Paper ID: 10022
oral
student

SPACE DEBRIS SYMPOSIUM (A6)
Mitigation and Standards (4)

Author: Dr. Charlotte Bewick
OHB System AG-Bremen, Germany, charlotte.bewick@ohb-system.de

Dr. Camilla Colombo
University of Southampton, Italy, camilla.colombo@polimi.it
Prof. Colin R. McInnes
University of Strathclyde, United Kingdom, colin.mcinnes@glasgow.ac.uk

A PASSIVE SATELLITE DEORBITING STRATEGY FOR MEO USING SOLAR RADIATION PRESSURE AND THE J2 EFFECT

Abstract

The growing population of space debris poses a serious risk to the future of space flight. To effectively manage the increase of debris in orbit, end-of life disposal has become a key requirement for future missions. This poses a challenge for many small satellites which cannot carry an active propulsion system because of their complexity and the increased risk to the main payload when launching as “piggy-back” with larger spacecraft.

This paper assesses the feasibility of a new passive strategy for the de-orbiting of small spacecraft from high altitude orbits. A large reflective balloon is deployed at the end-of-mission to increase the area-to-mass ratio of the spacecraft and thus the effect of solar radiation pressure (SRP) and drag. As opposed to conventional drag-increasing devices, which only enhance the effect of aerodynamic drag to decrease the orbit energy, the proposed strategy can be applied to circular orbits of high initial altitude well above the Earth’s sensible atmosphere. In the first phase of the decay sequence only SRP and the J2 effect are exploited to increase the orbit eccentricity until the perigee reaches the upper atmosphere. In the second phase the spacecraft then de-orbits due to drag. Besides of its low cost the proposed approach also has the advantage that the de-orbit process occurs passively after deployment of the balloon, solely through the effect of natural perturbations and thus no further control is required and so even a highly damaged satellite will be successfully de-orbited.

Previously a Hamiltonian approach was used to analytically model the evolution of in-plane orbits under the influence of SRP and J2 and to determine the required area-to-mass ratio to de-orbit a spacecraft from a circular orbit. In this paper the preliminary result is validated by numerical propagation of the full orbital dynamics in three dimensions through Gauss equations considering SRP, J2 and aerodynamic drag as well as the influence of eclipses. The revised minimum required area-to-mass ratio and decay time is computed for different initial semi-major axes and compared to the analytical results.

Moreover, a system design of the de-orbiting device is performed for different spacecraft sizes, from CubeSat up to satellites of 100 kg mass. The resulting mass and volume ratio of the stowed device to the total spacecraft mass is then calculated. The proposed design is compared to conventional de-orbiting strategies using thrusters to supply the required Δv.