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PROJECT OVERVIEW AND STATUS UPDATE OF DUAL-SATELLITE LUNAR GLOBAL NAVIGATION MISSION WITH 6U-CUBESATS

Abstract

Aiming to realize long-term presence at the Moon, interests in new and robust communications, navigation capabilities on the lunar surface are growing more than ever before. In response, positioning, navigation, and timing (PNT) services around the moon have been conceptualized and put into action by space agencies, namely *LunaNet* of NASA, and *Moonlight* of ESA. Our group proposed a 'small-start' precursor mission which aims to demonstrate a GNSS transmitter/receiver and store-and-forward radio around the moon as well as actually start providing PNT service to lunar surface assets. The project was kicked off with the funding support of Japan Ministry of Education, Culture, Sports, Science and Technology (MEXT) and has completed preliminary design in 2021. This year, we will proceed to detail design and develop a prototype of GNSS transmitter/receiver, store-and-forward radio, and structure-thermal model of the satellite. Our proposal is a dual-satellite lunar navigation system based on the multi-epoch double-differenced pseudorange observations (MDPO) algorithm, which was proposed by the author group: MDPO uses multi-epoch observations in a new way that reduces the number of navigation satellites required to as little as two. In addition, the double-differenced pseudorange eliminates the clock bias of the space and user segment as well as the satellite orbit determination error with the assistance of a reference station on the moon, where we assume a GNSS receiver on a lander can play a role. Our simulation analysis indicates, in case placing two satellites at 300 km low lunar orbit, the users can obtain 50 m twice the distance root mean square (2drms) user position accuracy within one-minute observation when the two satellites are in view. The mission will also demonstrate store-and-forward technology which has been demonstrated at low earth orbit in our previous project. With the designed store-and-forward payload, the users on the lunar surface can upload/download telemetry at a rate of maximum 2 kbps when one or both satellites are in view. The systems design was completed with respect to thermal, power, communication, attitude and orbit control, command and data handling, mechanical and electronics design as well as payload operations. As a result of the design study, the satellites consist of a 6U-size structure, 30W-class deployed solar panel, three-axis attitude control using a star tracker, sun-sensors, gyro, reaction-wheels, and RCS, orbit control using a water-based resistojet, with the total wet mass of less than 12 kg.