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SPACE SYSTEMS SYMPOSIUM (D1)
Innovative and Visionary Space Systems Concepts (1)

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TETHERED DOCKING SYSTEMS: ADVANCES FROM FELDS EXPERIMENT

Abstract

Technologies for spacecraft docking are quite well known and guarantee structural rigidity between the vehicles involved. Moreover significant drawbacks make this solution very challenging for small spacecraft systems because of complex mechanics and strict pointing/control requirements as well as being extremely massive for small satellites. Educational experiments from the University of Padova have given way to the design of missions for a novel soft docking concept that exploits an innovative tethered system whose main objective is to establish a mechanical connection through the use of a flexible wire. This technology proved its effectiveness through simulation and experimental results. This concept allows to relax the pointing requirements during the final approach phases, since the final trajectory adjustments will be performed passively by a magnetic self-aligning effect. The first setup was built and tested in microgravity at the ZARM Drop Tower facility. The experiment, called FELDs, was mostly successful, both as a proof of concept for the magnetic guidance and as a study of the tethered probe dynamics. The usefulness and limits of the electromagnet capture effect on the target were characterized clearly from the data obtained. In addition, the release system of the launcher proved to be critical and less resilient than expected due to very small friction forces that became significant in microgravity conditions. On one hand, future improvements focus on reducing the mass of the electromagnet by removing the central ferromagnetic material; the trade-off between the electromagnet mass and power consumption is central to the development of the docking system. Furthermore, a controlled and variable magnetic field is analysed dimensioning the electromagnet coil and its main parameters for the improvement of the capture effect considering the magnetic field range with the probe approach. Following the simulations, an experimental setup is designed to test this new development. On the other hand, simulations and design of the release system design are analysed to obtain a possible automatic and controlled tether rewinding which will have to unwind the tether with negligible friction and rewind it smoothly and in a controlled manner. Simulations are made on the tether friction behaviour in microgravity, as it is also a mostly unexplored research area. This paper describes a new implementation of the experiment focused on its mechanical design and advanced tests and simulations concentrated on the magnetic field and tether friction improvement following the experimental results obtained in microgravity.