Centre for Air Power Studies (CAPS)
Forum for National Security Studies (FNSS)
02/20

Realising the potential of Amateur Astronomers for enhancing India's Space Situational Awareness

Mrunalini Deshpande
Research Associate, CAPS

Keywords: Space Security Awareness, Multi Object Tracking Radar, Indian Institute of Astrophysics

Since the launch of Sputnik I in 1957, the international engagements in space have increased manifold, both in terms of magnitude and diversity. Although initially, space was dominated by a select few nations, over the years, the number of nations investing in space has increased. It is estimated that by 2026, a total of 81 countries are planning to invest in space activities.[1]

Rapid advances in space technology have led to a considerable decrease in the cost of accessing space. This has paved the way for a number of private players to enter the space arena besides the growing number of countries. This rise in the number of space faring entities has led to an inadvertent increase in the number of objects in space and hence eventually space is becoming crowded due to the increase in the number of satellites, debris created during the separation of launch vehicle stages, accidental collisions and intentional destruction of satellites for scientific or military experiments. As of February 3, 2020, there are 20,262 trackable objects in space out of which 2,690 are active satellites.[2]

This number is expected to rise exponentially as private companies like SpaceX plan to launch a constellation of up to 12,000 satellites. As of January 6, 2020, SpaceX has already launched more than 170 satellites for its Starlink constellation. Similarly, OneWeb, Amazon and Telesat are planning to launch constellations of 1980, 3236 and about 300 satellites, respectively. [3] These large constellations will be responsible for a monumental increase in the number of objects in concentrated orbits, especially the Lower Earth Orbit (LEO).

What is the need for Space Situational Awareness?

Space plays a vital role of being a force enabler and multiplier. Majority of the economic activities and military operations are heavily dependent on satellite systems. It is apparent that space is increasingly becoming congested, contested and conflicted. While threats to space assets can be natural, accidental or intentional, it is challenging to determine whether actions in space are intentional or benign. Also, actions in space have the potential to trigger conflicts on Earth and it is therefore vital to have in place a mechanism to monitor the happenings in space on a regular basis. Space Situational Awareness (SSA) capability is therefore cardinal for any space faring nation to protect its space assets and also to ensure its undeterred access to space.

In simple words, SSA[4] is the ability to determine the position, function and status of every object in space. Such a capability utilizes radar and optical sensors, complemented by space based sensors to detect and track space debris, active and inactive satellites, monitor space launches and maneuvers in space.

Bistatic, multistatic and phased array radars are primary sensors used to track and catalogue space objects in the Lower Earth Orbit. Optical telescopes are the second major type of SSA sensors used to track objects at a long range. However, optical telescopes come with their own disadvantages in terms of being able to track only those objects that are illuminated by the sun while the telescopes are in darkness. The third type of sensors are the space based optical telescopes which are now majorly forming a part of the SSA system as they provide a number of advantages over the ground based systems, primarily the absence of space weather and atmosphere. In addition to these, onboard GPS receivers and high accuracy laser ranging are also used to obtain the positional data on objects in LEO.

Currently, U.S operates the largest network of SSA sensors followed by Russia and Europe. China, Canada, South Korea and Japan also have a credible SSA capability. The U.S puts out the data collected from its sensors in public which can be accessed through their Space Track website.

India and SSA

About 50% of India's current operational satellites are in LEO which is also the most crowded orbit. Currently, India has only one ground based sensor dedicated for SSA purposes. The Multi Object Tracking Radar (MOTR), commissioned in 2015, is capable of tracking up to 10 objects of 0.25 m^2 in size, up to a maximum range of 1000 km. The radar is mainly used for space debris proximity analysis in the powered and orbital phases during satellite launches and re-entry predictions of debris.

In addition to this, India also hosts a number of optical telescope facilities on its mainland. These telescopes fall under the aegis of the Indian Institute of Astrophysics (IIA); while their primary focus is astronomical observations, few of the telescopes from these observatories have been used to track satellites on a need basis. India however, is still in the process of building its own satellite catalogue and primarily relies on the data put out by the US government. Therefore, for India to grow as a credible space power in the future it is imperative to enhance the SSA capabilities of the country.

