Low-thrust strategies and implications in the perspective of space debris mitigation for large constellations

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ABSTRACT

The planned future generation of large constellations of satellites in orbit around the Earth considers the application of low-thrust devices for the various phases of the mission. This choice is mainly due to the advantage of reducing the launch mass, possibly increasing the payload mass, while keeping advanced maneuvering capabilities.

The aim of this work is to address the operational aspects and the implications related to the collision avoidance and the end-of-life disposal procedures. On the one hand, we will show how the Gauss planetary equations can be applied to low-thrust maneuvering to avoid a collision and to deorbit. On the other hand, the corresponding consequences on the environment and on the management of the constellations will be evaluated.

The work will focus on the existing proposals for large constellations, which differ mainly in the number of satellites and in the nominal altitude. We will give as study case the Starlink constellation located at 340 km of altitude, the Kuiper constellation at 610 km, and the OneWeb constellation at 1200 km. We will describe the different low-thrust strategies during the complete lifetime of a satellite. In particular, in the case of conjunction warning, we will investigate the most efficient maneuvers in terms of both propellant consumed and time required to change the orbital regime in order to reduce the collision probability until a safety threshold. In the case of deorbiting, different solutions, like direct reentry or satellite repositioning, will be addressed.

The objective will be to provide a tradeoff between the reduced propellant consumption with respect to an impulsive strategy, but also to estimate the possible increase in ground operations or collision risk during the low-thrust phase.