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REPORT ON DELIBERATIONS

DEFSAT 2024

ORGANIZED BY CENJOWS & SIA-INDIA
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DEFSAT CONFERENCE & EXPOSITION
ORGANISED BY CENJOWS & SIA INDIA
MANEKSHAW CENTRE DELHI CANTT, NEW DELHI
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CONFERENCE REPORT

Introduction

The DEFSAT 2024 seminar was conducted jointly by CENJOWS-SIA on 07-09 February 2024 at Manekshaw Centre, Delhi Cantt, New Delhi. The seminar covered various facets of civil-military fusion in the Space Sector, focusing on the growing requirements of the armed forces. The seminar was aimed at providing opportunities for military leaders, scientists, members of private space companies, academia, Think Tanks to brainstorm emerging development on the subject and provide various actionable points for all stakeholders in space eco-system. In addition it aimed to harmonise national space endeavours and help the private players align their technology and capacity endeavours to match the requirements of the armed forces and CAPFs. It saw participation of nearly 500 stakeholders including government officials, military leaders, various foreign as well Indian private companies, DRDO, ISRO, and the PSUs. The event facilitated knowledge exchange among various stakeholders, reflecting India's commitment to advancing its space capabilities.

Growth in Space industry

Commercialisation of the space domain has encouraged development of dual use technologies that has brought about both opportunities and threats. While India ventured into space with the successful launch of Aryabhatta in 1975, the Indian space sector has witnessed remarkable growth for societal, economic and military needs only over the past few decades. With the release of the Space Policy in April 2023, new opportunities with a vision to augment space capabilities are expected. This would help the aviation, marine, agriculture, energy, telecom and service delivery sectors. On the military side, the salience of space for information management, command and control (C2) and precision strikes on the battlefield cannot be overlooked. This has led to a renewed impetus to various development activities in this field. As technology advances, it brings with it threats both from and through space. When comparing, even though the space activities of India are not at the same level as that of China or the US, India has earned numerous achievements by the proactive actions of ISRO. In recent times, India has witnessed the entry of startups, MSMEs and academic institutions in the Indian space sector, spurred by access to ISRO assets and technology. This is fostering innovation, competition and collaboration, besides driving technological advancements, economic growth and job creation, aligned with the vision of an 'Atma Nirbhar Bharat'. This spurt is expected to push the Indian space sector from $10 Bn a year, to $ 44 Bn by 2040. Role

differentiation with creation of NSIL, IN-SPACe, ISpA and the demonstrated potential of startups like Skyroot Aerospace (launch systems), Pixxel (imagery), Dhruva Space (satellites) and Agnikul Cosmos (India's first private space vehicle Launchpad), is underpinning this unprecedented growth. Currently, 68 private firms hope to build payloads, 30 of them plan to develop rockets and parts, and another 57 want to make ground stations and applications. The Indian space ecosystem, including private investments, is indeed buoyant.

Importance of Space for India

Space has not only joined land, air, sea, cyber space but has become one of the most prominent key domains of warfare. Accordingly, compelled by international security and geopolitics, India has moved to the second space revolution to focus on military exploration of space. Such exploration requires good investment in space diplomacy and the involvement of the Industry, research, academia, government, the users and international partners. In this effort the need of space for telecommunication and internet should not be overlooked. These all encouraged the formulation of the Space Policy of India which aims to take the space economy of the country forward duly supported by a growing start-up sector which had increased from one in 2014 to 204 now. With a focus on developing this sector for the military, the Indian armed forces have earmarked funds of nearly Rs 25,000 Crores to meet its defence space requirements. This highlights the importance of the sector and provides a significant opportunity to the private sector to benefit from this. Collaborations of the likes of SIA-India and the Space Industry Association of Australia will help foster growth in the global space sector through knowledge exchange and business collaboration and propel progress in space technology and deepen bilateral ties between India and Australia. Similar options exist with other countries of the world.

Emerging Trends in Space Militarisation

Counter space operations enable own forces to exploit space capabilities while disallowing the adversary to do so. To maintain a desired degree of space control/ superiority, some emerging trends are: -

- *Anti-Satellite (ASAT) Weapon Systems*. These systems can be Earth based (direct-ascent) or Space based and have been developed by some leading counties including China. These weapon systems can

melt satellites and are considered to be between conventional and the nuclear thresholds.

- *Rocket, Missile and Aircrafts*. Self-acquiring long range rockets are becoming a norm along with hypersonic missiles that can avoid detection and countermeasures. Missile systems and aircrafts that can engage aerial threats and satellites are also being developed. All these rely heavily on space-based capabilities.

- *High-Altitude pseudo-Satellite (HAPS) Systems*. HAPS are used in the "Near Space" threshold. Drones, swarms, HAPS, and their countermeasures rely heavily on space-based capabilities for C2, surveillance and targeting.

- *Electronic Warfare*. Space based services are dependent on the Electro-Magnetic Spectrum (EMS) for C2/ communication links and streaming of data. Space based assets are being leveraged for SIGINT, offensive dazzling using high energy lasers using miniaturised electronics technology.

- *Cyber Warfare*. Numerous financial and non-financial institutions use space-based services. Cyber-attacks are a threat that can target satellites and ground systems to deceive, disrupt, deny, degrade services to their users and if required even destroy space and ground based assets. This requires enhancing capabilities in cyber-defence, resilience, and legal regulations.

Requirements of the Military

As one of the major consumers, the broad requirements of the Military in various space systems are as under: -

(a) *Launch Capabilities*. Reusable Launch Vehicles (RLV), Launch on Demand (LoD), Nuclear power for interplanetary missions, Smart fuels to increase the payload carried and to reduce cost per launch.

