With Rising Space threats, Countries led by US are rapidly increasing their Space Situational Awareness capabilities

There has been exponential growth of space objects, including orbital debris that has increased the in-orbit collision risk. NASA estimates there are 21,000 objects orbiting Earth that are larger than 10 cm, 500,000 between 1 and 10 cm, and more than 100 million that are less than 1 cm. Orbital debris of even 1cm size, travelling at an average speed of about 11 km/sec can cause partial or complete destruction of satellite.

The large number of debris around Earth is a risk for the safety of operational satellites. Any of debris objects can cause harm to an operational spacecraft, where a collision with a 10-cm object could entail a catastrophic fragmentation, a 1-cm object will most likely disable a spacecraft and penetrate the satellite shields, and a 1-mm object could destroy sub-systems on board a spacecraft.

The space is also becoming increasingly militarized many countries are developing killer microsatellites and other antisatellite weapons (ASAT) that could be used to damage other satellites. There is also thrust on space robots which can perform repair of satellites and which could also put to deorbit adversary's satellites. They could provide complete awareness of adversary's activities in space so that one can take counter actions.

UK's Exeter Law School has recently joined a consortium of founding institutions, including McGill University and the

University of Adelaide, for the development of rules for space warfare. The Manual on International Law Applicable to Military Uses of Outer Space (MILAMOS) will also set out rules for war crimes in space and for the development of space-based weaponry, including lasers and missile defence systems. The manual will also look into the issue of who will be responsible for cleaning up space debris caused by military action

Space situational awareness (SSA) is the foundational element of space security, and it entails keeping track of all natural and artificial space objects, energy and particle fluxes and understanding how the space picture is changing over time. SSA is a system of systems dealing with space surveillance, space weather and NEOs.

The overall objective of space situational awareness (SSA) is to identify the location of every object orbiting the Earth, why it is there, what it is doing, and to predict what it will be doing in the future. Its aim is to track and understand what exactly is in orbit from either space or from the ground. This knowledge enables the management of space assets and the exercise of a level of control over the space environment.

Space situational awareness (SSA)

The US Strategic Command defines SSA as “The requisite current and predictive knowledge of space events, threats, activities, conditions and space system (space, ground, link) status capabilities, constraints and employment – to current and future, friendly and hostile– to enable commanders, decision makers, planners and operators to gain and maintain space superiority across the spectrum of conflict.”

SSA encompasses surveillance of all space objects, activities, and terrestrial support systems (satellites & debris), more detailed reconnaissance of specific space objects assets (mission identification, capabilities, vulnerabilities, etc.), discerning the intent of others who operate in space, knowing the status of our own forces in real-time, and analysis of the space environment and its effects (solar storms, meteor showers, etc.).

It also entails determining the various threats to space assets such as the growing number of debris, space weather, meteorites, orbital collisions and intentional attacks including directed energy attack, direct ascent and orbital ASAT, HAND events, etc. It involves the collection, processing, fusion and assessment of data and information from many different sources and dissemination of information to decision makers and various users.

Comprehensive SSA requires a networked system of radars and electro-optical sensors. Low altitude debris is usually observed by radar ground stations while high altitude debris is observed by optical ground stations. Bistatic, multistatic and phased array radars are widely used. The optical telescopes have some disadvantages like they can only track objects that are illuminated while the telescopes are in darkness. Recently the trend is to use space based sensors to provide timely detection, collection, identification and tracking of man-made space objects from deep space to LEO orbits.

US

United states operates the largest network of sensors and maintains the most complete catalog of space objects.”As the space domain has become more congested, the potential for intentional and unintentional threats to space system assets has increased. To mitigate these threats, the Department of Defense (DOD) has undertaken a variety of initiatives to enhance its network of sensors and systems to provide space situational awareness (SSA)—the current and predictive knowledge and characterization of space objects and the operational environment upon which space operations depend” , according to Budgets Information.

According to DOD, a potential of 375 sensors for SSA are available across the civil, military, commercial and intelligence communities. The US Space Surveillance Network (SSN) is the principal system used to detect, track and identify objects orbiting earth. It has the best set of SSA capabilities, operating a global network of 30+ ground based radars and optical telescopes and 2 satellites in orbit. It maintains the most complete tracking database of 23,000+ space objects bigger than 10 cm. SSN largely relies on phased array radars that are also used for early missile warning sensors.

US has two space based sensors to detect space objects- the Space Based Visible (SBV) sensor on the Midcourse Space Experiment (MSX) and Space Based Space Surveillance (SBSS) Pathfinder satellite.

The SSN has fewer telescopes, but they are better distributed geographically. The ground based Electro-optical Deep Space Surveillance System (GEODSS) consists of three separate sensor sites located in New Mexico Hawaii and Diego Garcia in the Indian Ocean. Each site operates a cluster of three telescopes, each of which can be operated independently of each other. Along with these sites there is a mobile site with one telescope located in spain. Together they provide global coverage of the GEO belt, although weather can cause gaps. The data is fed to the Joint Space Operations Center (JSpOC) in California that provides a range of data and services for US government, satellite operators, and public.

The SSN system is not ideal and has limitations like outdated hardware and software and provides very little coverage in the Southern Hemisphere like in Asia, Africa, and South America.

Space Fence program is the upgrading of current VHF based radar system to S-band radar system that will allow the Air

Force to track microsatellites or debris, as far out as 1,900 kilometers in space. The new system would have a maximum coverage area of 40,000 kilometers compared to 22,000 kilometers maximum of earlier system. It would track about 200,000 orbital objects and make 1.5 million observations per day, about 10 times the number made by previous the earlier Air Force Space Surveillance System (AFSSS).

