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# ATTITUDE DYNAMICS AND OPERATION RESULT IN HAYABUSA2 CAPSULE REENTRY

**Abstract**

Hayabusa2 is an asteroid sample return mission and collected the sample of asteroid Ryugu on 22. Feb. 2019 and 11, July. 2019 respectively. The spacecraft left the asteroid and came back to Earth on 5. Dec. 2020 and released the sample return capsule. The capsule successfully backed to the Earth and 5.4g sample was confirmed inside the capsule. The capsule reentry operation consists of trajectory control by 5 TCMs (Trajectory Control Maneuvers) and several attitude maneuvers for capsule release, optical camera shooting, and TCMs from astrodynamics point of view. AOCS (Attitude and Orbit Control System) has these functions. This operation is one-time opportunity and impossible to abort during the operation as well as operation failure is strongly related with mission failure. Therefore, accurate estimation and planning is the key for success of the operation. The main difficulties of the AOCS planning is attitude maneuver design and angular momentum control planning during TCMs and Earth swing-by. In terms of attitude control, especially, sequence of capsule release, the last TCM for divert from Earth entry trajectory, Earth swing-by is the busiest sequence in the operation. These events continue in about 24 hours and it includes 6 attitude maneuvers in series. In addition, Hayabusa2 is applied large attitude disturbance in this phase. The spacecraft has large magnetic momentum in IES (Ion Engine System) and large disturbance is caused by this momentum and Earth magnetic field during Earth swing-by as well as the altitude from Earth surface becomes at 335 km in nominal and the largest aerodynamic torque makes attitude disturbance in the mission. In order to realize several attitude maneuvers and not to lose attitude control, this sequence design was based on precise trajectory and attitude dynamics simulation including nominal and several off-nominal contingency trajectories. The design point is selection of control mode (Hayabusa2 has 2 attitude control modes, reaction wheels and thrusters), attitude maneuver timing

(attitude make difference of axis to which disturbance is applied), and reaction wheels unloading timing. The design was considered these issues and optimized to meet requirements and operational constraints. In this paper, outline of AOCS operation, simulation modeling and analysis result of reentry operation, and AOCS planning are described in detail. In addition, actual operation results and comparison with planning are also described.