Flight Status of Hayabusa2: Asteroid Sample Return Mission to C-type Asteroid Ryugu

Yuichi Tsuda, Makoto Yoshikaw (ISAS/JAXA)
Hayabusa2 is the 2nd Japanese sample return mission to small bodies. JAXA launched Hayabusa2 in 2014, which will explore the C-type asteroid Ryugu, and will return back to the Earth in 2020.

• **Round-trip mission**
  – High specific impulse ion engine for continuous-thrust trajectory control.

• **In-situ science at “Ryugu”**
  – 1.5year proximity operation at Ryugu
  – Four landers, four remote science instruments.

• **Touch down & sample collection**
  – Two normal touch down, one pin-point touch down (to an artificial crater) are planned.

• **Artificial crater forming**
  – Kinetic impact on the asteroid surface to create a 2m-class crater.
  – Investigating Sub-surface structure of the asteroid
The spacecraft carries an impactor. The impactor collides to the surface of the asteroid. The sample will be obtained from the newly created crater.

Launch
Dec. 3, 2014
Earth swingby
Dec. 3, 2015

June-July 2018 : Arrival at Ryugu
The spacecraft observes the asteroid, releases the small rovers and the lander, and executes multiple samplings.

New Experiment
The impactor collides to the surface of the asteroid.

Sample analysis
Earth Return
Nov.-Dec. 2020
Nov.-Dec. 2019 : Departure

Dec. 3, 2015

Mission Scenario of Hayabusa2

2019

Mission Scenario of Hayabusa2

Dec. 3, 2014
Earth swingby
Dec. 3, 2015
Hayabusa2 Spacecraft Overview

Launch Mass: 609kg
Ion Engine: Total $\Delta V=3.2\text{km/s}$, Thrust=5-28mN (variable), Specific Impulse=2800-3000sec. (4 thrusters, mounted on two-axis gimbal)
Chemical RCS: Bi-prop. 20N thrusters $\times 12$ (6 DOF maneuverability)
Solar Array Paddle: 2.6kW @ 1 a.u.
TT&C: X-band Uplink, X/Ka-band Downlink, 8-32Kbps, X/Ka RARR&DDOR capability
## Scientific Payloads

<table>
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<tr>
<th>Instruments</th>
<th>Specifications</th>
<th>Note</th>
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<tr>
<td>Multiband Imager (ONC-T)</td>
<td>Wavelength: 0.4 – 1.0 μm, FOV: 5.7 deg x 5.7 deg, Pixel Number: 1024 x 1024 px filter (ul, b, v, w, x, p, Wide)</td>
<td>Heritage of Hayabusa (modified)</td>
</tr>
<tr>
<td>Near IR Spectrometer (NIRS3)</td>
<td>Wavelength: 1.8 – 3.2 μm, FOV: 0.1 deg x 0.1 deg</td>
<td>Heritage of Hayabusa, but 3μm range is new</td>
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<tr>
<td>Thermal IR Imager (TIR)</td>
<td>Wavelength: 8 – 12 μm, FOV: 12 deg x 16 deg, Pixel Number: 320 x 240 px</td>
<td>Heritage of Akatsuki</td>
</tr>
<tr>
<td>Laser Altimeter (LIDAR)</td>
<td>Measurement Range: 50 m – 50 km</td>
<td>Heritage of Hayabusa (modified)</td>
</tr>
<tr>
<td>Sampler (SMP)</td>
<td>Minor modifications from Hayabusa-1 Three container, metallic sealing</td>
<td>Heritage of Hayabusa (upgraded)</td>
</tr>
<tr>
<td>Small Carry-on Impactor (SCI)</td>
<td>Small system released form the spacecraft to form an artificial crater on the surface</td>
<td>New</td>
</tr>
<tr>
<td>Separation Camera (DCAM3)</td>
<td>Small, detached camera to watch operation of Small Carry-on Impactor</td>
<td>Heritage of Ikaros (upgraded)</td>
</tr>
<tr>
<td>Small Rover (MINERVA II-1A,1B, 2)</td>
<td>Similar to MINERVA of Hayabusa-1 (Cameras, thermometers)</td>
<td>Heritage of Hayabusa (largely upgraded)</td>
</tr>
<tr>
<td>Small Lander (MASCOT)</td>
<td>Supplied from DLR &amp; CNES MicrOmega, MAG, CAM, MARA</td>
<td>New</td>
</tr>
</tbody>
</table>
Robotic Exploration with 12 Deployable “Robots”
Hayabusa2’s Target: 162173 Ryugu

