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# Second Space Age and Securing the National Space Architecture

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**Second Space Age: Space Commerce Exponential Growth**

The Morgan Stanley Research (July 20) states that the space commerce is presently valued at $350 Billion which is likely to triple to $1.1 Trillion by 2040. This Second Space Age is aimed at democratising access to space by providing fast launching, reliable & reusable launchers and low-cost satellite constellations which are disrupting the existing space commerce model. The cost to launch a satellite has declined to about $60 million, from $200 million, via reusable rockets, with a potential drop to as low as $5 million. And satellite mass production could decrease that cost from $500 million per satellite to $500,000.[1]

Elon Musk has already set his vision of making Mars a new home for humans, making mankind a multi-planetary species. His launch services to International Space Station and a

**Key Points**

- Space is becoming congested and contested, and there is a need for ensuring the securing of our space assets in a sustainable manner. The private equity is leading this new Second Space Age with the space agencies of the world are constrained by constant budgets.
- India needs to scout the emerging space market to enable Made in India approach and thus realign its space architecture i.e., space ports, launchers, satellites, space applications, ground stations, control centres and trained manpower to ensure a whole of government approach towards expanding the space commerce and exploration under ISRO (Department of Space) and the space security under the Defence Space Agency (Ministry of Defence).
- India should accelerate investment in ISR and Communication capabilities for enabling tactical commanders with a permanent stare capability and 5G communications. Also invest in space situational awareness and operationalise kinetic and non-kinetic counter space capabilities and ensure a manpower planning to enable training and specialist operations in space disciplines alongside international cooperation with strategic partners.
- International collaboration with Strategic Partners and Civil Military Cooperation with Industry, DRDO, ISRO and Academia is key to success. India should also conduct a risk assessment periodically of the existing space assets against space hazards and emerging counter space threats.

Low Cost Internet Constellation (STARLINK) are already generating revenues to fund his ambition of Star Ships (SN). The Virgin Galactic, the Blue Origin and Space X have already commercialised travel to space. The private space investments are following the Silicon Valley Dictum of 'Fail Fast and Fail Forward', innovation is driving the industry forward.

An example is Space X use of reusable Falcon 9 rockets. It has already operationalised its low cost (LEO 550 km) internet STARLINK constellation (with 60 satellites each weighing 260 kg being put into the orbit with each launch). ONEWEB along with Airtel is also partnering with ISRO for their internet constellations launches.

The disruption of space-based internet industry is attributed to lesser height of the constellation i.e. LEO vs GEO and rapid reusable launches. The private equity is leading this new space age with the space agencies of the world, constrained by constant budget and the governments around the world monetising their infrastructure and intellectual property and amending their regulatory frameworks to enable the Industry. This has started a virtuous cycle of reduced cost access to space thus, enabling the governments to focus on the Space Defence Forces to protect its existing space assets and focus on exploring the space sciences.

The Indian Space Association was launched on 11 October 2021. The purpose of which is to create better synergy and collaboration between the Space Industry, Start-ups, ISRO & IN-SPACe and the regulatory facilitations required for this sector to enable it to grab the rightful place for India in the emerging space commerce opportunities.

**Cis-Lunar Commerce**

The commercial opportunities available between earth and moon is termed as cis-lunar commerce. It includes earth's orbiting satellites in LEO and GEO, mining on moon and visiting asteroids. There is a talk of Space Escalators to enable mining of moon and asteroids. Japan has already successfully demonstrated collection of sample from an asteroid. Water on the Moon (Chandrayan Mission) is being considered as the 'new oil' to enable setting up gateway for further exploration to Mars. The Moon is three times the size of Africa and the space race is already off the blocks. The new space venture capitalists are looking to build new Navies in Space for the emerging space commerce which is in the field of transportation, information, manufacturing and energy.

