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Author: Ms. Makiko Kishimoto  
LaSEINE, Kyushu Institute of Technology, Japan

Dr. Sangkyun Kim  
LaSEINE, Kyushu Institute of Technology, Japan

Mr. Shota Kubo  
Kyushu Institute of Technology, Japan

Mr. Kenta Sawa  
Kyushu Institute of Technology, Japan

Prof. MENGU CHO  
Kyushu Institute of Technology, Japan

OPERA: ONBOARD PROCESSING ORBIT DETERMINATION BY ONE-WAY RANGING FOR  
LUNAR EXPLORATION MISSION**Abstract**

This paper presents whole OPERA (Onboard Processing of Earth-origin one-way Radio ranging signal) system overview and current development work status. Spacecraft need their own navigation system over LEO (Low Earth Orbit). Since 2014, micro spacecraft (~50kg) have started doing space exploration. The conventional navigation system for deep space exploration is two-way range and Doppler. Spacecraft receive RF (Radio Frequency) ranging signal from a ground station and send back the signal immediately from spacecraft to the ground station by transponder. A large parabolic antenna whose diameter is typically 50m is required at the ground station side to achieve this communication. In order to promote space exploration by university researchers without relying on the large parabolic antenna belonging mostly to space agencies. OPERA system uses multiple small parabolic antennas of several meters that can be installed at a university. The gain of the large parabolic antenna is larger than the small parabolic antenna by two orders of magnitude or more. If the small parabolic antenna installed at the university is used with the conventional orbit determinations, the receiving power at the ground station is extremely small. OPERA system performs one-way ranging where RF ranging signals are sent simultaneously from multiple ground stations to circumvent the need to transmit high power signals (hundreds of watts) from the spacecraft. RF range and range rate measurements are processed onboard and derive own position. The development of the OPERA system started at LaSEINE of Kyushu Institute of Technology in 2021. OPERA is aiming for an orbit determination accuracy of 5km for the future lunar exploration missions. OPERA system will be demonstrated in LEO before operation in the lunar environment. A 3U CubeSat installed with the OPERA system will be launched to LEO in 2024.