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PROLIFERATION OF SATELLITES AND NEED FOR SPACE DOCTRINE

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Abstract

The space technology is considered essential and an integral part of nation building. Nations are using space technology for military purposes besides peaceful ones. In recent years the focus of spacefaring nations has shifted to Low Earth Orbit where government-controlled space agencies and private players are deploying satellite mega-constellations. This aspect brings the owners at cross purpose as there is no legal framework to control or oppose rogue actions except a few treaties. So far total satellites in space are less than 10000 but within a decade the number may increase ten folds. This will lead to collision and consequent debris creation accidentally or when national interest is at stake, a satellite may be targeted using anti-satellite missile. The international legal framework needs to be strengthened to ensure that measures be put in place to minimise chances of debris creation, booking slots in space and ensuring a safe end of life termination of satellites. Therefore, there is a need to have an all-encompassing space doctrine in place. The space technology is considered essential and an integral part of nation building. Satellites are being used in many fields: communication, earth observation, navigation, space study, remote sensing, etc., all these are in domain of peaceful coexistence of humankind. However, nations are using space technology for military purpose to support functions like, reconnaissance, communication and navigation. This aspect brings them

at cross purpose as there is no legal framework to control or oppose these except a few treaties.

UNIQUENESS OF LOW EARTH ORBIT (LEO)[1]

Satellites are launched at different altitudes above the Earth. In last one decade, the focus for satellite launches has homed on to the LEO. The LEO altitude is below 2000 kilometres above the earth surface. Within LEO, lower the altitude, shorter is the life span of the satellite for a specific weight category. For a satellite to have a longer life, a good footprint (coverage) as well as have a reasonable low orbital period (90 to 120 minutes), the altitude is normally kept between 400 – 800 kilometres. There are presently thousands of operational satellites orbiting the Earth in LEO.

These satellites have to co-exist with millions of pieces of space debris. Space debris originates from defunct satellites, fragments of anti-satellites test, fragments of space objects, etc. These debris pieces are travelling at more than 7500 metre per second. As LEO becomes a congested space, the risk of collisions between and among objects increases exponentially, as well as the likelihood of an uncontrolled chain reaction of debris-generating events. A centimetre sized tiny fragment can cause tremendous damage to an operational satellite leading to critical disruption in provision of essential services.

For any satellite, with passage of time, the orbit tends to become shorter. In order to keep the satellite in their intended orbit over its life time, thrusters are used either to raise orbit or to maintain course. Thus, to ensure redundancy and a good coverage over complete earth, having a satellites constellation is the way out. This is because so many 'defence related functions' and 'weapon systems control' are dependent on inputs from satellites as in guided missiles, drones, surveillance, navigation, communication, etc.

PROLIFERATION OF SATELLITES IN LOW EARTH ORBIT (LEO)

A new trend has started of having satellite mega-constellation[2] in LEO. It is simply a set of satellites (hundreds or even thousands) which are linked

to each other and capable of carrying out coordinated activity. At present there are a few thousand satellites but in coming years, this number is likely to grow exponentially. Virtually all countries in this business are not adhering to the international protocols on space usage as due to entry of private players – no one is able to regulate their activities.

Normally, Satellites and satellites related activities have been a domain of government-controlled space agencies. The whole dynamics of satellites industry has changed. The number of satellites planned for launch is enormous, driven primarily by private company's motivation to earn profits. The major players are SpaceX, G60 Starlink, One Web, and others.

Elon Musk, privately owned and controlled American aerospace company **SpaceX**[3] is operating **Starlink** – a satellite internet constellation. The SpaceX has satellite research, development, manufacturing and orbit control facilities. SpaceX started launching Starlink satellites in 2019. The number of functional satellites in LEO has more than doubled since then, due to the advent of mega-constellations. As of early January 2024, Starlink consists of over 5,289 mass-produced small satellites, operating in LEO. It is providing internet services to over 70 countries and has started providing global mobile broadband too. SpaceX plans to deploy nearly 12,000 satellites and over a period extend to an astronomical 42,000 satellites. At behest of United States Department of Defence, Starlink has played a crucial role in the Russian-Ukraine war by providing internet data services for surveillance, communication and real-time intelligence sharing. Starshield, a military version of Starlink, is designed for United States government use.

