Asteroid explorer, Hayabusa2 press conference

December 13, 2018

JAXA Hayabusa2 Project

Topics

In connection with Hayabusa2:

- Solar conjunction operation
- MINERVA-II1 rovers

Contents

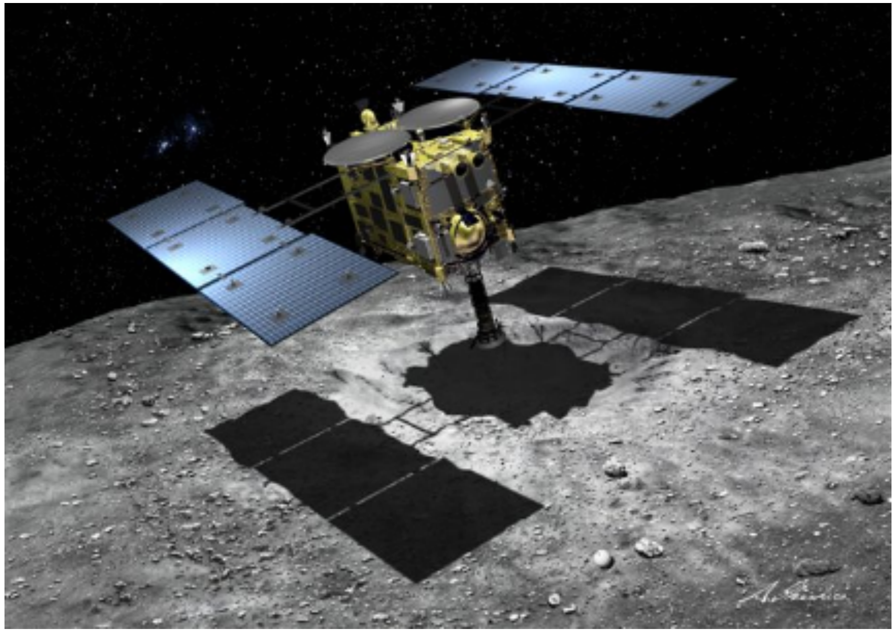
Overview of Hayabusa2

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.



(Illustration: Akihiro Ikeshita)

Hayabusa 2 primary specifications

Mass	Approx. 609 kg
Launch	3 Dec 2014
Mission	Asteroid return
Arrival	27 June 2018
Earth return	2020
Stay at asteroid	Approx. 18 months
Target body	Near-Earth asteroid Ryugu

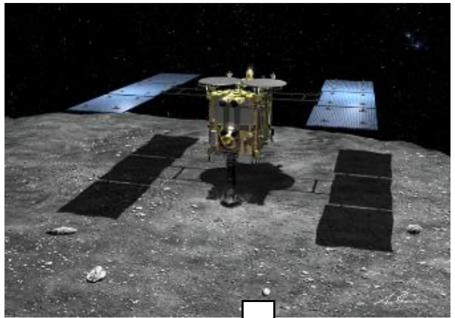
Primary instruments
Sampling mechanism, re-entry capsule, optical cameras, laser range-finder, scientific observation equipment (near-infrared, thermal infrared), impactor, miniature rovers.

Mission Flow

Launch
3 Dec 2014

Earth swing-by
3 Dec 2015

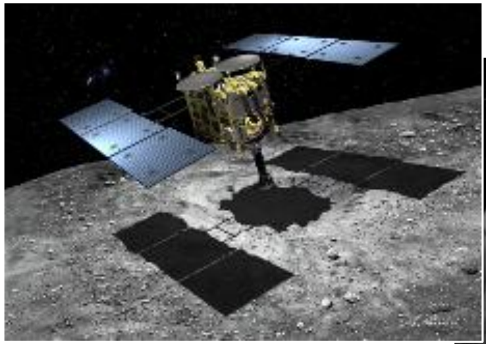
Arrival at asteroid
June 27, 2018



Examine the asteroid by remote sensing observations. Next, release a small lander and rover and also obtain samples from the surface.

Use an impactor to create an artificial crater on the asteroid's surface

Depart asteroid
Nov–Dec 2019



After confirming safety, touchdown within the crater and obtain subsurface samples

Earth return
late 2020

Sample analysis

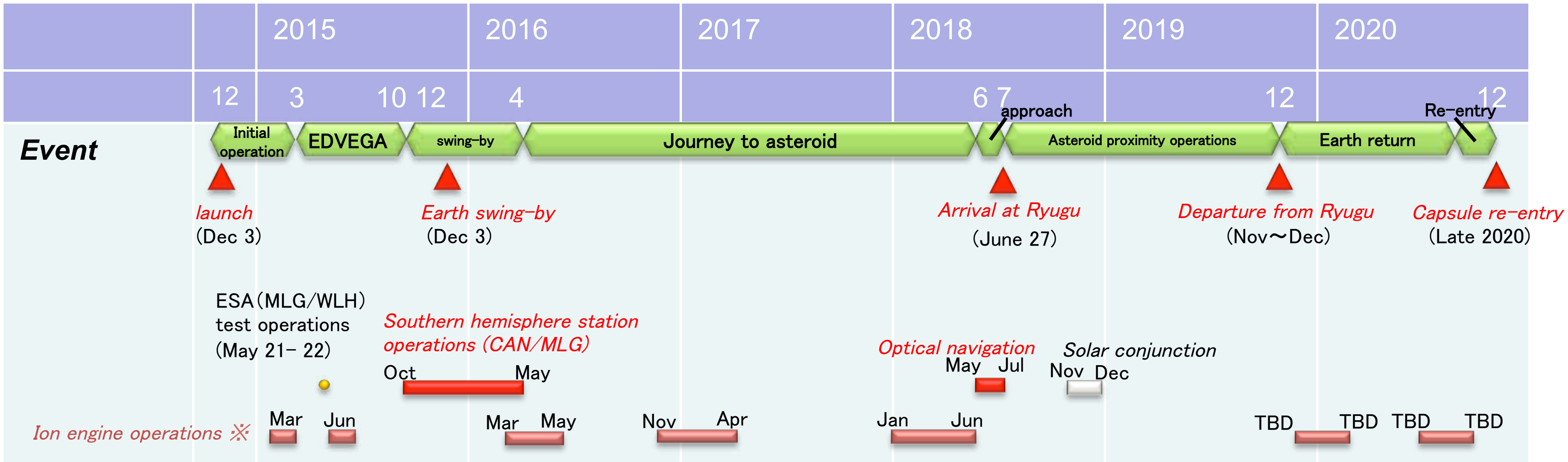
(Illustrations: Akihiro Ikeshita)

1. Current project status & schedule overview

Current status：

- Solar conjunction operation is underway.
- As of December 13, the altitude from Ryugu is about 108 km and the approach speed is about 1.3 cm/s.
- From here, we will return to the home position at the end of December.

