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Small Bodies Missions and Technologies (Part 2) (4B)

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REPORT ON HAYABUSA2 TOUCH-DOWN DYNAMICS AND SAMPLING OPERATION RESULT

Abstract

Japan Aerospace Exploration Agency (JAXA) launched the 1st C-type asteroid exploration and sample return probe "Hayabusa2" in December 3rd, 2014, and it arrived at C-type asteroid "Ryugu (1999ju3)" in the end of June, 2018. Hayabusa2 conduced science observation and several rehearsals of touch-down (TD) operation. Then, Hayabus2 has succeeded 1st TD and sampling operation on the surface of Ryugu on February 22nd, 2019.

TD operation for sampling is conducted at the surface area "L08-E1" where is without 50-cm sized or larger boulders and with the local surface angle of ¡30 deg for safety. Hayabusa2 controls 6-DOF (position, velocity) by autonomous on-board function and attitude / angular rate by feed-forward command at the altitude of 8.5 m before the final descent phase. Then, Hayabusa2 descents by a free fall in initial velocity -7.4cm/s from 8.5m altitude. After approximately 100 seconds, Hayabusa2 touches the surface of Ryugu and collects sample using the sampling system that applies the same projectile method as that of 1st Hayabusa. The projectile is shot for sampling, which is triggered by the detection of the bending of the sampler horn by a short-range laser range finder (LRF-S2).

For planning the TD operation, the important thing is to set sequence of event from final descent phase and detection parameters. We simulated applying dynamics model of Hayabusa2 including a sampler horn model and a surface reaction model to verify the sequence, detection method and parameters. Multibody dynamics and ground contact model are implemented in this simulator.

Hayabusa2 has several detection methods to detect the touch-down and trigger shot of projectile for sampling, that is, fluctuation of signal of distance and intensity measured by LRF-S2, attitude / angular rate fluctuation measured by the inertia reference unit of AOCS subsystem, acceleration integral value. We discussed appropriate threshold values for each detection method based on the result of the dynamics simulation. The dynamics simulation is also used to study spacecraft dynamics and safety of both spacecraft and the sampler horn during spacecraft contacts on the asteroid which surface properties are unknown.

In this paper, the design and parameter decision process which includes TD simulation results will be described. In addition, we will report the result of actual 1st TD dynamics and sampling operation, which is the world's first achievement in the deep space exploration.