- ***Transportation*.** The Transportation sector is already disrupted by the Space X and is not shackled by the earlier cautionary 'NASA approach to space' i.e., 'Failure is not an Option' (Apollo 13). The hypothesis is that, the Fast Space will bring with it the

benefit of Ultra Low-Cost Access to Space. It predicted that the space commerce in particular and the world economy in general will be disrupted by adapting to the new economic curves being created in the space commerce and thereby starting a Virtuous Cycle of accelerating the new paradigms. Elon Musk has professed that, in few years one would be able to move to any part of earth in just one hour.

- ***Information.*** The proposed low-cost internet constellations also have a strategic use for military planners. USA Air Force has awarded a contract for $13 Mn to Raytheon to develop 'phased array antennas' that would allow the aircraft to jump seamlessly between multiple commercially available LEO internet constellations. A new contract has also been awarded to Lockheed Martin for $12.7Mn for defence experimentation 'using commercial space internet' to exercise options for hardware and software integration for F35 A, to communicate using STARLINK and other LEO Constellations, which will now enable high throughput digital backbone coverage in remote areas also.

- ***Energy.*** Similar shift is happening in the energy field wherein the harnessing of solar power in space and nuclear production is being considered to challenge the existing plug-in paradigm (Edison and Tesla approach) vs trickle charging of energy from space like one's mobile data.

- ***Manufacturing.*** Zero gravity manufacturing is being bet upon by Jeff Bezos to disrupt the existing polluting global supply chain model which certainly requires rebalancing and rerouting in light of the overdependence on China as the 'Manufacturing Hub of the World'.

**Military-Civil Cooperation: Strategic Common Ground**

The venture capitalist are crystal gazing at the next Big opportunity in space, the military planners are looking at Military-Civil Cooperation for this strategic common ground.

**Table 1: Dual Use Space Applications**

| Sr. No. | Commercial Application | Military Application |
|---|---|---|
| 1. | LEO Constellation for Communication | Global Command and Control |
| 2. | LEO Constellation for Remote Sensing | • ISR<br>• Space Situational Awareness |
| 3. | Human Space Flight<br>(Reusable Space Access) | • Global Mobility & Strike<br>• Air And Space Superiority |
| 4. | • Space Debris Clean Up Research<br>• Satellite Inspection and Servicing<br>• Planetary Defence<br>• Space Mining<br>• Rendezvous and Proximity Operation | Counter Space Capability |

*Source: Fast Space: Leveraging Ultra Low Cost Access to Space (US Air University Paper 2017).*[2]

The Indian space defence architecture is nascent and requires massive capability building to secure the Indian space assets and interests. The National Security Establishment needs to actively involve itself in the Space Defence as a driver for multi-domain operations. The space security operations need to evolve into a synergised, flat, lean and high Technology organisation which provides a unity of command for joint operational forces.

Military-Civil Cooperation can leverage the Space Defence Capability. There is a need to focus on the last mile delivery of space applications for joint operations— ISR, Communication, ELINT, Targeting, Navigation and C4 functions.

Space Industry, Academia, DRDO and the Start-up ecosystem needs to be incorporated for Research and Development of Niche Technologies for both emulating world standards and incubating them.

The manpower planning for the Defence Space Agency (DSA) needs to focus on training and specialist operations in space disciplines alongside international cooperation with strategic partners.

**ISRO: A World Class Space Player**

ISRO is capable of providing end-to-end solutions in space activity —from space launches to satellites and space probes to space applications. ISRO had earlier suffered through debilitating technical sanctions from the West and has actually implemented a highly successful 'Made in India' programme for critical technologies. It identified 100 plus items for indigenous sourcing and conducted a proactive scan for the probable industry partners for

manufacturing— it provided them with firm quantity orders, testing facilities and permission to export world over less two border nations and also signed with them non-disclosure agreements. The Space, nuclear and missile programmes are world class stellar performing Indian State assets.