Unlike SpaceX, China's started the **G60 Starlink**[4] project in 2016, with the backing of Shanghai municipal government. The LEO based satellite mega-constellation is planned as a competition to SpaceX Starlink. The first satellite was produced by Gesi Aerospace Technology, Shanghai a state-owned company (established in 2022) towards end December 2023. The constellation will provide broadband internet services with an ultimate aim to explore potential in space technology. By end 2024, it plans to launch and

operate 108 satellites and provide commercial services. The capacity will be increased to 300 satellites annually for a target of 1300 satellites in phase 1.

China has increased its efforts to foster the commercial satellite market to counter United States. Along with the G60 Starlink 12000 satellites project, a second Guo Wang national network of 13000 satellites project is under construction. The G60 mega-constellation is a vital link in the aerospace information industry. It includes an industrial chain related to satellites, data application services, artificial intelligence and deep learning. The captured data will be applied to transport, energy, communications and the military after being analysed by ground-based big data analytics.

In Indian context, Bharti Airtel has bought a stake in **Eutelsat One Web.**[5] Eutelsat One Web launched its first 6 satellites in February 2019 but soon entered bankruptcy in March 2020 due to lack of capital. The company reorganised in November 2020 with a new ownership group. As of 2021, Indian multinational company Bharti Global (21.2 percent), France-based Eutelsat (13.6 percent) and the Government of the United Kingdom (10.9 percent) were the company's largest shareholders, while Japan's SoftBank retained an equity holding of 10.9 percent. One Web constellation plans to have 648 satellites of which 544 have been launched by January 2023. This constellation was placed at an altitude of 1200 km with satellites having longer life and fuel being earmarked separately for terminal phase. On 28 September 2023, Eutelsat and One Web were formerly merged.

Other companies such as Amazon and Planet are also planning their own satellite mega-constellations. Post the Indian government decision to permit satellite manufacture and launches by private companies to enlarge base, some companies[6] have entered into satellite related businesses. These include:

- **Dhruva Space.**[7] Founded in 2012, Dhruva are satellite experts to include satellite platforms, launch solutions, and orbital deployment, as well as providers of ground services.
- **Bellatrix Aerospace.**[8] The company founded in 2015, focusses on satellite and rocket propulsion and orbital manoeuvring. It also experimented

its Hall effect thruster – an engine using an electric field for propulsion, required for anti-collision manoeuvre. It is presently concentrating on orbital transfer vehicle (OTV).

- **Agnikul Cosmos.**[9] Agnikul was founded in 2016 for manufacturing rockets that can fly payloads from 25 to 100 kg, powered by four to seven engines. The company is also planning to have mobile launch pads. Its Agnite engines, will be completely 3D-printed. Agnikul has an MoU with DOS, for access to ISRO infrastructure.
- **Skyroot Aerospace.**[10] Established in 2018, Skyroot became the first company to partner with ISRO when the agency allowed access to its facilities and expertise towards the development and testing of subsystems and systems of satellite launch vehicles (SLV). It specialises in launch vehicles (LV) and cost-efficient, non-reusable rockets to launch small satellites. It launched Vikram-S, the first privately manufactured Indian rocket in November 2022.
- **Pixxel.**[11] Founded in 2018, Pixxel specialises in small, 15-kgs satellites capture images in hyperspectral frequencies, allowing analysis 'in 100s of wavelengths rather than 10s of wavelengths as done normally.' This makes it capable of identifying vegetation patterns, emissions, and ore deposits in up to five-meter resolution. After launch of few satellites, Pixxel's plans to have larger constellations of around 24 satellites.

RISK MITIGATION DUE TO SATELLITE DEBRIS

LEO crowding is changing the nature of the space environment. There's growing attention to the potential downsides, including an increased risk of collisions that could end up littering LEO with dangerous debris and rendering it unusable. To ensure that the LEO is kept 'clean' of decaying satellite debris, two methods may be used. Either push the satellite into a lower orbit where it burns out due to Earth's atmosphere or pushed out above LEO into a graveyard orbit. In both cases, certain reserve of fuel has to be maintained.

As the number of satellites in LEO keeps increasing, the chances of collision will also become greater. Monitoring [12] of space objects is an essential component for continual assessment of the space situation and devising appropriate mitigation strategies for space asset protection. To prevent satellite collision, autonomous and accurate tracking has to be ensured. Each satellite has to be designed to have thrusters as an anti-collision measure, to maneuver the satellite away from the path of the colliding satellite. Precision control of satellite will be required. Every satellite mega-constellation needs to be designed beforehand ensuring vertical spacing with other constellation, is adequate, such that no collision takes place. Artificial Intelligence (AI) may be used to ensure altitude differentiation for collision avoidance.

