most sought after orbit as it gives several advantages for earth observation and capability to responsive launch. Evolving technologies i.e. AI, edge computing and sensor fusion along with novel methods of ISR generation i.e. RF cueing and IR/SAR/Hyper spectral imaging gives a cutting edge in present era. Indian space ecosystem has got a boost in recent times with government policies and require public private partnership for success.

INTRODUCTION

Space has made substantial contributions to our civilisation. The moon was used to build the earliest calendars, the sun allowed humans to measure the number of hours in a day, and stars assisted explorers in navigating the world. In recent years, space has continued to drive human creativity, with scientific discoveries in space helping us to understand more about our own planet. Space has increasingly become a battlefield during the previous few decades. Since the start of warfare, obtaining intelligence on adversaries has been essential to military strategy. Being aware of your rivals' strategies, tactics, and goals might spell the difference between victory and failure.

There is a need for strategy oriented approach to evolve ISR mechanisms thereby ensuring meeting the commanders need on ground and expectations in a complex operating environment. ISR strategy is to start by examining and framing of the problem, identifying mission expectations and objectives in a way that fulfills the requirement. The capacity to observe what the opponent is doing, by any means of collection of intelligence on ground or from the air/space, is crucial to knowing about the enemy in advance which ultimately leads to conquest. With the evolving space-based imaging, intelligence analysts were able to gaze deeply and consistently into rivals' territories, frequently offering initial signals and indications of military activities in successive wars in recent past.

The space sector is undergoing significant changes, known as 'New Space'. This outlines the process of liberalizing space operations and reorienting the space sector for commercial objectives. New Space is related with the rise of new players from private entrepreneurship who wants to exploit space technology and create new market possibilities, lowering barriers to entrance into the industry. Convergence with the technological revolution is a critical component of the space sector's ongoing evolution. Global technological behemoths spent substantially in space in the early 2000s, developing their space systems with government assistance.

Intelligence, Surveillance and Reconnaissance (ISR)

The goal of ISR, a military activity, is to assist "decision makers in anticipating change, mitigating risk, and shaping outcomes." The definition of ISR is "an integrated operations and intelligence activity that plan and coordinate the use of assets, processing, exploitation, and dissemination systems, as well as sensors, in direct support of ongoing and future operations." The result of surveillance and reconnaissance activities, intelligence is produced at the nexus of military strategy, operations, and assessment.[1]

Intelligence. The outcome of gathering, integrating, evaluating, analysing, and interpreting the information that is now accessible about other countries, hostile or possibly hostile troops or components, or regions of current or future operations is intelligence.

Surveillance. Aerospace, cyberspace, places, people, or objects that are systematically observed using visual, auditory, electronic, photographic, or other methods is known as Surveillance.

Reconnaissance. It is intended to gather information on an enemy's or adversary's activities and resources by visual observation or other detecting means, or to secure data on the meteorological, hydrographic, or geographic aspects of a certain area.

Recent ISR satellites are technologically advanced and potent, but they are also incredibly costly. Because of the short period between design and manufacturing, it is impossible to include all technological improvements that have occurred in the meanwhile. An ISR satellite's life expectancy is typically five to 10 years, as constructed or computed. At lower altitudes, satellites suffer more from Earth's atmospheric drag and need more fuel to keep their orbit altitude. The principal cost driver, the size limits of the observation equipment, is influenced by the selected altitude. Reducing the satellite's orbital altitude results in a shorter lifespan because of the fuel's weight for operation of the satellite.

