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Development of separation mechanism of lunar penetrator module for installation in a three-axis stabilized satellite

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The lunar penetrator module (LPM) developed for the former LUNAR-A project consists of a hard landing probe ”penetrator” itself, a de-orbit motor to cancel the orbital velocity and attitude control system for 90 deg re-orientation by so-called Rhumb Line Control during the free-fall phase. The total length of LPM is 1.5 meters, and the total weight is about 45 kilograms. Though the impact on the lunar surface nominally designed to be vertical with a velocity of 280˜300 m/sec, there is a high possibility that the penetrator will hit on the surface with a finite attack angle, which is the offset angle between the longitudinal axis of LPM and the velocity vector. This will inevitably occur due to a possible misalignment of the separation mechanism w.r.t the carrier spacecraft, slight errors of the motor ignition, the attitude control of LPM, and other influences. In case of non-zero attack impact, rotational torque will be applied to the penetrator. And also, we concern that the large attack angle results in the deflection of penetration trajectory, and it provides the shock environment significantly different from the case of zero attack normal incidence. Therefore, the permissible range of initial attack angle at impact must be configured so that the lunar penetrator comes to rest with an adequate depth and a pitch angle. On the former LUNAR-A project, the maximum attack angle was set to 8 deg. We are conducting to design several types of separation mechanism for installation in a 3-axis stabilized satellite such as a series of Russian Luna-Glob and to make a trade-off study concerning assumed essential parameters and requirements with the carrier spacecraft. Furthermore, we should give careful consideration to allow us to make a full-size test on the ground facility. In this paper, we describe some formulas of newly designed separation mechanism and report a result of preliminary test using breadboard models.

Keywords: penetrator, separation mechanism, 3-axis stabilized satellite, lunar exploration, internal structure