Canada

Canada’s Near Earth Object Surveillance Satellite (NEOSS) orbits around 800 km above the earth to monitor space objects. It is the first micro satellite that is used for this purpose. Canada contributes to Us’s Space Surveillance Network.

Russia

Russia operates the second-largest network of sensors and also maintains a relatively complete catalog of space objects. The Russian system is known as the Space Surveillance System (SSS), which also consists of phased array radars used primarily for missile warning, along with some dedicated radars and optical telescopes. Several of the SSS sensors are located in former Soviet republics and are operated by Russia under a series of bilateral agreements with the host countries. Russia is also in the process of upgrading and modernizing its SSA capabilities with the Automated Space Danger Warning System (ASPOS) to track space debris and support national security.

Russia has two bistatic phased array radars in Pechora (Russia) and Gabala (Azerbaijan). There is another Bistatic phased array radar in Belarus, operating near 3GHz. The Don-2N radar, known as Pill Box, is a four faced phased array radar which is a part of the ABM system protecting Moscow. Russia also maintains older radars in Kazakastan.

Russia also operates an optical tracking facility in Tajikistan, which gives coverage of the GEO belt only over Russia. Similarly, Russian sensors offer less accuracy in LEO due to lack of geographical distribution. The Russian government does not routinely share data from these facilities with other entities.

Russian Academy of Sciences manages a network of optical telescopes known as International Scientific Optical Network (ISON) which is partnership between many academics and scientific institutions and consists of about 30 telescopes of 20 observatories in 10 countries. ISON as a network can track a wide range of objects through deep space with its facilities located mostly in Europe and Asia along with one being located in South America and off the coast of Africa.

People's Republic of China (PRC)

PRC has radar sensors that could be or are used for SSA purposes, but this information is not publicly known. Reportedly China has network of phased array radars with estimated range of 3000 km and 120 degree of azimuth coverage. It laos has long range precision mechanical tracking radar.

PRC does not have sensors outside of its borders and it is postulated that seven radar sites exist inside China which contribute to tracking of objects in LEO. China operates two Yuanwang tracking ships which can be deployed to broaden its coverage for SSA.

PRC does operate four optical observatory locations from its Purple Mountain Observatory. Again, due to sensors being located only in China, global coverage of the GEO belt is not possible with this optical network, even as objects can be tracked through all orbital regimes.

Europe

Europe has several SSA sensors and facilities. European radar capabilities are the French GRAVES radar, the German Tracking and Imaging Radar (TIRA) system, and the European Incoherent Scatter (EISCAT) system.

The GRAVES radar owned by French military is a continuous wave bistatic fence. It is primarily developed to establish and maintain a database of satellites flying over France at altitudes of less than 1000 kilometers. German TIRA is a monostatic mechanical tracker that can track objects as small as 2 cm at an altitude of 1000 km.

Germany’s fraunhofer institute for high frequency physics and radar techniques of is developing the German Experimental Space Surveillance and Tracking radar (GESTRA) to track objects in low earth orbit. Unlike TIRA, GESTRA has an electronically moving antenna and therefore can be reoriented faster as it has no heavy moving parts. The passed array system at 1.3 GHz is capable of tracking multiple objects at the same time while still supplying data of high accuracy and sensitivity.

Norway in cooperation with US government maintains GLOBUS II which is deep space mechanical tracking radar that can track and image objects in the GEO belt. Norway is also home to the European Incoherent Scatter (EISCAT) radar system which is used for space debris research.

The present Optical facilities are France’s SPOC, ROSACE, and TAROT, the UK’s PIMS, and Zimlat in Switzerland.

The European Space Situational Awareness (SSA) Programme is being implemented as an optional ESA programme with financial participation by 14 Member States. It began in 2009, and the programme's mandate was extended to 2019 at the 2012 ESA Ministerial Council. The second phase, Phase II, of the programme is currently funded at €46.5 million for 2013–16.

Some of the facilities that were developed in Phase-1 are Space Weather Coordination Centre, Space Pole, Brussels, Belgium , Space Weather Data Centre, ESA Redu Centre, Belgium, NEO Data Centre, ESA/ESRIN, Italy, Space Surveillance and Tracking Data Centre, ESA/ESAC, Madrid, Spain, SSA Tasking Centre, ESA/ESOC, Darmstadt, Germany, Development and installation of a monostatic test radar, Santorcaz, Spain, Development and installation of a bistatic test radar, France and Initial design of the SSA FlyEye automated telescope to enable full-sky NEO scan.

Australia

Australia's contribution tio the SSA effort is primarily on ground based sensors for space surveillance. It is hosting in collaboration with US USAF C-band radar and the DARPA Space surveillance telescope at the Exmouth in WA and laser tracking by EOS on Mt Stromlo. The complementary tracking is afforded by UNSW Canberra's new Falcon telescope, part of growing Falcon Telescope network.

Japan

The Kamisaibara Spaceguard centre, KSGC has radar sensor capability and is able to detect objects 1 m in diameter at 600 km range. It has a phased array with mechanical scanning in the azimuth direction. It can observe multiple space objects simultaneously (Max 10 objects). It can also observe reentry objects.

The Bisei Spaceguard Centre, BSGC has optical sensor capability and a longitudinal coverage of 68 deG E and an altitude of approximately 2000 km to 40,000 km. It observes space objects approaching to JAXA satellites and also facilitates NEO (Near Earth Orbit) observation.

References and Resources also include:

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