Lunar Exploration (2)
Lunar Exploration (1) (1)

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CIS-SIM FACILITY: THE GALILEO-BASED EUROPEAN NAVIGATION AND COMMUNICATION CONSTELLATION SIMULATOR FOR THE CIS-LUNAR SOCIETY

Abstract

ESA's Lunar Communication and Navigation Service (LCNS) programme aims to catalyse upcoming lunar missions, including NASA's Lunar Gateway, by offering a turnkey communication and navigation service solution. The service shall be enabled by a lunar satellite constellation and offered to potential customers in lunar orbit, lunar orbital descent and for lunar surface operations. To be able to develop, test and operate this lunar navcom infrastructure and the technology enabling and improving it, it is of importance to have a representative simulation environment as early as possible in the programme. Amongst others, such a simulation environment can be used, to evaluate the navcom signals, to train operators and service customers, to troubleshoot anomalies of the deployed lunar infrastructure, to support lunar PNT user segment development, to conduct test campaigns of orbital/surface mission scenarios (e.g for ESA's Moon Village, Lunar Gateway, etc.) and to develop advanced PNT solutions (e.g. lunar PPP corrections, terrestrial GNSS signal augmentation, etc.). We therefore suggest beginning with the development of the CIS-SIM Facility, representing a global first for a lunar navigation and communication constellation simulator, by reusing major components of flight-proven ground segment software of an active GNSS, namely Galileo. Its main purpose is to simulate the satellite constellation in the lunar orbit environment, to model the navcom signal propagation/distribution and to allow monitoring and control of the satellite platforms as well as their navcom payloads. Therefore, the here presented design is a holistic and hybrid solution, being a navcom signal service volume simulator and a spacecrafts constellation simulator in one facility. The facility core components are based on Galileo's Spacecraft Constellation and Control Facility (SCCF), Constellation Simulator (CSIM) Facility and Galileo System Simulation Facility (GSSF). Further potential extensions are also presented in this paper (Earth-based GNSS Augmentation, Precise Point Positioning Extension and Assembly Integration and Testing Extension). The facility is a key infrastructure for the development of future cis-lunar navigation and communication technologies and lowers the barriers for their potential translunar application. It brings commercial and scientific space together and helps legacy and new market entrants to participate in the lunar industrialization process. Within this paper, we introduce to the overall topic and in particular to ESA's LCNS programme. We elaborate the CIS-SIM facility design with its core elements. We then showcase the potential for extensions by exemplary outlining three options and conclude the paper with the current state of the development and the future outlook.