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Microgravity Experiments from Sub-Orbital to Orbital Platforms (3)

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PARABOLIC FLIGHT FACILITIES – A LESSON LEARNT ON FREE FLOATING OBJECTS

Abstract

A microgravity experimental campaign aims at testing technologies in representative 0-g conditions, to raise the technology readiness level up to a level of 5-6. Among the different facilities that can reproduce such an environment, the parabolic flight (PF) is taken as the preferred one to test robotics, due to larger available space and longer microgravity time span. This paper reports lessons learnt in designing setting and performing PF to test the effects of free floating objects dynamics within a space robotic mechanism; as a consequence, the free flying elements evolution must be either well known or accurately determined and predictable during the experiment. Being the free-floating objects' trajectory constrained by the boundary condition to end at a target, fixed on the airplane, issues rise for both the aircraft dynamics disturbances, affecting the fixed target location at any instant, and the free floating object actual dynamics.

Two different experiments, presenting this peculiarity, have been designed and recently implemented at Politecnico di Milano, Department of Aerospace Science and Technologies (PoliMi-DAST). The first experiment, flown during 61st ESA Parabolic Flight Campaign, has tested a Sample Canister Capture Mechanism, for the future Mars Sample Return mission. The goal was to capture a free floating spherical object with a mechanism fixed to the aircraft structure. The second, currently ready and awaiting for the flight campaign, is aimed at reconstructing the 3D motion of a net capturing a satellite mock-up: the net is deployed by shooting four bullets connected to the net itself; the dynamics evolution is observed and tracked using a high-speed camera system. The goal is to validate a developed dynamics simulator, conceived to support the design of tethered-net systems for Active Debris Removal.

These recent experiences have highlighted how PF test environment poses strong limitation for testing low speed free floating objects within a fixed envelope, these objects being really sensitive to the microgravity quality, which is completely unpredictable. Furthermore, relative apparent accelerations must also be taken into account. A strategy to simplify the overall dynamics in the numerical model, to allow running still effective sensitivity analyses, essential for the preliminary experiment design, is here proposed: a rapid estimation of the target ideal position and attitude according to all possible combinations of shooting parameters and flight conditions is obtainable. The effectiveness of an inertial measurement unit to trace and estimate the relative and perturbing accelerations on the free floating objects is also demonstrated.