IAF SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Advances in Space-based Navigation Systems, Services, and Applications (7)

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THE LUGRE PROJECT: A SCIENTIFIC OPPORTUNITY TO INVESTIGATE GNSS SIGNALS AT THE MOON

Abstract

The use of in-orbit Global Navigation Satellite Systems (GNSS) receivers has been experimentally validated within the Space Service Volume (SSV), at Low-Earth Orbit (LEO), and Medium Earth Orbit (MEO) altitudes as well as up to GEO altitudes. Latest missions, then, have unveiled GNSS performance for distances of about 150,000 km away from the Earth's surface. The use of terrestrial GNSS signals beyond such an altitude is still a matter of research and mostly leverages modeling and extrapolation relying on current Earth and lower orbit applications.

The Lunar GNSS Receiver Experiment (LuGRE) is a joint NASA-Italian Space Agency (ASI) payload of the Firefly Blue Ghost Mission 1 to demonstrate GNSS-based positioning, navigation, and timing at lunar distances. When launched in 2023, LuGRE will collect GPS and Galileo measurements across the Moon Transfer Orbit (MTO), in lunar orbit, and on the lunar surface, and will conduct onboard and ground-based navigation experiments using the collected data.

These investigations will address the data collected by a custom development performed by the company Qascom, based on the Qascom QN400-Space GNSS receiver. The QN400 is modular in both hardware construction and software implementation. The receiver embeds two core modules: a baseband processor and a Radio Frequency (RF) front-end. These modules work in tandem to capture RF signals and process them digitally. The receiver exploits Software-Defined Radio (SDR) technologies which provide high flexibility in the allocation of correlation resources as well as algorithms and architectures that can be tailored to the targeted signals.

The receiver can provide Position, Velocity, and Time (PVT) solutions, GNSS raw observables obtained by the real-time operation, as well as snapshots of Intermediate Frequency (IF) digital samples collected by the RF front-end at frequencies L1/E1 and L5/E5. These data will be the input for the different scientific investigations, requiring the development of analysis tools that will be the core of the ground segment during the mission. The current work, pursued by the science team of NASA and ASI, and supported by a research team at Politecnico di Torino, foresees data acquisitions during the time windows dedicated to the LuGRE payload in the checkout, transit, and surface mission phases, respectively. The final contribution will present the overall LuGRE project, its scientific objectives about GNSS at the Moon, as well as the development roadmap of the ground processing segment.