SPACE DEBRIS SYMPOSIUM (A6)
Space Debris Removal Technologies (5)

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DEPLOYMENT DYNAMICS OF THROW-NET FOR ACTIVE DEBRIS REMOVAL

Abstract

The geostationary orbit (GEO) has a high strategic value for telecommunication, TV broadcasting and weather forecasting satellites. The unique operational characteristics of GEO require that all satellites are constrained to the same narrow corridor of space. In order to preserve this resource for future satellite operations, users have been encouraged to boost their satellites to a graveyard region about 300 km above the GEO at the end of life. However, more than 40% geostationary satellites are not re-orbited at the end of their lives for some reasons. Given that there is no natural sink for objects at GEO altitude, the collision risk will continue to rise due to the increasing number of objects in the corridor, unless some mitigation measures can be implemented.

There are some concepts proposed for active space debris removal. Throw net is one feasible measurement to catch space debris. However, it is difficult to model the dynamics of the net for its complex dynamic characteristics such as nonlinear and large deformation. One approach regards the net as continuum and describes elastic deformation with floating frame of reference, but it cannot effectively deal with the effect of the large deformation and gravity gradient; another approach regards the net as consisting of relatively short springs or links connected to each other by means of revolute joints, it also neglects effect of gravity gradient, and cannot show the stress details of the flexible net. In this manuscript, the flexible net is modeled based on the absolute nodal coordinate formulation (ANCF), which applies absolute displacement and global slopes as element coordinate, and brings constant and symmetric mass matrix without the centrifugal and Coriolis forces. Since the orbit radius is much greater than the displacement of the flexible net, the earth-centered inertia frame and a floating frame that is attached to the net and whose axes are parallel to the earth inertial coordinate are used to build the flexible muti-body equation of the net based on ANCF. The orbit motion is calculated with respect to the earth inertia frame, and the shape and stress of the net is calculated with respect to the floating frame. Then, the characteristics of a space flexible net, such as shape and strain distribution during deployment, are investigated for the debris removal mission. Simulations are conducted to validate the effectiveness of the theoretical analysis.