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TETHER FORCE TRANSMISSION CAPABILITIES FOR APPLICATIONS AT ACTIVE DEBRIS REMOVAL MISSIONS

Abstract

The necessity of the removal of inactive spacecraft has been proposed for more than 20 years. In several studies many different concepts have been developed. Most of the concepts, with exception of ground based ones, can be divided into concepts with a flexible or rigid link between the chaser and the target. A flexible link is a promising solution for an ADR mission, as it does not need a specific docking interface or linking port as in missions with a rigid link. But the control and stabilization of the target after capture is much more ambitious. The target object, an old rocket upper stage or non functional satellite, might rotate or tumble. All maneuvers have to be performed by the chaser; the tether transmits the maneuver to the linked target. The aim is a fast stabilization of the target for a safe and secure de-orbiting to avoid for example a collision of the chaser and target in space that.

For the prediction of the motion state of the target after the chaser performed a maneuver (e.g. thruster firing) it is required to determine the force and direction the maneuver imposes on the target motion. Also the transit time of a maneuver signal between chaser and target needs to be determined. Therefore a tether signal/force transmission model is under development/improvement at the Institute of Space Systems of the University in Brunswick.

In the model the flexible link is represented by a discrete spring-damper-model. So it is possible to consider damping effects and the flexural stiffness of the tether material. Additionally the tether model can differ between longitudinal and transverse transmission of the force signal within the tether. Most of the transmission effects depend on the selected tether material, the diameter and length. So different material types like Dyneema® or Kevlar are saved in a material database. Differences and dependencies of the occurring transmission effects of the material are presented within this paper.

Through this paper consolidated findings shall be attained how tethers transmit forces. Different aspects as transmission transit time, occurring oscillation, damping effects and Elastic modulus are considered. With the knowledge respectively a model of tether transmission the development of control algorithms is supported and a more precise determination of the targets motion state is possible. With the model it is possible to determine the tether motion/damping effects and the intensity of chaser control maneuvers transmitted to the target.