On 17 March 2021, MoS PMO Dr Jitender Singh informed Parliament that ISRO had launched 303 foreign satellites during 2011-20 and earned a revenue of $07 Mn and Euro 179 Mn from these launches.[3] It indicates the role the space sector has so far played to strengthen India's space power in the world. 35 space start-ups and industries are in consultation with ISRO for support related to various domains of space activity such as development of satellites, launch vehicles, develop applications, providing space based services, etc.[4]

Two Start-ups in the satellite space vis. Satsure and Pixxel, both have planned launches in the year 2022. They are being assisted by Bellatrix Hybrid Propulsion System for Remote Sensing and Earth Observation Satellites.

In the launcher space, start-ups like Agnikul Cosmos and Skyroot Aerospace are looking at 3D printing of the semi-cryogenic engines. They are being facilitated by IN-SPACe (Indian National Space Promotion and Authority Centre). Both start-ups have signed the Non-Disclosure Agreements with the Department of Space.

***ISRO Future Missions.*** During the COVID pandemic while, ISROs programmes suffered universal delays[5], it upgraded its launch capability in the space architecture from existing six launches to fifteen launches. The Department of Space Budget in 2021-22 however, has only increased by 3% i.e. to around Rs.14,000 Crs, and the Finance Ministry has preapproved an additional budget of Rs. 10,000 Crs for the Gaganyan Mission (manned mission) and another Rs10,000 Crs for launch of 30 PSLV and 10 GSLVs in the next four years. [6]

**Space: A Military Domain**

Space has been a high ground which all military planners seek to dominate since the 1960s. USA re-launched its Space Force as a Sixth Service (2019) and has named them 'Guardians'. The earlier version of the US Space Command was in 1985 and Russia had launched Space Command in 1992. France Joint Space Command was launched in 2010.

China looks at USAs heavy reliance on space as a 'vulnerability' which it can exploit during a crisis. The counter space strategy also serves as an effort to boost its Anti-Area

Access Denial (A2/AD) Strategy. The outer space is witnessing an increasingly destabilising and escalatory action including ASAT tests, cyber attacks and electronic warfare. China's Space Force is part of the Strategic Support Force alongside EW and Cyber Forces.

China backs peaceful use of outer space and is officially against the weaponization of space. It is presently pushing for a treaty mechanism under the "Treaty on Prevention of Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects". China has not conducted a kinetic kill test since 2007 but has demonstrated co-orbital counter space capability.[7]

**Table 2: Satellites Projected Over Indo Pacific in 2025 (Near Parity)**[8]

| Sr. No | Types of Satellites | USA (Indo- Pacific) | China |
|---|---|---|---|
| 1. | Communication | 100 | 90 |
| 2. | Earth Observation | 180 | 200 |
| 3. | Navigation | 30 | 50 |
| 4. | Science & Technology | 80 | 130 |

*Source: Annotated by Author*

## International Space Security Scan

## PLA's Space Capability

*"To explore the vast cosmos, develop the space industry and build China into a Space power is a dream we pursue unremittingly".*

**— China Space White Paper (December 2016)**[9]

### *Organisation*

The Strategic Support Force (SSF) of China integrates space, cyber and EW capabilities for joint military operations since 2015. The oversight of the space acquisitions is by State Administration for Science, Technology and Industry for National Defense (SASTIND). The Aerospace Industries which are active in the field of space commerce are Zhuhai Orbita, Ex Space and Ok Space which offers Remote Sensing, launch and communication services respectively.

### *Space Assets* [10]

- Space Ports at Wenchang, Xichang, Jiuquan and Talun.
- Control Centres at Xian and Bejing.

- Launch Vehicles namely—Long March 5 (upto 50 Tons) and Long March 9 (more than 50 Tons under development)
- Military Satellites for — Communication (04-06), Relay (04), ISR (45-50), Navigation (28) and Science and Technology (02).

***Counter Space Capability***

The Chinese official stance with respect to Counter space is that it is against weaponisation of space, despite a successful ASAT Kinetic Kill Demonstration in 2007.