(b) *Spacecraft*. Advanced power sources for increased sustenance, CUBESATs, Nanosatellites, multi-sensor payloads, miniaturisation, robotic systems for on-orbit servicing, assembly and manufacturing (OSAM), high

resolution Hyper-Spectral Imagery (HSI), edge-processing, Counter-ASAT capabilities, electronic hardening, plasma thrusters for maneuvers.

(c) *Ground Infrastructure*. Adequate number of stations that are geographical spread. Need for mobile ground stations and scaling up of existing ground stations for LEO constellations.

(d) *Intelligence, Surveillance & Reconnaissance (ISR)*. Ability to provide persistent coverage over select areas; precise, real-time and predictive ISR using AI/ML, change detection, mixed/multiple sensors/payloads like EO, IR, SAR, ISAR, SIGINT; missile launch detection and threat intelligence integration; dynamic target recognition with real time downloading of data to static and mobile ground stations; data interoperability with weapon systems for Long Range Precision Targeting (LRPT); AI/ML enabled intelligence to identify and remove fake/poisoned data; Sensors with a dynamic range of 120 dB. Build indigenous capacity in Hyper-Spectral Imaging (HSI). Enhance revisit time to 1-2 hours over select areas, though combination of EO/IR and SAR.

(e) *Resilient Satellite Communications*. Need for disaggregated, distributed and diversified capabilities; LEO constellation based military internet; leveraging 5G/6G technologies for IoMT; software defined communications; high bandwidth laser/optical/ free space secure communications; Tactical Data Relay Satellites (TDRS), low latency; more exploitation of Ka, Ku, Q, V Bands; ELINT and COMINT with fingerprinting; Antenna nulling and adaptive filtering technology for anti-jamming and anti-spoofing.

(f) *Position, Navigation & Timing (PNT)*. Need for a resilient PNT; expanded IRNSS/NavIC coverage that can provide a minimum of 3,000 km coverage around the Indian sub-continent; small receivers, precise guidance of missiles, aircraft and unmanned vehicles.

(g) *Space Situational Awareness (SSA) and Space Surveillance & Tracking (SST)*. More ground (radars and telescopes) and space based systems (satellite based sensors) are needed to enhance SSA and SST capabilities to monitor and protect assets in space.

(h) *ASAT and Counter-ASAT Capabilities*. Need for Kinetic (Direct Ascent, Co-Orbital) and Non-kinetic (EW, Laser, HPM, chemical sprays and EMP) capabilities.

(j) *International cooperation*. To address gaps in technology, SSA, SST and to develop regulatory/ policy frameworks international cooperation is essential.

(k) *Human resource*. Need for a pool of trained human resource in AI/ML for imagery analysis and decision support systems.

(l) *Defense Space Policy and Joint Defence Doctrine*. Need a defence space strategy and joint space doctrine for greater cyber-space integration.

(m) *Synergy between Government and Industry*. To develop desired space services within the country, synergy between all stakeholders is essential. For this, the roles of all stakeholders need to be defined and streamlined.

Challenges. A number of challenges exist for Space in general.

(a) *Treaty on weaponisation of space*. No treaty or binding regulation exists on weaponisation of space, ASAT, ASAT mines, co-orbital warfare, EW and Direct Energy Weapons.

(b) *Space weather, solar phenomenon and space debris* are ever prevailing and hence need to be managed.

(c) *Competition*. With a spurt in the number of satellites launched, the space is becoming congested leading to contestation and competition, especially in the LEO. Such a situation will continue till some regulations are agreed upon.

(d) *For India*, a Defence Acquisition Policy and Defence Procurement Procedure for the space sector needs to be formulated with the involvement of relevant stakeholders. In addition, there is a need to foster greater synergy between civil, military, industry and academia to benefit from the technological spin-offs.

Key discussions in Various Sessions

Day 1

Meshed intelligence: Multi-sensor Payloads and Analytical Platforms. The idea of creating a mesh using small, inexpensive satellites is one of the most innovative new space technologies in recent years. This includes the integration of people, devices, IoT, data, processes for collaborative results to provide real-time information. Such networks are designed to cover entire regions with the satellites communicating not just with ground stations but also with one another akin to a Swarm. Such a mesh can be created by merging data from civilian satellites for strategic use which will become essential during conflicts. Today, digital technologies like AI and ML are encouraging the exploitation of older technologies (GIS) in an innovative manner. Geo-AI is a meshed technology that is an amalgamation of GIS, with AI and ML. Such meshed information becomes critical since ISR for the military needs to be of high information content, high resolution, timely, available round the clock, ready to use and with high security and high bandwidth.

To build such meshes at a lower cost, startups such as *Galaxeye Space* are working on providing optical results at sub-metre resolution by undertaking concurrent imaging using SAR and EO (Synthetic Aperture Radar and Earth Observation) which are temporally, spatially mapped and analysed by ML/ DL. Ideally one would like to capture spatial, temporal and spectral resolutions, however, this may not be possible due to limitation in physics. By using such a combination satellite one can optimise on the 3-D space to give meaningful output to the user. While other startups are also working with small satellites, they should not be considered competitors but as collaborating that are doing capability building. Another startup *Keledio*, is working to bridge the gap between the up-stream (launch facilities) and the down-stream (services) of EO. Using a mesh, they map a wide swath for high resolution data using 4 satellites and aim to cover one million sq km of area per day. Using Edge processing, they are able to reduce the cost of every Bit of data downloaded to economical levels. This allows immediate visualisation of the data downloaded rather than the conventional means wherein the data had to be processed before it can be appreciated. *Augsense lab* considers sensor output as the tip of the iceberg and believes that such outputs can be squeezed for more information. Accordingly, they built an RF sensor with multiple modalities to meet multiple tasks thereby allowing reducing the need for multiple sensors while being able to conduct multiple tasks in the same mission. This information is collected passively to avoid detection, especially during conflict. For weaker signals, they are building a Quantum enhanced

RF receiver which can scale information to HAPS, satellites, drones thereby creating modalities that have not even been visualised to date. Since the company is only a sensor company, they are not sure how exchange of this data would occur between the civilian and defence satellites. *QSTC Inc*. works on Quantum technology to replace other types of sensors. By merging multi-sensor payloads, a single output image can be created on a single terminal and QSTC is working on such a project. These advances have been possible due to availability of Cloud services where large amount of data can be stored. For such systems, especially for the military, Edge computing is essential along with AI/ML and DL to get the combined picture on the fly. For all this, cyber security is critical.

