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ON THE SIMULATION OF TETHER-NETS FOR SPACE DEBRIS CAPTURE WITH VORTEX DYNAMICS

Abstract

A promising method for containing the growth of space debris, which jeopardizes operation of spacecraft, is the Active Debris Removal (ADR) of large and massive derelict objects. An ADR technique that has been receiving some attention is to use a tethered net (tether-net for short) deployed from a servicing spacecraft, to capture and contain the debris. Since the behavior of tether-nets in space is not well-known, numerical simulation is needed to gain understanding of deployment and capture dynamics. Interest in net-based ADR is relatively recent, and the numerical simulation of this type of systems and their contact with debris is still an open problem.

Simulation of tether-net dynamics in space has multiple outstanding issues. First, to date, there is no agreement on the importance of modeling the tethers' bending stiffness. Moreover, modeling of snap loads in the net during the deployment is difficult and computationally expensive. Finally, contact between the net and the debris must be modeled accurately in the capture phase simulation in order to have reliable predictions of the success (or failure) of the capture: this remains a challenging and computationally intensive problem. The proposed paper's aim is to examine the effect of bending stiffness on tether-net dynamics, and to study the accuracy and computational burden of modeling snap loads and contact dynamics.

In order to simulate the net deployment and to investigate the effect of different contact dynamics models, a standalone simulator was assembled in Matlab, based on the lumped-parameter model and the continuous compliant contact dynamics formulation. Vortex Dynamics is a powerful multibody dynamics simulation platform designed for real-time simulation of complex systems; with its capabilities, the importance of bending stiffness on net response is investigated, and the additional computational cost associated with modeling of bending stiffness and snap loads is assessed. Comparison of results between the two simulators, in terms of response accuracy and of computational requirements, is presented for both a deployment simulation in microgravity conditions and a simplified contact scenario.

The results from the two simulators show a very good agreement in terms of positions and velocities, and it is demonstrated that either a variable step integrator or a very small fixed time-step is necessary to capture snap acceleration features in the net's threads, when simulating in Vortex Dynamics. A

preliminary analysis of bending stiffness effect seems to indicate that it has appreciable influence on the dynamics evolution of the net during deployment.