

19th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Interactive Presentations - 19th IAA SYMPOSIUM ON SPACE DEBRIS (IP)

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ANALYSIS OF POSSIBLE DEFINITIONS OF THE SPACE ENVIRONMENT CAPACITY TO
PURSUE LONG-TERM SUSTAINABILITY OF SPACE ACTIVITIES

Abstract

The ability of space activities to benefit Earth and its people is now threatened by the increasing density of objects in orbit. If no mitigation measures are taken, the population could reach a level in the future at which collisions would continue to increase the number of debris in orbit, even without new launches. Addressing the need for space sustainability means prevent negative trends from becoming norms and ensure that outer space can be used for many years to come. The expansion of space activities offers opportunities to expand access to the benefits of space applications on Earth, but it poses new challenges to maintaining a safe operational environment in space. Space may seem vast, but the orbits around Earth in which satellites reside are a limited natural resource. Like the Earth's non-renewable resources (i.e., minerals and fossil fuels), these unique orbital regions, that are now essential for humanity, exist in nature in a limited way because their regeneration involves the passage of many years.

The topic of sustainability is not a new one, and many studies have been conducted on the Earth's resources over the years. From what has been done and is being done for this problem on Earth, we take the cue to analyse and address a possible application in the space field as well. Particularly, the concept of capacity of an ecosystem is investigated and related to the space debris environment.

In this work a debris evolution model, based on MISSD (Model for Investigating control Strategies for Space Debris) developed by in Somma et al. (2017), is built. The model is a source-sink debris evolutionary model based on a set of first order differential equations, which describe the injection and removal rates of objects in several altitude bands. Explosions and collisions generate fragments via the standard NASA breakup model, while drag, the only natural sink mechanism, is computed through a piecewise exponential model of the atmospheric density. The post mission disposal is the other significant removing mechanism considered in the model.

The evolutionary model is used to study the future trends of the space environment and different definitions of capacity are investigated to find a sustainable future scenario. Various possible thresholds were assumed and checked; values derived from studies of the limits of space environment as well as techniques used on earth regarding limitations of CO₂ and other harmful agents in different domains.