Space enabled precision and deep battles (ISR, positioning, navigation, targeting and communication). Factors such as imaging cycle, sensor to shooter loop and spin offs, and factors that impact precision targeting are critical for ISR. Ground planning defines the command to the satellite for imaging which is dumped to the ground station for processing and analysis with human interface or otherwise. Sensors with better agility will provide lesser turn-around time and allow quicker reactions. Edge processing will help to remove corrupt information. AI models can provide faster identification of objects. Data received needs to be processed using AI or Quantum computing for absorbing it and providing an output using a decision support system that can be comprehended by the Commander on ground. Data received should be in a common format and provision to transfer quickly and efficiently to all users must exist. Once the decision has been made, the data needs to be provided to the attack platform which would provide the Bomb Damage Assessment data (BDA) after the attack is completed to define the next tasking for the platform. Precision targeting will be defined by the quality of the data received, its accuracy and how well it can be integrated with the weapon system. Accuracy of the provided coordinates, launch platform, the navigation accuracy and the drift will define the success of the strike. For self-reliance, all this data should be indigenous. Need exists for Launch on demand to replace damaged satellite if need arises. We could also use change of orbits of satellites if launch on demand not feasible. Similarly, redundancy in Command and Control centres is critical to ensure that in the event of a cyber-attack the required information can still be passed to the unit on ground.

When looked at from the research perspective, the most important part is to understand the user perspective. Some aspects critical during research include, safety of data which is used for ML and analysis. This requires having a standardised method for data collection and storage. The data should not be for

immediate needs but for the overall requirement. The second requirement is to have a vibrant open source community since all information need not be protected. Hyper-spectral data is desired as visualisation is easier to appreciate but not essential. This can be handled by using *super resolution* wherein few bands missing can be generated or by using data augmentation using AI and ML. This is required for human analysis but when the analysis is machine based, a super resolution is unessential. The data collected should usually be converted to knowledge to make it useful and this requires us to migrate from syntactic to semantic communication (to provide meaningful information from the source beyond theoretical capacity limit).

Adequate dataset of military problems is not available for ML and hence has to be synthetically developed for which capability has to be created by the industry. For actionable intelligence which is an act of fusion, the *Dasarathy* model should be used to create a fusion hierarchy for which the industry needs to work on building capabilities in this aspect through govt funding if required. For positioning, space based assets can give you ground based coordinate (lat, long, azimuth) that has started to take some maturity in India, or giving you space coordinate system. For joint operations of land and space based assets requires considering the transformation from one coordinate to another. The third system that is taking shape and still being worked out is the use of space based vectors as attack assets on each other (two space assets fighting). Navigation requires good quality vector data. In India we have used cartographic charts and digitised it to get raster data and it is not vector data and hence not amenable to navigation. **This requires indigenous algorithm based on Indian satellites and with crowd sourcing it be improved to get accurate vector data like what Google did.** Targeting requires sub-metre resolution maps in x-y-z coordinates, but available Indian military maps are not so. While the capability exists in the West it has not come to India and needs to be developed for using precision weapons. Since fibre communication cannot be maintained reliably over a long distance, developing quantum communication using satellites is essential.

Ultimate position is more important than ultimate weapon. Space has both military and intelligence aims. A combination of both provides an actionable intelligence image. For action, when satellites are used, we can get Kinetic warfare (anti-satellite operations, direct energy weapons, high altitude nuclear detonations etc.) or non-kinetic warfare (cyber operations, radio frequency jammer operations, laser beam attacks, chemical attacks etc.). Eventually the Space warfare will give us a clear understanding about the need to study the fourth frontier in detail and the need of a doctrine.

While gaps and issues are known, where to spend is a critical decision. This needs an understanding how real-time / accurate should the result be.

In the maritime domain while AIS can map ships, dark ships cannot be mapped which may be involved in narcotics, piracy and other activities. EO is good for monitoring ports and harbours while SAR is good for monitoring activities at sea. ELINT uses a vast swath and hence can be useful for activities at sea. Target verification can be then done by high resolution imagery. Key requirements of IN are EO with advanced remote sensors with high resolution with multi sensor all weather capability and ELINT satellites for vast swath surveillance. Integrate AI for decision making and create redundant systems for working in all conditions.

Collaborative Frontiers: Synergising the Defence Innovation Ecosystem. Collaboration has been an essential cornerstone for innovation. Till WWII technology development was for the military and then used by the civil world. After WWII, the concept has changed and now the industry develops the technology and the military adapts it to their requirement. If technology is to be developed for the military the exact requirement has to be told to the industry and the academia so that the R&D is in the correct direction. Hence collaboration becomes critical. For innovation, ecosystem consists of the academia, large industries, investors, users and the government. Synergising them is the most important part since requirement of each constituent of this ecosystem is different. This is important since India has already missed the Industrial Revolution and we should not miss this Industrial Revolution that is occurring around us. Hence, a need for a strong Defence R&D ecosystem exists where the user has a major role. A good thing that has happened to this innovation programme is the iDEX scheme (faith in startups) which has provided clarity between the user and the industry. Now need to lay the ground for follow up programmes to see how these challenges are developing. Risk appetite of the user for emerging technologies is an important element as they are probabilistic and not matured. Assessment mechanisms need to be changed to differentiate between success and failure since we are looking at emerging technologies. The govt has launched 25 technology innovation hubs that provide the required synergy. Most of the projects given to these hubs are TRL 4 and above. The hub also provides human resource for startups which can be UG students. For skill development, in collaboration with the industry this is taken forward. The startup ecosystem is yet another element which gets 40-50% of the funds available. Furthermore, international collaboration is ensured through handholding and IP procurement if required to eventually produce Make in India products. For space, we need to

