18th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Post Mission Disposal and Space Debris Removal (1) (5)

Author: Dr. Danil Ivanov
Keldysh Institute of Applied Mathematics, RAS, Russian Federation, danilivanovs@gmail.com

Prof. Mikhail Ovchinnikov
Keldysh Institute of Applied Mathematics, RAS, Russian Federation, ovchinni@keldysh.ru
Mr. Per-Erik Atterwall
Beyond Atlas, Sweden, per-erik@attwik.se
Mr. Mahdi reza Akhloumadi
Moscow Institute of Physics and Technology (MIPT), Russian Federation, akhloumadi@phystech.edu
Mr. Filipp Kozin
Keldysh Institute of Applied Mathematics, RAS, Russian Federation, filipp.kozin@gmail.com

SIMULATION AND LABORATORY TESTING OF THE 3U CUBESAT CONTROL IN THE PROXIMITY OF SPACE DEBRIS

Abstract

The goal of the proposed 3U CubeSat mission is to test GNC system for a future flight to a near-Earth asteroid. In order to gain the goal a 3U CubeSat is to get to a vicinity of a space debris in a sun-synchronous LEO. The satellite GNC system includes onboard propulsion, magnetorquers, reaction wheels and attitude determination sensors. Laser range finder and optical sensor measurements are used for the relative navigation. It is assumed that the maneuver commands to the CubeSat to approach to a vicinity of debris are uploaded from the ground control center. However, when the distance becomes less than 1 km the disturbances caused by J2, atmospheric drag and maneuver execution errors can lead to dangerous proximity and even to collision with debris during the time interval between the two communication sessions.

In the paper a scheme of the safe autonomous controlled relative motion of the CubeSat in the predefined relative area is proposed. An extended Kalman filter onboard the CubeSat is used to estimate the relative state vector. Using this vector and the covariance error matrix, the relative trajectory is predicted by integrating the equations of relative motion over the next two hours of flight. When the satellite position error ellipsoid reaches a dangerous distance with respect to the space debris, a collision avoidance maneuver is applied to achieve a safe relative distance. To provide necessary stabilization to the debris direction for the laser range finder measurements it is necessary to obtain optical sensor measurements available only for the illuminated part of the orbit. In case when the measurements are not available the current state vector is estimated using only the integration of the motion equations.

The controlled relative motion is studied numerically taking into account acting on the satellite unknown disturbances, uncertainties in the satellite and debris parameters and measurements noise. The proposed scheme of the controlled motion is tested in the laboratory facility COSMOS at KIAM using air bearing planar test bed. A debris mock-up and the 3U CubeSat mock-up equipped with thruster imitators move almost frictionless along the surface, and thus the relative motion in the orbital plane is simulated. The results of the control algorithm tests are presented in the paper.