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RELEVANCE OF SPACE SITUATIONAL AWARENESS FOR INDIA'S SPACE SECURITY

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Abstract

This paper brings to fore the need to build Space Situational Awareness (SSA) capabilities for India. It identifies threats affecting the smooth functioning of satellites through space thus arriving at the needs of SSA. It presents a brief discussion on the elements of SSA, including Data Collection by means of Sensors, Data Processing and Production at SSA nerve centres and finally Data Sharing between international partners. It differentiates between the military and civilian needs of SSA and discusses USA's SSA architecture which gives primacy to military SSA. It also briefly throws light on developments in SSA by major spacefaring nations with the aim of understanding how SSA can be conceived in India's context.

The paper discusses India's SSA proficiencies in light of SSA programmes of space faring nations. Finally, the paper suggests steps towards moderate capabilities in the near term and also an incremental approach for reaching maturation in SSA over the long term.

INTRODUCTION

Key military operations to include navigation, deep surveillance and long distance communication are increasingly being supported through assets

in outer space. These assets are also pivotal in running and sustaining vital civilian operations to include banking, weather forecast, resource monitoring etc., thus, making own governance increasingly reliant on them. While their role as enablers is well established, it must be understood that such assets are vulnerable to adversary actions thus jeopardising both civil and military operations. All events occurring in space, whether natural or by human design, need to be watched by observation equipment like radars and telescopes in order to assess vulnerabilities and undertake preventive measures. Space Situational Awareness (SSA) incorporates mechanisms to observe activities in space, collate the information centrally and suggest agencies for corrective actions in order to safeguard own assets in space. This paper focuses on understanding concepts of SSA, its emerging trends and steps that India may take towards building its SSA capabilities.

UNDERSTANDING SSA

The 1967 Outer Space Treaty lays down the general rules governing the use of Outer Space, ironically though, a clear definition of 'Outer Space' has yet not been arrived at. For common understanding however, space beyond 100 Km from the earth's surface is perceived to be Outer Space. In our immediate outer space operate the man-made satellites poised in the Low Earth Orbits (LEO), Medium Earth Orbits (MEO) and the Geostationary Earth Orbit (GEO). However, satellites are not the only objects present in this space. In it are also present Atomic Fluxes and Solar Winds which originate from the sun[1] and have the potential to impair satellite electronics. It also consists of Outer Space Objects (OSO) which include inactive or dormant satellites and Space Debris which refers to fragments ejected during the stages of satellite separation from the rocket body, paint flecks chipped off from the satellites and junks of dead or destroyed satellites. It is believed that every satellite launch may result in about 100 fragmented pieces chipping off from the satellite. Together the number of such Space Debris may well reach upto 5,00,000 in our immediate outer space.[2] These move at high velocities and even a tiny object of size one cm can damage a satellite while that of size 10

cm and above can completely disrupt a satellite's functioning on collision. Presence of these objects needs to be monitored and tracked in order to safeguard own satellites. While the number of Space Debris is high, only about 20,000 such objects may have been observed, logged and registered by major agencies worldwide. This is so since objects lesser in size than 10 cm are extremely difficult to track.

In the space are also undertaken bona fide human activities which are generally civilian in nature. Such activities undertaken by other nations need to be observed to extrapolate rocket trajectories in order to avoid accidental collisions and thus plan safe missions. Of grave concern are malicious activities which may include use of Anti Satellite (ASAT) missiles or Direct Energy Weapons (DEW), unannounced manoeuvring or launching of satellites or undertaking suspicious activities like use of robotic arms. Such activities need to be actively monitored in order to ensure continuity of own services during critical civil and military operations.

Radars and telescopes forming the basics of SSA infrastructure observe these solar winds, atomic fluxes and OSO. They also monitor human activities in outer space. Information so obtained is processed at a nerve centre where large pools of data bases help extrapolate trajectories to arrive at possibilities of collisions. Once the possibilities of collision are ascertained[3] course corrections can be undertaken for collision avoidance.

CIVIL AND MILITARY VIEWPOINTS ON SSA

The SSA programme of the European Space Agency (ESA) is expected to be oriented towards civilian objectives with an aim to monitor satellites, space debris and weather[4] in order to arrive at course corrections. A civilian perspective to SSA entails knowledge of activities in space in order to avoid accidental collisions. Avoidance of such collisions is for common good of all space users and thus nations are normally inclined to share such information with other space faring nations in order to ensure space traffic management.

On the other hand, the United States Strategic Command (USSTRATCOM) perceives SSA as a tool to enable space superiority during conflicts.[5]

USSTRATCOM lays down that SSA should be able to obtain data on use of military satellites by adversary nations, detect suspicious ascent, descent or manoeuvres, or detect offensive use of ASAT missiles by adversary. Such perspective on SSA is militarily oriented and not all of the data so obtained may be shared with other countries.

Thus, should a space faring nation seek SSA for accidental collision avoidance facilitating global Space Traffic Management, data is likely to be easily shared amongst countries. However, should it seek for advancement or progression of its own military activities or for protection of its assets which support military operations, preserve over data is likely to be maintained. Envisioning such scenarios, prominent space players are beginning to develop their own SSA capabilities.

