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THOR: A PAYLOAD SEPARATION SIMULATOR TOOL FOR CLUSTER LAUNCHES

Abstract

On February 13th 2012, at 10:00 UTC, the VEGA-VV01 launch was carried out from the European spaceport in Kourou, French Guyana. The main scientific payload, named LARES (LAser RElativity Satellite), aims at an accurate measurement of the Lense-Thirring effect. The microsatellite ALMASat-1 (a 30cm cube weighing 13.5 kg) provided by the II Faculty of Engineering of the University of Bologna and 7 Cubesat selected by ESA's Education Office, were also included as secondary payloads. LARES was released along a circular orbit while the 8 secondary payloads were released within a time interval of 51 seconds between the passivation of the upper stage (the AVUM - Attitude and Vernier Upper Module) and the depletion of the possibly contaminating liquids from the AVUM. Motivated by this the ALMASat-1 team, ESA/ESOC space debris office, the ESA-Integrated Project Team (ESA-IPT), ELV and ESA Education Office decided to carry out an analysis of payloads separation orbit propagation for investigating possible payload collisions and pollution-contaminations. The ALMASat-1 team, in collaboration with ALMASpace S.r.l., developed a simulation Tool for sHort and medium ORbital propagation (THOR). This tool is a MATLAB/Simulink-based payload dispersion simulator which includes a numerical integrator to propagate the orbital dynamics of each payload and to propagate the AVUM Euler rigid-body equations of motion. Each payload release is modeled through an initial v imposed by the separation system and the timing of the events is modeled by a finite state machine approach. The orbit propagation error was assessed though comparing the results with those obtained using ESA/ESOC's space debris office propagation tool, based on the propagator of the ODIN software package. The simulator output analyzes the motion of each payload component and their potential mutual interference both in a short and medium time-scale (a few tens of seconds, for the possible collisions at release from the launcher and a couple of weeks for the medium-term dynamics, respectively). Thanks to the versatility of the simulation framework, it was also possible to accurately predict the initial orbital elements (in the standard format of Two-Line-Elements) of all PLs for on-ground tracking operations purposes. Finally, a Monte Carlo statistical approach has been used to support the ESA-IPT and ELV payload orbital propagation and pollution analysis with the main objective to provide an assessment of compliance with respect to the international space debris mitigation guidelines endorsed by ESA and the European Code of Conduct for Space Debris Mitigation.