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Author: Mr. Thomas Heath  
Cranfield University, Cranfield UK, United Kingdom

Mr. Krystian Jakubczyk  
Cranfield University, United Kingdom  
Mr. Wei Ting Chien  
Cranfield University, UK, United Kingdom  
Mr. Hugo Berrivin  
Cranfield University, Cranfield UK, France  
Mr. Adrián Martín Ampuero  
Cranfield University, United Kingdom  
Ms. Ekaterina Shabalina  
Cranfield University, Cranfield UK, United Kingdom  
Mr. Marc Frederic Drenhaus Coll  
Cranfield University, United Kingdom  
Mr. Yeray Afonso  
Cranfield University, United Kingdom  
Mr. Sumanth Kumar Reddy Ramala  
Cranfield University, United Kingdom  
Mr. Jamal Mazar  
Cranfield University, United Kingdom  
Dr. Nicola Garzaniti  
Cranfield University, United Kingdom

TOWARDS A SUSTAINABLE LUNAR ECONOMY: SYSTEM ARCHITECTURE ANALYSIS FOR  
LUNAR COMMUNICATION AND NAVIGATION INFRASTRUCTURE

**Abstract**

Recent advances in space technology, alongside the increase in commercial space activities, and ambitious lunar programs like Artemis, have sparked a new wave of moon exploration and commercial opportunities, with 250 missions planned over the next decade. However, a significant inefficiency arises as each Lunar mission currently develops its own communication and navigation systems, costing tens of millions of USD per mission.

This paper presents a system level study for a Lunar communication and Navigation Infrastructure (LCNI). The objective is to identify a global infrastructure to deliver reliable navigation and communication services enabling commercial activities around the Moon. The infrastructure shall serve as a scalable platform that can be expanded based on the demand evolution. This can be achieved either through addition of service provider nodes or with the optional involvement of users' assets in an open, distributed relay network. A cost-effective and sustainable solution for supporting future lunar activities is proposed by leveraging commercial capability and fostering collaboration.

The study followed a trade-space exploration approach including stakeholder analysis, requirements definition, system level concept formulation and assessment. The aim is to maximise the value delivered to stakeholders whilst minimising architectural complexity in terms of orbital assets and hence, the cost.

The architecture resulting from the analysis includes a constellation of Moon satellites, a Moon ground station, a constellation of GEO satellites, and Earth ground stations. It offers a communication relay service between lunar assets and between the Moon and Earth, capable of supporting 500 users over a 10-year period, as well as Lunar global navigation services.

The LCNI is designed for interoperability with other missions and systems, whilst offering clients higher navigation precision and communication services with coverage of up to 99.9% of the Lunar surface, thus ensuring extensive coverage of the Lunar vicinity. Consideration of future development includes integration of present terrestrial network capabilities to the Lunar vicinity. Overall, LCNI provides customers with reliable and secure network and navigation services alongside other envisioned services such as LunaNet.