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

Author: Mr. Giacomo Gatto
Politecnico di Torino, Italy, giacomogatto90@gmail.com

Mr. Luca Levrino
Politecnico di Torino, Italy, luca.levrino@asp-poli.it
Mr. Eugenio Gargioli
Thales Alenia Space Italia, Italy, eugenio.gargioli@thalesaleniaspace.com
Ms. Sherrie Hall
Massachusetts Institute of Technology (MIT), United States, shall6@mit.edu
Prof. Jeffrey Hoffman
Massachusetts Institute of Technology (MIT), United States, jhoffma1@MIT.EDU
Mr. Paolo Maggiore
Politecnico di Torino, Italy, paolo.maggiore@polito.it
Dr. Nicole Viola
Politecnico di Torino, Italy, nicole.viola@polito.it
Dr. Maria Antonietta Viscio
Politecnico di Torino, Italy, Maria.Viscio-somministrato@thalesaleniaspace.com
Ms. Janelle Wellons
Massachusetts Institute of Technology (MIT), United States, jwellons@mit.edu

INCREMENTAL ARCHITECTURES FOR A PERMANENT HUMAN LUNAR OUTPOST WITH FOCUS ON ISRU TECHNOLOGIES

Abstract

Long-term strategic plans for future human space exploration are based on the idea of following an evolutionary path, as this is fundamental to reduce risks and costs associated to deep space missions, as well as to allow testing and validation of critical technologies required for ultimate goals, such as human Mars missions. In this context, in addition to its utility as a precursor for Mars expeditions, extended lunar exploration is of interest in itself, especially since the surface of the Moon is very rich in resources, but it has not so much been explored in-situ. Extended lunar operations may eventually require the establishment of a human lunar outpost. Determining what technologies will be required to accomplish this goal is the motivation for our research.

The present paper outlines the conceptual design of a permanent human Moon outpost located at the lunar South Pole, defining the main requirements and presenting the arisen system architecture, also highlighting the incremental steps needed to achieve full operational capability. Particular attention has been given to the design of the base main elements, especially incorporating In Situ Resource Utilization (ISRU) technologies as a paramount brick of the overall design process. Estimates regard the crew size and the related life support systems, and chiefly the ISRU plants production rate needed to allow the primary lunar base self-support. Moreover, ISRU is considered not only as an enabling factor for affordable human long-term presence on the Moon, but also as an opportunity to provide spacecraft travelling to the Red Planet with propellant, thus reducing their launch mass: calculations are made considering refueling at the Earth-Moon libration point L1, where liquid oxygen tanks would be delivered from the lunar surface. Oxygen extraction through ilmenite reduction is the main technology considered for dimensioning ISRU

plants. Another precious resource could be found in sunless “cold trap” craters at the Moon’s south polar region. However, ground truth for the presence of water ice inside these traps has never been provided. For this reason, the scenario described in this paper envisages robotic survey missions: initially, they will be tele-operated from the Earth, and later on from a lunar lander in sortie missions, or even from the outpost itself. In this way, alongside the ongoing production of oxygen through well-mastered technologies, research activities could flourish to improve and innovate the lunar outpost endeavor.