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Author: Mrs. Kimberly Kimsanton Sofge
Czech Republic

Dr. Uroš Kostić
Slovenia
Mr. Iulian-Emil Juhasz
Romania
Dr. Petr Kadera
TRL Space, Czech Republic
Dr. Martin Mačák
Austrian Institute of Technology GmbH (AIT), Austria
Mr. Martin Starek
TRL Space, Germany
Mr. Adam Hláčik
TRL Space, Czech Republic

LUREPOS - LUNAR RELATIVISTIC POSITIONING SYSTEM

Abstract

European commercial entities, scientists, and industrial partners have been invited to participate in humanities return to the Moon by the European Space Agency (ESA) through Small Missions for Exploration program. This opportunity for partners to contribute to the development of infrastructure and future missions has resulted in the Slovenian-led LUREPOS project, which addresses the challenges of Positioning, Navigation and Timing (PNT) in the lunar environment.

The classical concept of positioning in Galileo Global Navigation Satellite Systems (GNSS) assumes satellites and receivers are at rest in an inertial reference frame. However, at the precision required for modern systems, relativistic effects such as time dilation and gravitational redshift cannot be ignored. These effects, amounting to 38.5 s/day (microseconds/day), would otherwise introduce positioning errors of up to 12 km/day if not properly accounted for.

As a possible solution, the Lunar Relativistic Positioning System, LUREPOS, will pioneer the development of advanced navigation and communication systems for space exploration by testing the Relativistic Positioning System (RPS) around the Moon. This mission builds on earlier experimental work conducted in Earth's orbit and represents a crucial step in the journey from Earth to Mars, leveraging the proximity of the Moon to refine and validate autonomous navigation technologies with the support of Galileo GNSS.

The flexibility and adaptability of smaller spacecraft that can operate within the framework of the LunaNet architecture, as envisioned by ESA, JAXA and NASA allows for an interoperability capable communication and navigation asset to facilitate the evaluation of a new reference frame against those currently utilized. The RPS creates a self-assembled reference frame called the Autonomous Basis of Coordinates (ABC). This is achieved through the continuous exchange of timestamps between satellites, enabling precise determination of orbital parameters and ensuring robust positioning accuracy without dependence on external synchronization.

Testing this system around the Moon allows for the validation of its ability to autonomously construct and maintain its reference frame in a gravitationally complex environment, while still verifying results

with Galileo GNSS. The Moon offers an ideal proving ground for this technology as it transitions from Earth-based validation toward independent operation in preparation for Mars exploration.