- ***Space Situational Awareness.*** It has complete coverage of both LEO and GEO orbits. It have established an Asia Pacific Ground based Space Observation System and has provided Peru, Pakistan and Iran with 15 cm telescopes capable of tracking objects in space.
- ***Kinetic Energy Threats.*** Since the successful ASAT launch in 2007, China conducted seven more non kinetic launches including tests upto GEO (36000 KMs) and has termed them as missile tests. [11]
- ***Directed Energy Weapons.*** China is likely to deploy ground based high power lasers against optical and non-optical sensors of the satellites by 2025.
- ***Electronic Warfare.*** Under the garb of developing quantum communications, China has already launched a quantum satellite in 2016 and a 6G satellite in 2020. Spoofing of the GPS signal in China's ports has been widely reported and China has also incorporated military protection to protect high frequency communication.
- ***Cyber Space.*** China's Signal Intelligence Unit has supported hacking of Western Aerospace Industries and the Space Companies and Agencies since 2007.
- ***Orbital Threats.*** China is developing satellite inspection and repair capability and is also undertaking Space Debris Clean-up Research and MARS sampling mission— all these are dual-use capabilities and can also be used as co-orbital threats.

**US Space Force**

US Space Force is the smallest armed service, consisting of 4,840 personnel and operating 77 spacecraft. Major spacecraft and system includes the Global Positioning

System constellation, Military Satellite Communications Constellations, Boeing X-37B space plane, US missile warning system, US space surveillance network, and the Satellite Control Network. Under the Goldwater–Nichols Act (1986), the Space Force is responsible for organising, training, and equipping space forces, which are then presented to the unified combatant commands, predominantly to United States Space Command, for operational employment.[12]

***Space Doctrine.*** In the Doctrine published by the Space Force in 2020[13], the responsibilities of the Space Force has been explained as involving the following:

- Preserve Freedom of Actions.
- Enable Joint Lethality and Effectiveness.
- Provide Independent Options.

***Core Competencies***. The Space Power is employed in:

- Space Security.
- Combat Power Projection.
- Space Mobility and Logistics.
- Information Mobility.
- Space Domain Awareness.

***Space Force Disciplines.*** The human resource skill sets that are to be employed within the Space Force are defined as under: -

- Orbital Warfare.
- Space Electromagnetic Warfare.
- Space Battle Management Field.
- Space Access and Sustainment.
- Military Intelligence.
- Cyber operations.
- Engineering/ Acquisitions.

**UK Space Command**

The UK Space Command was raised on 01 Apr 2021**.** The MoD proposed a £5 bn investment over next ten years to enhance UK Satellite Communication Capability. Subsequently, an ISR Constellation and Digital Backbone in space has been proposed and

also to setup a Space Academy , to develop skill and training of future defence space specialists.

The space command brings together three functions commanded by a two star General — space operations, space workforce training & growth and space capability, developing & delivering space equipment programmes.[14]

The MoD Space Directorate is responsible for defence space policy and cross governmental and international cooperation. Directions from the Space Council will flow through the Space Directorate to the UK Space Command and other relevant elements of the defence sector. UK Space Command will interact with the UK Space Agency, when required, to deliver a Joint National Space Capability.

UK Space Command will have close links with the Strategic Command and Defence Science and Technology Laboratory (DSTL) to examine options for development of new capabilities, to enable multi -domain integration and capitalise on the rich R&D expertise.

- ***Strategic Intent.*** When fully operational, the UK Space Command will provide command & control of Defence Space Capabilities, including space operations centre, Skynet constellations for communication, RAF Flyingdales (networked ballistic missile defence radar for Space Situational Awareness {SSA}) and other enabling capabilities.
- ***International Collaboration.*** Combined Space Operations initiative of seven nations (France, Germany, Canada, Australia, New Zealand, UK and USA) seeks to improve cooperation, coordination and interoperability opportunities in space; its main effort is to ensure a safe, secure and stable space domain. It will also support the growth of NATO Space Enterprise.
- ***UK National Space Security Policy.*** UK should be seen as a safe and secure place to procure and operate space systems that are adequately tolerant to space hazards and threats. The policy response has four objectives: -
    - To make UK more resilient to risks to space service and capability.
    - To enhance UK's national security through space.
    - To promote safe and more secure space environment.
    - To enable academia and industry to exploit space science and grasp commercial opportunities in support of national space security.

