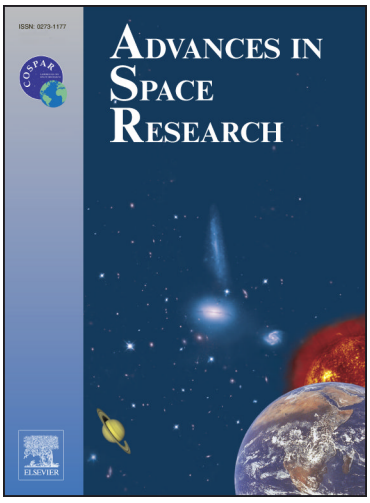

Multibody dynamical modeling for spacecraft docking process with spring-damper buffering device: a new validation approach

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PII: S0273-1177(17)30774-3
DOI: https://doi.org/10.1016/j.asr.2017.10.036
Reference: JASR 13468

To appear in: *Advances in Space Research*

Received Date: 7 April 2017
Revised Date: 25 September 2017
Accepted Date: 22 October 2017

Please cite this article as: Daneshjou, K., Alibakhshi, R., Multibody dynamical modeling for spacecraft docking process with spring-damper buffering device: a new validation approach, *Advances in Space Research* (2017), doi: https://doi.org/10.1016/j.asr.2017.10.036

Multibody dynamical modeling for spacecraft docking process with spring-damper buffering device: a new validation approach

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Abstract

In the current manuscript, the process of spacecraft docking, as one of the main risky operations in an on-orbit servicing mission, is modeled based on unconstrained multibody dynamics. The spring-damper buffering device is utilized here in the docking probe-cone system for micro-satellites. Owing to the impact occurs inevitably during docking process and the motion characteristics of multibody systems are remarkably affected by this phenomenon, a continuous contact force model needs to be considered. Spring-damper buffering device, keeping the spacecraft stable in an orbit when impact occurs, connects a base (cylinder) inserted in the chaser satellite and the end of docking probe. Furthermore, by considering a revolute joint equipped with torsional shock absorber, between base and chaser satellite, the docking probe can experience both translational and rotational motions simultaneously. Although spacecraft docking process accompanied by the buffering mechanisms may be modeled by constrained multibody dynamics, this paper deals with a simple and efficient formulation to eliminate the surplus generalized coordinates and solve the impact docking problem based on unconstrained Lagrangian mechanics. By an example problem, first, model verification is accomplished by comparing the computed results with those recently reported in the literature. Second, according to a new alternative validation approach, which is based on constrained multibody problem, the accuracy of presented model can be also evaluated. This proposed verification approach can be applied to indirectly solve the constrained multibody problems by minimum required effort. The time history of impact force, the influence of system flexibility and physical interaction between shock absorber and penetration depth caused by impact are the issues followed in this paper. Third, the MATLAB/SIMULINK multibody dynamic analysis software will be applied to build impact docking model to validate computed results and then, investigate the trajectories of both satellites to take place the successful capture process.

Keywords: Spacecraft docking; Multibody systems; Impact analysis; Probe-cone docking systems; Micro-satellite

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