IAF SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration – Part 3 (2C)

Author: Dr. Daniel Schubert
LIQUIFER, Germany

Mr. René Waclavicek
LIQUIFER Systems Group, Austria
Mr. Francesco Caltavituro
OHB System AG-Bremen, Germany
Dr. Marco Berg
OHB System, Germany
Dr. Manuel Ortega
Germany
Mr. Matvei Andreev
Germany
Dr. Anna Barbara Imhof
Liquifer Systems Group (LSG), Austria
Mr. Chris Gilbert
LIQUIFER, Germany
Dr. Advenit Makaya
European Space Agency (ESA), The Netherlands
Mr. Marco Blanco
European Space Agency (ESA), The Netherlands
Mrs. Monika Brandic Lipinska
LIQUIFER Systems Group, Vienna, United Kingdom

HARMONISE RECYCLING AND REPURPOSING OF HARDWARE FOR MOON AND MARTIAN HABITATS

Abstract

The pursuit of establishing permanent colonies on celestial bodies like the Moon and Mars represents a groundbreaking evolution in space exploration. Minimising dependence on Earth is fundamental to the establishment of sustainable space outposts. This endeavour compels researchers, scientists, industry, and agencies globally to reconsider space exploration methodologies, employing inventive thinking, cutting-edge technologies, and novel strategies to overcome challenges. Essential to this goal is the capacity to fabricate structures and spare parts on-site and as needed, utilising recycling and repurposing of available resources. This approach not only reduces costs, volume and constraints associated with transporting supplies from Earth, but also facilitates extended-duration and long-duration missions. By integrating in-situ manufacturing, harnessing advancements in additive layering manufacturing (ALM) and implementing innovative recycling techniques, we can achieve a remarkable 90 % reduction in the resources needed for space missions. These methods allow for the conversion of space waste into usable resources, supporting the objectives of human settlement. Additionally, adopting in-situ recycling aligns with the ESA Clean Space initiative's aim to minimise environmental impact. In this context, this paper aims to present the concepts explored in the HARMONISE (Recycling of hardware for Moon and Martian

settlement) technology development activity, focusing on in-situ recycling and the partial or complete re-use of end-of-life hardware from previous exploration missions. Primarily targeting Moon and Mars scenarios, the study investigates repurposing strategies to serve other purposes at mission destinations. The HARMONISE ESA-funded activty is structured into three distinct parts: recycling of basic materials (e.g., recycling polyethylene Ziplock® bags into filament for 3D-printing applications and melting and casting of scrap aluminium for tools fabrication), partial re-utilisation of parts and complete re-utilisation of hardware components (e.g., repurposing rack blind panels with integrated CTB dividers for furniture elements and recycling of propulsion system components). Each strategy involves designing, manufacturing, testing and benchmarking dedicated demonstrators against pre-defined success criteria to meet functional requirements in both Earth and lunar/martian environments. The successful completion of HARMONISE project and the consequent future implementation of its work-logic will contribute to enabling sustainable space exploration, significantly enhancing the circular economy through in-orbit servicing and off-Earth manufacturing by 2050.