ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation & Control (2) (8)

Author: Mr. Jean-Sébastien Ardaens
German Aerospace Center (DLR), Germany, jean-sebastien.ardaens@dlr.de

Mr. Winfried Halle
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany, winfried.halle@dlr.de
Dr. Gabriella Gaias
German Aerospace Center (DLR), Germany, gabriella.gaias@dlr.de

VISUAL TRAJECTORY RECONSTRUCTION OF A CUBESAT AFTER DEPLOYMENT

Abstract

The German Aerospace Center is currently preparing a challenging formation-flying experiment aiming at demonstrating the capability to perform autonomously far to mid-range non-cooperative rendezvous approaches by making use of angles-only measurements. This technology demonstration will be implemented onboard the DLR's Biros satellite, scheduled for launch in late 2015, and takes advantage from the fact that Biros embarks a third-party picosatellite which will be ejected in-orbit and which will thus serve as non-cooperative target for the sake of the experiment. The in-flight separation is a critical phase. The CubeSat will be ejected using a Picosatellite Orbital Deployer powered by a spring. Because of the small weight of the picosatellite, a colossal resulting velocity increment of about 1.5 m/s is expected during the expulsion. Small uncertainties concerning the direction of ejection and the strength of the spring will have dramatic impacts on the relative state reached by the CubeSat after few hours, creating a risk of evaporation of the formation or even of loss of track of the picosatellite. Fortunately, the Biros satellite will be equipped with a camera aligned with the deployment device which can be used to estimate the real velocity increment encountered during the ejection. Since the size of the picosatellite is perfectly known, it is in fact possible to measure accurately its relative position and reconstruct the relative trajectory right after the separation. This almost perfect initial knowledge of the state of the formation is then propagated to provide accurate relative state prediction to support the ground operations during the first days after the deployment. The paper gives an overview of the relative trajectory estimation process. First the images collected by the camera have to be downloaded during the next ground contact. The pictures are then processed using feature matching technique. Together with the knowledge of the attitude of the spacecraft, it becomes possible to measure the 3D relative position of the center of mass of the picosatellite with a precision of a few mm after separation (the accuracy slowly degrades when the intersatellite distance increases). Simulations of the ejection promise an observation time frame of almost one minute if the spacecraft attitude is kept constant after the separation. Afterwards, the picosatellite exits the field of view. This reduced observation window provides however enough measurements to reconstruct precisely the relative trajectory at the centimeter level and to provide subsequently accurate state prediction at the meter level.