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Orbit Determination and Time Transfer for a Lunar Radio Navigation System

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Within the pre-phase A of the Moonlight project proposed and funded by the European Space Agency (ESA), the ATLAS consortium has proposed an architecture to support a Lunar Radio Navigation System (LRNS) capable of providing PNT (Positioning, Navigation, and Timing) services to various lunar users. The Moonlight LRNS will be a powerful tool in support of the lunar exploration endeavors, both human and robotic.

The ESA LRNS will consist of a small constellation of 3-4 satellites put in Elliptical Lunar Frozen Orbits (ELFO) with the apselene above the southern hemisphere to better cover this region, given its interest for future lunar missions. This LRNS will be supported by a ground station network of small dish antennas (~30 cm), which can establish Multiple Spacecraft Per Aperture (MSPA) tracking at K-band. Any Earth station will be capable of sending a single uplink signal to multiple spacecraft thanks to Code Division Multiplexing modulation, while in the downlink multiple carriers can share the same K-band bandwidth by implementing Code Division Multiple Access (CDMA) on the onboard transponders. This allows the implementation of the Same Beam Interferometry (SBI) technique [1], which adds to spread spectrum ranging and Doppler measurements. In the scope of disseminating accurate PNT services to end users, the constellation will also be capable of maintaining a synchronization to the Earth station clocks to the ns level.

The performances of the proposed architecture have been validated through numerical simulations performed with the ESA GODOT software, enhanced with additional user-defined features and capabilities. For each satellite of the LRNS constellation, the attainable orbital accuracy is at level of a few meters for most orbit mean anomalies and it has been computed

considering a setup which includes a perturbed dynamical model (mainly coming from uncertainties in the accelerations induced by the solar radiation pressure and orbital maneuvers) and a realistic error model for Doppler, ranging and SBI measurements.

REFERENCE:

- Gregnanin, M. et al. (2012). Same beam interferometry as a tool for the investigation of the lunar interior. *Planetary and Space Science* 74, 194-201