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DYNAMICS OF A PLANET-TETHERED SPACECRAFT

Abstract

Studies of motions of a Moon-tethered spacecraft began long ago [1,2]. They show a large variety of possible applications, especially in new Moon and Deep Space exploration programs. Recently, we obtained some new results on station's equilibrium, including the conditions of stability for some spacecraft orientations [3-5].

Here we consider dynamics of spacecraft tethered to the surface of a planet, planet moon or asteroid. We study the possibility to provide some particular solutions to the equations of motion for future application as nominal motions in the respective control system. We show that these solutions can be implemented by variation of the system's parameters, e.g., the length of the tether.

The equations of motion are written in the Lagrangian form and then studied aiming to find a control function that causes a prescribed motion. Stability of the system is analyzed numerically by examination of the monodromy matrix in combination with the qualitative techniques for ordinary differential equations.

The analysis of motion of a planet-tethered satellite in the framework of the restricted elliptical three-body problem shows that, despite the orbits eccentricity, a proper change of the tether length results in a solution of the equations of motion that correspond to fixed orientation of the tether with respect to the axis connecting the attracting centers.

The results of this study promise many technological applications. The steady-state, periodic, and other particular motions of the surface-tethered spacecraft can be used in several control systems, e.g., for planet elevator, for communication satellite collocation, and for a payload delivery to the libration points.

[1] J.Pearson "Anchored Lunar Satellites for Cislunar Transportation and Communication," Journal of the Astronautical Sciences, Vol.XXVII, No.1, 39-62, 1979.

[2] E. Levin, Dynamic Analysis of Space Tether Missions, Advances in the Astronautical Sciences, Vol.126, 2007.

[3] I.I. Kosenko and S.Ya. Stepanov, Stability of relative equilibria of an orbit tether with impact interactions taken into account. The unbounded problem. Mechanics of Solids. 2006, Vol.41, No.4, 64–72.

[4] A.A. Burov and I.I. Kosenko, On relative equilibria of an orbital station in regions near the triangular libration points, Doklady Physics, 52(9), 2007, 507-509.

[5] A.A. Burov, O.I. Kononov, and A.D. Guerman, Relative equilibria of a Moon - tethered spacecraft, Advances in the Astronautical Sciences, 2011, v.136, 2553-2562.