USA'S SSA PROGRAM

- USA operates more that 375 telescopes and radars thus being a global leader in SSA.[6] Elements of USA's SSA are briefly discussed in following paragraphs.
- ***Data Collection***

  The USA is expected to host its sensors both on ground and in space aboard satellites. On the ground are Falcon Telescope Network (FTN), Ground Based Electro Optical Deep Space Surveillance (GEODSS), the 'Orbit Outlook' and the 'Space Fence'. GEODSS is a network of telescopes spread globally at Hawaii, Diego Garcia, and Socorro[7] with a likelihood of additional mobile facilities. The FTN is also a separate network of telescopes spread in countries of Chile, South Africa and Australia and is a collaborative effort between the US Air Force and educational institutes worldwide.[8] The 'Orbit Outlook' connects academic institutes and amateur observers and is expected to comprise of 29 radars.[9] USA's most premium asset the 'Space Fence' is a fence like radar which is three kilometer long and has the ability to track objects even lesser than 10 cm in size. Located at Kwajalein islands[10] the Space Fence can undertake upto 10,000 detections per day.

Based in space are USA's satellite constellations to include Space Based Space Surveillance (SBSS), Geosynchronous Space Situational Awareness Programme (GSSAP), the Space Tracking Surveillance System (STSS), and the Space Based Infra Red System (SBIRS). The GSSAP comprising of GSSAP 1, 2, 3 and 4[11] satellites can observe objects in GEO well upto 36,000 km, while the STSS and SBIRS form the essential eyes and ears of USA's Ballistic Missile Defence Systems with an ability to detect incoming missiles.

- ***Sharing of Data***

  The Joint Space Operations Centre (JSpOC) of the US Space Force functions as a nerve centre and controls most of its SSA sensors spread across the globe. Data obtained through these sensors is processed and registered in form of a Satellite Catalogue(SAT-C). This SAT-C is posted in the official website of US government called Space-Track.org. Data of space objects which have been detected and tracked is expected to be present on the website. This data is used by most space faring nations for planning the launch of their satellites and even their collision mitigation. Though the basic data is expected to be made available for all users, uninterrupted and unconditional supply of such information cannot be guaranteed. Further, advanced data having strategic implication is not posted on the website and is usually shared only on government to government basis under strategic agreements.[12] Thus, in order to seek comprehensive SSA data, countries have to develop their own SSA infrastructure. Further, such SSA infrastructure has to be spread across the globe in both northern and southern hemisphere in order to build the overall picture. Thus, arises the need to also simultaneously develop networking and strategic information sharing mechanisms with global partners. One such mechanism is the Joint Forces Component Command (JFCC) comprising of USA, Canada, UK and Australia functioning under the lead of the US Air Force. These countries jointly operate and contribute towards building common SSA picture which is then shared exclusively amongst the four nations.

SSA PROGRAM: GLOBAL TRENDS

The ESA employs Proba-2 and Proba-3 satellites for space based sensing. Based on ground are Solar and Heliospheric Observatory(SOHO), Space-Surveillance and Tracking-Data-Centre in Spain, Space Weather Centres in Belgium, Near-Earth-Object(NEO) Coordination Centre in Italy and Optical Telescopes spread worldwide. Its SSA operational centre is the European Space Operations Centre (ESOC) located in Germany.

Russia operates International Scientific Optical Network (ISON) consisting of nearly 25 observatories and about 32 telescopes[13] spread across nine different countries. In addition to its ground based sensors, Russia also operates surveillance ships which are mobile and can provide larger expanse of coverage.

Chinese space radars are likely to be located at Xuanhua, Kunming, Henan, Hainan, and Jiangxi. Its Yuangwang series of space tracking ships enhance the coverage over a much larger area. These ships have also been known to be operating in the much discussed port of Hambantota of Sri Lanka during the recent times. China's Purple Mountain Observatory is one of largest ground based telescopes in the world. China has also recently commissioned the Ngari telescope in Tibet and the Patagonia telescope in Argentina.[14] Being a prominent member of Asia Pacific Ground Based Optical Space Objects Observation System (APOSOS).[15] China also reserves its rights to base its observatories in other countries.

INTERNATIONAL COOPERATION

Private companies and business groups have built their own network of SSA. Formed in 2009 is the the Space Data Association (SDA) wherein key private players like INTELSAT, SES and INMARSAT have come together to share sensors and data. Freelance space observers and private companies also come together on a common platform called See Sat-L which is a highly active group sharing some of the most exclusive data on space. It is popularly believed that See Sat-L has been responsible for detecting nearly

200 space objects which otherwise have not been made known to common space faring nations.[16]

SUMMARY

In all thus, following aspects emerge with respect to SSA:

- Major space faring nations are alive to the growing needs of SSA and are continuing to steadily upscale their SSA programs.
- SSA strengthens space security and is much desired for any prospective space power.
- Advancements in SSA sensors need to be made to enable detection of tiny space objects. Further, such sensors need to be spread globally needing a collaborative effort at government level.
- In addition to building superior sensors, SSA needs networking of sensors and undertaking interlinkages of agencies for fluent data flow.
- SSA synthesis needs to be undertaken in form of a structured organisation and collating data from sources on ground and also from sources based in space.

