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

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VALIDATION OF FLEXIBLE BODIES DYNAMICS SIMULATOR IN PARABOLIC FLIGHT

Abstract

Purpose

In the context of debris removal technologies and preparation activities for e.Deorbit mission, the consortium led by SKA Polska has developed a simulator for net-shaped elastic bodies dynamics and their rigid bodies interactions.

Methodology

The main application of the simulator is testing of scenarios for space debris capturing and deorbitation with nets and designing nets themselves for particular targets. As it is to be used for mission analysis and design purposes, the underlying model has to be experimentally validated. In ground conditions gravity significantly affects net flight and target wrapping dynamics. Hence the requirement to do the experiment in microgravity conditions - in parabolic flight.
The experiment was performed on board of Falcon-20 aircraft, operated by National Research Council in Ottawa, Canada and it was the largest experiment performed in this aircraft. It was a downscaled (1:25) process of Envisat capturing with deployable net. The prepacked net with corner masses was launched towards the satellite model, it was expanding, hitting the model and wrapping around it. Whole the process was recorded with 2 fast stereographic camera sets for further full 3D trajectory reconstruction of each individual knot – in flight and satellite entangling phases. Knots are identified with the unique color code system. These digitally reconstructed trajectories are used to compare net dynamics to results of respective cases simulations and then to formally validate the simulation tool.

Results

Two types of nets with two velocities were tested. Each combination was repeated few times for statistical significance – 22 parabolas were flown in total. One of key driving factors for the success of experiment was its design methodology. Similitude to the target net application was required (dimensional analysis was used), but the specific conditions of parabolic flight and measurement requirements had to be taken into account as well. In particular statistical distribution of parabola parameters (such as residual gravity and aircraft pitch rate courses) appeared to be extremely important for failures avoidance.

Conclusions

The underlying experiment design methodology in described in this paper as well as its course, used equipment and results. Lessons learnt are presented as well – in terms of methodology and hardware, as well as human factor impact: organization, training and individual characteristics of the staff.

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