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A proposal of a small scientific satellite mission to validate penetrator systems

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We propose a new mission to validate the penetrator technology and to investigate the surface and subsurface structures on the far side of the Moon, using a miniaturized penetrator probe. The miniaturized penetrator is a missile-shaped instrument carrier and is planned to have a shape of about 60 cm in length and 10 cm in diameter, and a weight of 8 kg, which would be two thirds scale model of the lunar penetrator developed for the former LUNAR-A project. The major objective of this mission is to demonstrate the technical issues in penetrator system; (1) holding and separation mechanisms, (2) a sequence of de-orbit, attitude control and subsurface deployment, (3) data-relay and remote operation by way of an orbital spacecraft, and (4) simultaneous long-term geophysical observations. Furthermore, the developed miniaturized penetrator system can be applied to a future mission for a more distant planetary body than the moon.

A tri-axial stabilized satellite with two identical penetrator modules, which should be play roles of the carrier of them and of data-relay orbiter, is assumed to revolve in a near-circular orbit of 100 km by 25 km altitude around the Moon. After the separation from the spacecraft, the two penetrators will be deployed at an interval of a few hundred meters or a few kilometers from each other on the far side equatorial regions. The penetrator will hit on the lunar surface with a velocity of 250 to 300 m/sec and penetrate into the regolith up to a depth of 2 or 3 meters. Each penetrator can carry some of a short-period seismometer, heat-flow probe, magnetometer, and gamma-ray spectrometer and observe the sub-surface and internal structure on the most ancient geological unit, in which the initial product from a differentiated magma ocean might be still remain.

The magnetometer will monitor the time-series of magnetic field as a stationary point, and the gamma-ray spectrometer buried in the lunar regolith will be able to observe the abundance of heat-producing elements, under a condition of the significant low-level cosmic ray background. These data would be also useful for data reduction of seismic and heat-flow data. An optical camera onboard the spacecraft will search for impact craters and landslides around the network, which occurred during the observation period of penetrator seismometer. These detected landmarks will be available for seismological study as known earthquake foci. This paper describes the miniaturized penetrator design, the sequence of its deployment phase, potential onboard instruments, and their operational scenario.

Keywords: penetrator system, lunar interior exploration, small scientific satellite