understand the challenge first to see if TDF can work in this sector. The problem is that the user knowledge may not be sufficient to define a winner in the challenge. The second problem is that since 50% of cost is borne by the industry and the demand is only for a single item, effectively one is asking for the product in half the cost which will not happen and hence a revenue model may be better for Space. Commercial viability and commonality are two other issues that need to be addressed. Some technologies that are commercially available and can be imported should be imported and then made in India rather than starting afresh. It is better to work on something which the world is not working on rather than that is already existing and easily available. If the long term demand and perspective is known, the industry will be encouragement. Collaborative development is another thing that is the need of the hour. The next level of iDEX is named ADITI which will help airborne systems since the govt funding will be at 25 crore from 10 crore as in iDEX.

Redefining Aerospace – Near Space and Space Sovereignty. Near Space is used to transit to Space but was never in discussion. Conventional aeroplanes can go up in height to 20 km. Beyond that there is little atmosphere to create flight. For a satellite, there is too much atmosphere in this region and would need to rotate at a very high speed (a GEO satellite does ~3 km/sec speed at 36,000 km). With advent of technology we want to use this region. Hence we need to discuss capability to be there and what comes out of being there; make regulations for assets in this region; and integration of all the assets that have been put in the Space along with the civil application of the Near Space.

Drone market is a fountain head of growth in the global arena for India. They can be used for multiple applications right next to the satellite or in agriculture. For them to be effective, they need to speak to the ground and make the satellite to speak to regions that do not have any infrastructure. But this communication is unencrypted and hence can be spoofed. Space starts a 100 km and is a term of convenience and not a universally accepted term. The term Near Space was given by the US because they wanted to operate in this region and to work without inhibition they called it Space. Both Chicago Convention and Space Treaty have not defined the extent of Space. No ‘lighter than air vehicles’ operate in the 50 to 150 km region. For traffic management and control in this region surveillance is essential and accordingly weapons will need to be developed for this region. For continuity of operations the used region and the unused region need to be integrated and there is no need to integrate the entire region till the Space. Technology of exotic material, solar panels, battery, helium, communication etc. need to be developed afresh as conventional technologies do not work at that height. VLEO (160 - 400 km) require thrust assisted

satellites and Balloon zone is 20-50 km. At 20 km the line of sight zone is 500 km = 7.5 lakh km territory can be covered. In a dozen such satellites you can cover India and hence cost of the cover will be far lesser. Advantages of VLEO are also high if the technology can be mastered.

Day 2 Inaugural Session. Space has a critical role in national security, particularly in navigation, ISR, and ballistic missile defence. The ₹1 trillion budget allocations have a strategic significance for technological research, signalling a shift towards leveraging private sector capabilities. Initiatives like Space Situational Awareness (SSA) and startup funding under the Technology Development Fund (TDF), showcase the commitment towards innovation and resource facilitation for cutting-edge research. Usually, acquiring military-grade space assets, involving research, development, qualification, and testing phases follow a meticulous process and comprehensive approach, which are aimed at enhancing national security and readiness in outer space.

IndSpace Exercise: Industrial Space Wargame. To assess the readiness of the space industry, Space related simulated scenarios were discussed that helped clarify doubts of the stakeholders and provide the opposing parties a clearer perspective of the problems of each other. Accordingly the following emerge for forging better synergy.

***Defence Forces*.** Need to prioritize budget allocation for space ISR capabilities to ensure effective threat detection and analysis and foster closer collaboration between military and civilian sectors to enhance overall defence capabilities.

***Policymakers*.** Need to facilitate partnerships between defence and civil sectors to leverage expertise and resources efficiently; advocate for increased funding and support for space initiatives to meet evolving security needs; encourage the development of comprehensive policies to address challenges and opportunities in space technology as Space and Cyber have become seamless for network integration.

***Industry*.** Need to advocate for sustained investment in space technology research and development; enhance communication channels between industry and end users to ensure alignment with operational requirements; and explore innovative solutions and alternative space launch capabilities to enhance flexibility and resilience.

***Academia*.** Need to promote interdisciplinary collaboration in space research to address complex security challenges; foster partnerships between academia and industry to drive innovation and technology transfer; and support the development of educational programs to cultivate talent and expertise in space-related fields.

Smart Satellites for Defence: Balancing Robustness, SWAP and Flexible Design & Manufacturing. The biggest advantage of nano satellite in LEO orbit is the low cost and time required to launch is six to eight months. Since telecommunication networks are changing very fast, the replacement of nano satellites is better compared to launch of GEO satellites. LEO region is subjected to weather and radiation effects which affects the operations. Hence, the designers are increasing the parameters like size, weight and power (SWAP) while increasing functionality with COTS components. In this space segment the space designers will have to cater for cosmic rays and high energy protons. The heavy ions affects COTS CMOS segment like memory failures. The protons which emanate from solar will affect nuclear fusion with significant damages to the equipment. Hence, the launch of small satellites will require a balance between mass and cost. The electronic components used need to be hardened to cater for these contingencies by using silicon on insulator or silicon on sapphire for hardening of substrates rather than the chip. All this is required to be taken while compiling the QRs to undergo the tests for these environments.

