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EVALUATING THE ENVIRONMENTAL CRITICALITY OF MASSIVE OBJECTS IN LEO FOR DEBRIS MITIGATION AND REMEDIATION

Abstract

Approximately 95% of the mass in Earth orbit is currently concentrated in about 6500 intact objects, of which nearly 80% are abandoned and more than 90% cannot be maneuvered. The intact objects abandoned in Low Earth Orbit (LEO) above 650 km, i.e. with an average residual lifetime of more than 25 years, represent the main potential mass reservoir for the generation of new detrimental orbital debris in case of mutual collisions with the existing debris environment, taking into account that an 800 g impactor may be sufficient, in principle, to shatter a 1000 kg spacecraft or rocket stage. Since the 1980's, several mitigation measures were promoted and agreed at the international level in order to prevent the occurrence of new breakups in space and put under control the accumulation of mass abandoned in orbit, but unfortunately the level of compliance with such guidelines, requirements or standards is still far from satisfactory. Moreover, the appearance on the scene of space activity of new private and government actors from a growing number of countries makes the proper management of the circumterrestrial space a task of increasing complexity, taking also into account the rapid emerging of new potential applications, disrupting technologies and operational approaches quite different from the past. In this rapidly evolving environment, it might be useful to have a simple and flexible instrument for evaluating, over a temporal horizon of a few decades from now, the potential criticality for the environment of massive objects placed or abandoned in LEO. Having in mind this goal, in the last few years we concentrated our attention on the development of some "criticality indices", then applied to evaluate many families of rocket bodies and selected spacecraft. With the underlining ambition to be simple, intuitive and relevant, from a environmental point of view, one of these indices was coherently applied in order to assess the potential criticality of the most massive objects abandoned in LEO. The results obtained are presented here, also highlighting how this ranking might be used both for debris mitigation, for instance to choose the operational orbit of new spacecraft to be launched, or the disposal orbit of either spacecraft or upper stages to be dismissed, and for debris remediation, as a guide in the selection of the most appropriate targets for active debris removal, if and when such missions will become practicable.