So far there are no rules for how to avoid collisions in orbit, disposal of dead satellites, reduction of space debris and the like. International body has to lay down global policy and guidelines and enforce them strictly. The liability clause, when one satellite collides with another has to be defined without ambiguity.

EXPANDING THE SCOPE IN SPACE BY INDIA

Since the beginning of 2017, Indian Space and Research Organisation (ISRO) has been a newsmaker with series of upgraded and more powerful launch vehicles and more capable multi-purpose satellites. On 15 February 2017, it launched 104 satellites in a single mission, on 05 June 2017, it launched most powerful launch rocket, on 14 November 2018, India launched the heaviest satellite (GSAT 29) and later built the heaviest in December 2018 (GSAT 11). India launched Chandrayan 3 on 14 July 2023, and is slated to launch Mangalyaan 2 in 2024. India's Bharati Airtel is going in a big way of adopting One-Web satellite service on lines of Elon Musk Star-link services, and same commenced with effect from November 2023.

NEED FOR SPACE DOCTRINE

There is a high possibility of nations, either directly or indirectly, interfering in the strategic needs of the other countries resulting in their 'National

Interest' being compromised. A space-faring nation like India therefore, would like to secure its interests. So far as per international guidelines, it is first come first served basis in respect of use of orbital slots and radio frequencies. As the number of satellites being launched is increasing by the day, a fight for 'my right' is likely to commence in near future. With mega-constellation being deployed by, possibility of same increases manifolds. The space utilisation in LEO, by Russia, China and India, has great overlaps. Each one may hurt other's interest sooner than later. The other two had their Anti Satellite (ASAT) Missile in place. To protect India's interest, in times to come, an ASAT missile became the need of the hour. The ASAT Missile test '**Mission Shakti**',[13] **codenamed 'Project XSV-1',** was conducted on March 27, 2019 at around 1130 AM IST. Post 'Shakti', India too is in the same league as Russia and China (as also USA which has presently the largest number of satellites).

It is time that India spells out its Space Policy. How should the policy take shape and what should be its ingredients? It should be all encompassing, involving all agencies, from 'makers (policy, hardware, software) to users' and be available in open domain in parts/full for obvious reasons.

Space for Peace. India has maintained that space should be a frontier for peace and should not be militarised. The following has been clarified in no uncertain terms:

- India's space program is rapidly growing which has further accelerated rather rapidly in the last decade. India has presently about 108 active satellites consisting of communication, earth observation, navigation, experimental, apart from satellites meant for scientific research and exploration. New satellites are planned to be launched at a faster pace. India's space program is a critical backbone of India's security, economic and social infrastructure.
- India has no intention of entering into an arms race in outer space. It has always maintained that space must be used only for peaceful purposes. It is against the weaponisation of Outer Space and supports international efforts to reinforce the safety and security of space-based assets.

- India believes that Outer space is the common heritage of humankind and it is the responsibility of all space-faring nations to preserve and promote the benefits flowing from advances made in space technology and its applications for all.
- India is a party to all the major international treaties relating to Outer Space.
- The ASAT missile test was not directed against any country. India's space capabilities neither threaten any country nor are they directed against anyone.
- Simultaneously, the government is committed to ensuring the country's national security interests and is alert to threats from emerging technologies. The capability achieved through the Anti-Satellite missile test provides credible deterrence against threats to our growing space-based assets from long range missiles, and proliferation in the types and numbers of missiles.

FORMULATION OF SPACE POLICY

The agencies involved in making of each component (of satellite, missile, radar, etc) are many and each needs to be taken on board. The answer to, 'Who all will be involved in preparing doctrine' will fall out of, 'who all made the Anti-Satellite mission successful' and who the 'end user' will be in future. Is there a need for a separate Space Command or the Strategic Forces Command (SFC) will suffice and be made responsible. Since, a large number of International Treaties, to which India is a signatory, are involved and have to be taken care of from time to time, who all from the civil domain (read Department of Space including a legal team) should also be made part of it.