162173 Ryugu (1999 JU3)
Current estimate:
Rotation period: 7 h 38 m
Shape: almost spherical
Size: 820 – 890 m
Albedo: 0.05 – 0.06
H: 19.2
Type: Cg

Origin:
inner MB?
ν6 secular resonance?
Erigone Family?
(by Mueller et al.)
Present Status of Hayabusa2 (as of June 13, 2017)

- Traveled 23.3 billion km (w.r.t heliocentric inertial frame)
- Solar distance 1.13AU, Earth distance 1.05AU (Almost on Sun-Earth L5!).
- 3880hrs of ion engine operation has completed. Remaining burn to arrive at Ryugu is 3000hrs.
Asteroid Proximity Operation Plan

Spin axis: $\lambda = 325$ deg, $\beta = -40$ deg

We have (only!) 1.5 years of the asteroid proximity operation duration. The asteroid environment cannot be acquired before arrival. → *Quick scheduling right after the arrival is crucial.*

**Two pre-arrival trainings are planned**
(1) **LSSP** (Landing Site Selection Process) simulation: decision making process
(2) **RIO** (Realtime Integrated Operation) simulation: realtime operation practice
2017 – Final year before Arrival!

- Landing Site Selection (LSS) Training (2Q-3Q, 2017)
  - Purpose: Verification of LSS process
    - Decision making framework/criteria, Tools and interface, ...
  - Trainee
    - JAXA engineering, Science (International), MASCOT team
  - Training data
    - Asteroid images (fake, generated by computer graphics)
    - Science data (Thermal data, NIRS data)
    - Navigation data (position & velocity of S/C), Attitude data.

  - Purpose: Real-time training (GNC), Verification of online tools
    - Touchdown operation, Impact operation, ...
  - Trainee: GNC/SYS operators and staffs, relevant subsystem staffs
  - Training data
    - Asteroid images (Computer graphics-based, real-time)
    - Telemetry data (Communication delay emulated)
2013 Apr. - Aug. : Let's meet with Le Petit Prince! Million Campaign 2
Launch : 3 Dec. 2014
400,000+ registrations

2015 July - Aug. : Asteroid Naming Campaign for 1999 JU3
Earth Swingby : 3 Dec. 2015
7,300+ proposals

2015 Dec. : Swing-by Observation Campaign
39 observations

2016 July - Aug. : Ryugu Observation Campaign
14+ observations

2017 Feb. : Ryugu Spin parameter Campaign
100+ participants
Talk Live 2016 Feb. - 8 days 1500+ audience
Arrival at Ryugu : June - July 2018

New events
Conclusion

- Hayabusa2 spacecraft is flying normally. Two third of the ion engine powered cruise has been completed successfully.

- Hayabusa2 also succeeded in accurate Earth gravity assist (EGA) operation on December 3, 2015.

- Hayabusa2 is scheduled to arrive at Ryugu in June-July 2018. One year to arrival!

- The operation team is now preparing for operation practice/rehearsals using the hardware-in-the-loop simulator to get prepared for the asteroid arrival in the summer 2018.
Thank you very much.

Dec.3, 2015,
At the success of the Earth swing-by operation

Dec.3, 2016,
Hayabusa2 Joint Science Team Meeting