ISRO extends the test facilities to the ecosystem to design and develop small and nano satellites. The use of quantum communication for these satellites is a need of the hour. Many startups have their own satellites. The challenges are how these small satellites are tested and for low cost, usability and low life, launching capabilities are the points for consideration. The growth of an ecosystem has led to foreign companies evincing interest in sharing technology. The awareness of satellite utilization, customization and affordability is in its application for use and should be the points of consideration. This will lead to generation of revenue and optimizing the investment while using COTS in the space vehicles. The use of standardization will enable confidence on use of these components.

KaleidEO is launching four satellites at 380 km in LEO. Challenges and benefits are higher resolution, better swath and with better quality pictures with low signal to noise ratio. The mission design of these systems will cater for revisit of the intended target and coverage area, contact points for ground station to download data, and

satellite reliability. Then comes the stage where depending on the area to be covered, we start looking for polar or inclined orbit. Then we start with trade off with the requirement of manoeuvrability of the satellites, selection of components, the factor of available technology and cost of the project will decide the mission parameters. Therefore, we need to have a careful watch of cost products by having trade-off between missions and systems requirements by having few satellites at smaller cost or at a higher cost with the best ROI with adequate reliability.

Dhruva Space deals with civil as well as military segments. Data is essentially three segments (a) Orbital deployers which are machines which ejects cube satellites when all the parameters have been met from the launch vehicles (b) launch of busses with cube satellites to 30/90 cm with 500 kg load factor (c) Ground Stations which manage power and weight of the payload. The company has launched eight satellites.

Xilinks LAB works on space based ISR requirements of defence. The company configures the satellites payload to meet the customers need by configuring service using configuration with EO, Optical, SIGINT and IOT based payload. We are technology developers and partner with manufacturing partners. We have the road map for platforms for ten kg nano to 200 kg class with 60-Watt generation to host and manage multi payloads sensors to bring fused data for processing.

QSTC Inc works with remote Sensing solutions from GEO satellites. The functionalities of nano satellites cannot match what the GEO satellites are capable of. Thanks to SWAP capabilities where the miniaturization with enhanced capabilities has been done, the company has launched a GEO satellite with 40 kg payload with Ku and Ka band with 1 to 2 Gigabit of throughput. The user has to get in touch with the service provider who can launch a backup satellite and switch it on whenever the user wants the services. The company has moved to multiple cameras with Q and V B and is offering the solution to the US. Hence, the Indian industry too must move on the Q, V and E band .There is a need to move to new technologies. Ten years ago the LEO satellites were catering for remote sensing. Now the company offers IoT, Communication, weather monitoring, RF sniffing in LEO satellites. In 2026, the company will launch satellite with technology like QKED with atomic clock for synchronization and re-hop transponder to cater for frequency jamming using SDR and hacking. The industry has the solution and it is imperative for the user to ask for solutions. The ground station we offer are optical link ground station where one project is for offering the optical link on ground is connected to ground fiber. **India needs to allow setting up of more ground stations easily by licensing.** The

ground station with AI, ML and onboard processing with cloud reduces the need for large ground stations.

Acquisition Process for Military-Grade Space Assets. China adopted 4 modernisations in 1977 to rejuvenate the Chinese economy with military as one of the four pillars. In India, the military was the exclusive domain of the DRDO and DPSUs. Only after the Kargil War, Defence procurement was opened for the private industries. 2015-16, new DAP came in and FDI norms modified and call for *Aatma Nirbharta* was given. However, space was opened up only in 2020 to the private industry followed by 75 challenges in 2022-23 and the Space Policy in 2023. To make this programme successful, sitting together and deciding what is required and what can be given is essential. We may discuss whatever we may want in terms of technology and developing equipment, but if procurement does not happen everything is lost. This is critical to understand since the existing DAP is not relevant to Space. Space requires Make-I, but it still struggles between DRDO and the industry. Make-II on the other hand is not supported by budgets. If one looks at the DAP, the term space is listed only 13 times in 681 pages of which aerospace is only 3 times rest all are physical space. Some suggest we need a separate chapter for Space, but that would be a compromise as no separate chapter has ever succeeded. When we look at procurement process, should we get stuck to the L1 process wherein in the next 3 years possibly there will be a new L1 while the benchmarked technology would be an obsolete one! For the Space, can we define cyber hardening, have we been able to define MIL grade. Even if we do, do we have the knowhow of doing QA checks and accepting these items in this ever evolving technology. Hence, we require a completely new methodology to address Space. There is hence a need to ensure that we limit the concept of secrecy to what is essential and not everything. Infact DAP permits that the industry partner can be taken onboard under the Official Secrecy Act. There is a need for the service officers to interact with the industry to understand the growth in the technology and solutions available. There is a need to find out the source of components and the technology being used and the current DAP does not cover this aspect. SIA must see how the acquisition process of buy global to buy Indian and the industry must become capable for export.

Since the Space industry in India is on the rise, the acquisition process needs to be redefined to become a value-based acquisition system for which the finance people and the auditors both need to be accountable for delays and the technology flow and implementation should be known to them. A single window acquisition member

should interact with the service providers and bring out a document to acquire systems.

Gilar Satellite System specializes in the ground-based processing systems of drones and space feed. Over the years, the field of Space for military purposes has matured and the cost of launch has decreased. High throughput satellites for military by our northern neighbour has increased manifold and we need to have a relook at our procurement procedures. Since satcomm is a sensitive area it has been kept secretive with restrictive policies. Only in the last two years the space policy has been released. If this sector has to grow it cannot be kept secretive. When formulating the acquisition process, IPR should be respected. To assist acquisition, the Vision 2047 in space has been prepared which is the first step for space supremacy. When we borrow policies for Space of other nations we should also look at their procurement system which for the US is Cost plus Profit. A challenge that exists for the industry is that before getting any kind of an FDI, approvals of the government are required which delay the entire process and sometimes do not allow them to be achieved. Similarly, the concept of NC-NC still exists in the system even though it has been done away with by the top management. To add to this, when we know that the Space will not see more than 50-60 satellites at max do we really require an elaborate acquisition procedure can this not be handled by a high level empanelled committee. Another area of concern is that when systems are being developed, should we hold these developments to Standards which are not even ours and have been borrowed from advanced nations like the US. It prudent that we look at standards and develop ours only once the industry has gained some expertise. When looking at the procurement process, it does not even cater for the cost associated with drawing generation which is very critical and essential for manufacturing. Effectively, procurement of Space assets should be looked at from the Milestone based allocation process (based on outcome required).

