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MISSION DESIGN AND RESULT OF ARTIFICIAL OBJECTS ORBITING AND OBSERVATION FOR GRAVITATIONAL ENVIRONMENT ESTIMATION OF SMALL BODIES

Abstract

For small bodies exploration missions, accurate prediction of the gravity environment of a small bodies after its arrival is very important for spacecraft navigation and guidance control, as well as for safety. However, in the case of many small bodies exploration missions, it is rare to have sufficient information on the body before the spacecraft launch. Therefore, observations and modeling of the shape, gravity field, and scientific properties of small bodies are conducted after the arrival. As for the modeling of the gravity field, it is difficult to obtain a gravity field of a celestial body as desired for a spacecraft that performs guidance by hovering. Therefore, this paper proposes a method to obtain data that contributes to the estimation of the gravity field by inserting artificial objects into orbit and observing it instead of the spacecraft itself. This method is useful in that it allows the selection of a positive injection trajectory for the desired gravity model element data (e.g., J2 term) and also allows the injection of artifacts into trajectories that are not possible that the spacecraft cannot insert because the safety requirements for artifacts are not as high as those required for spacecraft. The difficulties in this method are the design of the orbit in which the artificial objects will be injected, the method of injection, and the method of observation. To validate the feasibility and effectiveness of this method, the authors conducted an orbiting and observation mission of retroreflective artifacts in the Hayabusa2 project. This mission is characterized to observe orbiting objects at a distance of 20 km by appropriately designing the optical environment, thereby capturing the entire image of the orbiting artifact. The important design items are the location of orbit insertion, the method of guiding the spacecraft to that position, the design of the observation method after orbit insertion, and the method of guiding the spacecraft during the observation. In this paper, we present the design and actual mission results for these items in detail.