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## MEGA-CONSTELLATIONS VULNERABILITY ASSESSMENT

**Abstract**

In the last years, plans for the deployment of large ( $> 100$  satellites) Low-Earth orbit constellation have been published from several companies. Above all, OneWeb constellation will be composed of 720 operative satellites and about 200 spares, while SpaceX plans to launch about 4000 spacecraft to a 1100 km of altitude orbit. Several other projects are under development for both creating new constellations (e.g. Boeing NGSO System) and upgrading the existing ones (e.g. IRIDIUM-NEXT). Despite their great advantages in terms of reliability and access time, mega-constellations must be monitored due to their influence on the space debris environment: the presence of a large number of satellites increases collisions probability and deorbiting strategies must be implemented to avoid further crowding highly packed orbits. In this contest, the analysis of the mega-constellation vulnerability is a powerful tool for defining the hazards for the space environment as well as evaluate the proposed solutions for satellites survivability and end-of-life strategies. It must be underlined that if catastrophic fragmentation threshold is fixed by the EMR criteria (that, for microsattellites, gives a critical debris size of about 5 cm), smaller debris (in the class  $> 1$  mm) may cause partial failures that may influence the EOL deorbiting operations. For this reason, vulnerability assessments are performed for three debris size classes ( $> 1$  mm,  $> 1$  cm,  $> 10$  cm). In this work, a simple tool for mega-constellations vulnerability assessment is introduced, as well as its application to two reference cases; the results in terms of impact probability are reported with particular attention to their dependence on the constellations main parameters (i.e. operational life, number of satellites, spacecraft cross section).