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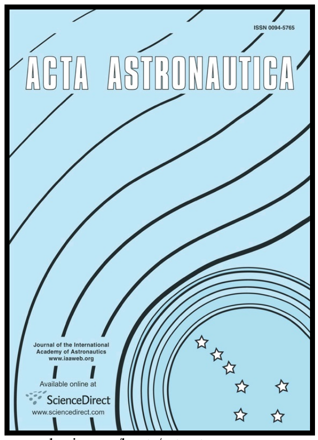

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Swing Principle for Deployment of a Tether-assisted Return Mission of a Re-entry Capsule

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Abstract. Dynamics and control of a tether-assisted return mission of a re-entry capsule are considered. Efficiency of the braking process of the capsule depends on a deflection angle of the tether from a local vertical before separating the capsule from the tether. The aim is of this paper to find a tether length control law that allows to increase the deflection angle of the tether from the local vertical. The control law is based on a principle of a swing. This control law may be applied to the final phase to two possible options to perform a tether-assisted deorbit maneuver: static and dynamic release. An approximate analytical solution for the deflection angle from the local vertical is obtained for the control law. The numerical simulations have shown that the application of the control law allows a reduction in the required tether length of a tether-assisted deorbit maneuver. The proposed control law can be applied to develop new space tethered systems.

Keywords: Tethered satellite systems; Re-entry capsule; Swing; Tether length control law

1. Introduction

Space tethers have received more attention in recent decades, with many articles and books [1-3] available. The fundamental paper by Beletsky and Levin [1] played an important role in providing the basis for the study of tethered system dynamics. Tethered systems offer numerous benefits to modern spacecrafts. One central advantage is that they use less fuel. Another advantage is that tethers allow payload delivery from the Earth's orbit [1-7]. There are two essentially different approaches to the tether release with the re-entry capsule: static and dynamic deployment [4]. Static deployment is the slow release of the tether close to the local vertical. Dynamic deployment means that the decrease of payload velocity comes from the swinging of the tether impacted by the Coriolis force acting on it [4]. Successful experiments of payload delivery occurred in 1993 and 2007 [5-7]. The 1993 mission, SEDS-1, used static deployment, while the 2007 mission, YES2, used dynamic deployment. The YES2 mission was demonstrated an ability to return a re-entry capsule to the Earth using a tether. Using a swinging tether releasing the re-entry capsule from an end of vertical tether 30 km below mother satellite orbit provided braking the re-entry capsule.

The aim of this paper is to develop a control law for the final phase of the deployment of the tether system for payload delivery to Earth's surface. This leads to an increase of a deflection angle of a tether from a local vertical and hence reduces perigee altitude of a re-entry trajectory of a capsule [7]. This control law is based on the principle of a swing and the control law should be applicable in cases where the initial deployment was performed in static or dynamic modes. In

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