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Proposal for Demonstration of Penetrator Technology by Small Satellite and Epsilon Launch Vehicle

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A new mission to validate the penetrator technology and to investigate the shallow structure of the Moon, using a small satellite and a penetrator module developed for the former LUNAR-A project is proposed. The lunar penetrator module consists of a penetrator main body, a de-orbit motor and an attitude control system. The de-orbit motor attached at the rear end of the penetrator module is used to cancel the orbital velocity, and the attitude control system which consists of a small gas jet and a sun-sensor is also attached to the central part of the module. The penetrator probe is a missile-shaped instrument carrier and is about 75 cm in length, 14 cm in maximum diameter and about 14 kg in weight. The penetrator contains a two-component seismometer and a heat flow probe, together with electronics, primary batteries, a tiltmeter, an accelerometer, and radio communication system. The primary objective of this mission is to demonstrate the technical issues in penetrator system; (1) holding and separation mechanism, (2) sequence of de-orbit, attitude control and subsurface deployment, (3) data-relay and remote operation by way of an orbital spacecraft, and (4) long-term geophysical observation on the Moon. The flight-proven penetrator system could be applied to the future lunar mission for a full-scale network.

The Epsilon launch vehicle lifts off a spacecraft (or lunar orbiter) with a solid propellant motor newly developed as the upper stage. The spacecraft, which should be play roles of the carrier of penetrator module and of data-relay orbiter, is assumed to revolve in a near-circular orbit of 100-200 km by 25-45 km altitude around the Moon and to release the penetrator module to deploy on the low latitude zone of the lunar nearside or terminator. The penetrator will hit on the lunar surface with a velocity of 270 to 300 m/sec and penetrate into the regolith up to a depth of 2 or 3 meters, and then it will measure the acceleration record and the stop angle at the rest position. These data would be also useful for data reduction of seismic and heat-flow data. After that, it will observe the near-surface and internal structures on the geological unit different from the past Apollo and Luna landers. Ground-based optical telescopes will continuously monitor meteoroid impact flashes on the night side of the Moon, which should frequently occur during the observation period of penetrator seismometer. These landmarks detected in the vicinity of the penetrator will be available for seismological study as known moonquake foci.

This paper describes the spacecraft design, the mission profile from launch to deployment and an operational scenario of geophysical instruments.

Keywords: small satellite, Epsilon rocket, penetrator, seismometer, heat flow probe