Asteroid explorer Hayabusa2
Press Conference

December 4, 2020
JAXA Hayabusa2 Project
Hayabusa2 capsule separation operation

The spacecraft, spacecraft operation, re-entry capsule recovery preparation work and ground systems are not experiencing any problems. The re-entry capsule will be separated and operated as planned.
Status of spacecraft re-entry

- On December 1, orbit control with TCM-4 was performed and the spacecraft is on the planned trajectory.
- The orbit control amount in TCM-4 is about 4.6 cm/s.
- TCM-4 adjusted the planned landing area for the capsule by 33km to the south-east.
- Subsequent orbit estimation confirmed the spacecraft is on the planned trajectory.

(image credit: JAXA)
When the capsule is separated, the attitude of the spacecraft will be greatly tilted (with respect to the Sun). This ensures the capsule will be in the right position for entering the atmosphere.

- After capsule separation has been confirmed, TCM5 will be executed.
- For implementing TCM5, permission will be obtained to change the trajectory (after the start of the operation on that day) from the Commonwealth Return Safety Officer (CSRO).
Movement of spacecraft / capsule during re-entry (December 6)

- **Atmospheric entry**
  - Altitude: 120km
  - Flight speed: 11.6km/s

- **Fireball phase**
  - Altitude: 80→40km
  - Flight speed: 11.6km/s→3km/s

- **Parachute descent phase**
  - Altitude: 10km→surface
  - Flight speed: 0.1m/s
  - Beacon transmission

- **Ballistic descent**
  - Flight speed: 3km/s→100m/s

- **Heat shield separation / Parachute deployment**
  - Altitude: around 10km
  - Flight speed: 100m/s→0.1m/s

- **Landing**
  - Parachute detachment

- **Passing through shadow** (about 35 minutes)
- **2:31〜2:33 JST**
  - <Heat shield separation / Parachute deployment>
  - Altitude: around 10km
  - Flight speed: 100m/s→0.1m/s

- **The brightness of the fireball is uncertain as it depends on place and time, but is estimated to be equivalent to a maximum of minus 7 ~ 9 mag.**

(image credit: JAXA)

2020/12/4 Hayabusa2 Press Conference
## Capsule separation & re-entry schedule

### Schedule

<table>
<thead>
<tr>
<th>Event</th>
<th>Time (JST)</th>
<th>Earth distance (altitude)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCM-4 (orbit correction)</td>
<td>Dec 1 around 16:00</td>
<td>1,740,000 km</td>
</tr>
<tr>
<td>Capsule separation</td>
<td>Dec 5 14:30</td>
<td>220,000 km</td>
</tr>
<tr>
<td>TCM-5 (orbit control to depart from the Earth’s sphere)</td>
<td>Dec 5 15:30 ~ 18:00</td>
<td>200,000 ~ 160,000 km (spacecraft)</td>
</tr>
<tr>
<td>Spacecraft enters shadowed area</td>
<td>Dec 6 1:57</td>
<td>12,000km (spacecraft)</td>
</tr>
<tr>
<td>Capsule imaging</td>
<td>Dec 6 2:28 ~ 2:30</td>
<td>700km ~ 300km (spacecraft)</td>
</tr>
<tr>
<td>Spacecraft exits shadow</td>
<td>Dec 6 2:31</td>
<td>350km (spacecraft)</td>
</tr>
<tr>
<td>Capsule atmospheric entry</td>
<td>Dec 6 2:28:27</td>
<td>120km (capsule)</td>
</tr>
<tr>
<td>Capsule : fireball phase</td>
<td>Dec 6 2:28:49 ~ 2:29:25</td>
<td>80 km ~ 40 km (capsule)</td>
</tr>
<tr>
<td>Parachute deployment</td>
<td>Dec 6 2:31 ~ 2:33</td>
<td>11~7km (capsule)</td>
</tr>
<tr>
<td>Capsule landing</td>
<td>Dec 6 2:47 ~ 2:57</td>
<td>0km (capsule)</td>
</tr>
</tbody>
</table>

※The time of the fireball phase can have an error of several seconds due to orbit error, weather, etc.
Preparation for capsule collection

From Dec 1 to Dec 2, a recovery rehearsal was held in Woomera in real time.

