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SPACE DEBRIS SYMPOSIUM (A6)
Modelling and Risk Analysis (2)

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ORBITAL DYNAMICS OF LIGHTWEIGHT FLEXIBLE DEBRIS

Abstract

In 2004, an unexpected space debris population was detected: the objects had the same orbital period as geostationary orbit (GEO), but exhibited high eccentricity and rapidly changing orbital parameters. The objects were identified as being very high area-to-mass ratio (HAMR) debris. Scientists explored their origins, and one of the hypothesis that has been considered is multi-layer insulation (MLI), separated from the spacecraft due to fragmentation events or delamination. These objects, like any other debris, pose a collision hazard for active satellites, both in GEO and in other orbits that cross the ones of the debris. HAMR debris objects have been studied as rigid bodies previously, coupling the equations of attitude and orbital dynamics. This assumption, however, is not fully justified for the MLI, which as mentioned before, lacks almost any structural strength. Large sheets of MLI are very flexible, and the change in geometry due to their flexibility can affect the effective area -to-mass ratio (AMR). It is therefore expected that small forces and moments will produce deformations resulting in changes to its geometry and consequently its AMR and ensuing SRP acceleration. The deformation can be induced by forces acting differently on different parts of the object. They can either be external forces, due to SRP, drag, electromagnetic fields, or internal, due for example to centrifugal and Coriolis forces. This, in turn, affects the impact that perturbations such as SRP will have on the orbital parameters, in a way that is difficult to predict. The aim of this paper is to define a simplified but effective model to represent the deformation of such debris, subject in particular to torques caused by SRP forces. This model adds a further set of dynamical equations into the attitude and orbital equations; the resulting system is then numerically integrated to better evaluate the coupling between orbital and attitude dynamics. Due to a more precise estimation and prediction of the actual shape and orientation of the debris at any given time, the effects of the perturbations on the orbit can be computed more precisely, leading to improvements for the long-term prediction of the orbit. Results will be shown for debris in GEO, geosynchronous and medium Earth orbits.