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MINERVA-II rovers developed for Hayabusa-2 mission

Tetsuo YOSHIMITSU, Takashi KUBOTA, and Atsushi TOMIKI (Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency)

The authors have installed a rover package named "MINERVA-II" to the asteroid sample return mission "Hayabusa-2", which was launched on 3 December 2014 heading for the C-type Near Earth asteroid 1999JU3.

The package consist of two rover containers, a relay module and an antenna to communicate with the rovers. Three rovers are included in the two containers. Two of them are the responsibilities of the authors installed together in one container. Another one rover packed in the secondary container comes from the domestic university members.

All the rovers were developed without the official budget from the mission to seek for the technology-driven challenges on the surface of the target asteroid. This paper describes what the authors developed as well as the capabilities and the current status of the rovers.

The rovers are ejected with an expected speed of 5[cm/s] when the spacecraft descends to the asteroid after the arrival at the target around 2018. They fall into the asteroid surface captured by the weak gravity and then start the autonomous exploration when the obtained data are transmitted to the relay module on the mother spacecraft. They have a hopping mobile system fitted for the movement on the microgravity environment of the asteroid surface.

Two rovers are almost identical except the thermal parameters of the surface with a mass of approximately 1.1[kg]. They are deployed at the same time since they are installed in one container.

Technical experiments on the evaluation of the hopping mobile system and demonstration of the fully autonomous exploration are the main purposes of the rovers. But we do not forget about the scientific characterization of the asteroid by the rovers. The scientific results are obtained by the installation of tiny sensors, by the ingenious operation, and by the analysis on technical data.

We have installed several tiny sensors into the rovers, such as cameras, thermometers, potentiometers, accelerometer, gyro, and photodiodes. Some of them are processed onboard to use for the autonomous navigation, the others are purely used for scientific observation.

Cameras are most elaborate sensors among the ones installed in the rovers since reducing the weight is completely made. Each rover has two types of cameras.

The wide angle camera with a mass of 15[g] will shoot the asteroid surface from a distance when the rover is hopping. It has a field of view of 125[deg] with a combination of eight tiny lenses. You can get a nearly perfect perspective view with this camera since the distortion is less than 3[%] for all the region.

When the rover is on the surface, it will make the measurement by thermometers and potentiometers, as well as the terrain shooting by the camera. The stereo pair of normal cameras is optimized to acquire the precise terrain features when the rover stays on the surface. Thermometers can directly measure the temperature at the contact point on the surface. Potentiometers can obtain the potential differences between the two contact points.