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NOVEL CONCEPT OF MICRO/NANO-SATELLITE SYSTEM DESIGN AND OPERATION ASSUMING ON-ORBIT RECONFIGURABILITY OF ATTITUDE DETERMINATION AND CONTROL SYSTEM

Abstract

Verification tests of an attitude determination and control system (ADCS) are important for almost all satellites to achieve their missions. In conventional satellites, these tests such as sensor calibrations are usually performed on the ground using various ground test facilities to simulate space environment. However, in small satellites, these verification tests on the ground are difficult to perform, because calibrations of small components which small satellites generally have often require very precise ground test facilities. Usually, such ground tests causes lager development costs in small satellite projects. Therefore, these ground tests generally reduce the advantage of small satellites in cost.

This research focuses on orbit environment after a launch to perform these tests effectively and to reduce the development costs. This concept has been employed to some conventional satellites as "on-orbit calibrations" only for several components of an ADCS. This research extends this "on-orbit calibration" concept to "on-orbit reconfiguration" concept in which almost all components of an ADCS are calibrated and reconfigured in orbit. This proposing concept achieves more accurate parameter estimations at smaller cost.

This research has two objectives for the realization of "on-orbit reconfiguration" concept. The first objective is to propose design methodologies to achieve the on-orbit reconfiguration quickly, safely and surely. This research makes clear which satellite systems can be reconfigured quickly with minimum operation time, safely with the avoidance of uncontrollable satellite states, and surely with minimum costs for grand tests to achieve precise parameter estimations. The second objective is to propose operation strategies to perform the reconfiguration efficiently. This research optimizes the operation schedule of a satellite. In consideration of on-orbit reconfiguration systems, this research simulates an on-orbit reconfiguration sequence which is composed of parameter estimation steps and parameter setting steps. The key point of this schedule optimization is that most of ADCS parameters have very complex cross relationships with each other. This research proposes a schedule optimization methodology with the consideration of these relationships.

The proposing "on-orbit reconfiguration" concept for an ADCS effectively decreases developing costs of small satellites. To realize the reconfiguration concept, this research proposes the methodology of the system design and the operation optimization including what we should confirm on the ground and what we should estimate in orbit. The novel "on-orbit reconfiguration" concept, which realizes a low-cost satellite with a precise ADCS, will clear the way for new space system applications for the future.