Mission Scenario of Hayabusa2

Launch
03 Dec. 2014

Earth swing-by
03 Dec. 2015

Arrival at Ryugu
June-July 2018

New Experiment

The spacecraft observes the asteroid, releases the small rovers and the lander, and executes multiple samplings.

Sample analysis

2019

The impactor collides to the surface of the asteroid.

Earth Return
Nov.-Dec. 2019: Departure

The sample will be obtained from the newly created crater.

Nov.-Dec. 2020
Hayabusa2 Spacecraft

Small Lander and Rovers

MASCOT
by DLR and CNES
II-1 : by JAXA MINERVA-II Team
II-2 : by Tohoku Univ. & MINERVA-II consortium

MINERVA-II
II-1A
II-1B
II-2

Science Instruments

ONC-T
LIDAR
NIRS3
TIR

ONC-W2
LIDAR

MASCOT Lander
MINERVA-II Rovers

Ion Engine
RCS thrusters ×12
ONC-T, ONC-W1

Target Markers ×5

Size : 1m×1.6m×1.25m (body)
Mass : 600kg (Wet)
Trajectory Design for the way to Ryugu

- **Launch** (Dec. 3, 2014)
- **Earth swing-by** (Dec. 3, 2015)
- **Ryugu arrival** (June-July 2018)

**Key Events**:
- **Launch** (Dec. 3, 2014)
- **Earth swing-by** (Dec. 3, 2015)
- **Ryugu arrival** (June-July 2018)
Launch and Initial Operations

2014/12/3
04:22:04 Launch
06:09:25 Separation
06:14:53 SAP deployment
06:16:31 Sun acquisition maneuver
09:06:51 Single spin established

1st, 2nd, 3rd tracking passes
• Three axis attitude stabilization established
• Sampler horn deployed
• Ion engine gimbal launch lock released
• Moon photo taken by ONC-W2, benefit for scientific calibration purpose
<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014 Dec. 3-6</td>
<td>LEOP</td>
</tr>
<tr>
<td>Dec. 7-8</td>
<td>XMGA pointing calibration, X-band COMM characterization/testing</td>
</tr>
<tr>
<td>Dec. 9</td>
<td>EPS/BAT testing</td>
</tr>
<tr>
<td>Dec. 10</td>
<td>NIRS3 health check</td>
</tr>
<tr>
<td>Dec. 11</td>
<td>TIR/DCAM3/ONC health check</td>
</tr>
<tr>
<td>Dec. 12-15</td>
<td>AOCS characterization/testing</td>
</tr>
<tr>
<td>Dec. 16</td>
<td>MINRVA-II/MASCOT health check</td>
</tr>
<tr>
<td>Dec. 17</td>
<td>CPSL/SCI health check</td>
</tr>
<tr>
<td>Dec. 18</td>
<td>XHGA pointing calibration, IES turn-on preparation</td>
</tr>
<tr>
<td>Dec. 19-22</td>
<td>IES baking</td>
</tr>
<tr>
<td>Dec. 23-26</td>
<td>IES testing (ITR-A/B/C/D, single-thruster-at-once operation)</td>
</tr>
<tr>
<td>2015 Dec. 27-Jan. 4</td>
<td>Precision OD, DDOR testing</td>
</tr>
<tr>
<td>Jan. 5-10</td>
<td>Ka-band COMM characterization/testing, KaHGA pointing calibration</td>
</tr>
<tr>
<td>Jan. 11</td>
<td>IES turn-on preparation</td>
</tr>
<tr>
<td>Jan. 12-15</td>
<td>IES testing (&lt;A+C&gt;,&lt;C+D&gt;,&lt;A+D&gt;,&lt;A+C&gt;, dual thrusters operation)</td>
</tr>
<tr>
<td>Jan. 16</td>
<td>IES testing (&lt;A+C+D&gt;, triple thrusters operation)</td>
</tr>
<tr>
<td>Jan. 19-20</td>
<td>IES 24hr continuous operation demonstration (&lt;A+D&gt;)</td>
</tr>
<tr>
<td>Jan. 23</td>
<td>LIDAR/LRF/FLA health check</td>
</tr>
<tr>
<td>Jan. 24-Mar. 2</td>
<td>IES-AOCS coordinated operation testing</td>
</tr>
<tr>
<td></td>
<td>SRP dynamics characterization / “Solar Sail Mode” demonstration</td>
</tr>
<tr>
<td>Mar. 2</td>
<td>Commissioning phase completed</td>
</tr>
</tbody>
</table>

