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ASSESSMENT OF ENVIRONMENTAL CAPACITY THRESHOLDS THROUGH LONG-TERM SIMULATIONS

Abstract

The simulation of the future evolution of the debris population can be used to assess the efficacy of proposed mitigation actions and of current behaviours. This work will look at how the debris environment would evolve if the current behaviour is extrapolated into the future and compare this to a reference scenario (e.g. no-future-launches or one with strict compliance to the Inter-Agency Space Debris Coordination Committee guidelines). This reference scenario is set here as a proxy for a sustainable environment and used to compare how far the current space activity is from such target. The extrapolation of the current behaviour relies on the definition of trends in launch traffic, explosion rates, disposal levels, etc, a data-driven approach based on the analysis of historical data will be presented. The approach is routinely reproducible allowing also for tracking of such predictions over time to further assess the effect of the on-going mitigation actions and launch traffic.

The analysis of such future scenarios will be presented in terms of not only number of objects, but also of their consumption of the space environmental capacity, to reflect that the criticality of scenarios with the same number of objects may be very different, depending on the type of objects, where the objects are located, their manoeuvrability status, etc. The notion of environment capacity was established by linking it with a measurement for the short and long-term interference cause by human space operations on other missions and the potential to trigger a Kessler syndrome. In practice, this means identifying the level of interference deemed acceptable in a sustainable scenario (such as the ones previously mentioned) and compare it with the sum of the individual contributions of each mission over time considering the assumed performance in terms of debris mitigation actions. Besides the application to the scenario obtained from the extrapolation of current behaviours, the approach will be tested considering variations in terms of level of adherence to space debris mitigation guidelines, collision avoidance strategies, and predicted space traffic levels with the aim of identifying the relative importance of these different factors in the computed capacity consumption.

Rule-based traffic models that can support automated processes in tracking the environment capacity consumed are introduced to this end, for example considering the application to the design and operations of a fictional large constellation in LEO, whose measured interference is within the boundaries set by the thresholds on environment capacity.