“What Space Traffic Management measures must be internationally implemented to improve the safety and sustainability of outer space?”

ABSTRACT

From the past two decades, space sector is witnessing unprecedented advancements - from serving security applications, science and space exploration to commercialization ensuring equal participation of both public and private organizations, coping policy and regulatory challenges. However, all space missions have an operational lifetime after which the spacecrafts essentially become space junk/ derelict objects floating mostly in the lower earth orbits (LEOs) with no *single* operation protocol or strategic disposal implemented globally yet. About 95% of this region is filled with dead and inactive satellites. Most debated issues in this sector include small satellite businesses such as the Megaconstellations, space mining, reusable rockets, liability roles and space debris mitigation measures. This has given rise to the need of solid international Space Traffic Management and coordination measures that could implement a framework allowing multilateral gatherings and sharing of data and address the concerns of long-term safety and sustainability of outer space. Numerous efforts have been put together by various countries at national level that have increased our alertness towards the issue, but at the same time we also need more innovative and economical solutions implemented worldwide soon.

1. What is Space Traffic Management (STM)?

STM is a multifaceted concept of planning, coordination and on-orbit synchronization of space exploration activities incorporating emerging norms, best practices and implementation of both national and international regulations while enhancing the safety, sustainability and stability of operations in the space environment (Moranta, 2020). International Academy of Astronautics (IAA) defines this as a set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space and return from outer space to Earth free from physical or radio-frequency interference (Jorgenson, 2006), but this has become an umbrella term nowadays including many more operations.

2. Why is it important and how is it related to Space Safety and Sustainability?

Both old and new space activities such as Megaconstellations (e.g. SpaceX's Starlink with 12000 nodes) and microsatellite missions (e.g. CubeSats) for global broadband internet services, communication and military purposes are mostly operated in lower earth orbits (LEOs) regime of less than 2000 kms above Earth's surface, posing a high collision and conjunction risk with either other satellites passing by or old space debris (McDowell, 2020), also making technical maneuvering and proactive planning more challenging. For example, in 2009, a US commercial Iridium satellite smashed into an inactive Russian communications satellite called Cosmos-2251 creating thousands of new pieces of space debris and threatening other satellites in the LEO region. Each day, the US military issues an average of 21 warnings of potential space collisions, a number that is likely to rise dramatically every year (Hainaut, 2020). STM measures are therefore important to avoid such situations in a best possible way and simultaneously ensure the safety and sustainability of our *limited common resource* 'outer space' for not just present, but for all the future missions.

3. What have been done so far to implement this?

Several international and national studies like '*Cosmic Study on Space Traffic Management*', 2006 and '*STM: Towards a Roadmap for Implementation'*, 2017 by International Academy of Astronautics (IAA), *Orbital Traffic Management Study - Final Report*, 2016 by NASA, United States (U.S.) and *Implementation of a European Space Traffic Management System*, 2017 by European Space Agency (ESA) have emphasized the importance of a unified body that can provide traffic rules and multilateral open information system, namely Space Situational Awareness (SSA), improvising the currently well-established Outer Space UN Treaties (Taiatu,2017). Technologically, new sensor systems such as Space Fence (should be operational by end of 2020) will help detect, track and characterize objects in LEOs with 5 times better accuracy than before. Space debris growth mitigation measures like deorbiting and subsequent destruction upon reentry, post-mission self-removal to the graveyard orbit and external removal to a central station via remotely controlled vehicles have been extensively researched and implemented with both successes and failures (G Peterson, 2018).

4. How can we improve this with international collaboration and efforts towards STM?

What we need today is a collaborative effort towards the implementation of a balanced approach to the most feasible and robust space safety and sustainability methods internationally. There should be ONE authoritative catalogue that accurately lists the orbits, potential threats, physical types and dimensions of all known space debris created so far in the human history, helping the operators to do informed maneuvers and better planning of mitigation methods (Ailor, 2014). To maintain an acceptable debris environment, not just mitigation but active remediation of debris is also required. Most LEO objects and small satellites can be safely friction-burnt in the atmosphere while their fall toward Earth. For higher altitude and large satellites, it takes less fuel to blast it farther into space than to send it back to Earth- but this aggravates the situation! (Witze, 2018). Rather we should take advantage of passive approaches that utilize gravitational resonances with the Sun and the Moon to put satellites off-orbit toward the Sun leading to their eventual self-destruction (Muelhaupt, 2019). There is tremendous development scope for ideas such as Space Pods and Recycling Satellites. Space Pods will be nuclear-powered space stations operational up to 15 years designed to knock the junk out of orbit back down to the Earth, letting it either burn in the atmosphere or sink into the ocean. Recycling of satellites will build on the idea that dead satellites in grave-yard orbits could be 'mined' by other nanosatellites for reusable components to complete their own construction through latching. Biggest caveat is that even the graveyard orbits have limited space and is not an ultimate disposal solution. Innovations such as Giant Lasers, Space Balloons and Wall of Water to slow debris down and help it enter the atmosphere have a lot of potential but need to be weighed in terms of long-run feasibility. One such novel idea in my mind is to launch a SINGLE Recycling Station (just like ISS) that could be used as a final destination for all the defunct objects and has a facility to reprocess/urban space mine it's material in an environment friendly manner. At this site, a decision could also be made about which stuff to send toward the earth for friction-burning, which to send toward the Sun for heat-burning and which to melt/reprocess and send back to Earth via a different satellite/rocket for further reprocessing. I believe that this will be tremendously useful in the long-run and soon we will have sophisticated techniques and unanimous approval to achieve this.

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