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ORBITAL ENVIRONMENT SHELL MODELS TO SUPPORT COMPLIANCE WITH UN SUSTAINABLE DEVELOPMENT GOALS

Abstract

Orbit overcrowding and space debris will be an increasing problem as the international space industry grows, especially for Low Earth Orbit (LEO) due to its many applications such as Earth Observation (EO). EO is used to assist intergovernmental sustainability goals. This paper examines orbit collision probability calculations, along with other sustainability factors relating to EO for 25km orbital regions, referred to as shells. Shells will be given a sustainability rating from collision likelihood and ability to contribute towards goals from usefulness to EO missions such as resolution at each altitude. Resulting analysis identifies optimum shells for future constellations to reduce the risk of overcrowding and collisions while increasing the benefit for sustainability.

This is considered in terms of the 17 UN sustainable development goals (SDGs) as it relates to responsible use of orbital space and decommissioning procedures to keep the space community sustainable. EO missions can contribute towards these goals such as clean water, climate action, life below water and on land. To achieve these observation missions satellites may compete for similar orbit space and detract from the sustainability of the space environment, being counter productive for goals such as responsible consumption and production and sustainable cities and communities.

Multiple companies are planning to launch large constellations of hundreds or thousands of satellites in the near future. This will increase congestion in LEO and the risk of collisions and debris generation. In response, existing models have been created to estimate LEO orbital capacity such as the multi-shell, multi-species, source-sink model MOCAT-3, in addition to other alternative methods.

This paper describes a methodology to create a three dimensional model of existing collision probability data, using a model of the Earth and LEO orbital shells to create a clear representation of collision likelihood. Astrodynamics of existing EO missions are plotted and analysed within the context of the probability maps. This is used to comment on the environmental implications of the missions and how they can be improved to better fit SDGs and enables identification of shells to avoid for satellite constellations. Further factors such as carbon cost of launch can also be explored as well as linking back to EO capability such as resolution at each shell. These factors can be weighted and a sustainability score assigned to each region. This contributes to keeping the space environment sustainable and aligning the near future of satellite missions with the UN SDGs.