While these concerns are well received, there is nothing wrong with the DAP. Unfortunately, these changes are driven by mostly a buyer and seller nexus and cannot be permitted and that is why DAP 2020 has been amended numerous times and is continuously being updated if it is considered essential. Even a Chapter for Space was recommended for the DAP but the industry refused the need and hence nothing has been added.

Day 3: Inaugural Session. Boundaries between terrestrial and non-terrestrial being are becoming blurred. A number of technologies such as Green hydrogen, AI, and Space are being developed. Accordingly, in the last decade India has taken

significant strides in the Space sector. The Space Policy has taken a more liberal approach and allowed non-government entities to participate in the sector that is likely to make India a dominant player in the space sector. This is likely to help India contribute about 8 to 10% of the global space economy in coming years. Hence it is imperative that both public and private sectors come together to develop the space sector, create collaborative space and defence ecosystem. The MEA is happy to access all possible stakeholders in helping India for creating a collaborative defence space ecosystem.

The role of defence space is crucial and need exists for a robust budget allocation for this rapidly evolving sector. The potential of startups in leveraging the vibrant ecosystem and India's attractiveness to global private equity cannot be overlooked. Expansion of NavIC in civil and defence sectors is crucial for strategic navigation, while robust cryptographic protocols are essential for satellite communication security. To support all this, the Defence Acquisition Procedure should support innovation in services and manufacturing to simplify procurement processes. For this IN-SPACe's vision for a $22 billion investment over the next decade, projecting India's space industry to reach a $44 billion market by 2033, with export sales of $11 billion will be instrumental.

Space warfare: Space deterrence and Space domination. Denial of services is a form of Space warfare and hence needs to be worked upon. Deterrence can be by denial or by punishment and requires heavy coordinated between military, academia and industry. Low Earth orbit (LEO) has seen steady increase in the number of satellites and it is expected that their number will double every two years. During conflict these satellites will need to manoeuvre to ensure their safety. For India, space domination is at a nascent stage. Will activities on land stop if Space warfare happens, so the nature of space deterrence we are looking at needs to be discussed. China began with the concept of DIOD (Disruption, Interference, Obstruction and Destruction). In general Space dominance is through - Enter Space (India has but without cyber hardening, China has both), Exploit Space (India has tried peaceful exploitation only while the military usage is lacking, China has done both), control Space (India has not reached there but China already does). Hence the nature and need of dominance needs to be understood and accordingly the desired capabilities should be developed by active participation of the Industry. Warfare in Space cannot be managed by the attacker and it can impact them itself. Deterrence is the greatest enabler of peace and hence is essential. ISRO monitors their assets continuously to avoid debris. This requires now-casting and fore-casting of the space that provides the desired SSA. SDA is extension of SSA as it requires

certain amount of intelligence in SSA to assess as to what happened was intentional or otherwise and falls in the domain of the military. For monitoring space activities one needs ground facilities which need to be spread around the globe. Presently, most of the facilities are in the northern hemisphere due to the way land mass is distributed. We need to have augmentation of these facilities to complement the data. With availability of low trajectory provisions it is now difficult to predict the path. This required fusing data acquired from various sources including small satellites, radars and onboard tracking facilities. Since no nation can do this alone, cooperation and collaboration is essential. To reduce vulnerability and improve redundancy, use smaller satellites in place of bigger ones. Satellites need to have collision avoidance mechanisms, micro thrusters, docking and orbit servicing facilities to keep them serviceable. Responsive space program is another aspect that can help redundancy management. All this is feasible with good public and private collaboration as enablers for space deterrence and space domination. Since CIS lunar and deep-space region is starting to develop, these regions need to be looked into as they will be regions of contestation in the near future. *Agnikul* can provide launch on demand using a mobile launch pad from a barren land. Such facilities can provide a space deterrence posture to a nation. To maintain dominance and reduce cost, in orbit servicing is required that includes refuelling and safety from debris. Refuelling will reduce debris and allow more transponders to be added to the satellite. These efforts will enhance our dominance in Space.

Comms strategies for modern military operations under contested and EW environment. The military operations aims to shorten the OODA loop so that timely decisions and actions can be made to outdo the adversary. All equipment is complex dependent on electronics, connectivity, timely information, PNT requirements, varied platforms, different services, varied cultures, varied requirements, different terrains, geographies all add to the challenges. All this is happening in a common contested space which could be human-human space, human-machine space, machine-machine space, EM space, physical space, cyber space and Space. This can lead to contact, non-contact, kinetic, non-kinetic warfare. This makes things multi-domain. Hence for C4I2SR to work comm is the backbone which should be basic, available, reliable, and survivable. They should be able to share information, employment of combat power for mission accomplishments through secure communications, seamless integration of ICT at theatre, operational and tactical level. Communication network need to be omnipresent, responsible, flexible and ruggedized to handle all conditions. Cyber security is a major element in this. If the technology is compromised it is useless. People should be encouraged to hack and find vulnerabilities of systems and suitably rewarded for which budgeting should be done.