Schedule overview:



2. Conjunction Operation Report

- Currently, we are in solar conjunction. The angle of the Sun-Earth-spacecraft is less than 3 degrees and it is difficult to communicate with the spacecraft.
- On 12/29 ΔV（HPR：Home Position Recovery） is planned to return to the home position.

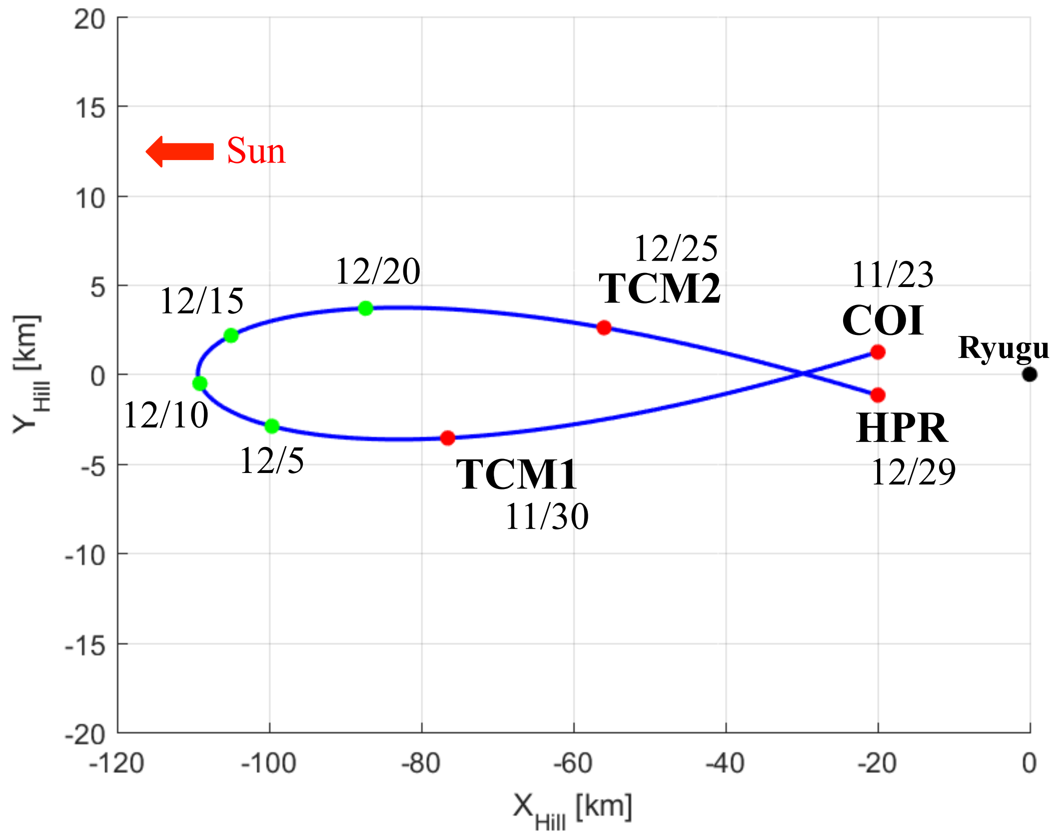
Orbit control

Name	Date
COI	2018/11/23
TCM1	2018/11/30
TCM2	2018/12/25
HPR	2018/12/29

COI : Conjunction Orbit Insertion

TCM : Trajectory Correction Maneuver

HPR : Home Position Recovery



Conjunction transition orbit in the Hill coordinate system

3. MINERVA-II1

- 9/21 13:06 JST separation from the Hayabusa2 spacecraft
- Day 1 (SOL.1) Telemetry received from the rovers
  ･Image data received
- Day 2 (SOL.2) Rover ON confirmed, waiting for telemetry
- Day 3 (SOL.3) Rover ON confirmed, waiting for telemetry
- Day 4 (SOL.4) Rover-1A telemetry received
  - Rover-1A hopping confirmed
  - Rover-1B telemetry received, preparing to hop

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(Note) SOL (solar day). Sun day. This means one sun day usually on a celestial body other than the Earth. For example, it is also used for the operation of the Mars probes. In the case of Ryugu, 1 sol is about 7.6 hours.

3. MINERVA-II1

■ Day 7 (SOL.7) Rover-1B telemetry received

- Rover-1B hopping confirmed
- Image data received

....

■ Day 10 (SOL.10) Rover-1B telemetry received

- Power decline during telemetry transmission
- Thereafter, no further telemetry received

....

■ Day 27 (Sol.27) Rover-1A telemetry received

- Stereo image from Rover-1A received

....

3. MINERVA-II1

■ Day 113 (SOL.113）Rover-1A telemetry received

■ Day 114 (SOL.114）Rover-1A

- Telemetry not received
- Thereafter, no further telemetry

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During solar conjunction, there is no operation of the MINERVA-II.

