Achievements of Hayabusa2: Unveiling the World of Asteroid by Interplanetary Round Trip Technology

Yuichi Tsuda
Project Manager, Hayabusa2
Japan Aerospace Exploration Agency

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Lunar and Planetary Science Missions of Japan

Moon
- 1990 Hiten
- 1998 Nozomi (Mars)
- 2007 Kaguya
- 2010 Akatsuki
- 2018 Mio
- 2010 IKAROS
- SLIM

Planets
- 1980
- 1990
- 2000
- 2010
- 2020 (Future Plan)
- Venus
- Mercury
- Phobos/Mars
- Destiny+
- MMX

Small Bodies
- 1985 Suisei
- 1985 Sakigake
- Comet Halley
- 2003 Hayabusa
- Asteroid Itokawa
- Asteroid Ryugu
- 2014 Hayabusa2
- Comet Pheton

Flyby → Sample Return
Hayabusa2 Mission

✓ Sample return mission to a C-type asteroid “Ryugu”
✓ 5.2 billion km interplanetary journey.

Launch Dec.3, 2014

Earth Gravity Assist Dec.3, 2015

Ryugu Arrival Jun.27, 2018

MINERVA-II-1 Deployment Sep.21, 2018

MASCOT Deployment Oct.3, 2018

MINERVA-II-2 Orbiting Oct.2, 2019

Target Markers Orbiting Sep.16, 2019

First Touchdown Feb.22, 2019

Second Touchdown Jul.11, 2019

Kinetic Impact Apr.5, 2019

Ryugu Departure Nov.13.2019

Earth Return Dec.6, 2020

MINERVA-II-1 Deployment

Target Markers Orbiting

Second Touchdown

Kinetic Impact

First Touchdown

MASCOT Deployment

Earth Return

Ryugu Departure

MINERVA-II-2 Orbiting

Target Markers Orbiting

Second Touchdown

Kinetic Impact

First Touchdown

MASCOT Deployment
Hayabusa2 Spacecraft Overview

Launch Mass: 609kg
Ion Engine: Total $\Delta V=3.2\text{km/s}$, Thrust=$5$-$28\text{mN}$ (variable), Specific Impulse=$2800$-$3000\text{sec.}$ (4 thrusters, mounted on two-axis gimbal)
Chemical RCS: Bi-prop. $20\text{N}$ thrusters $\times 12$ (6 DOF maneuverability)
Solar Array Paddle: $2.6\text{kW} @ 1 \text{a.u.}$
TT&C: X-band Uplink, X/Ka-band Downlink, 8-32Kbps, X/Ka RARR&DDOR capability
International Collaboration in Hayabusa2

200+ Japanese researchers, 100+ international researchers

**USA**

1. NASA
   - Tracking and navigation support by JPL
   - Asteroid observation
   - Sample exchange with OSIRIS-REx mission

**Europe**

1. DLR (Germany)
   - Provision of MASCOT Lander
   - Tracking support thr ESA
   - Drop tower experiment

2. CNES (France)
   - Provision of instruments aboard MASCOT

**Australia**

1. Australian Space Agency (ASA)
   - Landing authorization

2. Department of Defense (DOD)
   - Provision of Landing site
Arrival at Ryugu on June 27, 2018

- **Top shape** with a very circular equatorial bulge
- Spectrum type: Cb
- Diameter: \( \sim 900 \) m
- Mass: \( \sim 450 \) million ton
- Obliquity: \( \sim 8^\circ \)
- Rotation period: \( P = 7.63 \) hours
- Reflectance factor (v-band): 0.02
- Terrain: **Very bumpy**
Accomplishments of Hayabusa2 (1/2)

1. Mobile activity of exploration robots on small body
2. Multiple robots deployment on small body

3. 60cm-accuracy landing and sampling on extra-terrestrial celestial body

image credit: JAXA
Accomplishments of Hayabusa2 (2/2)

4. Artificial crater forming and detailed observation of impact process
5. Multiple landing on extra-terrestrial celestial body
6. Access to subsurface material

7. Smallest-object constellation around extra-terrestrial celestial body

image credit: JAXA
Reentry Terminal Guidance Phase

- 5 TCMs in the last 2 months before Earth return.
- The SRC was separated 12 hrs before reentry.
- The spacecraft diverted from the reentry trajectory 11 hrs before reentry.
Hayabusa2 has returned!

Coober Pedy, Australia, Dec.6, 2020, 2:28:48-2:29:11JST (Altitude 80〜50km)
Sample Return Capsule recovery

Dec.6 (JST)
02:28   SRC reentry
02:32   SRC beacon signal detected
02:54   SRC landed (loss of beacon signal)
04:47   SRC found
08:03   SRC arrived at Quick Look Facility
11:13   Fore-heat shield found
12:31   Aft-heat shield found
Dec.7   
22:30   SRC shipped to Japan
Dec.8   
11:27   SRC carried into curation facility

57hr! (requirement 100hr)
Ryugu samples found in the sample container!
Sample yield: 5.4g (requirement: 0.1g)
Hayabusa2 Extended Mission

- Multi-swingby + solar electric propulsion
- Pursuing for *Planetary Defense* technologies and sciences
- High speed flyby of asteroid 2001 CC21
- Rendezvous to fast rotator asteroid 1998 KY26
Significance of Hayabusa2

Science

Space Exploration Engineering

Planetary Defense

Planetary Resource

Hayabusa2 is pushing forward the boundaries of small body surface activity

ACCESS / ROVING / SAMPLING / IMPACTING
Launch Mass: About 4,000 kg
Mission Duration: About 5 Years
Launcher: H3 Launch Vehicle
Target Launch Year: JFY2024

The sample return mission from the Martian moon, Phobos
Thank you for your attention