Operation status for the asteroid explorer, Hayabusa2

October 23, 2018

JAXA Hayabusa2 Project
Contents Today

Regarding Hayabusa2:

- Report on TD1-R1-A
- TD1-R3 operation plan

TD1-R1-A : Touchdown 1 rehearsal 1A (equivalent to the second rehearsal)
TD1-R3 : Touchdown 1 rehearsal 3 (equivalent to the third rehearsal)
Topics

0. Hayabusa2 overview & mission flow outline
1. Project status & overall schedule
2. TD1-R1-A operation report
3. TD1-R3 operation plan
4. Press conference at DPS
5. Future plans

TD1-R1-A : Touchdown 1 rehearsal 1A (equivalent to the second rehearsal)
TD1-R3 : Touchdown 1 rehearsal 3 (equivalent to the third rehearsal)
DPS : Division for Planetary Sciences of the American Astronomical Society
(one of the world’s largest meetings for planetary science)
Objective
We will explore and sample the C-type asteroid Ryugu, which is a more primitive type than the S-type asteroid Itokawa that Hayabusa explored, and elucidate interactions between minerals, water, and organic matter in the primitive solar system. By doing so, we will learn about the origin and evolution of Earth, the oceans, and life, and maintain and develop the technologies for deep-space return exploration (as demonstrated with Hayabusa), a field in which Japan leads the world.

Features:
- World’s first sample return mission to a C-type asteroid.
- World’s first attempt at a rendezvous with an asteroid and performance of observation before and after projectile impact from an impacting device.
- Comparison with results from Hayabusa will allow deeper understanding of the distribution, origins, and evolution of materials in the solar system.

Expected results and effects
- By exploring a C-type asteroid, which is rich in water and organic materials, we will clarify interactions between the building blocks of Earth and the evolution of its oceans and life, thereby developing solar system science.
- Japan will further its worldwide lead in this field by taking on the new challenge of obtaining samples from a crater produced by an impacting device.
- We will establish stable technologies for return exploration of solar-system bodies.

International positioning:
- Japan is a leader in the field of primitive body exploration, and visiting a type-C asteroid marks a new accomplishment.
- This mission builds on the originality and successes of the Hayabusa mission. In addition to developing planetary science and solar system exploration technologies in Japan, this mission develops new frontiers in exploration of primitive heavenly bodies.
- NASA too is conducting an asteroid sample return mission, OSIRIS-REx (launch: 2016; asteroid arrival: 2018; Earth return: 2023). We will exchange samples and otherwise promote scientific exchange, and expect further scientific findings through comparison and investigation of the results from both missions.

Hayabusa 2 primary specifications
Mass: Approx. 609 kg
Launch: 3 Dec 2014
Mission: Asteroid return
Arrival: 27 June 2018
Earth return: 2020
Stay at asteroid: Approx. 18 months
Target body: Near-Earth asteroid Ryugu

Primary instruments
Sampling mechanism, re-entry capsule, optical cameras, laser range-finder, scientific observation equipment (near-infrared, thermal infrared), impactor, miniature rovers.
Arrival at asteroid
June 27, 2018

Examine the asteroid by remote sensing observations. Next, release a small lander and rover and also obtain samples from the surface.

Sample analysis

After confirming safety, touchdown within the crater and obtain subsurface samples

Use an impactor to create an artificial crater on the asteroid’s surface

Depart asteroid
Nov–Dec 2019

Earth return
late 2020

Launch
3 Dec 2014

Earth swing-by
3 Dec 2015

Mission Flow

(Illustrations: Akihiro Ikeshita)
### 1. Current project status & schedule overview

**Current status:**

- Second rehearsal for touchdown, TD1-R1-A, was performed between October 14 – 16. The spacecraft descended to an altitude of 22.3m on October 15 and confirmed the functionality of the LRF.
- The third rehearsal for the first touchdown (TD1-R3) will be held from October 23 – 25 (already started).

**Schedule overview:**

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**Ion engine operations**: Mar, Jun, Mar, May, Nov, Apr, Jan, Jun, TBD, TBD, TBD, TBD
2. TD1-R1-A operation report

TD1-R1-A purpose

- Confirmation of navigation guidance accuracy at low altitude (altitude less than 40m).
- Confirmation of operation characteristics of LRF (Laser Range Finder) that measures altitude at short distances.

