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Small Bodies Missions and Technologies (Part 1) (4A)

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OPERATION PLANNING AND RESULTS OF HAYABUSA2'S FIRST ASTEROID TOUCHDOWN

Abstract

A Japanese interplanetary prove "Hayabusa2" was launched on December 3rd, 2014. After long transfer period including the ion engine powered cruising, the prove arrived at the vicinity of C-type asteroid 162173 Ryugu on June 27th, 2018 and started its 1.5 years asteroid proximity phase aiming "touchdown" for surface sample collection to carry back to the Earth by end of 2020.

Proximity operation started from remote sensing at "Home Position (HP)", 20km above the sub-Earth point. Together with 5km altitude observation data,"Landing Site Selection (LSS)" was successfully performed internationally to decide 100m scale surface region named "L08" relatively safe and suitable for touchdown. However, successful landings of three robotic proves (MINERVAII-1 rovers on September 21st, and MASCOT lander on October 3rd, 2018) revealed Ryugu's exceptionally rough surface covered by substantial numbers of boulders with dimension which may harm spacecraft during surface contact at touchdown. Therefore, by postponing the first touchdown operation originally planned at late October 2018, three touchdown rehearsals were conducted by end of October 2018 for detail terrain observation over L08 region which can only be observed from less than several 100m altitude as well as technical demonstration. Especially on October 26th at third rehearsal, spacecraft successfully released "target marker (TM)", an artificial landmark covered by retroreflection material, and demonstrated autonomous hovering capability at 12m above surface by visually tracking surface-settled TM continuously.

Utilizing solar conjunction period during December 2018, local terrain inside L08 region was investigated to find 6m diameter area named "L08-E1" at approximately 6m away from TM. Project team made a decision to adopt "Pin-Point Touchdown" scheme prepared newly for Hayabusa2 mission which enables the spacecraft to find and track pre-thrown target marker on surface to guide itself autonomously toward touchdown target point precisely at particular attitude and velocity required for safe landing and sampling. As a result, on February 22nd, 2019, first touchdown was accomplished to confirm nominal progress of touchdown sequence and secure return to HP.

This paper focuses on planning methodology and operation of entire touchdown sequence. First, introducing touchdown target L08-E1 and touchdown scheme to describe boundaries and restriction for operation planning (e.g. touchdown target epoch, descending target point, ground station assignment, communication link, etc.). Then, actual operation sequence is introduced together with representative onboard mission abort function and ground monitoring activity using doppler monitor. Finally, touchdown operation results are described and evaluated based on actual flight data.