3. MINERVA-II1

◆ Rover-1A :

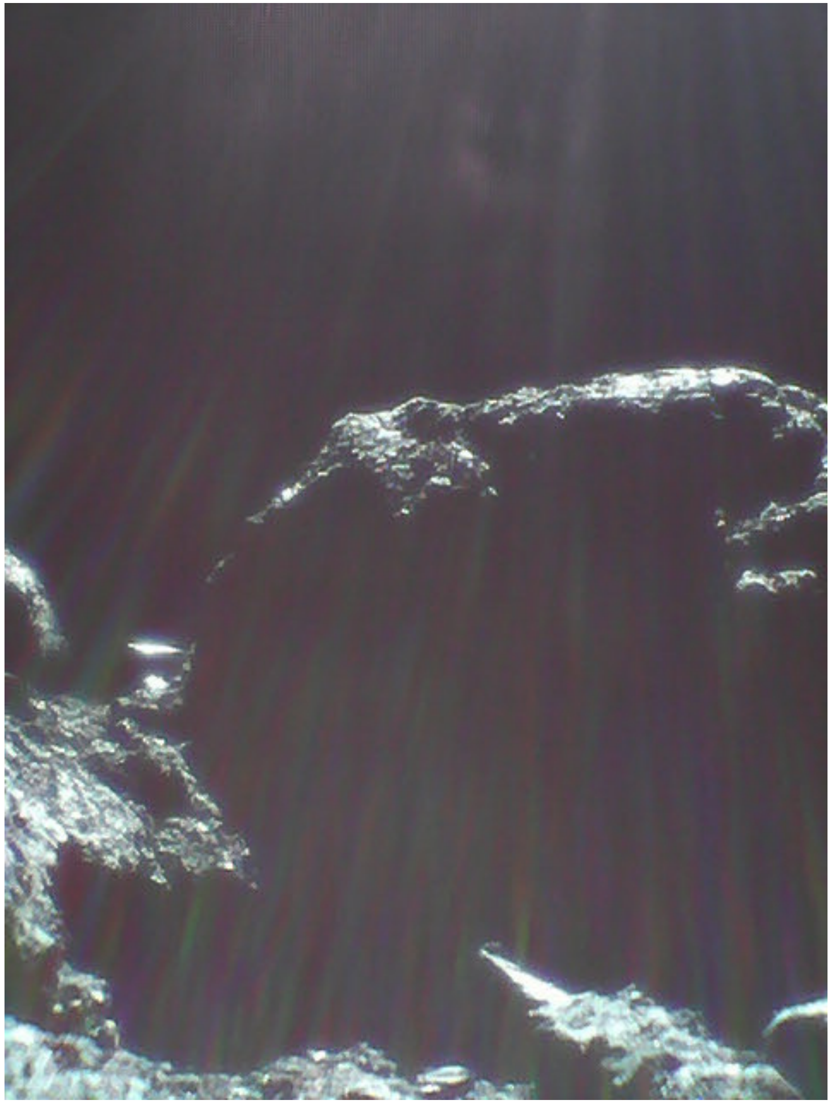
11/02 : During the BOX-C operation, we proceeded to process and send commands. Rover-1A turned ON and the transmitted command was received. However, we did not receive telemetry from Rover-1A. It is estimated that there is a shortage of power, possibly from the rover being in shadow.

◆ Rover-1B

Radio waves were received from Rover-1B several times. However, after the radio waves were received, the rover turned off and we could not receive any telemetry. This is also thought to be due to a power shortage due to the rover possibly being in shadow.

As the seasons on Ryugu change, there is a possibility that Rover-1A, 1B may wake up as the sunlit environment changes. We plan to resume operations after solar conjunction.

Images taken by Rover-1A



【first public release】

（image credit：JAXA）

Figure 1　SOL.27：Image taken on September 29, 2018 JST by Rover-1A, captured with the on-board stereo camera. Proximity image of the asteroid surface.

Images taken by Rover-1A

【first public release】

Figure 2　SOL.76：Image take on October 14, 2018 JST by Rover-1A with a wide-angle camera during a hop.　（image credit：JAXA）

Images taken by Rover-1A

【first public release】

Figure 3　SOL.94：Image taken on October 20, 2018 JST by Rover-1A with the rear wide angle camera while stationary on the asteroid surface.（Image credit：JAXA）