**Japan**

Japan raised a Space Operation Squadron in May 2020,[15] within its Self-Defense Air Force (JASDF), with the primary goal of protecting the Japan's Space Assets, and monitoring any armed attack directed towards its space assets, as also to track space debris, satellites and meteorites to avert future satellite collisions. Based at Tokyo, it is likely to be operationalised by 2023.

The Space Operations Squadron is expected to start full-scale activities when a SSA, system will go online. Japan is aiming to launch an SSA satellite by fiscal year 2026. It actively collaborates with the USA Space Force and Japanese Aerospace Exploration agency (JAEA). To operationalise this initiative Japan has also posted a liaison officer at the US Space Command at Peterson Air force Base, Colorado.[16]

The Liaison Officer will provide JASDF expertise and insights to USSPACECOM, facilitate communications among Japan and US space units, support US-Japan space related partnership opportunities and perform tasks that are mutually beneficial for strengthening US-Japan defence cooperation.

**Indian Space Defence Doctrine**

Space has an interplay with all three domains of war fighting —land, sea and air, another inter-dependence is with cyberspace. Securing our space assets is a national security need. There is a need to publish a Space Defence Doctrine on similar lines of the Nuclear Doctrine to enable strategic signalling of own intent and capabilities. This doctrine will enable the Defence Space Agency to codify its role and missions as well as look into the force structuring and capability development & sustenance of the Space units.

Presently, India has raised a Defence Space Agency (DSA) in Bangalore in 2019 under the Integrated Defence Staff along with Defence Cyber Agency and a Special Operations Division. The two organisations that were subsumed to the DSA are the DIPAC (Delhi)and Satellite Control Centre (Bhopal). It is presently manned by tri -services personnel. The DSA has only limited assets and manpower. There is a need to grow this institution to meet the existing and forthcoming challenges to space security.

Indian Space Security needs to enhance its footprint in militarisation of space needs, and also work on the pending projects delayed due to the COVID pandemic like the NAVIC (IRNSS) system and needs of dedicated EO, SATCOM, SAR payloads, IR payloads,

Telemetry Relay and SIGINT constellations and formalise Civil-Military Cooperation by signing an MoU with ISRO in satellite design, applications and launch on demand capability.

India presently remains dependent for international collaboration for SSA and Basic Exchange and Cooperation Agreement (BECA).* It will allow India and US to share military information including advanced satellite and topographic data.[17]

ISROs limited budget and capability points to the new reality of the space age i.e. to rely on Industry, DRDO and Academia and the need to involve the start-up ecosystem for Space Security Operations.

The essential requirement also is to operationalise counter space capability despite Anti weaponisation stand due to our imminent security needs, manpower training in space disciplines and the ethos of Space Command and acknowledgment among the military planners that, 'space' is the 'new domain of future war fighting'.

**Space Concepts: Counter Space Capability**

For ensuring a space defence architecture, it is essential to acquire various counter space capabilities for ensuring the space defence deterrence.[18]

**Table 3: Counter Space Capabilities Attack Profiles**

| Sr. No. | Counter Space Capabilities | Type of Attack |
|---|---|---|
| 1. | Kinetic/ Physical | Co-orbital ASAT |
| | | Direct Ascent ASAT |
| | | Ground Station Attack |
| 2. | Non Kinetic | High Altitude Nuclear Detonation |
| | | High Powered LASER |
| | | Directed Energy Weapons |
| | | Laser Dazzling/ Blinding |
| 3. | Electronic | Jamming: uplink/ Downlink |
| | | Spoofing |
| 4. | Cyber | Data Intercept or Monitoring |
| | | Data corruption |
| | | Seizure of control |

*Source : CSIS Space Threat Assessment 2020*

***Defence against Dark Arts in Space***[19]

Dark Arts refers to covert options available to space players against weaker space faring nations which can have plausible deniability. CSIS and Secure World Foundation are two US think-tanks focussed towards space threats to USA and enable formulation of policy responses. In CSIS 2021 annual report authored by Todd Harrison and his two colleagues, it highlights threat in space as a 'war fighting domain'. In a 'Harry Porter inspired format', they suggested passive and active defences in Space. They also war-game four possible conflict scenarios in space domain.

