Asteroid explorer, Hayabusa2, reporter briefing

November 30, 2020
JAXA Hayabusa2 Project
Topics

Regarding Hayabusa2

- Results from TCM-3
- Details of capsule separation and re-entry
- Preparation status for capsule collection
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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.

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.

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 impactor.
• Comparison with results from Hayabusa will allow deeper understanding of the distribution, origins, and evolution of materials in the solar system.

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.

Overview of Hayabusa2

Hayabusa2 primary specifications
<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>Approx. 609 kg</td>
</tr>
<tr>
<td>Launch</td>
<td>3 Dec 2014</td>
</tr>
<tr>
<td>Mission</td>
<td>Asteroid return</td>
</tr>
<tr>
<td>Arrival</td>
<td>27 June 2018</td>
</tr>
<tr>
<td>Deoarture</td>
<td>13 Mov 2019</td>
</tr>
<tr>
<td>Earth return</td>
<td>6 Dec 2020 (plan)</td>
</tr>
<tr>
<td>Stay at asteroid</td>
<td>Approx. 18 months</td>
</tr>
<tr>
<td>Target body</td>
<td>Near-Earth asteroid Ryugu</td>
</tr>
</tbody>
</table>

Primary instruments
Sampling mechanism, re-entry capsule, optical cameras, laser range-finder, scientific observation equipment (near-infrared, thermal infrared), impactor, miniature rovers.
Mission flow

Launch
Dec 3, 2014

Earth swing-by
Dec 3, 2015

Ryugu arrival
June 27, 2018

MINERVA-II1 separation
Sep 21, 2018

MASCOT separation
Oct 3, 2018

MINERVA-II2 separation
Oct 3, 2019

Target marker separation
Sept. 17, 2019

Target marker separation
May 30, 2019

Impactor (SCI)
5 April, 2019

First touchdown
Feb 22, 2019

Ryugu departure
Nov 13, 2019

Second touchdown
July 11, 2019

Target marker separation
Oct. 25, 2018

Earth return
Dec. 6, 2020

(complete)

(image credit: illustrations including spacecraft by Akihiro Ikeshita, others by JAXA)
1. Current project status & schedule overview

Current status:

– On November 25, we obtained permission from Australia to transition to the re-entry orbit.
– TCM-3 was conducted on November 26, and the control maneuver to place the spacecraft into the atmospheric entry orbit towards Woomera, Australia was completed.
– After precisely estimating the resultant orbit, it was determined that it was unnecessary to correct the TCM-3 orbit itself, and it was decided to move onto the next TCM-4.
– In Woomera, the preparations underway for re-entry capsule recovery.
2. Results from TCM-3

- On November 25, we obtained permission from the Commonwealth Return Safety Officer (CRSO) to transition Hayabusa2 onto the re-entry trajectory to the Woomera Prohibited Area (WPA) in Australia. (Judgement found no problem with navigation, guidance, planning, spacecraft or ground system)
- On November 26, TCM-3, the third precision orbit control using the chemical engines (RCS) was performed, and the orbit correction was achieved as planned (TCM: Trajectory Correction Maneuver).
- The main control for TCM-3 was performed around 16:00 JST and the controlled correction (trim) around 17:00. The orbit control amount was about 1.2 m/s.

(image credit: JAXA)
2. Results from TCM-3

Orbit guidance by TCM

Orbit determination: measure and calculate the flight position of the spacecraft. (JAXA, Fujitsu, JPL)

Orbit evaluation: evaluate calculation results of the flight position and chose one from 3 solutions (JAXA, Fujitsu, JPL, NEC)

Trajectory plan: create trajectory correction plan (JAXA, NEC)

Attitude plan: attitude plan for injection, create thruster injection plan (JAXA, NEC)

Confirm plan: Final confirmation meeting (TCM Go/No Go)

For each TCM, there are 2 cycles of practice/production

11/30 1-12 JST
Orbit determination: measure and calculate the flight position of the spacecraft. (JAXA, Fujitsu, JPL)

11/30 13-14 JST
Orbit evaluation: evaluate calculation results of the flight position and chose one from 3 solutions (JAXA, Fujitsu, JPL, NEC)

11/30 14-19 JST
Trajectory plan: create trajectory correction plan (JAXA, NEC)

11/30 17-22 JST
Attitude plan: attitude plan for injection, create thruster injection plan (JAXA)

11/30 night 22-23 JST
Confirm plan: Final confirmation meeting (TCM Go/No Go)

The Australian permit was obtained after TCM3

12/1 all day
Actual operation

In precision guidance, a virtual target is set around the Earth and orbit control is performed to aim for a specific point on that target.

Guidance target area at TCM3 (inside Woomera)

(image credit: JAXA)
2. Results from TCM-3

TCM3, TCM4 concept

- TCM3 adjusts the course to one that enters the atmosphere over Woomera.
- TCM4 modifies this trajectory to land closer and more accurately to the area where the recovery team awaits.