Industry should share knowledge to increase awareness. Communication should have 100% availability, with reliable operation, lower probable of detection and interception; have small form factor, and high data rate. However, integration and data transfer is a huge challenge. Similarly, EW needs real time connectivity and higher data rate. As more and more systems and sensors are integrated, the network is going to be congested so mechanisms are required to overcome this congestion. Space is one feature that can overcome this congestion. It also develops resilience. There is also a need to integrate between layers of communication so that if one layer fails the communication is still available.

For the Indian defence, sat comm is critical since on the borders the terrains are extreme where terrestrial infrastructure is difficult to operate that requires sat comm to be available. Never fight till you put yourself beyond defeat. This can be achieved by securing own communications and denying enemy access to his. Hence, minimise human damage will give the will to fight. For this use unmanned warfare using autonomous bots. This will minimise our cost of warfare and increase the enemy's fighting cost. If our SDR is secure and we can find vulnerabilities in the enemies we can definitely be in a stronger position.

Managing space control, information and Mosaic C2 enabled by effective ground infrastructure. War fighting is becoming complex with a lot of activities of warfare likely to be outsourced to machines which need to be programmed and designed accordingly. A country needs to be prepared for its entire frontline even when war may actually happen only in a certain region for which one may or may not get a warning. When the warfare becomes network centric and a common operating picture is available, the number of sensors increase and the data collected and power used increases. Such a collation of sensors forms a mosaic. Such mosaics allow the field units to make changes to decision making parameters based on ground conditions. Understanding how this can be altered is important. Such mosaics will be localised to each Commander with his data and then fed to form a larger mosaic at the central command or localised commands. This will allow decentralisation of decision making and improve war fighting.

Flow of information in a network chain can be disrupted which can make a weak enemy also powerful. Mosaic and multi-domain warfare are interrelated. AI and ML will decide where to overwhelm the adversary system and hence mosaic is a kill web and not limited to a kill chain. Mosaic requires connectivity. It does not matter if it from space or land based systems. Today sensors collect information and decision makers that support key elements of network oriented attack and defence. If we

have to fight remotely we need to utilise this connectivity to be dynamic, flexible and resilient when things go wrong. This requires that the military needs to look at commercial systems. Such connectivity can be created using lasers which is required to download the large amount of data generated from sensors since RF cannot allow such large data to be downloaded. Such lasers also permit optical ground stations to be smaller in size as compared to conventional stations that require antennas of the size of 30 m at times. Since information has to move fast in mosaics, laser plays an important role.

Catalysing National Industrial Capabilities for Space and Defence. DPSUs play an important role in catalysing the industrial capabilities of the nation. This is done by technology development and transfer, industrial scale manufacture, critical infrastructure development, collaboration with academia and startups, partnering with private industries, skilling of work force and energising of strategic projects and building an innovative ecosystem. DPSUs fund iDEX programme. They make available their test facilities to the industry when required and are establishing test facilities at various techno parks. Tata Advanced Systems Ltd. (TASL) is launching a satellite in Apr 24 using SpaceX which will meet the requirement of the strategic community. For Pinaka, they developed vendors who are today their competitors. For their other products also, they have developed numerous vendors. To be the most dominant regional power in Space by 2033 the private investment required is 22 billion dollars. To achieve this we need to look at localisation of the ecosystem. Carbon composite is one such industry that needs to be developed which will help other industries also. Sensors, semiconductors, electronics are some other areas of focus. We need an additional launch facility, space parks, and tiered supply chains. Additionally space laws, FDI policy, industry seeking incentives, inverted GST structures, sovereign guarantee, and a movement away from L1 sector need to be looked at. Standards, joint design centre, access to test facilities, and some imports are other areas of concern. Skilling is another area that will need to be strengthened. To support the industry, user will have to be anchor customers. A level playing field between the private and public sector is essential. Technology transfer from ISRO and continuity of order and enabling of export are considered essential. For the military, till the ecosystem is not established little can be achieved. However, what needs to be done first is something that requires a separate debate altogether. NASA provides a two decade roadmap which is missing from ISRO. This would help the industry to focus on areas to be developed. Infrastructure in tech parks is something that the state government need to look at so that people can be employed and industry can perform. When foreign partners visit India they need to be impressed

with the infrastructure when compared to other nations so that investments can flow in.

Policies, Doctrines, and Strategies for Securing India's Security Interests. Each user should have their own strategy to have their own policy. International Law does not permit the use of Space for any other purpose other than Peaceful purposes. For drafting the required policies domain knowledge is essential. This means that civil agencies cannot draft policies relevant for the military. So for Space, if the policy is drafted by ISRO, it may or may not be acceptable to the military and vice versa. This requires in house expertise and involvement of international security people (MEA, NSA and NSAB) which needs to be developed if not available.

Everything that happens in Space impacts the entire Globe. Cyber and Space have democratised the development of Space and made us naked as everything that we do can now been seen by others. The implication is that integration and cohesion is required when we frame our policies, it has to run across the institutions, policies, human resources, apex leadership, and international collaborations. Military space organisations need to be reoriented which requires deep expertise which requires continuity of tenure and being agile with retraining. Things to remember - Strategic autonomy should never be lost; strategic ambiguity needs to be adopted; strategic alliances and collaborations encouraged; ecosystems elements (academia, R&D, user, capital, industry, startups) need to be streamlined; internal expertise should be catalogued and connected; academia should necessarily hand hold startups; scientific responsibility of companies is also essential. In policies we need simplification, stability in policy, support infrastructure and fund. Fund controllers must be made accountable to progress of a project, data management policy is also required. Develop a capability; demonstrate it to show that you have it to display deterrence, be resilient (build in survivability, graceful degradation, restore what is lost, augment) have numbers and be able to retaliate.

