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THE DYNAMICS OF TETHERED DEBRIS WITH FLEXIBLE APPENDAGES AND RESIDUAL FUEL

Abstract

Further space exploration is impossible without solving the problem of cleaning space from orbital stag, nonfunctional spacecraft and their elements. It is difficult to find more important international problem as cleaning space debris. The removal of space debris with flexible appendages and some fuel residues is complex problem. The possibility of a vibration of the flexible appendages should be considered that may leads to the destruction of the spacecraft and the emergence of an even greater number of small fragments. Removal of debris can be carried out by space tug, balloon, electrodynamics cable, solar sail, etc. The active debris removal technique is considered that intend to use a space tug or a balloon attached by a tether to space debris.

This paper focuses on the dynamics of the space debris with flexible appendages and some residual fuel. We considered removal of the space debris by means a space tug and a balloon separately, and a hybrid scheme with the consistent use of the space tug and the balloon. The equations of motion around the center of mass of the system which involves space debris, a tether and a space tug or a balloon are written using Lagrange formulation. The motion of the system's center of mass is described in terms of osculating orbital elements. Several numerical examples are presented to illustrate the mutual influence of the oscillations of the flexible appendages and the oscillations of the tether. It is shown that flexible appendages can have a significant in influence on the attitude motion of the space debris and to the safety of the transportation process. The proposed mathematical models can be used to develop and analyze on-orbit operations using tethered space tug or balloon including servicing missions and large space debris removal missions. This paper develops results obtained in [1-4].

[1] V.S. Aslanov and A.S. Ledkov, Dynamics of the Tethered Satellite Systems, Woodhead Publishing Limited, Cambridge, UK, (2012) 350 pp.

[2] V.S. Aslanov, V.V. Yudintsev, Dynamics of Large Debris Connected to Space Tug by a Tether. Journal of Guidance, Control, and Dynamics, (2013), Vol. 36, No. 6, pp. 1654-1660.

[3] V.S. Aslanov, V.V. Yudintsev, Dynamics of Large Space Debris Removal Using Tethered Space Tug. Acta Astronautica, 2013, Vol. 91, October-November, pp. 149-156.

[4] V. S. Aslanov, A. S. Ledkov, Dynamics of towed large space debris taking into account atmospheric disturbance. Acta Mechanica, (2014), doi: 10.1007/s00707-014-1094-4 (accepted for publication).