Images taken by Rover-1A

【first public release】

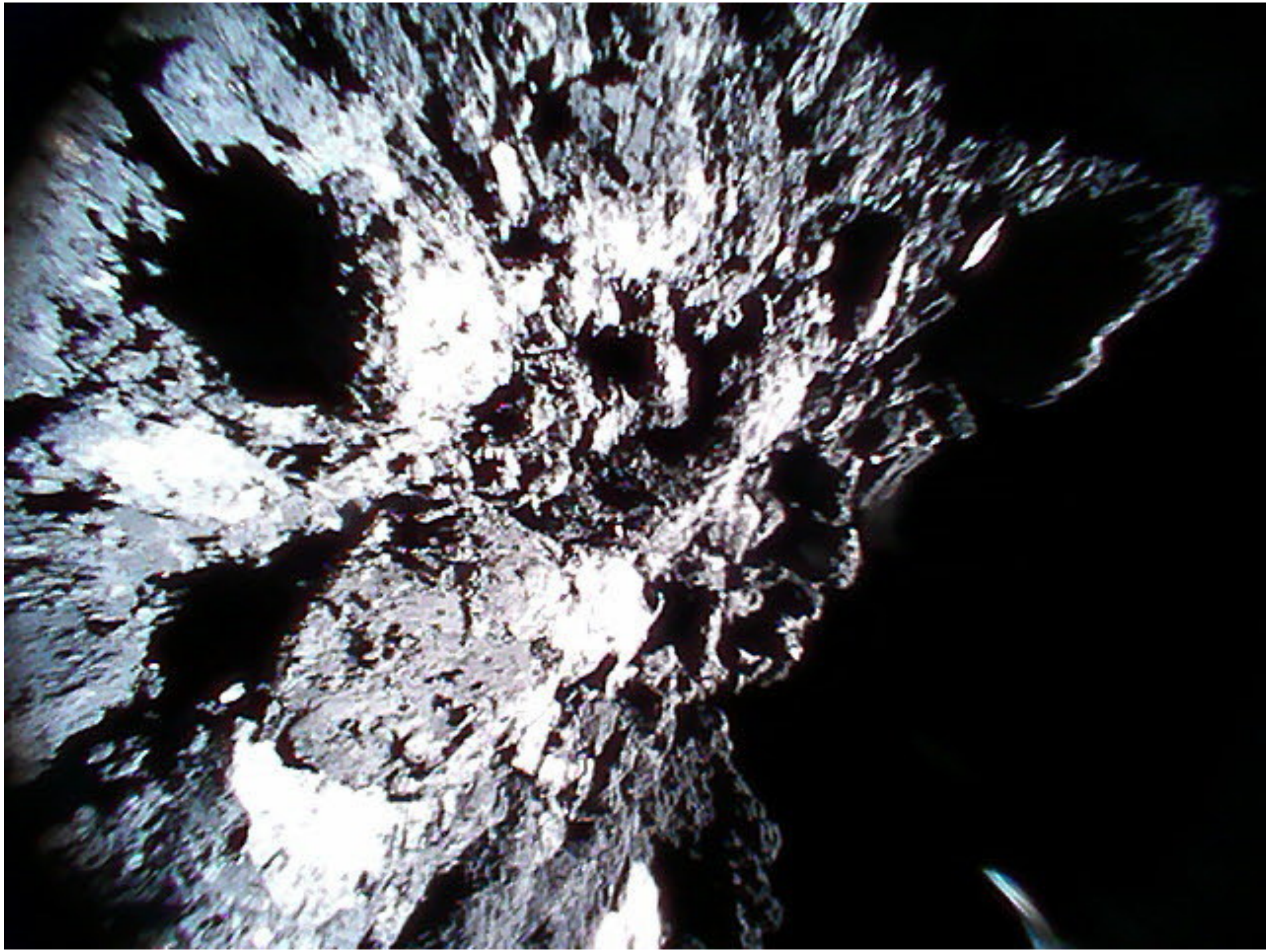


Figure 4 SOL.94: Image taken on October 20, 2018 JST by Rover-1A while stationary with the forward wide-angle camera.

（Image credit：JAXA）

Images taken by Rover-1A

【first public release】

Figure 5 SOL.97: Image take on October 21, 2018 JST by Rover-1A by the wide angle camera during a hop. (Image credit: JAXA)

Images taken by Rover-1A

【first public release】

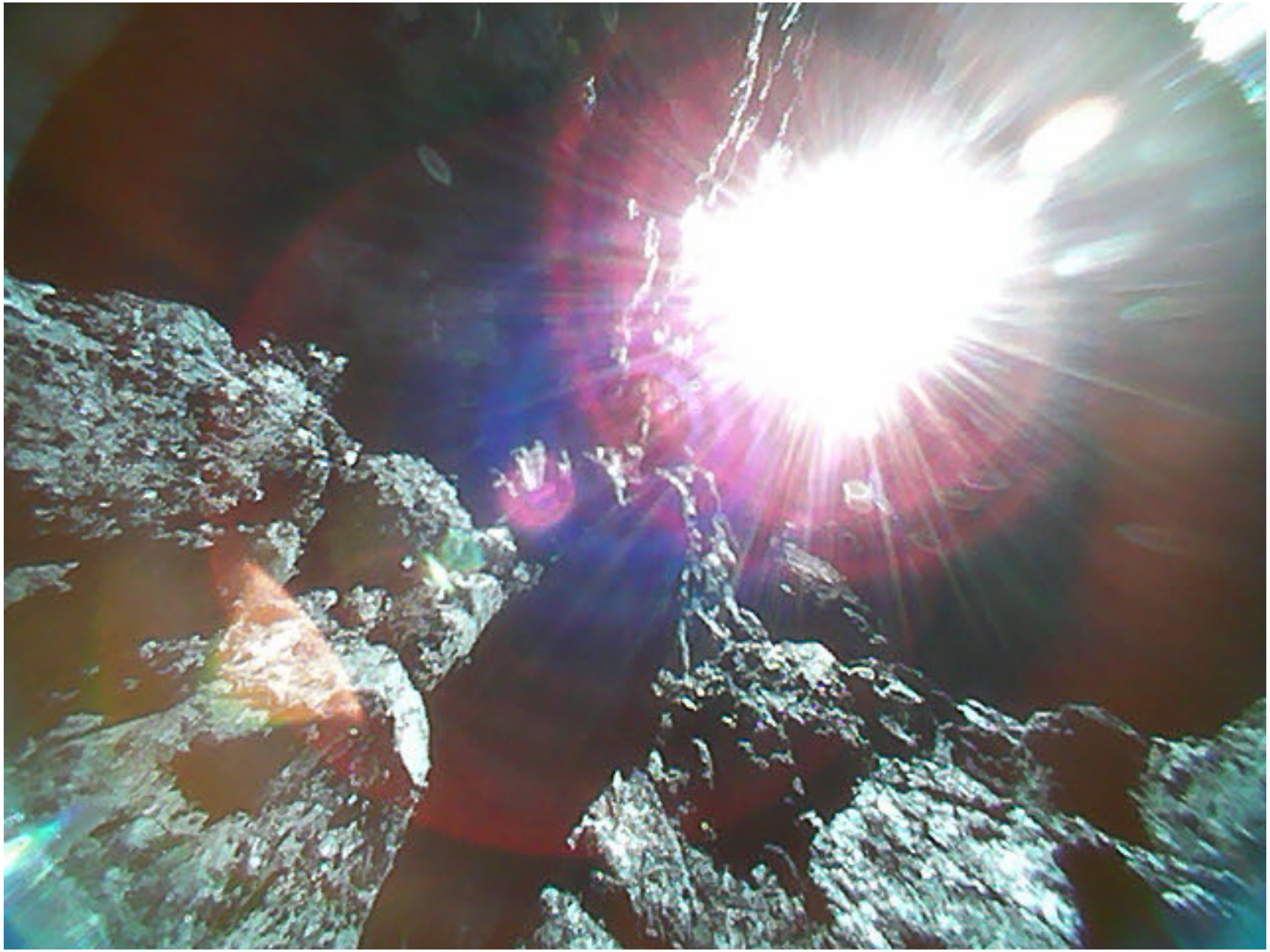


Figure 6　SOL.112：Image taken on October 26, 2018 JST by Rover-1A with the wide angle camera while stationary.