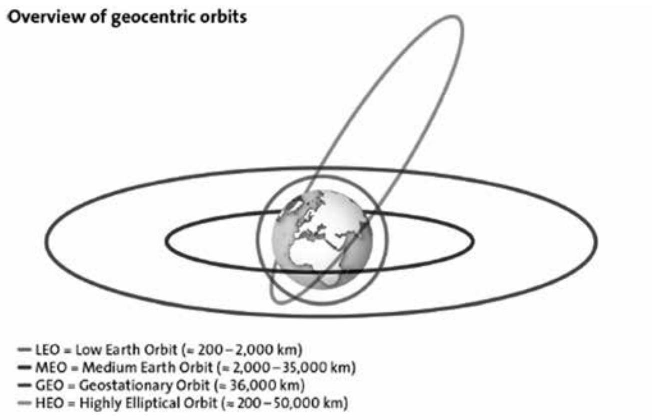
On the other hand, lowering the orbit height enables a decrease in the overall optical system's size and weight or an increase in the maximum ground resolution. Reducing the satellite's total launch mass will also decrease its anticipated lifetime and thus launch costs. Satellites operate in a hazardous atmosphere wherein it is important that the exposed components are radiation hardened and ensuring redundancy of involved sub-systems will help them attain their intended lifespan while drastically increasing production costs. Shorter-lived, smaller satellites are less expensive, and until they are deployed, provider countries may continue to upgrade them with cutting-edge technology.

There are technologies available now that allow for resilience and reconstitution, and they may be developed and demonstrated using tiny satellites. These technologies will address customers' most difficult challenges, significantly shorten the design-to-launch timescale, fly in formation to provide huge synthetic apertures for improved resolution, and quickly alter on-orbit configurations in response to changing mission sensing needs. In the years running up to 2035, such technologies will continue to progress, creating off-ramps to fresh, perhaps superior capabilities.

Congested, contested, and competitive are the three tendencies that will shape the strategic environment of the future. In terms of the trend of congestion, as more countries enter the space industry, their satellites and space debris are contributing to physical congestion. The radio frequency spectrum for space applications is also becoming more crowded. As more nations attempt to launch their systems into space, the trend of space as a disputed region will only intensify. The United States will face ongoing challenges in space as nations like China and Russia vie for supremacy. The third trend of competitiveness has also increased with commercial imagery providers like MAXAR, ICEYE and countries such as the Japan, Germany, Canada and India.[2]

Nowadays, the fifth operational area in combat is space. It consists of the space-based satellites, the terrestrial infrastructure they support, and the information layer that links the two. Our Armed Forces can now compete in the Information Age thanks to all of this. In order to deal with ongoing competition in the future, we need to establish a standard for space behaviors that will improve the predictability, security, and transparency of all space systems and allow us to operate—and compete, if needed—in and via space. Enabling our Armed Forces to respond to upcoming global problems will need a thorough awareness of activities in the space domain and the capacity to guard, defend, and integrate, just as we have done for the other domains.

Current Space-Based ISR Architecture. Presently, the space-based ISR architecture consists of satellites in Low Earth Orbit (LEO), 200–2,000 km; Medium Earth Orbit (MEO), 2000–35,000 km; Highly Elliptical Orbit (HEO), 200–500 km above the earth at the closest point, and 50,000 km above it at the farthest point, as well as Geostationary Orbit (GEO), which is roughly 36,000 km above the earth.



For space-based ISR applications, each form of orbit offers pros and cons. A system in LEO provides superior resolution and a greater return rate over earthly points of interest because of its close proximity to the planet, but it also needs more satellites for global or regional coverage and is more vulnerable to attacks. Due to its orbit, a system in MEO can cover a larger area continuously and with fewer satellites than a system in LEO. It also offers faster response times in the event of launched threats. However, achieving the same resolution as LEO systems requires a larger sensor, and launching and positioning into a final MEO orbit requires more power.

The benefit of hours of continuous coverage over a region of interest is available to a system deployed into a High Earth Orbit (HEO). Since a GEO system is further from Earth than the other three, it would be harder for an enemy to threaten it; nevertheless, its resolution is lower and its launch needs more power to this orbit.[3]

