IAF ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (1) (3)

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TETHERED TOWING LARGE SPACE DEBRIS WITH FUEL RESIDUES BY A SMALL SPACECRAFT-TUG

Abstract

The problem of space debris mitigation is one of the most important problems of modern astronautics. Among existing projects and studies, a special place is occupied by an active removal of large space debris, which includes non-functional satellite and upper rocket stages. Many of these space objects have fuel tanks, in which residual fuel can remain. The movement of fuel can have a significant impact on the behavior of the large space debris during its removal. The purpose of this work is to study the dynamics of large space debris with fuel residues during its deorbiting by an active spacecraft-tug.

The motion of a mechanical system consisting of a small tug, a massless tether, and passive large space debris with fuel residues is considered in an orbital reference frame. It is supposed that the system is under the influence of the gravitational torques and the constant thrust force generated by engines of the tug. It is assumed that the motion occurs in the plane of the orbit. The tug is considered as a material point, and the space debris is a rigid body. The equations of the space tether system motion were constructed by the means of the Lagrange formalism. The relative equilibrium positions of the system were found. For each of them, the first-approximation equations were constructed. These equations were used to study the influence of the system parameters on the stability of the equilibrium positions. Two different configurations of the space tether system, corresponding to stationary motions, were found as a result of the analysis. Numerical simulation of the mechanical system motion was carried out. Its results were compared with small oscillations, which were determined using the first-approximation equations.

The results of the study can be used to select the parameters of the transport system intended for towing and removing large space debris with fuel residues.