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A COMPARATIVE REVIEW OF 2D AND 3D DRAG SAIL GEOMETRIES FOR SATELLITE DEORBITING

Abstract

As the number of satellites in LEO is growing rapidly, we need effective deorbiting strategies for space debris mitigation. Drag sails offer passive deorbiting, and they are also reliable, clean, and cost-effective solutions by using atmospheric drag forces to accelerate deorbiting. While 2D drag sails such as rectangular and triangular designs are widely used because of their simplicity and proven performance, 3D drags sails including tetrahedral, conical, parachute-like, and spherical geometries offer potential advantages in deorbiting efficiency and aerodynamic stability.

In this paper, we explore a comparative analysis of 2D, and 3D drag sail geometries by evaluating the deorbiting efficiency based on drag performance, deployment feasibility, and aerodynamic stability. The most common 2D drag sail designs are rectangular and triangular sails, offering simple deployments and lightweight structures, but providing suitable orientation is a must for high drag efficiency. On the other hand, 3D drags sail designs like tetrahedral and conical sails provide more aerodynamic stability because of their self-orienting nature. Other 3D designs such as parachute-like and spherical sails can provide maximum drag by providing uniform aerodynamic resistance without considering the satellite's attitude.

A comparative analysis is developed to assess each of 2D and 3D geometry's pros and cond. The study highlights that 3D sails surpass 2D sails in general by providing higher drag efficiency and stability, but they provide more complex deployment mechanisms. The findings of this study aim to support future design and selection of drag sail geometries for satellite missions, ensuring compliance with the new regulations and providing more sustainable, clean, and cost-effective deorbiting solutions.

Keywords: Satellite deorbiting – Space debris mitigation – Drag Sails – Low Earth Orbit (LEO) – Space sustainability.