（Image credit：JAXA）

Images taken by Rover-1A

【first public release】

Figure 7:　SOL.113：Image taken on October 26, 2018 JST by Rover-1A with the wide angle camera during a hop.　（Image credit：JAXA）

Images taken by Rover-1A

【first public release】

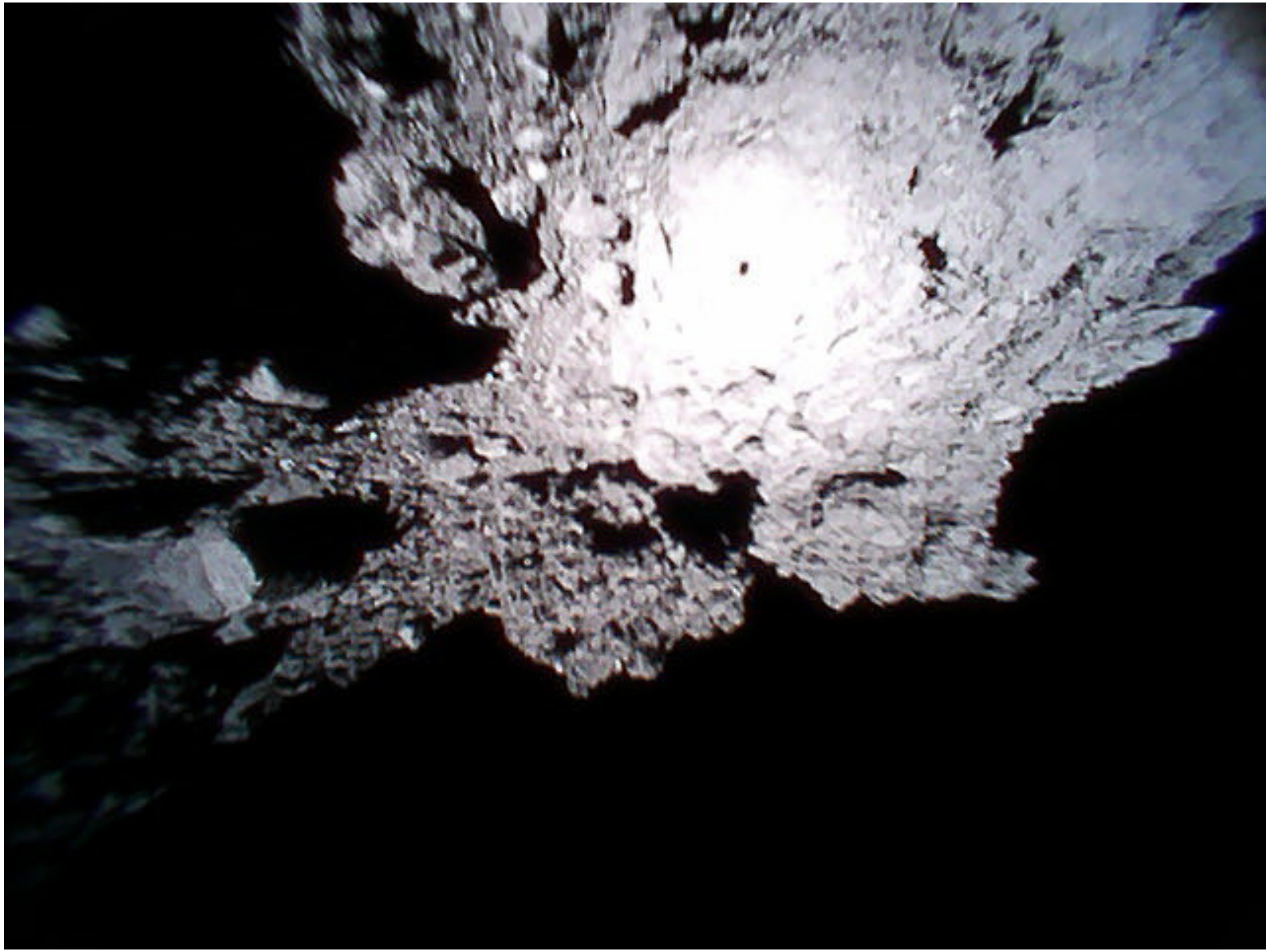
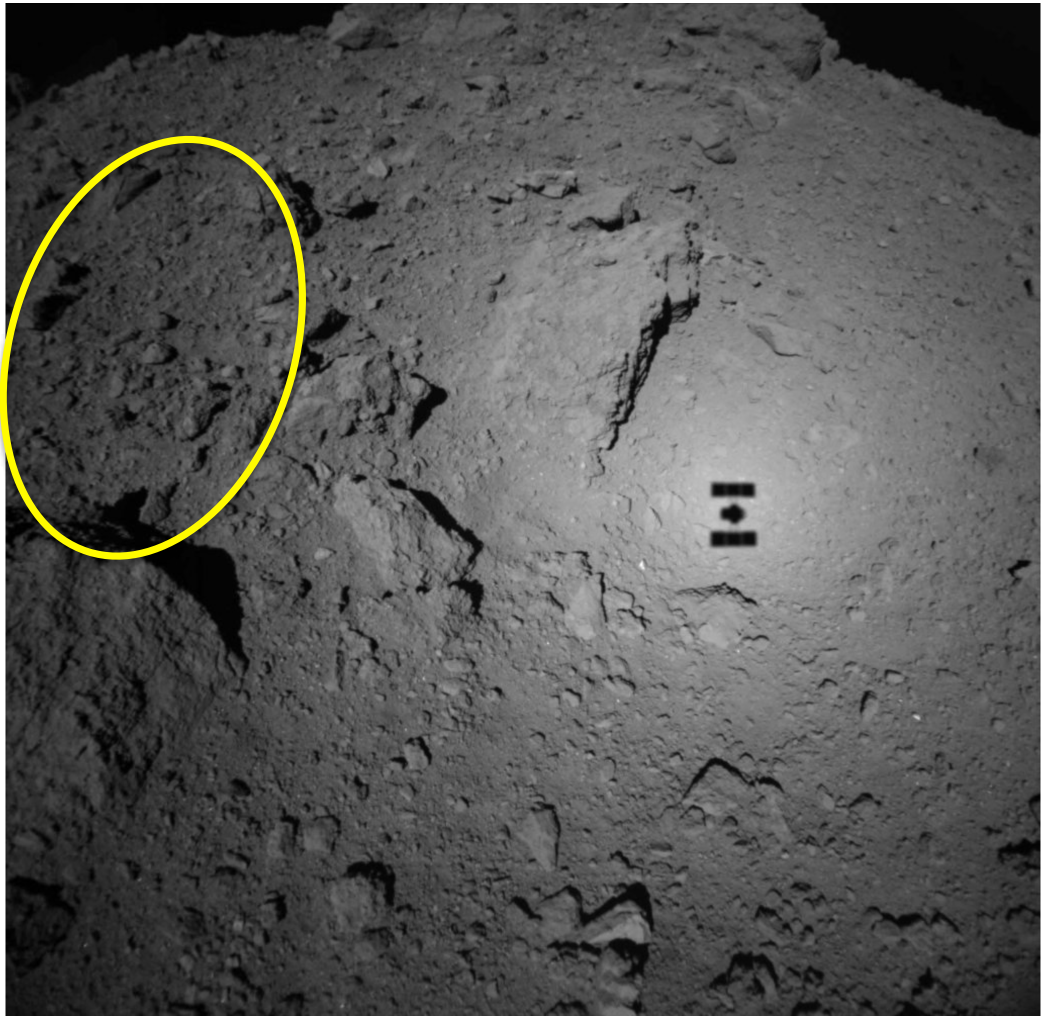