**Commissioning Phase**

DSN GDS/CAN/MAD

DSN MAD
### Regular Operation Phase to Earth Swing-by

<table>
<thead>
<tr>
<th>2015</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar. 3</td>
<td>Regular Operation Phase started</td>
</tr>
<tr>
<td>Mar. 3-21</td>
<td>First IES Operation in EDVEGA Phase : 409 hours</td>
</tr>
<tr>
<td>Mar. 27 – May 7</td>
<td>Attitude control in the solar sail mode (One RW operation)</td>
</tr>
<tr>
<td>May 12-13</td>
<td>Three IES operation for 24 hours</td>
</tr>
<tr>
<td>June 2-6</td>
<td>Second IES Operation in EDVEGA Phase : 102 hours</td>
</tr>
<tr>
<td>June 9-</td>
<td>The solar sail mode operation</td>
</tr>
<tr>
<td>Sep. 1,2</td>
<td>TCM by IES</td>
</tr>
<tr>
<td>- mid Sep.</td>
<td>Precise OD</td>
</tr>
<tr>
<td>Oct.-Dec.</td>
<td>Precise TCM by RCS</td>
</tr>
<tr>
<td>Dec. 3</td>
<td>Earth swingby</td>
</tr>
<tr>
<td>Dec. 2015-Apr. 2016</td>
<td>Post-Swingby southern hemisphere operation</td>
</tr>
</tbody>
</table>
Approach to the Earth

- **2015/11/3**
  - TCM1

- **2015/11/10-13**
  - TIR Obs.

- **2015/11/26**
  - TIR, TIR, NIRS3 Obs.

- **2015/12/3**
  - TIR and ONC-T Obs.
  - ONC-W2 Obs

- **2015/12/4**
  - TIR and ONC-T Obs.

- **2015/12/22**
  - End of Swingby Operation

Orbit near the earth

- **2015/11/26**
  - TCM2

- **2015/12/1**
  - TCM3—cancel

- **2015/12/3**
  - the closest point

- **2015/12/19**
  - LIDAR Experiment

Sun direction

Eclipse
- Starts (18:58JST)
- Ends (19:18JST)

Closest
- (19:08:07JST)

Orbit of Hayabusa2

Orbit of Moon

(Time is in JST)
The Earth images at swing-by (animation)

The images of the Earth taken by ONC-W2. The time (UTC) of each image and the distance from the Earth are shown in the photo. The images were taken from 00:00 to 09:15 (UTC) on December 3, 2015. The viewing angle is at about 60 degrees.
Operations of Science Instruments

ONC-T
- Color image
- Plants exist reason

TIR
- Thermal Image
- Australia

NIRS3
- Absorption by water on the earth

LIDAR
- Optical Link Experiment at 6,700,000 km from Earth
### Operations and Experiments after Earth Swing-by

<table>
<thead>
<tr>
<th>2016</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. - April</td>
<td>Southern hemisphere operation</td>
</tr>
<tr>
<td>March 22 – May 21</td>
<td>1st long-term IES operation after Earth Swing-by : 798 h</td>
</tr>
<tr>
<td>May 24 – June 9</td>
<td>Mars Observation (by ONC-T, NIRS3, TIR)</td>
</tr>
<tr>
<td>June 22, 23</td>
<td>Experiment of uplink transfer</td>
</tr>
<tr>
<td>June 29 – July 8</td>
<td>Experiments of Ka-band communication</td>
</tr>
<tr>
<td>Dec. – May 2017 ?</td>
<td>2nd long-term IES operation</td>
</tr>
<tr>
<td>Nov. 2017 - June 2018 ?</td>
<td>3rd long-term IES operation</td>
</tr>
</tbody>
</table>
Target Asteroid: 1999 JU3 = Ryugu

Asteroid (162173) 1999 JU3
- Discovered in May 1999 by LINEAR Team
- Shape: almost spherical
- Size: 900 m
- Rotation period: 7.6 h
- Pole orientation (320°, -40°): current estimate
- Albedo: 0.05
- Type: Cg

Spectrum
(Data by Viras 2008, Sugita+ 2012, Abe+ 2008)

Light curve

Shape
(by T. Müller)
International Cooperation Structure of Hayabusa2

USA
NASA

Europe
DLR
CNES

Australia
SLASO/DIISR
DoD/AOSG
AQIS/AC

OSIRIS-REx
(101955) Bennu