SENSORS ONBOARD COMMERCIAL SATELLITES

- **Electro Optical (EO) Spectrum Sensors.** The aim of satellite constellation of Planet is to be able to capture a daily image of the whole world. The WorldView Legion constellation, which Maxar is developing, is expected to visit similar spots on Earth by viewing them several times every day for better battle transparency. A fleet of high-resolution satellites teamed with high revisit rate on daily basis for intelligence gathering is operated by BlackSky. Indian start up KaleidEO is developing EO satellite with onboard edge computing for faster data delivery.[4]
- **Synthetic Aperture Radar (SAR) Sensors.** Commercially owned SAR satellites, such as those being developed/operated by Capella, ICEYE and Umbra Lab, are able to capture images of the Earth under a variety of atmospheric conditions both during the day and at night. In addition to supporting several other uses, the NASA-ISRO jointly developed SAR (NISAR) Mission will assess Earth's dynamic surfaces, ice masses, and changing ecosystems. This data will be useful in determining groundwater levels, biomass, natural hazards, and sea level rise. NISAR will be the first radarof its kind in space with two different radar frequencies which will observe Earth's surfaces globally with regular intervals.[5]
- **Infrared (IR) and Hyperspectral (HSI) Sensors.** Commercial satellite operators are also developing systems with evolving technology in Infrared region and Hyperspectral imaging that can potentially determine chemical and material composition of the surface monitored. This ability of the satellite helps to identify the agricultural pick and subsequently finalising what crops to put in which fields while simultaneously detecting different camouflage materials aiding in concealing a weapon system. Teledyne, HySpecIQ, Orbital Sidekick, Albedo, and Hypersat are among

the global commercial suppliers. Indian start up Pixxel is establishing a constellation of HSI satellites after initial technology demonstrator.[6]

- **Multi Sensor Fusion Data.** Maxar is working with numerous commercial service providers to integrate its GEOINT capabilities with various sensor types for sensor fused data. Ursa is working on a software program that would allow users to leverage SAR from several sources. Image aggregators are able to identify the need of the user and provide the best solution for the military requirement. Indian start up GalaxEye is developing SAR+EO sensor on a single satellite platform to boost the requirements.[7]
- **Space-based SIGINT Sensors.** The satellite-based radio frequency (RF) collecting tools from Hawkeye 360 and Aurora Insight are available. This has a number of uses, including search and rescue and cargo tracking, by identifying and geolocating a variety of radio frequency emitters. Hawkeye 360 started tracking GPS interference with this technique in late 2021 and successfully discovered jamming of GPS signals by Russian forces around Chernobyl before they entered Ukraine. The Space Systems Command of the USSF is creating instruments to identify, track, and eventually reduce GPS and radio frequency interference. Commercial RF developers Spire, an American company, and its international partner Kleos are constructing constellations to detect and pinpoint the location of radiofrequency signals for military uses.

INDIA'S PERSPECTIVE FOR ISR

India has a lengthy coastline (about 7,516 km) and a border (length 15,106 km).[8] As a result, space-based reconnaissance capabilities for continuous area monitoring of the key regions become essential for national security. ISR space based systems gather and analyse signals and imagery for a variety of purposes to enhance efficacy of combatants: preserving order of battle and situational awareness; keeping an eye on enemy movements and weaponry; creating extremely precise targeting data; issuing alerts and warnings; and evaluating battle damage. Comprehending the adversary's counter-space capabilities and devising strategies to neutralise them or devise alternative approaches is also crucial. ISR should include any constraints or influences on assets that are in orbit rather than relying just on satellites. For example, adversaries with effective counter-Space capabilities or jamming devices may interfere with the utilisation of images to facilitate targeting assessment. It should be taken into account that the earliest generation of satellites lacks self-defense or anti-jamming hardware. In addition, ISR enhances space situational awareness and must to be protected against any encroachment or assault on military satellites.[9]

The term "New Space" describes the recent opening of the Indian space industry to private enterprises following the enactment of the national geospatial policy (2022), the Indian space policy (2023), and the Indian space FDI policy (2024). The fast growth of the downstream space segment—that is, space-related commercial applications and services—is linked to the liberalisation of space operations, which takes place at the same time that the economy is becoming more digital. To increase battlespace awareness and target beyond line-of-sight, commercial satellite images must be utilised. India's national security must take advantage of all available public and commercial space-based ISR capabilities. The mix of available resources implies that combined capabilities can be genuinely spectacular, even while no particular entity can offer the fully persistent view of all the ISR requirements of any specific defence requirement. New solutions to help make it achievable will come from industry innovation in the present times. ISR has a crucial role in disaster mitigation and management. It is prudent to have advanced information about disaster from modeling and simulations. Stake holders involved must be capable of handling the disaster as and when it strikes.

