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Author: Prof. Yue Wang
Beihang University, China, ywang@buaa.edu.cn

Ms. Jingyi Zhang
Beihang University, China, zhangjingyi_buaa@163.com

AEROASSISTED ORBIT CONTROL OF VERY LOW EARTH ORBIT SATELLITES

Abstract

Very Low Earth Orbits (VLEOs) can be defined as the orbits with a mean altitude below 450 km. It is between the dense atmosphere and the lowest orbital altitude of a traditional low Earth Orbit (LEO) satellite, and has important application potential in environmental exploration, earth observations, gravitational field measurement, and etc. With the development of aerospace technology, a new frontier of space utilization has been opened on VLEOs. Many satellites, such as the Gravity field and Ocean Circulation Explorer of ESA, the Super Low Altitude Test Satellite of Japan, etc., have been launched to verify the possibility of being operated in VLEOs.

Because of the very low altitude, VLEOs satellites will face with much denser atmosphere and the resulting much more significant aerodynamic force compared with the traditional LEOs satellites. Aerodynamic force needs to be modeled accurately in order to assess their impacts on satellites. Although the atmospheric density in VLEOs is several orders of magnitude higher than that in traditional LEOs, aerodynamic force is still not the main perturbation force. Aerodynamic control panels are required to provide additional aerodynamic force to control the orbital elements. However, when control panels provide effective control force to affect the changes of orbital elements, they will also produce aerodynamic force in other directions. Therefore, several associated problems deserve further investigations, regarding how to utilize aerodynamic force, reduce unfavorable effects, and assist the orbit control.

In this paper, an Earth Observation satellite operated in a VLEO at 200km altitude will be investigated, including calculating the aerodynamics force for a given configuration, and iteratively optimizing the aerodynamic configuration. On the premise that the satellite attitude is three-axis stabilized and nadir-pointing, an aeroassisted orbit control model is established to achieve the control strategy of very low orbit maintenance by considering the influence of perturbations, such as the Earth's nonspherical gravity, solar and lunar gravity, and solar radiation pressure. Finally, numerical simulations are carried out for several typical control scenarios to validate the control strategy and analyze the control ability of aerodynamic force. The results will provide useful insights for the design of the VLEOs satellites in the future.