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

Dr. Mikhail Mogilevsky
Space Research Institute (IKI), RAS, Russian Federation, mogilevsky2012@gmail.com
Ms. Uliana Monakhova
Keldysh Institute of Applied Mathematics, RAS, Russian Federation, monakhova@phystech.edu
Prof. Mikhail Ovchinnikov
Keldysh Institute of Applied Mathematics, RAS, Russian Federation, ovchinni@keldysh.ru
Dr. Alexander Chernyshov
Space Research Institute (IKI), RAS, Russian Federation, achernyshov@iki.rssi.ru

DEPLOYMENT AND MAINTENANCE OF NANOSATELLITE TETRAHEDRAL FORMATION FLYING USING AERODYNAMIC FORCES

Abstract

For an experimental study of the spatial distribution of the Earth magnetosphere parameters it is necessary to conduct simultaneous measurements at several points in a given region of near-Earth space, which can be achieved using satellite formation flying. At least four satellites are required to carry out spatial measurements. In the ideal case the satellites should fly so that they are always at the vertices of the regular tetrahedron. To construct and maintain such a configuration the relative motion control must be applied. For the Low-Earth Orbits the control can be performed using aerodynamic forces which act on the satellites in the upper atmosphere.

The paper is devoted to the study of decentralized control using differential lift and drag for the construction and maintenance of the tetrahedral configuration. The most popular in the class of nanosatellites 3U CubeSats are considered. They have a suitable form-factor which let the cross-sectional area of satellites relative to the incoming airflow vary by a factor 3 depending on the attitude. The satellites are assumed to be subsequently deployed from the launch bus. Each satellite is equipped with a reaction wheel-based attitude control system which allows to provide the required angular motion. Each satellite has also information about the relative state vector of all neighboring satellites provided by the inter-satellite communication or sensors of relative motion determination system. In this paper a decentralized control algorithm is developed which ensures the tracking of the relative reference trajectory. Due to this reference trajectory the satellites moves at the vertices of the tetrahedron. The possibility of constructing a tetrahedral configuration after deployment of the satellites depending on the initial conditions is studied. The influence of perturbations and parameters of the control algorithm on achieving the desired motion of the satellites is considered.

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