Passive Defences are measures to mitigate the effect of counter space weapons.

- Adopting a distributed architecture or proliferation of assets, or loss of a single satellite, will not disable space based capability.
- Technical defences like jam resistant waveforms, antenna nulling and using filters or shuttering for protected sensor payloads from harm or blinding.
- Operational defences like stealth, manoeuvring satellite away from threats and rapidly deploying new satellites to replace damaged or disabled ones on orbit.

Active defences are kinetic and non-kinetic options that attacks counter space threat. Some of the satellite-based options are:

- Satellite mounted lasers to blind an incoming missile or mechanism that could grab and remove enemy satellites positioned to attack.
- Strikes on adversaries' ground stations or enemy satellites in response to an attack. However, it remains a challenge to be seen as defensive and not an orbital offensive weapon.

***Cyber and Space Operations***

Cyber and Space have unique inter-dependence; cyber is at the heart of the Defence Space Missions:

- For protecting the cyber space, the military relied on Air Gap but with numerous vendor base for space systems, any small vulnerability becomes the key concern for cyber security.
- There is a need to adopt 'risk and system-based approach' rather than isolating a system with a firewall. There is an urgent need to review personnel, doctrine, processes and policy, legislation as well as physical security.
- As long as humans are clicking in the system, it will be vulnerable to phishing attacks. Design of protection need to be planned in terms of risk based approach. Fall back plans are more about risk management than risk avoidance.

**Space Hazards**

- ***Asteroids*.** NASA Asteroid Watch is looking after the Planetary Defence and observing Near Earth Objects (NEO) to enable mitigation of potential future 'near impacts on Earth. [20] Summary of the existing space hazards in numbers to the existing Space Architecture (Act of God kind) are:-
  - 25,400 : Discovered NEOs.
  - 15000 : More than 140 meters diameters in size yet to be found.
  - 9592 NEOs: Larger than 140 meters.
  - 107 NEOs : Passed closer to earth than moon in 2020.

  100 Tons : Amount of Dust sized particles which bombard Earth Daily.

- ***Space Weather.*** It is due to solar eruptions, that we are not able to predict it with accuracy; one will get only 12 hours to 48 hours' notice before Earth and its vulnerable satellites get hit. It can damage and penetrate or interact with the Earth's magnetic field—like Carrington Event of 1859.[21]The extreme space weather could disrupt satellite signals and operating temperatures in extreme cases permanently due to satellite being exposed to elevated levels of radiation and energy particle effects. It would also disrupt the ground support for space activities as well as power networks, communication and aviation. The Geomagnetic storm of 2003 caused the GPS to be dormant for 30 hours.[22] As the reliance on space assets increases, there is an urgent need to conduct a risk assessment for the space hazard events.

**International Space Regulations: 1967 Outer Space Treaty (UN Office of Outer Space)**

The Outer Space Treaty declares the space to a province for all mankind, free for exploration and use by all nations and places international responsibility on the State for its national space activities as well as liability on the launching state for any damage caused by space objects and ban the use of weapons of mass destruction in outer space. [23]However, Space remains lightly regulated than the Air, Sea and Land domains. Hence, there is a need to reinforce the safety and security environment for state and commercial space users in a sustainable manner and needs new global consensus to regulate Space activities.