Maxar, a commercial imagery supplier, has made a significant worldwide advancement by providing mobile pads that provide real-time, direct access to their imaging satellites, therefore altering the Indian perspective, drawing on its experience in Ukraine. As a tactical operational tool, this might allow military forces in the field to download electro-optical (EO) pictures from

Maxar's satellites. Tactical timelines have shortened from days or hours to minutes or seconds as the battlefield requirements have shifted from isolated regions to several simultaneous locations at the same time. This has shortened the sensor-to-shooter latency and therefore the OODA loop.

In order to avoid relocation costs and relaying activities, LEO satellites cover all the areas that aircrafts were previously used to cover between regular satellite operations. The ISR niche may then be further narrowed to include UAVs. UAVs may be designed to deploy localised "Cubesats" at heights of 60,000 feet, pop up and loop to remain in one place for twenty-four hours a day, and provide commanders access to satellite-based communication and relay capabilities.

RESPONSIVE LAUNCH OF ISR SATELLITES

High-tech ISR satellites are and will continue to be an essential component of decision-making. They are best positioned in polar orbits to provide persistent global ISR gathering. ISR satellites would probably be the first to be targeted in a confrontation when adversaries having kinetic or non kinetic counter-space capabilities would engage in the temporary/permanent disablement of certain satellites. The development and multiplication of counter-space assets will make this even more crucial in the future. Small and quickly ready-to-launch satellites will be increasingly crucial to launch new assets in specially-designed orbits and to repair or reconstruct a degraded capacity. Definitely it is a strategy that by using satellites in an optimal orbit, nations may cover a specific area of operations.

This makes it possible for the operational planning procedure to incorporate the particular orbit design. "Operational responsive launch" is the name of this methodology. Particular orbital characteristics that are computed for a given mission define operational responsive launches. Although highly developed satellites will never be completely replaced by small, quickly launched ISR satellites, they can step in to bridge coverage gaps left by counter-space activities or technical breakdowns. The satellites that countries need to do this are modular, pre-made, or completely built.

Nationwide space stakeholders may leverage this demonstrated capacity for prompt launches, as demonstrated by India's ASAT test on March 27, 2019. In the test the Prithvi Delivery Vehicle acting as ASAT destroyed a disfunctional satellite named Microsat-R.[10]

THWARTING CHINESE CAPABILITIES

China's military satellite constellation, known as Yaogan-30, serves as the backbone for the country's implementation of Anti Access/Area Denial (A2/D2) across the South China Sea (SCS). It supports the DF-21&DF-26 class missiles launched from the land and the YJ-21 Anti-Ship Ballistic Missile launched from ships. This strengthens China's Anti-Ship Ballistic Missile systems and enhances its ability to deny access and control areas. It is anticipated that in order to challenge the American Carrier Strike Group, China would eventually deploy eighteen triplets of these satellites. The satellite could cover certain areas of the northern Indian Ocean in addition to continuously monitoring the Pacific and SCS.

The constellation of Yaogan-30 satellites offers a half-hour revisit period over a SCS region of interest, which improves China's MDA (Maritime Domain Awareness). China hopes to have three ELINT satellites in orbit that can cover an area of at least 3000 kilometers to enable space-based ELINT capabilities that include the whole planet. India needs these type of satellites constellations to improve its MDA in the vast IOR, which is bolstered by ground assets capabilities, in order to give effective ISR and long-range kill capabilities at sea.