Strategies for addressing maritime threats exist and they revolve around – accepting, resolving, reducing, monitoring and controlling.IN Maritime Doctrine 2009 pays emphasis on Space for MDA and command and control at sea. IN Space Vision 2014 addresses how IN can acquire Space based capabilities and futuristic space based communication and surveillance requirement up to 2027 and beyond. Similarly, other policies in India of conflict address Space based reliance.

For security of the nation indigenisation is a must so that the security of the nation is not compromised. Knowledge transfer should be controlled so that it does not fall in wrong hands.

Key Takeaways from the Deliberations

Day 1

- *Integration*: Military satellite communication integrated with IoT for enhanced connectivity.
- *Analytics*: AI and ML used for informed decision-making with large data volumes.
- *Miniaturization*: Cost-effective deployment through satellite miniaturization.
- Data Processing: Prioritizing data processing for optimized decision-making.
- *ISR*: Real-time monitoring via Intelligence, Surveillance, and Reconnaissance capabilities.
- *Remote Sensing*: Balancing resolution for data quality optimization.
- Algorithm Awareness: Understanding limitations of ML algorithms for effective data processing.
- *Navigation Accuracy*: Vector data and crowdsourcing improve navigation accuracy.
- *Quantum Potential*: Potential of quantum computing for data processing revolution.
- *Standardization*: Standardizing data collection methods for better interoperability

Day 2

- *Operational Requirements Customization*: Tailor operational strategies to specific mission objectives, ensuring adaptability and efficiency in achieving desired outcomes.
- *Enhanced Collaborative Platforms*: Foster collaborative efforts across sectors by establishing structured platforms, promoting synergy, and leveraging diverse expertise.
- *Engagement with International Partnerships*: Strategically engage with foreign partners to capitalize on their expertise, fostering mutually beneficial collaborations and advancing India's space capabilities.
- *Space Asset Acquisition Framework*: Appoint specialized executives to oversee efficient procurement processes and develop tailored policy frameworks to streamline the acquisition of space assets.

- *Satellite Design Optimization*: Prioritize the design of satellites for optimal performance, reliability, and radiation shielding, ensuring longevity and effectiveness in space missions.
- *Investment in Ground Systems Development*: Allocate resources to develop robust ground systems infrastructure integrated with artificial intelligence (AI), enabling efficient satellite operations and data management.
- *Adoption of Emerging Technologies*: Embrace emerging technologies to enhance space capabilities, fostering innovation and staying abreast of advancements in the field.
- *Regulatory Framework Enhancements*: Advocate for clear regulatory guidelines and foster collaboration on space debris management, ensuring responsible and sustainable space exploration practices.
- Develop technologies where the world is not working rather than that is already existing and easily available.
- Even though Vision 2047 provides a long term roadmap, the demand and perspective if known to the industry, they will be encouragement.

Day 3

- *Maximize Dual-Use Technologies*: Leverage NavIC navigation systems and quantum encryption for both civilian and military purposes, enhancing satellite capabilities.
- *Simplify Defence Acquisition*: Streamline procurement processes to encourage innovation in services and manufacturing.
- *Develop Indigenous SSA Capabilities*: Invest in indigenous Space Situational Awareness (SSA) to monitor adversary activities.
- *Ensure Communication Resilience*: Utilize AI, quantum encryption, and satellite constellations for secure communication networks.
- *Build Robust Ground Infrastructure*: Develop laser communication and other infrastructure for effective space control.
- *Foster Public-Private Partnerships*: Incentivize private investments in R&D through partnerships.
- *Formulate Clear Policies*: Standardize definitions and draft coherent military space doctrines.
- *Space warfare: Space deterrence and Space domination*
    - For space safety - collision avoidance is necessary for which SSA is critical. This requires creating a catalogue for space collision avoidance is important which requires international collaboration.

- There is no sovereignty for any satellites, it is mere orbital dynamics. No one can prevent a satellite from any territory. If a commercial satellite is used to get data for a particular country, what do you do?
- The ecosystem of SSA is a matter of deliberation. Does it require a separate ecosystem to be created and if yes with what sensors and at what cost.
- To create space deterrence launch pads are essential and this can be done by mobile launch pads. This will also help achieve launch on demand but storage of a ready space craft and various components is a matter of deliberation
- In-orbit servicing can reduce debris and allow payload and sensors to be increased on the same satellite.

- *Policies, Doctrines, and Strategies*
  - Need for a personalised Space strategy for the Defence, civil, commerce, and cyber.
  - Need to enhance specialized courses on space laws or policies in India.
  - Implementing an internal space control mechanism is crucial for national security and operational integrity.
  - Need for the apex-level organizations and leadership to be strategically alignment to ensure cohesive policy implementation and operational execution.
  - Fostering international collaboration is imperative for the advancement of global space endeavours and the peaceful use of outer space.
  - Engagement with adversaries regarding space traffic management is necessary, where deterrence measures should be clearly communicated.
  - Optimizing the use of resources is critical for the sustainability and efficiency of space missions.
  - Generating new resources, currently lacking, is vital for continued innovation and exploration in space.
  - The establishment of a military space organization demands profound stability and specialized expertise to address the unique challenges of space defence.
  - Maintaining strategic autonomy is non-negotiable especially when it comes to ensuring national interests.
  - Forming strategic alliances or collaborations, particularly with the United Nations and international partners, leverages collective strength and fosters cooperative engagement.

- The academic sector should be actively supported and developed, ensuring that startups thrive. Collaboration between academia, industry, and government is essential to break down silos and promote innovation.
- Deterrence strategies should be transparent, ensuring that potential adversaries are aware of the consequences of hostile actions.
- Retaining the capability to retaliate is crucial for maintaining a posture of strength and ensuring national security in the space domain.
- Clarifying the concept of "peaceful use" is essential; it is imperative to establish a clear definition that reflects our understanding and intentions.
- Build a capability and show it to the world to communicate to the global community that India has deterrence in place and is a significant and influential player.