

## IAF HUMAN SPACEFLIGHT SYMPOSIUM (B3)

Human and Robotic Partnerships in Exploration - Joint session of the IAF Human Spaceflight and IAF  
Exploration Symposia (6-A5.3)

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TESTING ROVERS FOR HUMAN AND ROBOTIC LUNAR EXPLORATION IN THE ESA/DLR  
LUNA ANALOGUE FACILITY

**Abstract**

The European Space Agency (ESA) and the German Aerospace Centre (DLR) are actively preparing for human missions beyond Low Earth Orbit (LEO). In particular, the agencies are developing together the LUNA analogue facility to provide the exploration community with a testbed to prepare for sustainable human presence on the Moon.

In recent years, information technologies and robotics have evolved significantly. The present study focuses on the status of planetary space robotics development in Europe, and identifies its important needs that are still unaddressed. The current work shows that a few enabling technologies have developed beyond what could be predicted a few years ago. Recently, computer vision and autonomous guidance, navigation and control (GNC) have both gained momentum in robotics. Unfortunately verification and validation of these new technologies remain challenging today. Of the 28 interviewed organisations, none reported knowing a test environment that is both representative and allows repeatable experiments for computer vision or GNC. Technical tests are either done on computer simulation, where representativeness is hard to ensure, or via field simulation, where repeatability is hard to ensure.

To allow representative and repeatable tests of computer vision or GNC integrated systems in LUNA, the present study found that three key needs must be addressed. First, it must allow its 700 m<sup>2</sup> indoor regolith landscape to be modelled to a desired shape. Second, it must enable experiments to be carried out under representative lighting conditions. Third, it must provide a ground truth position tracking

of experimental devices. LUNA will be outfitted to enable development regarding In-Situ Resource Utilization (ISRU), rover navigation and teleoperations and excavation and drilling, and eventually lead to crucial experience and recommendations. This facility will notably be unique as both ESA and DLR will provide more than 30 years of experience with the International Space Station (ISS).

In an open-hub concept, LUNA shall provide access for interested international partners, academia, industries and for education and outreach purposes. The present work describes the identified unaddressed needs of planetary space robotics developers, and how the LUNA design was adapted to address them.