STRATEGY FOR INDIA'S ISR GOVERNANCE

India's ISR need primarily emanates out of two neighbors Pakistan and China. China has fully developed space based ISR programme in place with ever evolving technologies while Pakistan keeps on struggling with its space programme. The threat perception of China is totally different and far bigger from Pakistan. China poses a bigger threat in land as well as in maritime domain however Pakistan's ability to exert itself limits in many ways apart from its nuclear propaganda. Indo Pacific Region and Indian Ocean Region pose a lurking Chinese threat in global relations of India. India is prepared to launch 50 Spy satellites in next five years as stated by ISRO chairman in December 2023.[11]

India established the Indian Ocean Region Information Fusion Center (IFC-IOR) in 2018 with the goal of becoming a regional leader in maritime domain awareness (MDA). The center offers regional MDA by "creating a common coherent maritime situation picture and acting as a maritime information hub for the region." The IFC-IOR is an operational entity designed to materialise the Indian navy's goal of providing net security; rather than seeing the Indian Ocean through subregions, it aims to provide an interoperable picture of the whole ocean. The IFC-IOR offers and facilitates information exchange across IOR countries to create an interoperable MDA image in real time, using Indigenous software. Information sharing on a range of topics, including as maritime terrorism, illicit drug trade, human trafficking, environmental risks, and natural catastrophes, is coordinated and facilitated by the center with partner nations and stakeholders. Anywhere in the IOR, illegitimate vessels can be identified because to the extensive database of commercial and nautical boats.

CONCLUSION

A space-based "Integrated Aerospace ISR Grid" must be established for shared aerospace awareness throughout the area and beyond, as evidenced by the success of IFC-IOR. Intelligent space borne intelligence, surveillance, and reconnaissance technologies enable automated data analysis. Instead of spending their time and skills on data analysis, this enables operators to concentrate on making critical decisions. Automated sensing systems can supply intelligence to assist combat team members in achieving high-level mission objectives. When AI and edge computing are fully exploited, the chances of any ISR operation success increases manifold. The information is sent on the first attempt, providing decision-makers and military leaders with further assurance that nothing is being overlooked and they have full intelligence to act.

Gp Capt Arvind Pandey (Retd) is a geospatial intelligence professional. Presently he is employed as senior fellow at Centre for Air Power Studies, New Delhi and is researching on creation of geospatial ecosystem in the Indian context. Linked In- https://in.linkedin.com/in/arvind-pandey-ab096aa6, Twitter- https://twitter.com/ScoutPandey

NOTES

1. Jake Harrington and Riley McCabe, August 6, 2021,Modernizing Intelligence, Surveillance, and Reconnaissance to 'Find' in the Era of Security Competition (csis.org). Accessed on 06 March 2024.
2. Department of Public Information, News and Media Division, New York, General Assembly GA/DIS/3487, 25 October 2013,Outer Space Increasingly 'Congested, Contested and Competitive', First Committee Told, as Speakers Urge Legally Binding Document to Prevent Its Militarization | Meetings Coverage and Press Releases (un.org). Accessed on 06 March 2024.
3. NASA Earth Observatory. "Catalog of Earth Satellite Orbits," n.d. https://earthobservatory.nasa.gov/features/OrbitsCatalog.
4. KaleidEO. "Home - KaleidEO," 16 January 2024, https://kaleideo.co/.
5. NASA-ISRO SAR Mission (NISAR). "Home – NASA-ISRO SAR Mission (NISAR)," n.d. https://nisar.jpl.nasa.gov/.
6. "Pixxel | Hyperspectral Imagery and Space Data Company," n.d. https://www.pixxel.space/.
7. "GalaxEye Space," n.d. https://www.galaxeye.space/.
8. Border Management II Division, "Annexure V", Ministry of Home Affairs, Government of India, https://www.mha.gov.in/sites/default/files/2022-08/BM_II_Mandate_18062019%5B1%5D.pdf. Accessed on 2 April 2024.
9. Group Captain Arvind Pandey (Retd), May 21, 2023,Cyberattack On European Spacecraft! How 'Hackers' Took Control Of Satellite's Imaging Sensors & Jeopardized Its Data (eurasiantimes.com). Accessed on 09 March 2024.
10. Group Captain Arvind Pandey (Retd), 17 October 2022. As US, Russia, China Increasingly Conduct Anti-Satellite Tests, Has The Time For Responsive Satellite Launch Arrived? (eurasiantimes.com). Accessed on 09 March 2024.
11. 29 December 2023, ISRO's Big Defence Boost For India - 50 Spy Satellites In 5 Years. Details Here (ndtv.com). Accessed on 10 March 2024.