Asteroid explorer, Hayabusa2, reporter briefing

September 2, 2020
JAXA Hayabusa2 Project
Regarding Hayabusa2,

- Permission to land re-entry capsule in Australia
- Operation plan for re-entry terminal guidance
Contents

0. Hayabusa2 and mission flow outline
1. Current status and overall schedule of the project
2. Permission to land re-entry capsule in Australia
3. Operation plan for re-entry terminal guidance
4. Outreach
5. Future plans
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.

Hayabusa 2 primary specifications
<table>
<thead>
<tr>
<th>Mass</th>
<th>Approx. 609 kg</th>
</tr>
</thead>
<tbody>
<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>Earth return</td>
<td>2020</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

Ryugu departure
Nov 13, 2019

MINERVA-II2 separation
Oct 3, 2019

Target marker separation
Sept. 17, 2019

Second touchdown
July 11, 2019

Target marker separation
May 30, 2019

Impactor (SCI)
5 April, 2019

First touchdown
Feb 22, 2019

Earth return
Dec. 6, 2020

(complete)

Target marker separation
Oct 25, 2018

(image credit: illustrations including spacecraft by Akihiro Ikeshita, others by JAXA)

2020/9/2 Hayabusa2 reporter briefing
1. Current project status & schedule overview

Current status:

The 2nd ion engine operation was nearly complete on August 28 (99.9% of the operation was then completed for both forward and return trips). After precise orbit determination, the ion engine operation for the fine correction of the orbit will be performed in mid-September, and then the return ion engine operation will be complete.
2. Permission to land re-entry capsule in Australia

- On August 10, 2020, we received notification from Australian Space Agency (ASA) notified that landing permission for the Hayabusa2 re-entry capsule, the Authorisation of Return of Overseas-Launched Space Object (AROLSO), has been issued.
- Published: August 6, 2020
- Signatures: Karen Andrews, Minister of Industry, Science and Technology

- Original text:
  - (Section 1: Authorisation)
    This Authorisation is granted to JAXA as the responsible party for the return of the space object described in section 4 of the Authorisation.
  - (Section 4: Space object)
    The space object is the Sample Return Capsule.
2. Permission to land re-entry capsule in Australia

For the AROLSO application, the following contents were submitted in writing in August 2019:

- Management: capsule collection system etc.
- Safety: landing range and risks
- Emergency: Possible contingencies and response plan
- Environment: Environmental impacts during a normal and abnormal landing
- Recovery plan: Capsule search plan, recovery/transport sequence, schedule etc.

After submitting the plan, meetings in Australia and via video conference were held, providing supplementary explanations for the plan and adding and revising any missing information. After about a year of further examination, the landing clearance was granted.
3. Operation plan for re-entry terminal guidance

■ 2nd ion engine operation
  • On August 28, the trajectory correction using the ion engines was almost complete, and the ion engines were stopped.
  • After making a precise orbit determination, the ion engines will be restarted in mid-September to fine-tune the orbit (TCM-0).
  • This completes the ion engine operation for the return trip, and the RCS (chemical thrusters) will be used for subsequent trajectory correction.

■ Re-entry terminal guidance
  • Orbital corrections TCM-1~5 will be made via the RCS.
  • Dates of the TCM (Trajectory Correction Maneuver) are shown on the following page.
3. Operation plan for re-entry terminal guidance

Through orbital control by the ion engine, we gradually approach an orbit that intersects the Earth.

As of August 26, Hayabusa2 is in an orbit where the Earth’s closest distance is 20,000 km.

It is expected the complete process of ion engine operation will be completed on 9/15〜21. Hayabusa2 will then be on an orbit with the closest approach to Earth of 1000 km or less.
3. Operation plan for re-entry terminal guidance

<table>
<thead>
<tr>
<th>Operation name</th>
<th>Date</th>
<th>Earth distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCM-0</td>
<td>around 9/15~21</td>
<td>about 36 million km</td>
</tr>
<tr>
<td>TCM-1</td>
<td>around 10/20~26</td>
<td>about 17 million km</td>
</tr>
<tr>
<td>TCM-2</td>
<td>around 11/2~19</td>
<td>about 12 million km</td>
</tr>
<tr>
<td>TCM-3</td>
<td>around 11/25~29</td>
<td>about 3.5 million km</td>
</tr>
<tr>
<td>TCM-4</td>
<td>around 12/1</td>
<td>about 1.8 million km</td>
</tr>
<tr>
<td>Capsule separation</td>
<td>12/5 14:00~15:00 JST</td>
<td>about 220,000 km</td>
</tr>
<tr>
<td>TCM-5</td>
<td>12/5 15:00~17:00 JST</td>
<td>about 200,000 km</td>
</tr>
<tr>
<td>Capsule landing</td>
<td>12/6 2:00~3:00 JST</td>
<td>0km</td>
</tr>
</tbody>
</table>

TCM: Trajectory Correction Maneuver

Note: Subject to change due to flight conditions.
3. Operation plan for re-entry terminal guidance

※TCM: Trajectory Correction Maneuver

- Ion engine TCM (around 9/15-21, ~36M km from Earth)
- TCM-0: Orbit fine adjustment (using RCS, same for later TCMs) (around 10/20–26, ~17M km from Earth)
- TCM-1: Orbit fine adjustment (around 11/2-19, ~12M km from Earth)
- TCM-2: Targeting to Woomera (around 11/25-19, ~3.5M km from Earth)
- TCM-3: Orbit fine adjustment (around 12/1, ~1.8M km from Earth)
- TCM-4: Capsule separation (around 12/5 14:00-15:00 JST, ~220,000 km from Earth)
- TCM-5: Change to Earth departure trajectory (around 12/5 15:00-17:00 JST, ~200,000 km from Earth)
- Capsule landing (around 12/6 2:00-3:00 JST)

• 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.

(Image credit: JAXA)
3. Operation plan for re-entry terminal guidance

CG video explaining the Earth return.

Hayabusa2 Earth Return

(credit: JAXA)
4. Outreach

The following outreach activates are planned for the Earth-return:

- Call for messages of support
  - Request support messages for re-entry to be posted on the Hayabusa2 website.

- Release of the spacecraft’s return trajectory
  - We will publically release information about the Earth return orbit of the spacecraft.

- 2nd Ryugu observation campaign
  - Asteroid Ryugu will approach the Earth between October and December this year, providing an opportunity for observation. An observation campaign will be conducted during this time.

- Hayabusa2 welcome home observation campaign
  - Since there is a possibility that the spacecraft can be observed with a telescope just prior to re-entry, we will conduct a campaign similar to the observation campaign for the Earth swing-by.
5. Future plans

■ Operation schedule
  2020/9 15〜21  Fine orbital correction by the ion engines (TCM-0)
  2020/10〜  Re-entry terminal guidance
  2020/12/6  Re-entry

■ Press and media briefings
  2020/9 (TBD)  Press briefing @ online (TBD)
Reference
Return cruise operation plan

Return phase orbit map

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

(image credit: JAXA)