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EVALUATION OF A SIMPLE BARBER POLE BRAKING MECHANISM IN THE DEPLOYMENT OF BARE CONDUCTIVE TETHER FOR DEBRIS REMOVAL

Abstract

The Japan Aerospace Exploration Agency (JAXA) has been investigating Electrodynamic Tether (EDT) system as an effective means for de-orbiting existing debris. EDT is high-efficiency propulsion system to generate a Lorentz force by the interaction with the Earth magnetic field and make space debris re-enter the atmosphere. It is necessary to deploy a bare conductive tether several kilometers in length in order to obtain sufficient thrust for large debris removal. In this deployment phase, the increases in the deployment velocity and the in-plane libration due to the influences of the gravity gradient and the Coriolis force become issues. Consequently, there is a possibility that the behavior of the tether becomes unstable or the tether is severed by the tension over the withstand load. From the middle to the end phases of deployment, the deployment velocity and the in-plane libration should therefore be controlled by a simple braking mechanism without stopping tether deployment. In some previous ight experiments, a barber pole braking mechanism was adapted as the simple braking mechanism consisting of a motor and wheels, the pole winding the tether to acquire effective braking force. However, the braking mechanism hasn't used for tether deployment with a relatively heavy satellite or a conductive bare tether. In the above tether deployment, a braking mechanism should also have simple braking law from the viewpoint of control. The purpose of this study is to evaluate a simple barber pole braking mechanism with a net-type bare conductive tether. On-ground tests for the braking mechanism using the net-type bare conductive tether and numerical simulation of tether deployment are conducted in order to evaluate the characteristic. First, we estimated braking force and its applicable limitation based on on-ground tests with a tension meter and a drum-type winding motor. In addition, the difference between measured and calculated values is compared. Next, numerical simulations about deployment dynamics on orbit are performed in order to evaluate the braking mechanism. A tether is modeled as a lumped mass to take into account tether flexibility, and the gravity gradient force and the Coriolis force are considered. In the numerical simulations using the measured parameters from the on-ground tests, a 10-km-long tether is deployed, and the changes in the form of the tether and the tether oscillations are also calculated. It was shown that a barber pole braking mechanism was effective for debris removal.