INDIAN SPACE POLICY 2023[14]

The Indian Space Policy was formulated and disseminated in 2023. Basically, it defines the way Government of India (GoI) post 2020, has embarked upon allowing Non-Governmental Entities (NGEs),[15] to participate in space

domain and the overall role of Indian Space Research Organisation (ISRO)[16] and Department of Space (DoS).[17] It has defined the creation of Indian National Space Promotion and Authorisation Centre (IN-SPACe)[18] as an autonomous Governmental organisation and its role in laying down the rules and guidelines for various entities working in space sector. However, few aspects should be clarified as private participation increases:

- Audit of activities carried out by NGEs on quarterly/half yearly/yearly basis.
- Rules and guidelines for NGEs when dealing directly with other nation space related agencies on subjects which may be detrimental to own 'National Interests.'
- At no point, NGEs activities should be objectionable to armed forces.
- Sharing of sub-meter resolution images be termed as restricted and sub 30 centimeter be termed as confidential (or as decided).
- Earmark clearly no coverage zone or 'black out' areas over areas of national interest.
- It does not cater of anti-satellite missile and offensive action that needs be initiated in case of clash of interest.

Therefore, there is a requirement of groups/bodies which need to align with both the satellites for peaceful mission and the offensive actions. The following committee/groups are recommended as given in succeeding paragraphs.

THE CORE COMMITTEE (OR APEX BODY)

This should include Prime Minister, Cabinet Committee on Security, National Security Advisor (NSA), three Chiefs, Commander Strategic Forces Command (SFC), Commander, Strategic/Defence Space Command,[19] and the heads of DOS, ISRO and Defence Research and Design Organisation (DRDO). The body should lay down the broad framework for the Space related issues to include:

- Define India's national interest in space.

- State the strategic relationship in space domain with neighbors and in international forums.
- Lay both offensive and defensive guidelines for India's stance on various space related issues in international forums.
- Lay aim and guidelines and ratify space related research and development in fields of launch vehicles, satellite capability, ASAT capability, electronic warfare, cyber warfare, etc.
- Ratify and revisit the treaties which India is signatory to.
- Decide the budgetary support for the smooth growth of space-based applications.
- Lay guidelines for space related education and promotion of research and capability development.
- Since the private sector have been given a green signal to launch satellites, therefore lay guidelines for joint public-private collaboration or pure private participation in the field of satellites and space.

THE PLANNING GROUP

This Group should comprise the heads of DOS, ISRO, DRDO and Commander, SFC/Space Command. Besides, a legal team dealing with the international treaties and United Nation resolutions on space. The body should be responsible for Space related issues to include:

- Propose and/or define minimum and credible deterrence in space domain.
- Propose and suggests changes and/or modifications in the existing policies to Core Committee.
- Propose space cooperation among friendly nations and support United Nations backed development in space domain for benefit of human kind.
- Coordinate the activities of the various stakeholders viz ISRO, DRDO, Manufacturers, SFC/Space Command, etc.
- Monitor the progress of various agencies of the Space Commission in respective fields.
- Lay guidelines for establishing a Space Technology and Research University with core being provided by ISRO and DRDO. It should include

verticals such as satellite, launch vehicles, radar and radar systems, missile and missile systems, laser weapons, metallurgy, electronic warfare, cyber warfare, artificial intelligence, international space legal laws, etc.

- Lay guidelines for military training including space intelligence and surveillance.
- Lay guidelines for indigenous development and for involvement of private industry in the space program and selective or complete outsourcing for components/sub-systems/systems manufacture.

THE WORKING GROUPS

A number of working groups need to be established. Each should have a well-defined role. Within each working group, each member's role should also be defined. The dual responsibility for a specific issue should be avoided to eliminate confusion. The following working groups should be formed:

- **Working Group 1 – Satellite Operations.** This should include representatives of DOS, ISRO, DRDO, DPSUs, NGEs and Space policy related legal experts. The group should be responsible for the following:
  - **Planning and proposing launches.** This focuses on launching of all types of satellites including:
    - **Communication**: INSAT and GSAT.
    - **Earth Observation Satellite**: RESOURCESAT, CARTOSAT, RISAT, OCEANSAT, SARAL and SCATSAT, INSAT, etc.
    - **Space Science and Exploration**: Astrosat, Mangalyan, Chandrayan.
    - **Navigation Satellite**: IRNSS, GAGAN (GPS Aided GEO Augmented Navigation).
    - **Experimental Satellites**: Remote Sensing, Atmospheric Studies, Payload Development, Orbit Controls, recovery technology etc.
    - **Small Satellites**: Indian Mini Satellites.
    - University/Academic Institute Satellites.
  - **Debris.** Ensure debris management from the 'dead' satellites.