Russia has refused to join the USA led Artemis alliance for lunar exploration but agreed with China to cooperate on a vision of an International Lunar Research station (ILRS). [24]

**Indian Space Security Capability Building**

***Mission Shakti (ASAT 2019)***

Post China's ASAT test (2007), Prof Saraswat had claimed that India also had the capacity to conduct a similar test. He said that, the DRDO had anti-missile technology, including the algorithms required for setting the trajectory to hit the moving target. He further stated that, it would have taken about two years for scientists to perfect the missile launch once the go-ahead for the test was given by the government.

The Microsat-R target satellite was launched on 29 January 2019. The Prithvi Delivery Vehicle Mk II's, a missile defence, three stage interceptor destroyed the satellite in low altitude (300 KM) i.e. the Sun Synchronous orbit on a downward trajectory thus reducing the debris quantities and muted the international outcry vis a vis China's ASAT test in 2007 at 700 KM altitude which generated about 2000 debris which still continues to orbit the earth. The USA 18 SPCS tweeted post Indian ASAT that they were tracking 250 debris from this test.[25]

PM Modi had however, reiterated India's stand against Weaponisation of Space—"India has always been opposed to the Weaponisation of Space and an arms race in the outer space and this test does not in any way change this position". [26]

Though, India has joined the elite club of four nations to have demonstrated kinetic kill capability in the Space Domain intending to achieve Space Deterrence for security of its

space assets, however, India needs to review its position in the multilateral world. France has already declared its intention to deploy Lasers in orbit by 2023. India needs to operationalise its kinetic and non-kinetic capabilities in the counter space domain. India also needs to conduct 'Missile Tests' upto GEO constellations.

Space Weaponisation rests on three assumptions — inevitability, vulnerability and control. The higher the level of reliance on space assets for military purposes the greater will be the vulnerabilities of the Space Power. Most Space faring nations are concerned that the space weaponisation would be expansive, provocative and escalatory.

***Space Security Capability Requirements***

Dr. S Chandrasekhar in his study ***Space, War and Security- A strategy for India'***,[27] (National Institute of Advanced Studies, 2015) identified major space based components requirements :

• A robust SSA capability comprising radar, optical and laser tracking facilities complemented by an organizational and human resource base that is able to operationally monitor the space environment.

• A four-satellite constellation of advanced communications satellites in GSO that use ion propulsion for carrying out vital C4 functions.

A constellation of 40 satellites in LEO that provide Internet services for the military.

• Three clusters of 3 satellites each for performing the ELINT function.

• A constellation of 12 EO and SAR satellites in appropriate Sun Synchronous Orbits (SSO) for meeting ISR needs.

• A constellation of 24 small satellites in LEO for meeting ISR needs during times of crisis.

• Three TDRSS satellites in GSO for performing the tracking and data relay functions needed for a C4ISR capability.

• Two operational satellites in GSO along with 3 orbiting satellites in an 800 Km SSO for meeting operational weather requirements.

• Seven satellites in Geostationary and Geosynchronous Orbits for meeting core navigation functions.

• A 24 satellite constellation in MEO, established over a ten year period, for providing an indigenous navigation solution

To meet the above requirements, he estimated an annual Launch requirement for military applications for the Nation of 16 PSLVs, Seven GSLV and Seven AGNI-5 based launchers.[28]

The imagery analysis has become an important commercial product, as was well documented from the Ladakh Incident of 2020, with panellists on TV debates and digital channels explaining the terrain and their own understanding of the sequence of events for larger narrative building for the nation and international strategic partners— most of them used imagery from Google Earth, Planet Labs and Maxxar Technologies. However, this reliance on commercial imagery also had a caveat in 2020.

Reliance of Iran on commercial satellite imagery for planning and executing a ballistic missile strike on US forces (deployed at Al Assad Air Base, Iraq) failed as the US forces exploited the Decision loop anomaly and vacated the base just in time for strikes to be ineffective. In an interview to the 60 Minutes TV program on the anniversary of the strikes, the US Central Command Cdr General Frank McKenzie confirmed that they were fully sure of Observe, Orient Decide and Act planners of the Iranian ballistic missile targeting capability. [29]

On 28 February, DRDO's Sindhu Netra satellite was deployed to augment the maritime domain awareness. The surveillance satellite was launched on the PSLV and is now functional over the Indian Ocean Region.[30] Similar requirement for our land borders would be 4-6 satellites.

