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MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Microgravity Experiments from Sub-Orbital to Orbital Platforms (3)

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PARABOLIC FLIGHT EXPERIMENT TO VALIDATE TETHERED-TUGS DYNAMICS AND CONTROL FOR RELIABLE SPACE TRANSPORTATION APPLICATIONS

Abstract

The Fly Your Thesis! programme of the European Space Agency's Education Office offers university students the opportunity to conduct their scientific experiments in microgravity conditions, during a parabolic flight campaign. In this framework, the PoliTethers team, from Politecnico di Milano, Department of Aerospace Science and Technologies, was selected to fly an experiment on-board Novespace's Zero-G aircraft, the flight campaign being scheduled for October 2016. The SatLeash experiment is going to investigate the dynamics and control of tow-tethers, for space transportation: tethered towing objects in space is becoming an appealing concept for many missions, such as Active Debris Removal, LEO satellites disposal, low-to-high energy orbit transfer and even asteroids retrieval. Space tugs, made of a passive orbiting target interconnected through a flexible link to an active chaser the thrusters of which excite the stack dynamics, open new challenges for guidance and control design. The chaser is required to robustly and reliably perform operations, while damping dangerous vibrations of flexible elements and connections, avoiding instability, collisions and tether entanglement. One of the most common critical modes that may arise during towing operations is the bounce-back effects: whenever thrust is shut down, the tether slackens and the residual tension accelerates the two objects towards each other, increasing the collision risk; the control recovery is then difficult and not always possible. The tether may entangle on the target or the chaser itself and, hence, break. Control methods based on feedforward shaping of the pulling thrust proved to be effective in simulation, stabilizing the system by cutting off the tethered-system's first modes frequencies, significantly reducing the bounce back. Validated simulation tools describing tethered-tugs dynamics, and their stabilization via control laws, are considered of primary importance to design future

missions. To this end, the team exploits a multibody dynamics simulator – developed at PoliMi-DAER - to describe tethered-satellite-systems dynamics and synthetize their control. The in-flight experiment focuses on validating the adopted models and verifying the implemented control laws. A reduced-scale tethered floating testbed is going to fly equipped with a stereovision system to reconstruct its 3D trajectory. Different tether stiffness will be tested as well as differently-shaped open-loop thrust profiles to verify their effectiveness in reducing bouncing-back effects. Developed models and control laws, together with numerical simulation results will be presented; the experiment design and integration will also be described and ground tests' results will be summarised.