(image credit: JAXA)
### 3. Details of capsule separation & re-entry

#### Schedule

<table>
<thead>
<tr>
<th>Event</th>
<th>Time (JST)</th>
<th>Earth distance (altitude)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCM-4 (orbit control correction)</td>
<td>12/1 Around 16:00</td>
<td>1.74 million km</td>
</tr>
<tr>
<td>Capsule separation</td>
<td>12/5 14:30</td>
<td>220,000 km</td>
</tr>
<tr>
<td>TCM-5 (orbit control correction to depart from the Earth’s sphere)</td>
<td>12/5 15:30〜18:00</td>
<td>200,000 – 160,000 km (spacecraft)</td>
</tr>
<tr>
<td>Spacecraft enters shadowed area</td>
<td>12/6 1:57</td>
<td>12,000km (spacecraft)</td>
</tr>
<tr>
<td>Capsule imaging</td>
<td>12/6 2:28〜30</td>
<td>700km〜300km (spacecraft)</td>
</tr>
<tr>
<td>Capsule atmospheric entry</td>
<td>12/6 2:28〜29</td>
<td>120km (capsule)</td>
</tr>
<tr>
<td>Spacecraft exits shadow</td>
<td>12/6 2:31</td>
<td>350km (spacecraft)</td>
</tr>
<tr>
<td>Parachute deployment</td>
<td>12/6 2:31〜33</td>
<td>11〜7km (capsule)</td>
</tr>
<tr>
<td>Capsule landing</td>
<td>12/6 2:47〜57</td>
<td>0km (capsule)</td>
</tr>
</tbody>
</table>
3. Details of capsule separation & re-entry

Re-entry explanatory diagram

(image credit: JAXA)

2020/11/30
3. Details of capsule separation & re-entry

Closed off area published by the Australian Air Force

4. Preparation status for capsule collection

• The main team arrived at Woomera on 11/24 and began settling up antennas, etc.
• The temperature at the time of installation was over 40°C. Work was under the scorching sun while trying to prevent heat stroke.

(image credit: JAXA)
4. Preparation status for capsule collection

- The main team arrived at Woomera on 11/24 and began settling up antennas, etc.
- The temperature at the time of installation was over 40°C. Work was under the scorching sun while trying to prevent heat stroke.

(image credit: JAXA)
4. Preparation status for capsule collection

- The QLF clean booth has been set up and is being tested.
5. Outreach

Ryugu & Hayabusa2 return observation campaign

• Number of registered campaigns: 135
• Many reports (28 as of November 26) have already been made of observations of Ryugu.
• For observations of Hayabusa2 just before re-entry, data for the observation will be provided to registrants.
• A special observation team (nicknamed “Hayabusan2”) was formed among the registered observers and if the observation is successful, the position and luminosity will be measured. Also, attempts will be made to try and observe the separated capsule. (24 teams as of November 26)

※ The Subaru Telescope succeeded in imaging Hayabusa2 on November 20 (Hawaii time)

• Organisers: Hayabusa2 Project, Japan Public Observatories Society (JAPOS), The Planetary Society of Japan (TPSJ)
• Campaign URLs:
  - TPSJ    http://planetary.jp/Haya2-Special/projects/hayabusa2-serv.html
6. Future plans

■ Operation schedule
  2020/12/1  TCM-4
  2020/12/5  TCM-5
  2020/12/6  Re-entry

■ Press and media briefings
  2020/12/4  16:00～ Press conference @JAXA Sagamihara Campus
  2020/12/6  16:30～ Press conference @JAXA Sagamihara Campus

■ Internet live broadcast
  2020/12/5  13:30～16:40 (until 17:30)  Capsule separation
  2020/12/6  02:00～03:10               Capsule fireball
Reference
Return cruise operation plan

Return phase orbit map

- **Hayabusa2 orbit**
- **Ryugu orbit**
- **Earth orbit**
- **Sun**
- **Earth re-entry** (Dec 6, 2020)
- **Ryugu departure** (Nov 13, 2019)
- **2nd ion engine operation** (May 12, 2020 – Sept 17, 2020)
- **1st ion engine operation** (Dec 3, 2019 – Feb 20, 2020)
- **Re-entry terminal guidance** (Oct 2020 ~)

(image credit: JAXA)
Operation plan for re-entry terminal guidance

※TCM: Trajectory Correction Maneuver

- May change depending on conditions.
- At TCM-0,1,2, the spacecraft will enter an orbit that passes more than 200 km away from the Earth.
- After capsule separation, the spacecraft will divert from the reentry trajectory by TCM-5.

2020/11/30 Hayabusa2 reporter briefing
Ryugu & Hayabusa2 return observation campaign

observation site

(image credit: Ryugu & Hayabusa2 Return Observation Campaign Team)