<Rehearsal flow>
- Standby for headquarters, antenna stations, observation stations
- Measurements at each antenna station
- Estimation of landing point from measurement results
- Fly helicopter towards the landing point.
- Collected simulation capsule
- Transport capsule to QLF

<Rehearsal results>
- Overall flow of collection operation was confirmed.
- Minor corrections have been identified and will be reflected in the actual procedure. (e.g. communication of latitude and longitude of the landing point, etc.)
Preparation for capsule collection

Optical observations (GOS)

Transporting the collected sample from the helicopter to QLF (Quick Look Facility)

(image credit: JAXA)
Preparation for capsule collection

“Sagamin” is also in the field

(image credit: JAXA)
Observation operation after the Earth swing-by

After capsule separation, observations and experiments will be conducted using the spacecraft’s onboard equipment. The main observations and experiments are:

- **Observations with the Optical Navigation Camera (ONC)**
  - Earth imaging (12/6 ~06:30JST) and “Goodbye Earth” observation (12/6~)
  - Moon imaging (12/6~)
  - Purpose: Calibration and public relations

- **Observations with the Thermal Infrared Imager (TIR)**
  - Observations of the Earth & Moon (12/6~)
  - Purpose: Calibration. Investigate the characteristics of the instrument and use this in Ryugu data analysis.
Observation operation after the Earth swing-by

(Continued)

- LIDAR optical link experiment
  - Experiment: After the return of Hayabusa2 to Earth, attempts will be made to send a laser beam from the ground station and receive it at Hayabusa2, and then to send a laser beam from Hayabusa2 towards the ground and receive it at the ground station.
  - Significance: Aid in the development of laser range technology in space exploration.
  - Cooperation: National Institute of Information and Communications Technology (NICT), Australian, French, German observatories
    - (Ground station): National Institute of Information and Communications Technology Koganei Station (Japan), Mount Stromlo Observatory (Australia), L’Observatoire de Grasse (France), Geodetic Observatory Wettzell (Germany).
  - Schedule: Begin immediately after returning to Earth. Scheduled period is December 7 ~ 23. This may be cancelled depending on weather.
Schedule

- **Press conference**
  
  **2020/12/6  16:30～**
  JAXA Sagamihara campus

- **Online relay**
  
  **2020/12/5  13:30～16:40 (possible extension until 17:30)**
  Capsule separation

  **2020/12/6  02:00～03:10**
  Capsule fireball
Reference
Observation of the re-entry fireball phase

App that displays the predicted trajectory of the re-entry capsule in AR (Augmented Reality): 「Reentry AR」(from Toriningen)

- When you select the observation site, the predicted track of the fireball is displayed in AR.
- The expected brightness according to altitude is also displayed.

App download (iOS only)

![Japanese QR Code](image)
![English QR Code](image)

Trajectory when the observation site is Coober Pedy.
The background here is in front of the JAXA Sagamihara campus

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Return cruise operation plan

Return phase orbit map

2nd ion engine operation (May 12, 2020 ~ Sept 17, 2020)

Hayabusa2 orbit

Ryugu orbit

Earth orbit

Sun

Earth re-entry (Dec 6, 2020)

Ryugu departure (Nov 13, 2019)

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

- 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.

TCM-0: Ion engine TCM
(9/17, ~36M km from Earth)

TCM-1: Orbit fine adjustment (using RCS, same for later TCMs)
(10/22, ~17M km from Earth)

TCM-2: Orbit fine adjustment
(11/12, ~9M km from Earth)
Targeting to Woomera
(around 11/26, 3.6M km from Earth)

TCM-3: Orbit fine adjustment
(around 12/1, 1.74M km from Earth)

TCM-4: Capsule separation
(12/5 14:30 JST, 220,000 km from Earth)

TCM-5: Change to Earth departure trajectory
(12/5 15:30-18:00 JST, 200,000~160,000 km from Earth)

Capsule separation
(12/5 14:30 JST, 220,000 km from Earth)

Capsule landing
(12/6 2:47-2:57 JST)

Capture altitude
290 km

Passing altitude
290 km

Target trajectory for TCM-0,1,2

Escape trajectory

Done

Done

Done

Done

Done

2020/12/4

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(Image credit : JAXA)