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INVESTIGATION OF ON-ORBIT ELECTODYNAMIC TETHER DEPLOYMENT BY GROUND EXPERIMENT AND NUMERICAL SIMULATION USING A DETAILED FRICTION MODEL

Abstract

The pollution of the space environment by space debris is one of the most serious problems in space. As an effective means of removing space debris growth, the Aerospace Research and Development Directorate of the Japan Aerospace Exploration Agency (JAXA) has been investigating an active space debris removal system that employs highly efficient Electrodynamic tether (EDT) system for de-orbit into a disposal orbit. An electromotive force is set up within conductive net-type bare tethers deployed from space debris as it moves through the geomagnetic field around the earth. If a pair of plasma contactors at either end of the tether emits and collects electrons, the circuit is closed via the ambient plasma and an electric current flow through the tether. The interaction between the current and the geomagnetic field then generates a Lorentz force on the tether which acts opposite to the direction of flight. In some previous tether flight experiments, tether deployment stopped halfway because the deployment friction was greater than expected. The force was modeled by means of an experiment that was done by end-mass installing the tether inside on an air table. But the model is a liner function of deployment velocity. It needs to estimate the force in detail by other experiments. Thus this study investigates the deployment friction and deployment dynamics in numerical simulations. First, we estimated deployment friction by means of a deployment experiment using a high sensitivity force sensor. The sensor was used for hanging reel case installing the tether and measured the severity and behavior of the force directly. By this experiment, we found the friction tends to vibrate according to tether deployment and tangle among tethers often stops tether from deploying. Next, tether deployment using the EDT mechanism proposed for the flight demonstration was analyzed by numerical simulation. The tether was modeled as a lumped mass by dividing it into point masses connected by segments consists of a spring and viscous damper to consider tether flexibility. This simulation showed the vibration tendency of the deployment friction according to tether deployment has a low influence on the deployment and if the end-mass doesn't has initial velocity enough, tether deployment will be stopped by the tangle.