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TRAJECTORY DESIGN AND DISPERSION ANALYSIS OF NANO MOON LANDER OMOTENASHI

Abstract

OMOTENASHI (Outstanding MOon exploration TEchnologies demonstrated by NAno Semi-Hard Impactor) is a CubeSat that will be launched by a NASA SLS rocket after 2022. Its mission is to demonstrate that a CubeSat can make a semi-hard landing on the Moon. The 6U-sized spacecraft, which weighs 12.6 kg, consists of an orbiting module (OM), a rocket motor (RM) for decelerating, and a surface probe (SP) on the landing module. A large propulsion system would be required to land an entire spacecraft on the Moon, but it is difficult to mount a large propulsion system on a CubeSat. Therefore, after approaching the lunar surface, the RM and the SP disengage from the OM at the same time the RM ignites. Following this, the RM and the SP make a semi-hard landing on the Moon's surface. Resource limitations on the design reduce the mass that needs to be decelerated. To lessen the landing impact, the SP uses an airbag and a crushable material as a shock absorption system. The mission will prove successful when the accelerometer, mounted on the SP, sends its information back to Earth.

This paper analyzes the trajectory design of the Moon landing and the method of increasing the landing success rate under the tight constraints of the CubeSat. It also proposes a method of setting the appropriate parameters for deceleration using the RM not under active control.

To reduce both fuel and power consumption, several maneuver conditions for reaching the target landing site are evaluated. The effect of a trajectory correction maneuver (TCM) for improving the landing site accuracy is confirmed by considering several error factors of the spacecraft. As the deceleration maneuver is executed using only the RM on approach to the Moon, active control is not possible during the deceleration. Moreover, there are several error factors, such as attitude fluctuation of the RM and timing deviation between the spacecraft and ground stations. Therefore, the setting of initial parameters is important to increase the landing success rate. This paper discusses the optimal altitude at the start of the deceleration maneuver, and calculation of the success rate. It also presents the most sensitive parameter for improving the accuracy of landing and increasing the success rate. Moreover, the trade-off between vertical and horizontal landings is described by considering these effects.