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Policy, Legal, Institutional and Economic Aspects of Space Debris Detection, Mitigation and Removal
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MEGA-CONSTELLATION ANALYSIS: RELIABILITY STRATEGY AND INSURANCE POLICY

Abstract

The work considers the problem of an individual satellite reliability in mega-constellations. It is inspired by many projects that have been announced by significant players of the telecommunications and space sectors (e.g. OneWeb [1], Starlink [2] and some others). Moreover, the issue has been raised before by reinsurance company Swiss Re [3]. Since it is not only the financial metrics of the operator that a malfunctioning satellite affects, but also the acute problem of space debris [4], the research has pointed out the study of the active debris removal (ADR) problem as the second most important goal.

Comprehensive multiparametric mega-constellation operation model has been developed that accounts for the orbital motion, coverage, ground communication, reliability, collision risks, and service consumption in the global telecommunication market. This model allows analyzing possible bottlenecks and weak points of the mega-constellation as a business solution.

Our simulations mainly focused on the effect a satellite reliability has on the services provided by an operator. Several important financial and technical parameters were monitored, such as: cash flow, coverage, revenue, total cost and etc. We evaluated numerically the cost of a satellite loss in orbit or any other kind of emergency. Further on, this model can help evaluating various end-of-life strategies.

We also used the model to assess the business-case applicability for the active debris removal process. We present a strategy for a company to develop ADR services to compensate the risks of satellites failures and possibly augment the operator's business case by replacing and de-orbiting defunct satellites [5]. We have considered a number of scenarios: spare satellites in orbit, ADR tug in orbit, ADR and spare satellites "launch-on-demand" [6].

This step helped to evaluate existing ADR approaches, understand their applicability to the current situation in space sector and assess possible business outcomes of the start-up operation process, based on the considered ADR scenarios. The results we present are based on technologies developed in the ClearSpace [7] project (eSpace/EPFL, Switzerland).

[1] OneWeb non-geostationary satellite system - FCC, 2017 [2] SpaceX non-geostationary satellite system - FCC, 2016 [3] New space, new dimensions, new challenges - Swiss Re, 2019 [4] Simulation of the space debris environment in LEO using a simplified approach - Christopher Kebschull, 2017 [5] Satellite constellation mission analysis and design - Stefania Cornara, 2001 [6] Review of Active Space Debris

Removal Methods - Priyant Mark, 2019 [7] <https://clearspace.today> - ClearSpace project official web, 2019