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MODELING FOR ELECTRODYNAMIC TETHER WITH HIGH-FIDELITY AND HIGH-EFFICIENCY

Abstract

The electrodynamic tether (EDT) is one of the most potential techniques for removing space debris due to the merits of low mass, compact size, propellantless, ease of operation and low cost. Up to now, a number of tethered spacecrafts have been launched to perform the demonstration of core EDT technologies, such as TSS-1, PMG, TSS-1R, T-Rex, and KITE.

In order to characterize the motion of EDT accurately, it is necessary to consider the flexibility of tether as well as high order environmental perturbation effects, such as high order geomagnetic field, gravitational field, drag force, solar radiation pressure and thermal flux effect. Previous work, however, have shown that it will cost large computational power if such a high-fidelity model has been considered, especially for long-term simulation.

Motivated by previous researches, this paper aims at increasing the simulation efficiency of a high-fidelity model of the EDT system in which the tether is regarded as a multibody system and multiple environmental forces are included precisely. The main contents of this paper are summarized below:

1. The high-fidelity model is developed by considering flexible dynamics of the tether and precise environmental effects with the latest models for atmospheric and plasma density, as well as high order gravitational and geomagnetic field.

2. Since the flexible tether is divided into a number of segments with a large number of degree of freedom (DOF), a recursive method of multibody system is employed to increase the simulation efficiency.

3. Comparisons are made between the traditional model and the proposed model in this paper to show its efficiency. The computational complexity of the proposed model is linear with the DOF of system while the traditional model is cubic, so the former is more efficient than the latter especially with large DOF.

The results obtained in this study will show an enhancement to computational efficiency, especially for long-term dynamics simulation of the EDT system. The contributions made by this study will complete the knowledge of dynamics of EDT with high-fidelity model.