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MULTIBODY SIMULATIONS AND IMPACT TESTS OF A DOCKING SYSTEM FOR SMALL SATELLITES

Abstract

The in-orbit servicing missions aim at improving the operability or extending the operational life of a satellite through activities like refuelling, refurbishment, de-orbiting, inspection. The mission scenario includes two satellites, a chaser equipped with a capture mechanism, which performs the servicing operations, and the target.

This research project is involved in the development of the Space Rider Observer Cube (SROC) mission, which is an in-orbit servicing mission carried out using a microsatellite adhering to the CubeSat standard. SROC will be released by ESA Space Rider (SR), it will perform inspection of SR and then it will dock back to the SR cargo bay.

The SROC Consortium is composed by Tyvak International, the University of Padova, Stellar Project, and the Polytechnic University of Turin. The University of Padova and Stellar Project are responsible for the development of the docking system (DOCKS) that equips the SROC spacecraft, as well as a dedicated laboratory facility for dynamic testing. DOCKS is a smart capture system that is semi-independent with respect to the host spacecraft, since it can autonomously compute the relative pose between SROC and SR, and actuate the mechanisms at the proper time. It presents a probe-drogue configuration, it can perform electromagnetic soft-docking, and hard-docking by means of a three-claw locking mechanism.

This paper describes the multibody dynamic simulations performed with the commercial software Hexagon ADAMS, and the tests to evaluate the performance of the docking system laboratory prototype.

Simulations focus on two aspects: 1) simulation of the locking mechanism, considering the ball bearing friction loads, aiming at the suitable claws actuator choice and 2) evaluate the impact loads during the

docking manoeuvre to support the design of a shock absorber system to manage them. These simulations are performed considering different misalignments and approach velocities to evaluate the docking system tolerance.

Simulations are verified through a test campaign, which is performed under representative kinematic/dynamic conditions. These tests are carried out exploiting a low-friction table vehicle that is partially representative of the mass and inertia of SROC, and a motion capture system as a ground truth, and provide a preliminary assessment of tolerated misalignments, maximum approach velocity, impact loads, and electromagnet soft-docking capabilities.