FIRST FLIGHT RESULT OF ATTITUDE DETERMINATION FOR 50KG CLASS MICRO SATELLITE SDS-4

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Keywords: *micro satellite, attitude determination, flight result*

ABSTRACT

This paper reports on a flight data analysis of the on-board attitude determination of 50kg class micro satellite: SDS-4. In recent years, the capabilities of micro satellites have been highly valued and many important missions have been achieved using micro satellites. In order to respond to the increasing demands from various missions, such as earth observation or science, it has been inevitable for them to provide precise 3-axis attitude determination and control. However, for 50kg class micro satellites like SDS-4, size limitation is a common and severe problem. They are so small that very small space is left for mounting attitude determination and control hardware. It is even more difficult to make redundant configuration. Under such limitation, SDS-4 has achieved on-board attitude determination system which can meet high mission requirements.

Small Demonstration Satellite 4 (SDS-4) is the first 3-axis stabilized satellite from Japan Aerospace eXploration Agency(JAXA) SDS program. This program provides small satellite platforms to demonstrate newly developed technology and components. The total mass of SDS-4 is about 50kg and the dimensions are about 50x50x50 cm3. SDS-4 was launched as a piggyback payload of H-IIA launch vehicle in May 17, 2012. It has been operated in Sun-synchronous LEO orbit at an altitude of 677km. In order to meet the mission requirements, SDS-4 selected to be controlled in inertially-fixed sun oriented attitude and adopts zero momentum control with 3 reaction wheels. The attitude determination is implemented by using Extended Kalman Filtering algorism (EKF) based on 3-axis MEMS Gyro output. SDS-4 has a Star Tracker for a precise static attitude determination. However, the difficulty is that there can mount only one Star Tracker because of size limitation. The satellite's nominal attitude is inertially fixed, so there must exist loss of star tracking during every orbital pass. In order to avoid accuracy reduction, SDS-4 implements algebraic attitude determination using a miniaturized Digital Sun Sensor and 3-axis Magnetic Sensor. They estimates the attitude quaternion through QUEST algorism and are used as a compensation for Star Tracker data. It is to be noted that this method is not valid in shade because the sun vector is necessary. Even in sunlight, it is preferable to avoid the derived quaternion in a certain time period, because the accuracy of the QUEST attitude determination gets worse when the sun and magnetic vector gets

close to parallel. Adding to this, during the period when the attitude estimation from gyro propagation is predicted to be accurate than the QUEST estimation, SDS-4 simply keeps gyro propagation with no measurement update. As seen above, SDS-4 selects appropriate attitude determination method depending on the situation and improves determination accuracy. It is of course possible to use only one static attitude determination method when some failure occurs to the other component. SDS-4 keeps functional redundancy and improves robustness in this way.

In this paper, we present the details of the attitude determination system design of 50kg class micro satellite SDS-4, and reports on the operation results during 5 months from the launch.