Paper ID: 84574
oral

IAF ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (2) (2)

Author: Mrs. Kiyona Miyamoto
Tokyo Institute of Technology, Japan

Dr. Toshihiro Chujo
Tokyo Institute of Technology, Japan
Mr. Kei Watanabe
Tokyo Institute of Technology, Japan
Prof. Saburo Matunaga
Tokyo Institute of Technology, Japan

ON-ORBIT EXPERIMENT RESULTS ON VARIABLE-SHAPE SATELLITE ATTITUDE DYNAMICS USING ATMOSPHERIC DRAG TORQUE AND GRAVITY GRADIENT TORQUE

Abstract

Disturbance torques, such as atmospheric drag torque and gravity gradient torque, have always been an issue in attitude control for satellites in low Earth orbit. Although attitude control systems using disturbance torques have been studied with various methods, most previous research has focused on attitude control using aerodynamic stability to counteract disturbances. Instead of merely counteracting these disturbances, we propose a novel attitude control system that actively uses disturbance torques. This system controls the attitude using disturbance torques by changing the equilibrium point of the attitude motion by changing the shape of the satellite. Since the control target is the equilibrium point, it has advantages that the control is stable, and the control strategy is simple. One application is to control the relative attitude between satellites in a formation flight. In this study, we show the results of on-orbit evaluation for the attitude dynamics of a variable-shape satellite around the equilibrium point. In previous studies, we formulated the attitude dynamics of a variable-shape satellite under atmospheric drag torque and gravity gradient torque and showed that the attitude motion oscillates around the equilibrium point when it is Lyapunov stable and diverges when it is unstable. In addition, it was shown that the equilibrium point changes according to the shape change. To demonstrate this theory in orbit, it is necessary to consider errors not covered by the theory, such as atmosphere model errors, spacecraft model errors, and residual magnetic torque. Therefore, we performed numerical simulations that modeled these errors and investigated their effects on the attitude dynamics. As a result, it was confirmed that the attitude motion behaves approximately according to the theory, although the errors have some effects on the amplitude and frequency of its oscillating around the equilibrium point. To validate our simulation results, we performed on-orbit demonstrations with "HIBARI", a variable-shape attitude control demonstration satellite. Developed at the Tokyo Institute of Technology, "HIBARI", a 50-kg-class microsatellite, features four drivable solar array paddles for shape change, and was injected into orbit in 2021. As part of the on-orbit demonstration, we performed experiments to evaluate the attitude dynamics around the equilibrium point by changing the shape of "HIBARI". Ultimately, we obtained data showing the attitude motion oscillating around a Lyapunov stable equilibrium point. This paper describes the evaluation results of the attitude dynamics around the equilibrium point by comparing simulation data with the findings from on-orbit experiments.