Figure 8 SOL.113 : Image taken on October 26, 2018 JST by Rover-1A with the wide angle camera during a hop. （Image credit : JAXA）

MINERVA-II1 Rover landing site



September 21, 2018 at 13:02 JST
Image with the ONC-W1 at 70m altitude

MINERVA-II1 rover landing site nickname

「トリニトス」
TRINITAS

Trinitas is the birthplace of the goddess Minerva.

(Image credit: JAXA, University of Tokyo, Kochi University, Rikkyo University, Nagoya University, Chiba Institute of Technology, Meiji University, Aizu University, AIST)

MINERVA-II1 collaborators

- Aichi University of Technology, Nakatani Laboratory (mounted camera lens)
- University of Aizu（mounted solar cell）
- Addnics（mounted communication equipment）
- Antenna Giken（mounted antenna）
- WEL Research（zero gravity experiments）
- Elna（ mounted electric double layer capacitor）
- Keio University, Ishigami Laboratory（zero gravity experiments）
- System Consultants（FPGA spacecraft I/F）
- SECCIA Techno（OME development, experimental rover, zero gravity experiments）
- Digital Spice（OME data processing, mounted processing ）
- Tokyo Institute of Technology Co60 irradiation room（radiation test）
- University of Tokyo, Sugita Laboratory（camera calibration）
- Tokyo Denki University, Kurisu Laboratory（zero gravity experiments）
- Tokyo Denki University, Kobayashi Laboratory（communications test）
- Nittoh Optics（now，nittoh inc.）（mounted camera lense）
- Maxon Japan（mounted motor）
- Meiji University, School of Science & Engineering, Kuroda Laboratory（zero gravity experiments）
- DLR（Drop experiment）
- NOVASPACE（aircraft experiment）
- ZARM（Drop experiment）

MINERVA-II1 Rover naming

In Roman mythology, Minerva is the goddess of music, poetry, medicine, wisdom, commerce, magic, weaving and crafts. In works of art, she is also depicted with an owl as her sacred creature and symbol of wisdom.

Goddess's bird：Owl (horned owl)

■From the French for horned owl:

Rover-1A：イブー（HIBOU）

Highly Intelligent Bouncing Observation Unit

■From the English:

Rover-1B：アウル（OWL）

Observation unit with intelligent Wheel Locomotion

MINERVA-II1 Rover naming

Rover-1A

From the French for horned owl

イブー

HIBOU

Rover-1B

From the English

アウル

OWL

4. Other

■AGU Fall Meeting notes:

- The fall meeting of the AGU（American Geophysical Union）is being held in Washington DC (Period: 10 – 14 December, 2018). This is a large planetary science academic society based in the USA. The number of registered participants for this meeting reached 20,000 (announced by organizer).
- In collaboration with OSIRIS-REx , a session was held entitled "A First Look at 162173 Ryugu and 101955 Bennu: Hayabusa 2 and OSIRIS-REx Arrive at Their Respective Target Asteroids".
- Session data: December 11 (oral), December 12 (poster)
- Lecture stats:

	Hayabusa2 topic	OSIRIS-Rex topic	Both missions	Total
Oral presentations	13	8	2	23
Posters	14	9	1	24
Total	27	17	3	47

4. Other

■AGU Fall Meeting notes:

Main announcements in the oral sessions:

■Related to Hayabusa2
- Mission explanation (science, spacecraft etc.)
- Summary of observation data so far
- Details of the surface spectrum
- MASCOT related operations
- Details of the results from each instrument

■Related to OSIRIS-REx
- Mission explanation (purpose, spacecraft, schedule, etc)
- Latest observation data (surface environment, shape, density, spectrum etc.)
- Water absorption measurement
- Large variations in surface reflectance
- Distribution and shape of craters and boulders

Photograph from the joint oral session of Hayabusa2 and OSIRIS-REx on December 11, 2018 (US time). Participants filled the seats in the large room.（Credit：JAXA）

5. Future Plans

■Scheduled operations

- Until the end of December : Solar conjunction
- From January, 2019 : Normal operation

