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GNC STRATEGY AND RESULTS OF HAYABUSA2 PINPOINT TOUCH DOWN OPERATION

Abstract

Hayabusa2 is a Japanese sample return mission from the asteroid Ryugu. The Hayabusa2 spacecraft was launched on 3 December 2014 and arrived at Ryugu on 27 June 2018. It will stay there until December 2019 for in situ science observation and soil sample collection and will return to the Earth with the collected sample in December 2020. During the stay, the spacecraft is planned to carry out several numbers of descent operation to deploy and land rovers, and to touchdown and collect soil sample. On 22nd February 2019, the spacecraft successfully touched down on Ryugu.

Since the surface of Ryugu is extremely rough and full of boulders, and the number of areas with small-enough and low-enough boulders is limited. The target point named “L08-B” has “safety area” with radius of only 3m and the accuracy required to the guidance, navigation and control of the spacecraft was challenging. For the “pinpoint touchdown” it was necessary to follow step-by-step approach including touchdown rehearsal descent operations in order to check GNC sequence, performance of laser sensors such as LIDAR (long range laser altimeter) and LRF (short range four beam laser distance sensor), to collect closer images of the surface of Ryugu and to drop TM (Target Marker) that is retro-reflected ball used for image-based navigation reference.

There are three key GNC features for “pinpoint touchdown”, that is (1) position control of the spacecraft from the altitude of 20km to 45m toward the area that TM is in the field of view of navigation camera, (2) feed-forward attitude control of the spacecraft in order to align to the unlevel touch down area using noisy LRF output, (3) high precision six-degrees-of-freedom feed-back control using TM as a lateral position navigation reference in order to descend and touch down to the small safety area.

This paper introduces strategy, sequence and algorithms for the last two GNC features for touch down of Hayabusa2 stated above with numerical simulation results and actual flight data.