***Space Situational Awareness (SSA)***

As in April 2021, around 25000 space objects, including debris, were being monitored by the US Space Command's 18 Space Operations Squadron. [31] Of this only 3,500 are operational satellites; the debris includes Rocket bodies, mission related debris, spacecraft and fragmentation debris. The satellites' catalogue are able to see most of the satellite orbits and is able to predict a Near Collision Event, but some satellites which are designated as classified, give no warning being "invisible" and are a risk both in orbit and while deorbiting. [32]

The ISRO has setup a NETRA in December 2020 (Network for Space Object Tracking and Analysis).[33] It comprises of a Radar, optical telescope facility and a control centre. It will enable first steps towards SSA for the civil space assets. The cost associated with more frequent manoeuvre of satellites to avoid debris includes, increased fuel usage and hence shortened operational life of the satellites leads to an economic burden on the space users. Hence the SSA is an essential requisite.

The DSA had issued a Request for Information for the space situational awareness in January 2021, for a complete solution to the SSA and to integrate various inputs to obtain a complete operational picture, to maximise the effectiveness of operations in the land, sea, air and space domains.[34] The DSA is also looking at analysis and prediction of threats from ASAT, space debris, Directed Energy weapons and Radio Frequency Interference. The DSA also wants to catalogue space objects, acquire analysis tools and undertake predictive assessments.

**Way Ahead: Proposed Space Defence Architecture**

- There is a need to define the space ISR and Communication requirements as per the area of Interest i.e. land border monitoring, maritime domain awareness and some areas for internal security.
- A state-of-art Space Operations Centre needs to be established. Its primary function should be to collect and collate inputs from ISRO and the strategic partners about SSA.
- Operationalise a 'Launch on Demand Capability' for ISR and Communication satellites including capability to launch from 'other than designated space ports'.
- Design Earth observation satellite constellation with EO, IR, SAR payloads for achieving a permanent stare capability.
- Enable space applications which permit easy dissemination to the tactical level for both ISR and digital communication needs.
- A risk analysis test needs to be conducted periodically of the existing space assets against both counter space threats and space hazards.
- DSA should integrate with dual-use capabilities of ISRO and practice interoperability with international partners.
- Achieve capability enhancements in manpower training through innovative use of existing talent for the DSA on contract basis or lateral entry from

DRDO, ISRO, Industry and Academia. Embed own officers into ISRO space ports, application centres and satellite control centres.

- Space manpower to be either absorbed as a special branch or at least have an extended viable tenure of 4-6 years. International collaboration is the key to success. Liaison officers need to be embedded with strategic partners like USA, France and Japan and also actively participate in the space security exercises.
- Adopt whole of government approach and coordinate all assets needed to achieve space security and deterrence.
- Ideation and industry interactions through seminars conducted by think tanks. Thereafter, jointly participating in policy/doctrine formulation.
- Publish the Space Security Strategy to enable industry to plan for the requirements of launch capabilities, design satellite constellations and applications for space security architecture.

## Conclusion

The DSA should be responsible for the defence architecture of the Indian space assets. They should be capable of tracking and directing space utilities in Earth Observation, Signal Intelligence, Communication, Space Situational Awareness, Missile Warning and Space Based Navigation. Basically, it should create space security architecture for our existing and future space assets. Multi-domain operations with the Joint Forces should be encouraged. It should function as a single point of contact with international defence partners and ISRO. It should chalk out a Space Defence Strategy for the Nation to enable strategic signalling, force structuring and enable private equity to plan their investments in this 'sunshine sector'.

## End Notes

*Basic Exchange and Cooperation Agreement (BECA) for geo-spatial cooperation, is an agreement between the National Geospatial-Intelligence Agency of the US Department of Defense and the Ministry of Defence of the Government of India.

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