Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PPS22-P03 Room:Convention Hall Time:May 22 18:15-19:30

Investigation of Martian surface and internal structure by multiple penetrator probes

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A new mission to investigate the Martian surface and interior structures using multiple penetrator probes is proposed. As a decelerator and a heat shield during the Martian atmospheric entry, a flare-type thin membrane aeroshell sustained by an inflatable torus frame will be applied to attain a compact and low-weight space vehicle. The most significant advantage of the aeroshell is to reduce the aerodynamic heating during the atmospheric entry due to its low ballistic coefficient. In addition, even though dependent on the spacecraft configuration (in most cases), there is no need to equip with the conventional thermal protection system like an ablator or a heat-resistance material. Concerning to the aeroshell system, a flight validation test was successfully concluded using a sounding rocket in the summer of 2012. The Martian penetrator is a missile-shaped instrument carrier and is planned to have about 80 cm in length, 15cm in diameter, and 14 kg in weight, which would be almost identical with the lunar penetrator. Its development was completed in 2010 through several times impact penetration and thermal cycle tests at the ground test facilities after cancellation of the former LUNAR-A project. A 3-axis stabilized satellite with four identical penetrator modules, which should play roles of the carrier of penetrator modules and of data-relay orbiter, is assumed to revolve in a circular orbit of 300 km altitude around Mars. After separation from the carrier spacecraft, four penetrators will be deployed at intervals of a few hundred kilometers from each other, due to the limited number of probes and ability to detect of seismometer on-board. Each penetrator installed seismometer and heat-flow probe will operate on the potential active regions in volcanism or seismic fault zones, associated with magmatic tectonics, crustal structure and current thermal state of Mars. 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. A meteorological sensor package embedded in a backside of aeroshell will observe the atmospheric structure and possibly monitor the environment on the surface. These monitoring data would be useful for data reduction of seismic and heat-flow data. This paper describes the martian penetrator design, the sequence of its deployment phase, onboard instruments, and their operational strategy.

Keywords: Mars Exploration, surface Environment, internal Structure, penetrator, seismometer, heat flow probe