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SPACE SURVEILLANCE & TRACKING (SST)

A Critical Capability for Ensuring the Safety & Security of Space-Based Infrastructure; and a Major Future Business Opportunity

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Introduction

Orbital debris is any human-made object in orbit about the Earth that no longer serves a useful function. Such debris includes non-functional spacecraft, abandoned launch vehicle stages, mission related debris, and fragmentation debris. As per an ESA Space Debris Office report of 04 Apr 2022, there are 36,500 space debris objects of size greater than 10 cm, one million space objects between 1 cm and 10 cm in size and 130 million objects between 1 mm to 1 cm in size.

The chance of colliding with debris varies greatly with orbital altitude and, to a lesser extent, with orbital inclination. The probability of colliding with large or medium-sized debris in Low Earth Orbit (LEO) is at least 100 times greater than the average probability in Geostationary Earth Orbit (GEO) and is likely to be 1,000 times greater than the probability in less used orbital regions. Space debris can stay in orbit for hundreds of years and present a real danger to the rapidly increasing number of new satellites being launched each year which provide vital services, including communications and climate change monitoring. Space debris collision is considered the main cause of premature failures/losses of satellites.

Space Surveillance and Tracking (SST) is the detection, identification, range finding, tracking and cataloguing of space objects to determine their orbits, the status of the object (e.g. is it stable or tumbling), and to help predict/prevent future collisions and re-entry events. Measurements of near-Earth orbital debris are accomplished by conducting ground-based and space-based observations of the orbital debris environment. Data is acquired using ground-based radars, optical telescopes, lasers, and space-based sensors.

Importance

Space object tracking is very important to Governments and industry for many reasons including:

Safety

There are many objects in Earth's orbit, including active and inactive satellites, debris from space missions, and spent rocket stages. These objects can pose a risk to other objects in space, including functioning satellites and crewed spacecraft. By tracking these objects, we can better understand their trajectories, potential collision risks and take measures to avoid collisions. For example, the International Space Station (ISS) had to conduct two manoeuvres in 2021 to avoid potential collisions with large debris. The November manoeuvre was triggered by a high-risk impact from a breakup fragment generated from the Fengyun-1C (FY-1C) anti-satellite test conducted by China in 2007.

National Security

Some countries have military or intelligence satellites in orbit which are critical to their national security. Tracking objects in space can help these countries identify potential threats to their satellites and take measures to protect them. Many nations have improved and tested means to attack satellites, including missiles fired from a high-flying combat aircraft to sophisticated self-manoeuvring satellites visiting distant but critical satellites in Geostatic Earth Orbit (GEO).

Space Exploration

As we explore space, we are launching more and more objects into orbit. Tracking these objects is critical for ensuring that they don't collide with other objects, and for safely navigating crewed spacecraft. This is especially true for Low Earth Orbit (LEO) satellite placement, as rather than 'punch through' the debris layer, it must move through it to reach its intended destination.

Environmental Concerns

Space debris can contribute to the build-up of space junk, which can pose a risk to spacecraft and even the International Space Station. By tracking these objects, we can better understand the impact of human activity on Earth's orbit and take measures to mitigate potential environmental harm.

Monetization

Space debris tracking is primarily a responsibility of government agencies and international organizations concerned with space activities. It is not typically monetized directly, but rather funded through government budgets or international cooperation. Frost & Sullivan believes that SST will become increasingly valuable to competing NewSpace companies and start-ups. Orbit data, enabled by investment in SST infrastructure will generate increasing returns, potentially offsetting financial risk in the wider NewSpace market.

SST Capability Delivery & Development

SST is a capability derived from a production line running from observation for data collection to SST-enabled products and services. Sensors such as radars and optical are the primary source of SST data. The data obtained must then be analyzed and classified against an up-to-date catalogue. The data so obtained is used to task sensors further, or to provide various products and services. For example, the USSPACECOM operated Space Surveillance Network (SSN) is widely recognized as the most comprehensive SST system globally. The SSN consists of a global network of phased array radars, conventional radars, electro-optical sensors consisting of telescopes linked to video cameras and computers, Low Earth Orbit (LEO) based satellites with optical, Ultra Violet, and very long-range IR sensors, plus 'Ground-Based Electro-Optical Deep Space Surveillance (GEODSS)', for deep space objects. Other countries who are active in developing SST capabilities are: France, Germany, Italy, UK, and Spain in Europe, with Australia and Japan in the Asia-Pacific also developing good SST capabilities.

