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THE ROLE OF GROUND SEGMENT AS A SERVICE IN SUPPORTING LUNAR EXPLORATION

Abstract

The next years will see an increasing number of planned Moon missions, due to the pivotal role that lunar exploration plays in the advancement of many different technologies necessary to sustain the human presence in space. Such missions, despite involving either surface or orbiting users each with their different objectives, will surely require efficient and stable communication with Earth and navigation services.

Within this context, providing ground connectivity is something that is really crucial to ensure safe and fruitful operations. However, with respect to the LEO environment where the contact opportunities are frequent and can happen with low-diameter antennas, things are more complex for Moon missions. The number of daily visibilities is restricted to a single portion of the day, with the addition of lunar occultations, based on the type of orbits, e.g. Low Lunar Orbit (LLO), Lunar Frozen Orbit (LFO), and Lagrange Point Orbit (LPO). This adds complexity and proves how concepts of operations can vary largely across different users.

Most of the past missions have relied on direct-to-Earth links for both communication and ranging. However, many space agencies are developing constellations of lunar satellites to provide relaying and ranging services to both orbiting and surface users. Most relevant examples are ESA's Moonlight, NASA's LCRNS and JAXA's LNSS, all designed with common standards to allow for interoperability.

What is currently kept outside the great picture, are the Ground Segment as a Service (GSaaS) providers, which for different reasons could be beneficial for this long-term vision. Their added value is the possibility to have more ground terminals to support both the users and the constellations, exploiting the already available sites and related infrastructure, which is becoming more and more capillary on the globe. Moreover, the same antennas could also be used for other purposes during the portions of the day that do not provide Moon visibility, such that also the idle time is minimised.

The goal of this paper is then to study in depth the operability of this concept using a few sites from Leaf Space network. After providing detailed analyses of the visibility distribution for different lunar users (surface, LLO, LFO and LPO), the opportunities to exploit the antenna for different purposes is investigated, targeting either high datarate EO satellites, GEO or deep space satellites. The analysis considers multiple technical aspects involving operations, hardware capability for the antenna movimentation and RF-related constraints from compatibility and regulatory issues.