INDIA'S SSA CAPABILITIES

In the recent times, India has taken remarkable steps in the domain of SSA. In 2019, ISRO commissioned the SSA control centre which is to act as nerve centre for SSA data. As regards sensors, ISRO has developed the Multi-Object Tracking Radar (MOTR), which can simultaneously track 10 objects[17] in space. India may has also developed various civilian facilities like optical telescopes, radio telescopes, Gamma Ray & Metrewave Telescopes and Solar Observatories for scientific observations.[18]

In the domain of international cooperation, India together with the USA has worked towards a joint-statement in SSA in 2014. Further, BECA agreement with the USA and the SSA agreement in 2022 are noteworthy and speak of government's resolve in the domain. In 2018, India together with France, identified SSA as a one of the key domains of cooperation.[19] As bilateral cooperations are being progressed well by India, multilateral

forums like the Consultative Committee of Space Data Systems (CCSDS) are yet to register India as a member country.

While considerable steps are being taken, ISRO has remained concerned about the need to further our SSA capabilities in light of India's reliance on USA's SSA data. ISRO's former Chairman, Dr K. Sivan highlighted the need to develop indigenous systems of sensors to reduce reliance on SSA data obtained from USA.[20] This may entail having a greater number of sensors with a much larger expanse. This also entails that India may not only have to rely on ground based SSA but also on SSA obtained from space-based assets thus requiring launch of a separate constellation on the lines of USA's SBSS, GSSAP & STSS.

WAY AHEAD FOR INDIA

A comprehensive and worldwide SSA network is cost prohibitive. It is therefore that most space faring countries have adopted a measured approach in the domain. Growing security concerns in space and fluid geo-political scenarios however imply that, SSA be given its due priority. While an all-indigenous SSA mechanism is an ideal answer, its practicability is questionable. A more pragmatic approach is to make gradual and steady progress in terms of building SSA sensors and their networks while also simultaneously progressing sharing mechanism with countries worldwide. India should, in the near term, aim to build moderate capabilities and work gradually with an eye for maturation in the domain in the long term. Five major lines of effort are presented here.

Policy Orientation. For most space faring nations, as began their endeavours for space, so did also begin their efforts for its military utilisation. National security, thus, lies at the heart of their space programmes. On the contrary, security as a defining tenet, was apparently not an essential component in India's case. Recent incorporation of the same in the India's Space Policy of 2023 is a remarkable and much awaited change. India should aim to build upon this policy change by strategically aligning its SSA program while also retaining its civilian scientific character. This entails that duality may

have to be built in the SSA programme to meet the needs of both Civil and Military users.

Development of Superior Sensors. India may have to develop sensors with superior capabilities to observe immediate outer space in order to detect, track and catalogue OSO of sizes upto 10 cm or even below. This is significant not only from the point of view of collision avoidance with space debris, but also in light of presence of suspicious micro satellites which may have sizes as less as 10 cm.

Expanding the Spread of Sensors. In the near term, presence of these sensors has to be built across the Indian landmass while in the long term, presence of Indian sensors may have to be built globally. Initiation of such international mechanisms need to be undertaken now for their fructification in the long term. India may also consider developing and operating ships with inbuilt space tracking facilities on the lines similar to Russia and China.

Building a Sensor Network. Once data is collected, a network is required to enable its collation and processing at the Control Centre. Further, such network not only connects sensors to control centre but also to executive agencies which can undertake corrective actions on receipt of a collision warning. While building a national level network should be a near term objective, building a global network as also patching with networks of other countries should remain in the long term vision.

Data Sharing Mechanisms. Data sharing mechanism needs to be two pronged. Firstly, data sharing with international partners and secondly, collaboration with private partners. While international partnerships are being initiated, in the long term, India should aim for their maturation with robust mechanisms built-in. Participation in multilateral institutions like CCSDS needs to be given due weightage. Mechanisms like Defence Trade and Technology Initiative (DTTI) may be identified as a joint platform for research and development in this domain. India may also need to develop a more vibrant and comprehensive ecosystem of private SSA players. Public-private ventures in the domain not only speed up the SSA capabilities, but also help them expand faster globally.

CONCLUSION

India's space assets are likely to increase and so shall its civilian and military reliance on space. Safeguarding against collisions and countering malicious adversarial actions will therefore remain a desired capability. SSA will therefore be a key facilitator for India's continued space access. As major space faring entities are incrementally enhancing their budget allocations for SSA every year, their intentions for Space Control are becoming increasingly evident. To start with, moderate and short term objectives may have to be undertaken essentially focussing on strategic orientation and building of own capabilities. In the long term, increased indigenisation, matured international data sharing arrangements, global networking and well coordinated national level SSA organisation may have to be kept in the horizon in order to arrive at comprehensive solution.

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