Re-entry strategies to comply with Space Debris Mitigation guidelines

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ABSTRACT

The rising concern of space debris has driven guidelines to limit and reduce their creation in the future. One of the key requirements lies in the removal of space objects from protected regions within 25 years following the end of their operational life. LEO below 2000km altitude is particularly concerned, as it remains a favored region for many types of space missions, it is getting easier and easier to access it for a growing number of space-fair nations, and it will soon welcome several mega-constellations.

Complying with the Space Debris Mitigations guidelines requires changes in the design of the satellite in many aspects, and specifically in the propulsion systems. Indeed, the propulsion system used to de-orbit the spacecraft will drive the type of re-entry achievable, controlled or un-controlled re-entry. The choice between these two options depends on the casualty risk: un-controlled for below 1/10000 risk and controlled above this threshold.

Performing controlled re-entry has many advantages, though it is challenging. Because of the complex and changing interactions between the atmosphere and the debris, the longer the debris stays in the atmosphere, the more difficult it is to predict accurately the fallout area on-ground. Indeed, in order to perform controlled re-entry, the debris has to enter the atmosphere with a steep angle making the predictions for the fallout area more accurate.

A controlled re-entry is feasible with propulsion systems having powerful enough thrust, meaning that electrical propulsion systems are not sufficient and would require an extra system. Different combinations of systems have been studied, considering classical options – monopropellant in blowdown mode or actively pressurized, Hall Effect Thrusters and Arcjets – to evaluate the impact on the overall system from a mass, cost and reliability point of view, while considering other constraining factors, such as acceleration, gravity losses, temperature and pressure changing inside the tanks, thruster constraints, etc.

This study now provides ESA quick and simplified guidelines when it comes to choosing the most relevant – combination of – propulsion systems for a given mission and payload, as well as evaluating roughly the impacts of these options on the overall mission.

Keywords: Space Debris Mitigation, ESA, Clean Space, un-controlled re-entry, controlled re-entry, propulsion system