- **Commercial.** Identification of data for commercial purpose including marketing to friendly foreign countries through Antrix Corporation.
- **Legal**. Understanding all United Nations General Assembly (UNGA) resolutions, their implications and understanding space related treaties. The legal team should be well versed with following:
  - **UN Resolutions** such as Committee on the Peaceful Uses of Outer Space (COPUOS) of 1959, and 'No First Placement of Weapons on Outer Space' vide UNGA resolution 69/32 dated 02 December 2014.
  - **Treaties** such as Prevention of Arms Race in Outer Space (PAROS), Outer Space Treaty, Inter Agency Space Debris Coordination (IADC), etc.
  - **Space Use** Legal issues related to space such as first use of a specified orbit, radio frequency/s, etc.

- **Working Group 2 – Missile and Radar Manufacture and Operations.** This should include representatives of various DRDO establishments, SFC/Space Command, the Defence Forces, DPSUs and NGEs. It would continuously assess 'National Interest' based on directives as given by the core committee. The group should be responsible for the following:
  - Planning and monitoring of various missile and radar manufacture.
  - Upgrade and integrate various technologies and remain abreast with latest development in respective fields.
  - Electronic and cyber warfare inclusion and adaptation of electronic and cyber warfare in all equipment.
  - Co-opting of DPSUs and Private Industry would include Bharat Electronics Limited (BEL), Bharat Dynamics Limited (BDL), Electronic Research and Design Establishment (LRDE), Tata Power, Bharat Forge, Skyroot Aerospace, Dhruva Space, etc.
  - Establishment of a Space Command Post (SCP) and a 24x7 surveillance of critical Space over India and selective space on as required basis.
  - Manning of ASAT missile stations as well as other strategic missile for a K-kill of hostile ground stations.

  - Ground Protection of Assets lay down standard operating procedures (SOPs) for protection of space related establishment including training of quick reaction teams (QRTs) against terrorist threat and security force for first layer ground defence.
- **Training.** This should include reps of all stake holders and heads of faculty of various departments of Space University. The group should be responsible for the following:
  - Involvement of all DRDO laboratories and DPSUs in aiding training with a long-term perspective.
  - Deciding on syllabus and courses keeping in mind the future requirement. Involving selected private universities/colleges to run courses based on prescribed syllabus.
  - Establishment of a library including a repository of past history on space research and historic data.
  - Be responsible for the effective functioning of the space university.

SPACE FOR MILITARY

The dual use nature of space technology enables its utilisation for security purposes too. In the last few decades, military campaigns have demonstrated the significance of space technology for military purposes. The use of outer space for military support functions like reconnaissance, communication and navigation have received global acceptability since such usage does not directly violate any existing international legal regime. The ASAT missile brings to fore, the assertion of nation state will, to allow/disallow the use of Space over its geographical boundary. The free use of space for navigation, reconnaissance, intelligence (spying), so far has been relentless and at freewill. Now it may not be so. The owner countries of satellites, in LEO, will have to inform (and may have to seek permission) to fly over-head, least it be declared as hostile action and shot down. Possibilities in form of carrying out electronic and cyber warfare against such satellites also exist. With advent and advancement of direct energy weapons (DEW)

and laser guns, a day is not far when these too will form part of nation inventory in ASAT role. Thus, from the geostrategic view, space may form part of foreign policy tool.

CONCLUSION

The lack of coordinated and effective global policy, regulation and oversight among spacefaring nations and space actors has led to the prospect of hundreds of thousands of satellites planned for launch in the coming decade. It is imperative for all responsible space faring nation and private players to limit the creation of space debris by conforming to space debris mitigation guidelines. Towards this goal, space object observation capabilities need to be enhanced through the establishment of necessary infrastructure.

A space-faring country like India needs to ensure that its interests in respect of orbital slots, radio frequency spectrum, etc., are protected. The rapidly changing global space order could also give rise to newer challenges. Given all this, it is important that India formulates an effective policy to secure its interests in space.

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