■Results of the Ryugu Imagination Contest

- Scheduled for late December

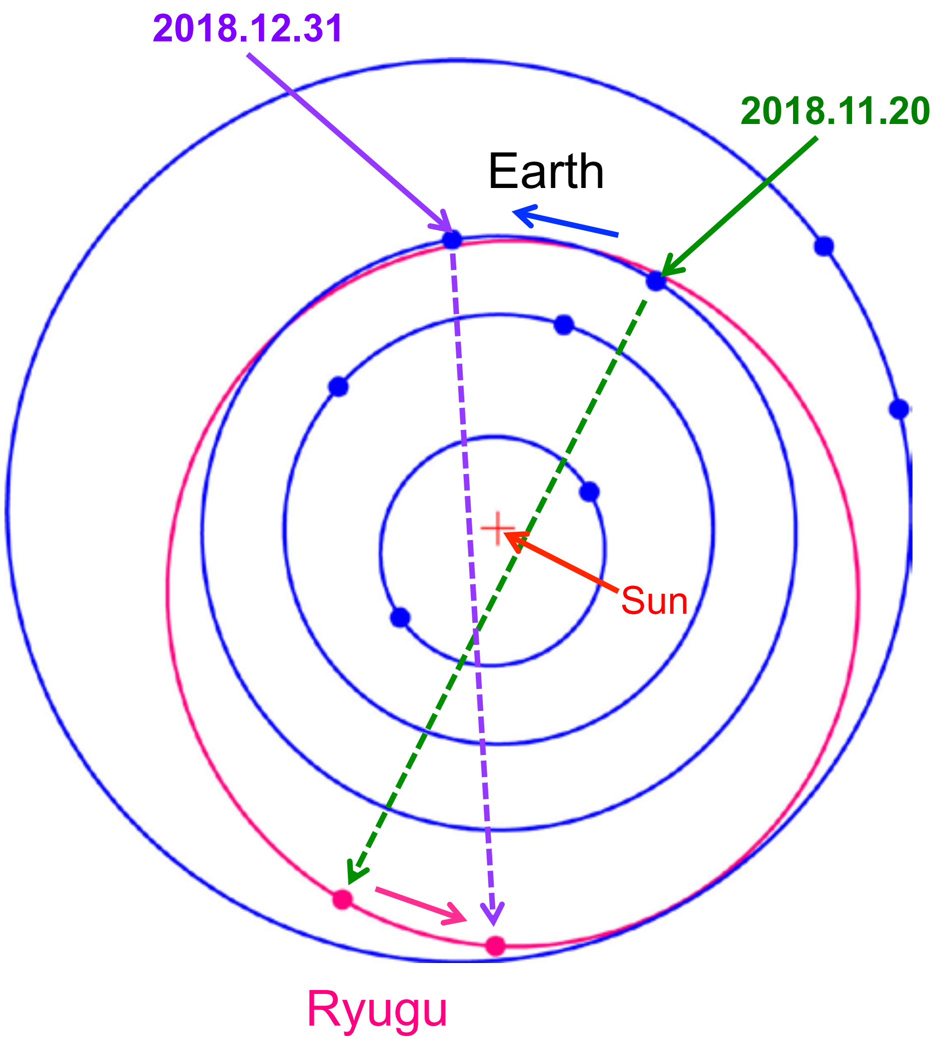
■Press Briefings and Media

- Tuesday, January 8 afternoon, reporter briefing @ Ochanomizu

Reference

Conjunction operation

- "Conjunction" for spacecraft operation refers to the case where the spacecraft is in the direction that almost directly overlaps with the Sun when viewed from Earth.
- The alignment means that communication with the spacecraft is not secure due to radiowaves radiated by the Sun.
- In this period, critical operation is not carried out.
- For Hayabusa2, the duration of this period is from late November 2018 – end of December.



Positions of Ryugu and the Earth

Conjunction operation

Orbit and trajectory control during the operation

Orbit control

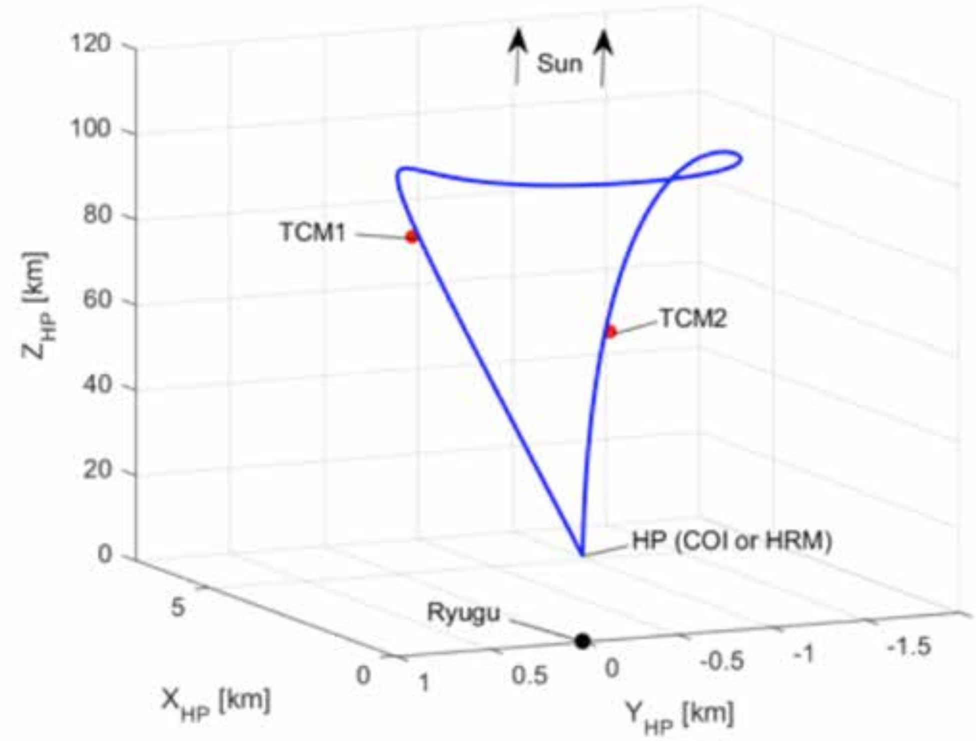
Name	Date
COI	2018/11/23
TCM1	2018/11/30
TCM2	2018/12/25
HPR	2018/12/29

