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# COMMUNICATION SYSTEM OF SMALL PLANETARY ROVERS WITH RANGE MEASUREMENT CAPABILITY

**Abstract**

Hayabusa2 is a Japanese asteroid explorer which aims to get some fragments from the C-type asteroid Ryugu and bring them back to the Earth. It was launched in December 2014 and arrived at the target asteroid in June 2018. The spacecraft stayed at the vicinity of the asteroid for 1.5 years and finished the proximity operation in December 2019. Currently it is on its way back to the Earth.

Hayabusa2 included four payloads which were deployed onto the asteroid. The payloads were developed by several organizations but used a common communication module.

The telemetry data generated at payloads were once stored in the relay component of the mother spacecraft, and then transmitted to the Earth. The commands sent from the Ground station were also stored in the relay component and then transmitted to the payloads when the downlink radio from the payloads was sensed at the relay component.

Maximum of four different payloads can simultaneously communicate with the relay component using two different frequencies of downlink radio from and Time Division Multiple Access (TDMA) technique.

The communication system was additionally equipped with a range measurement capability between the relay component and the payloads.

The distance is measured by the time of flight of PN codes inserted during the guard time after the relay component stops the uplink radio transmission to the payloads. When a payload receives PN codes, it relays the same codes during the guard time after it stops the downlink transmission to the relay component. The relay component measures the time of flight of PN codes to get the round trip distance.

There is no clock synchronization between the relay component and the payloads. The internal delay at payload from the reception of the codes to the transmission of the relayed codes is calculated using the clock count of the payloads sent to the relay component independently included in the control information of TDMA system.

There were three deployment operations conducted after the arrival at the asteroid. They were made in September 2018, October 2018, and October 2020. The communication module and the range measurement were successfully made for three deployment operations.

The performance of the communication system was tested on the ground using a small balloon prior to the first deployment operation.

This paper describes the communication system, the range measurement capability as well as the results of the Ground-based experiment and the actual operations.