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Modeling of centrifugal deployment of three-section minisatellite boom

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The aim of the article is to model the processes of centrifugal deployment of a three-section boom and preliminary analyze the feasibility of this deployment method for an Earth remote sensing (ERS) minisatellite (MS).

During the research, methods of theoretical mechanics, multibody dynamics, control theory, and computer modeling were used.

Centrifugal deployment of multi-section booms have been successfully used on spin stabilized satellites, but not on ERS satellites, which have other features of operation and require additional studies.

The main part of the MS is a platform to which a transformable antenna is attached by means of a transformable boom. Before deployment, the stowed boom and antenna are attached to the MS platform. The boom sections are connected by joints with one rotational degree of freedom and deployed sequentially due to centrifugal forces when the MS rotates in the required direction. Each of the boom joints has a locking mechanism that latches when a predetermined deploy angle is reached.

To model the processes of the boom deployment, the MS is presented as a system of connected bodies, where the platform and the stowed antenna are absolutely rigid bodies, and the boom consists of three flexible beams of a tubular cross-section. The differential equations of the MS dynamics during the deployment are obtained using the Lagrangian formalism, which are supplemented by algebraic equations describing the constraints from the joints.

The scenarios of the boom deployment with a constant control torque and a constant angular velocity of the MS are considered. These scenarios are simulated, and estimates of the control actions needed to ensure full deployment of the boom and the stabilization of the MS after latching of the joints are calculated. Dependences of variations of the loads on the boom structure during deployment are obtained.

The simulation results allow us to conclude that it is feasible to implement the method of the boom centrifugal deployment for the MS, which can perform fast rotations about the three axes of the body reference frame. Implementation of this method allows designers to reduce mass of the MS because it does not require any servo drives in the boom deployment system.

Keywords: *minisatellite, boom, centrifugal deployment, fast rotation, revolute joint, multibody dynamics.*

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