COI : Conjunction Orbit Insertion

TCM : Trajectory Correction Maneuver

HPR : Home Position Recovery

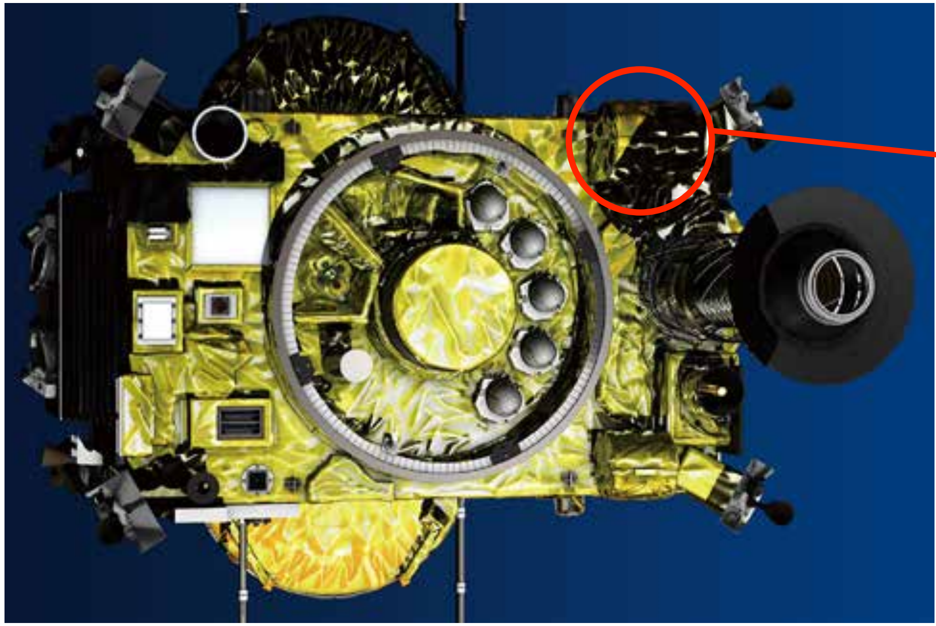
Due to the influence from solar tidal forces, asteroid gravity and solar light pressure, the trajectory forms a complex shape.



Transition orbit during solar conjunction in the home position coordinate system

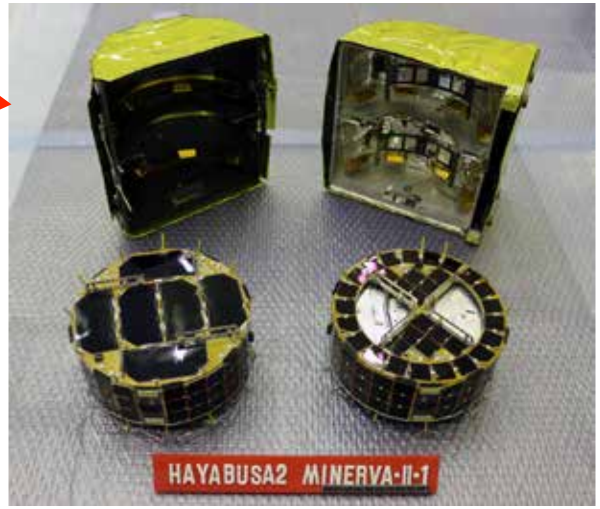
MINERVA-II1 Rovers

MINERVA-II is the successor of MINERVA installed on the Hayabusa spacecraft.



(©JAXA)

MINERVA-II1 (Rover-1A, Rover-1B)



Produced at JAXA

＜ Collaborating manufacturers, universities and related organizations＞

Aichi University of Technology, University of Aizu, Addnics corp., Antenna Giken Co., Ltd., ELNA , CesiaTechno, The University of Tokyo, Tokyo Denki University、Digital Spice Corp., Nittoh Inc., Maxon Japan, DLR, ZARM

- Weight (including deployment)

MIMERVA-II1 :2.5kg

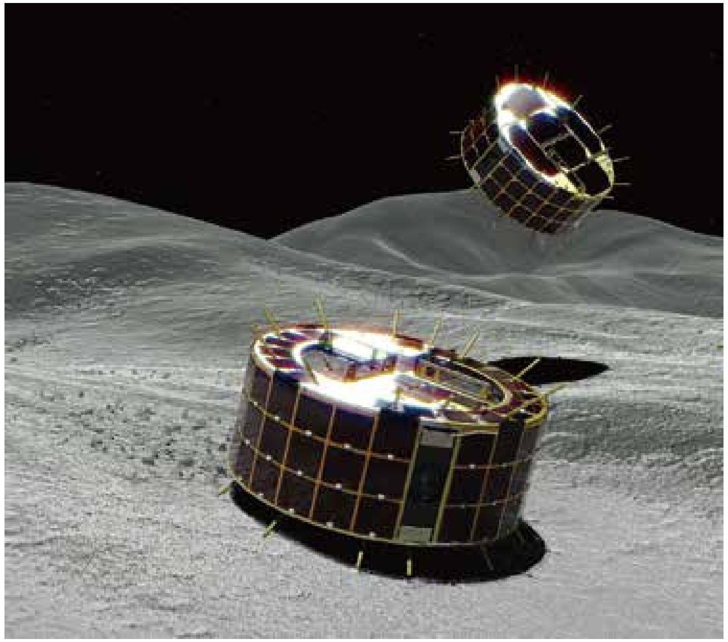
- MINERVA-II1

Twin rovers

MINERVA-II1 Rovers

MIcro Nano Experimental Robot Vehicle for Asteroid,
the Second Generation

- New hopping mobility
- Adaptation with AI
- Small, light-weight,
- Low power consumption
- Autonomous behavior
- Scientific observation （stereo sensing, thermometer)



（©JAXA）

MINERVA-II1 Rovers

body size	Cylinder (hexadecagonal pole) Diameter: f180[mm] Height: 70[mm]
weight	1A:1151[g], 1B:1129[g]
actuators	DC motor
sensors	4 cameras(1A), 3 cameras(1B) photodiodes, accelerometer thermometers, gyro
com.	32k[bps](max)

MINERVA-II1 Rover landing site (N6)