The commercial position of Government agencies that run SST capabilities (e.g. USA, EU, Russia and China, France) depends on local legislation, and that commercial position is expected to change, offering opportunities for new entrants, even when core SST services are free of charge. For example, the US makes surveillance data available free of charge to US companies, but even so has created a market in data processing and collision warnings for commercial operators.

Operations in GEO are well understood, and it has responsible, large companies providing the services, aware of, and using SST. They are willing to invest significant sums in ensuring that the GEO environment remains viable long-term. In general, they are fee-paying members in data-sharing associations such as the Space Data Association (which costs about $7,500 per satellite per year), but generally rely on free Space Domain Awareness (SDA) services from the US led multinational 'Combined Space Operations Centre (CSpOC)'. GEO congestion is unlikely to increase significantly, though the advent of small GEO satellites is complicating the picture.

LEO operators are in many cases start-ups, with unproven business cases and no steady revenues. As such, they are focused on short-term objectives and tend not to have dedicated SST personnel. This could be because LEO is adjudged to be a "self-cleaning" orbit, requiring no corrective action by many companies. SST coverage costs per satellite are much higher in LEO than in GEO; perhaps $4,000 per month per satellite in LEO. Take-up of these SST services is currently relatively low, but is likely to change, as the market is significant with many offerings already available. In fact, by 2037 the total SST market is expected by Frost & Sullivan to reach approximately US$ 2,474 million with the market averaging around US$ 210 million between 2028 - 2037. The majority of the market valuation will be driven by large constellations in the LEO orbit for companies such as SpaceX and Amazon, that will require some form of SST services by 2028.

Monetization

As alluded to already, the primary motivation behind space debris tracking is to ensure the safety and sustainability of space operations and mitigate the risks posed by space debris to satellites, spacecraft, and astronauts. However, there are some indirect ways in which space debris tracking can generate revenue or be associated with 'Monetization'. Recent Frost & Sullivan work has identified many, such as the following revenue growth opportunities:

Satellite and Spacecraft Protection

Companies and organizations that operate satellites or spacecraft in Earth's orbit may invest in their own tracking systems or purchase data and services from existing tracking entities. By monitoring the positions of space debris, they can take proactive measures to avoid collisions, prolong the lifespan of their assets, and minimize potential damages. In addition, the orbital data catalogue can be sold, bartered, traded, or licenced for money, or to gain orbit data outside their own SST systems part of the sky.

Space Insurance

Insurance companies that provide coverage for satellites and spacecraft may utilize space debris tracking data to assess risks and determine insurance premiums. Accurate tracking information allows insurers to evaluate the probability of collisions and estimate potential damages, which influences the cost of insurance policies.

Orbit Clearance & Trading

As orbits in LEO become increasingly cluttered through an increasing launch rate, and the exponential increase of fragments from collisions and intentional destruction, it is expected that 'optimum orbits' for an new launch will require checking, and potentially clearance, by emerging new business and technology solutions for debris removal.

Research and Development

Institutions, research organizations, and companies involved in space technologies may engage in research and development related to space debris tracking. They can receive grants, funding, or investments to develop new technologies, algorithms, or techniques for more efficient and accurate tracking. Such R&D efforts can be monetized through licensing, selling products or services, or by offering expertise and consultancy.

Government Contracts

Governments can award contracts to private companies or research organizations to perform space debris tracking on their behalf. These contracts can provide financial compensation for the services rendered, such as data collection, analysis, and reporting.

Public-Private Partnerships

Collaborative efforts between government entities and private companies can be established to share the costs and responsibilities of space debris tracking. In such cases, the government may provide funding or resources to private entities in exchange for specific services, data sharing, or technology development.

Conclusion

It's important to note that while there is definitely potential for monetization in these areas, the primary focus of space debris tracking is safety, and maintaining the long-term sustainability of space activities. Collaboration, cooperation, and responsible practices remain crucial in addressing the challenges posed by space debris.

In conclusion, a recent Frost & Sullivan study found that the SST market is expected to reach $90m in 2023, growing to $370m in 2037 at a Compound Annual Growth Rate (CAGR) of 9.4% split across products and services. This represents a considerable growth opportunity for countries and corporate investment in a capability critical to humankinds' exploration, expansion, and exploitation of Space.

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