※This is the second rehearsal for the touchdown, but repeated operations that could not be competed during the first rehearsal (TD1-R1, September 10-12). We therefore refer to this as TD1-R1-A. (To avoid confusion, the name TD1-R2 will not be used as this is the name of a second rehearsal planned for the first time.)
2. TD1-R1-A operation report

TD1-R1-A operation

Altitude

Return to home position

Home position
20km

GCP-NAV

GCP-NAV

HPNAV

Deceleration \( \Delta V \)

\( V = -0.4 \text{m/s} \)

Initial velocity:
\( V_{\text{initial}} = -0.1 \text{m/s} \)

Increase \( \Delta V \)

LIDAR Shot

10/14 23:50
10/15 10:10
10/16 15:00

Lowest altitude: 22.3m
10/15 22:44

GCP-NAV (Ground Control Point Navigation)

→ Method of determining the position and speed of the spacecraft by observing characteristic points on the asteroid surface.

HPNAV (Home Position Navigation)

→ Method of determining the position and speed of the spacecraft from direction of the center of the asteroid image and attitude of the probe.

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Altitude measurement value using LIDAR (green) and the LRF (yellow) almost coincide over the overlapping altitudes from 27m to 25m, indicating the altitude measurement was inherited correctly from LIDAR to LRF.
2. TD1-R1-A operation report

Level of accuracy in navigation guidance

In this operation in which the spacecraft descend to an altitude of 22.3m, the level of accuracy recorded was 10.8 on the asteroid surface.
2. TD1-R1-A operation report

Image captured by the ONC-W1 near lowest point

Image taken with the ONC-W1 at an altitude of about 47m. Capture time was October 15, 2018 at 22:45 JST. (Image credit: JAXA, University of Tokyo, Kochi University, Rikkyo University, Nagoya University, Chiba Institute of Technology, Meiji University, Aizu University, AIST.)
2. TD1-R1-A operation report

Image captured by the ONC-W1 near lowest point

Red circle marks the candidate touchdown site, L08-B.

Image taken with the ONC-W1 at an altitude of about 47m. Capture time was October 15, 2018 at 22:45 JST. (Image credit: JAXA, University of Tokyo, Kochi University, Rikkyo University, Nagoya University, Chiba Institute of Technology, Meiji University, Aizu University, AIST.)
3. TD1-R3 operation plan

From October 23 - 25, the third rehearsal for touchdown will be performed.

■ Aim

- Confirm the accuracy of the navigation guidance control at low altitude by the following steps.
- Use the measured LRF (Laser Range Finder) value to control the spacecraft.
- If conditions are satisfactory, release a target marker.
- Track released target marker.
3. TD1-R3 operation plan

TD1-R3 schedule

GCP-NAV (Ground Control Point Navigation)
→ Method of determining the position and speed of the spacecraft by observing characteristic points on the asteroid surface.

HPNAV (Home Position Navigation)
→ Method of determining the position and speed of the spacecraft from direction of the center of the asteroid image and attitude of the probe.
3. TD1-R3 operation plan

TD1-R3 low altitude sequence

- Begin LRF altitude control from ~25m altitude.
- Lateral thruster injection to synchronize with asteroid rotation speed.
- Maintain ~20m altitude while tracking TM with camera.
- Descend at 10cm/s while using LIDAR.
- Descend a few meters while pushing TM towards surface to separate.
- After tracking TM, ascend and return to 20km altitude.
3. TD1-R3 operation plan

Target marker

- Size of body (ball): about 10cm
- Retroreflective film
- 4 bars: rolling prevention
- Inside contains many polyimide globules

- First to separate: B
- On the inside of the target marker is a sheet on which is written the names of members from the general public.
4. Press conference at DPS

DPS = Division for Planetary Sciences of the American Astronomical Society (one of the world’s largest academic societies in planetary science, date/place: October 21 – 26, Knoxville, USA)

• Hayabusa2 press conference: October 25, 12:15～13:15 (October 26, 01:15～02:15 JST)
• Information: https://aas.org/meetings/dps50/2nd-media-advisory
• Title: Hayabusa2 Explores Asteroid Ryugu
• Presenters (titles omitted): Masaki Fujimoto (JAXA), Hikaru Yabuta (Hiroshima U.), Eri Tatsumi (U. Tokyo), Deborah Domingue (Planetary Science Institute), Lucille Le Corre (Planetary Science Institute), Ralf Jaumann (German Aerospace Center)
• New information: also to be released in Japan

※Hayabusa2 special session in DPS
  • Oct 25 (Poster presentation : 13), Oct 26 (Oral presentations : 9)
5. Future plans

■ Scheduled operation
  • October 23 – 25: TD1-R3 (3rd touchdown rehearsal)

■ Press and media briefings
  • November, 8 (Thurs) 11:00～ Press briefing @ Ochanomizu
  • December 6 (Thurs) Afternoon TBD～ Press conference @ Sagamihara