Role of Amateur Astronomers in SSA

In 1957, when Soviet Union launched Sputnik 1, the worldwide network of the enormous Baker-Nunn cameras that would be used to track satellites in LEO was still well behind its schedule to become operational.[5] It was Operation Moonwatch, a team of amateur astronomers that helped track Sputnik 1 using a bench mounted telescope. Led by Harvard astronomer Fred Whipple, Operation Moonwatch was also involved in tracking and documenting the launch of the dog Laika aboard Sputnik 2 in November 1957, tracking U.S's first launched satellite, Explorer I in 1958 and played an important role in the recovery of Sputnik 4 after it re-entered over the US in 1962. Therefore, in addition to the radars and optical telescopes, harnessing the capabilities of the amateur astronomer community in detecting and tracking satellites have proved successful for countries such as U.S, Russia and Europe.

This legacy of the amateur astronomer community in aiding the detection and tracking of objects in space has successfully continued and widened since then. For instance, in 2018, a Netherlands based satellite-tracker photographed U.S Air Force's secretive spy plane, X37B over Leiden. The Orbital Test Vehicle is a classified object and is therefore not in the catalogue maintained and made public by the US military tracking network. Another successful case was in January 2018, a lost weather tracking NASA satellite called IMAGE was found by a Canadian amateur astronomer, almost a decade later after NASA had given up on its search.[6]

Over the years, amateur astronomers have been able to add a number of objects to the space catalogue globally. This capability of the astronomer community has been acknowledged in the US and Europe where amateur astronomers are encouraged to crowdsource their observations and contribute to the space catalogue building and maintaining process.

At home, the amateur astronomer community is not a very strong movement in India and therefore, their potential has been unutilized. A few of the astronomical telescopes on the Indian mainland have been used to track and detect satellites on a need basis.

In December 2019, NASA credited Shanmuga Subramanian, an amateur astronomer from Chennai, for successfully identifying the debris of the Vikram Moonlander launched by the Indian Space Research Organisation (ISRO) in September 2017.[7] Vikram had lost radio contact just minutes before its landing on the lunar surface. Subramanian located the lander using images taken by NASA's Lunar Reconnaissance Orbiter.

Despite its proven potential, a dedicated effort towards encouraging the amateur astronomer community in India to contribute to satellite catalogue building and its maintenance has largely been absent.

With the setting up of the Directorate of Space Situational Awareness and Management by ISRO in August 2019, India is taking long strides towards building a credible SSA capability. And while it is important to have in place a robust infrastructure of SSA sensors, it would be worthwhile for India to realize and harness the potential that the amateur astronomer community has to offer towards tracking and detection of space objects.

(Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily reflect the position of the Centre for Air Power Studies [CAPS])

Notes

[1] Government Space Affairs, eurosconsult, http://www.euroconsult-ec.com/government-space, ,Accessed on February 3, 2020

[2] Satcat Boxscore, celestrak.com, https://www.celestrak.com/satcat/boxscore.php, Accessed on February 4, 2020

[3] Henry, Caleb. "SpaceX becomes operator of world's largest commercial satellite constellation with Starlink launch", spacenews.com, https://spacenews.com/spacex-becomes-operator-of-worlds-largest-commercial-satellite-constellation-with-starlink-launch/ ,Accessed on February 4, 2020

[4] Components of SSA can broadly be classified as data collection, data fusion, analyses of the data and decision making tools developed on basis of the analysed data. The positional data obtained from SSA sensors is stored and maintained in a satellite catalogue in the form of Two Line Elements (TLEs). These TLEs aid in performing a variety of analyses related to commercial and military space applications. Currently, about 20,000 objects are being tracked and catalogued.

[5] Dickinson, David. "Citizen Science, Old-School Style: The True Tale of Operation Moonwatch", Universetoday.com, https://www.universetoday.com/100744/citizen-science-old-school-style-the-true-tale-of-operation-moonwatch/ (Accessed on February 4, 2020)

[6] Klein, Allison. "Meet the amateur astronomer who found NASA's lost satellite in space", washingtonpost.com, https://www.washingtonpost.com/news/inspired-life/wp/2018/02/01/this-amateur-astronomer-found-a-satellite-lost-in-space/ Accessed on February 5, 2020

[7] Wu, Katherine J. "Amateur Astronomer Locates India's Moon Lander Crash Site", smithsonianmag.com, https://www.smithsonianmag.com/smart-news/amateur-astronomer-aids-nasas-discovery-indias-moon-lander-crash-site-180973692/ , Accessed on February 5, 2020