



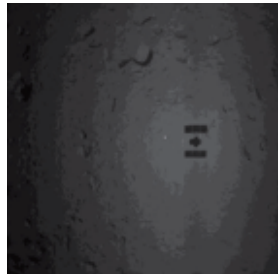
Asteroid Explorer Hayabusa 2 Asteroid Exploration Robot MINERVA-II

Japan Aerospace Exploration Agency (JAXA)
Hayabusa 2 Project Team
MINERVA-II Project Team

Sample return mission from deep space

■ Deep space exploration robotics technology ahead of the world

Outer space is a region that humans can't generally just reach out and touch, so we have continued to make mistakes, unable to work towards success with trial-and-error, but instead requiring highly reliable spacecraft. However, with deep space, a place where humans have never gone and careful investigation is required, high reliability must be combined with ambitious exploration, combining two essentially opposing ideas. In this unique environment, Hayabusa 2 succeeded in touching down and gathering samples twice, flexibly adapting to the unknown environment that only became known upon arrival and maintaining a steady level of reliability. It was controlled through two methods: the Human in the Loop method which is based on commands from Earth, and autonomous functions of the spacecraft such as the event-driven control sequence function and artificial features such as target markers.



Hayabusa 2 tracking the target marker

■ Compact and light autonomous exploration robot MINERVA-II

The MINERVA-II are twin robots that were put on board Hayabusa 2, with the goal of performing mobile exploration on the surface of the asteroid Ryugu, which is just under 1km in size. The robots are 18cm in diameter and 7cm tall (excluding protrusions), and each one is extremely small and light with a mass of just over 1.1kg. They are powered by solar cells attached to the surface. The robots are equipped with mechanisms, cameras, sensors, and radios to move by hops in the very small gravity environment of the asteroid surface (approximately 1/100,000 compared to Earth). Since there was a big communication time lag (approximately 40 minutes round trip) between the asteroid and earth, the software on



board the robots had algorithms enabling them to operate completely autonomously without commands from Earth.

■ The world's first celestial body surface exploration robot

The two robots were launched from the mother ship to the asteroid on September 21, 2018. Rover 1A observed the asteroid's surface from multiple locations for 113 asteroid days (approximately 35 Earth days) until October 26, 2018. It sent a total of 609 images of the surface of the asteroid to Earth. During that time, it covered approximately 1/4 of the asteroid's surface.

Rover 1B was active from September 24, 2018 for ten asteroid days, and took 39 images.

This feat was the world's first mobile exploration of the surface of a small celestial body in our solar system. The robots were also the first from Japan to directly explore the surface of a celestial body.

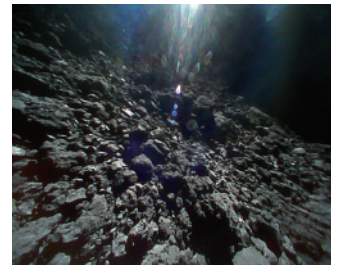
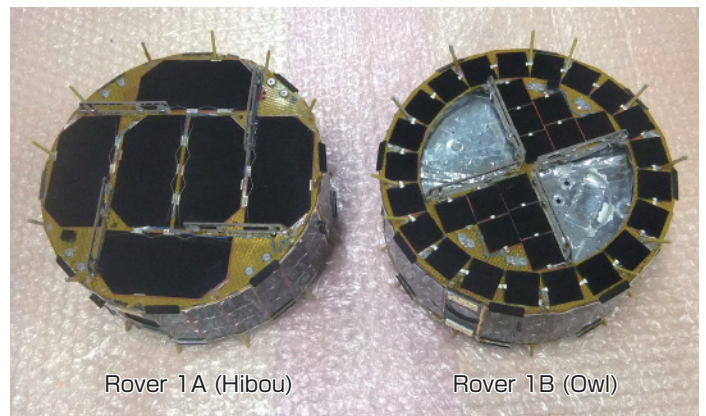


Image shot by MINERVA-II



Two MINERVA-II robots

Contact:

JAXA Institute of Space and Astronautical Science

Address: 3-1-1 Yoshinodai, Chuo-ku, Sagami-hara, Kanagawa

(Hayabusa 2) Yuya Mimasu
(MINERVA-II) Tetsuo Yoshimitsu

Tel: 070-3177-7030
Tel: 042-759-8304

E-mail: mimasu.yuya@jaxa.jp
E-mail: kikko@nnl.isas.jaxa.jp