

SPACE DEBRIS SYMPOSIUM (A6)
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DESIGN AND ANALYSIS OF A DRAG SAIL TO DE-ORBIT LOW EARTH ORBIT SATELLITES

Abstract

A major issue in space exploration is space debris caused by defunct satellites, satellite collisions, spent rocket stages, fragments from disintegration and erosion. It is essential to cause disintegration of spent satellites in a manner that de-orbits them to clean up the low earth orbit and prevent increasing contamination of space with time. This paper proposes an innovative and simple solution to mitigate potential space debris caused by satellites. India's first twin nano satellite programme STUDSAT-2 has been undertaken by a group of undergraduate students. STUDSAT-2 consists of satellites STUDSAT-2A and STUDSAT-2B, each with dimensions 300300150 mm and weighing 7 kg. A drag sail with a very compact packaging and deployment mechanism has been designed to be employed on STUDSAT-2B to facilitate quicker de-orbiting. The sail increases the effective area for enhancing the drag force experienced by the satellite. The drag force acting on the sail causes deceleration of the satellite, hence, the centrifugal force of the satellite reduces and it is pulled towards the earth. As the satellite nears the earth, the drag force experienced by it is raised due to increasing atmospheric density. The increasing friction with descending altitudes eventually causes the satellite to incinerate. Packaging and deployment is the biggest challenge in designing a drag sail. Our mechanism involves booms of a sail that are kept compactly wound around a small cylinder which are released by an escapement mechanism. A thin Mylar or Kapton film between the booms unfurls into a planar umbrella and on unfolding utilises atmospheric resistance to slow down the satellite akin to a sail. The proposed design occupies a planar volume. It can therefore be placed on any side of a satellite that is normal to the velocity vector, without interfering and allowing space for other subsystems. Through iterations of finite element analysis, the drag sail system has been designed to withstand the launch loads and operate under extreme space conditions. In keeping with the finest traditions of mechanical engineering an attempt has been made to dispense entirely with the need for electrical energy in operation of this sail.