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BIOREGENERATIVE SYSTEMS ON MARS : WHY, CHALLENGES, AND HOW TO GET THERE

Abstract

In the upcoming years, humans are returning to the Moon to prepare for further sustainable exploration of outer space, with a long-term objective of putting humans on the Red Planet. Sustaining life in outer space and on other planets, where Earth resources are not available, presents unique challenges. Life Support Systems (LSS) are designed to provide humans with everything they need to survive (food, oxygen, water, ...), and dispose of their byproducts (CO2, perspiration, feces, ...). The simplest form of LSS is based on storage, resupply of all consumables to the crew, and disposal of wastes, without recycling. On the opposite, Bioregenerative Life Support Systems (BLSS) aim at re-creating a virtual "closed" ecosystem, like on Earth, involving plants and animals to grow food, and bacteria to recycle wastes, closing the loop of recycling as much as possible, reducing the needs of resupply from Earth.

This paper first presents the situations where a bioregenerative system is desirable in space exploration scenarios. It is then described how technologies developed for improving the closure level of BLSS can aid attaining sustainable development goals for Earth, and how they can help addressing challenging environmental and societal problems in Europe and the rest of the world.

The Martian environment features unique opportunities for In-Situ Resource Utilization (ISRU), in synergy with bioregenerative processes. It is discussed how opting for solutions at limited closure level can actually have benefits for a Mars settlement, while maintaining or even improving the benefits of technology transfers to Earth.

A design for a BLSS sustaining a crew of 6 based on current and near-future technologies is described, highlighting the challenges faced by such architecture. In particular, the issues of crop lighting, habitat construction, and pressurization, are discussed. Stemming from these challenges, we propose a roadmap of technologies to be developed for building a sustainable Mars habitat. Technologies needed for building a sustainable Mars settlement are put in perspective with nearer-term objectives of Lunar exploration. Starting to build surface habitats and BLSS on the Moon could provide experience on designing and operating several relevant components, with the goal of risk mitigation and cost reduction. It is also shown how these first steps would benefit nearer-term exploration of the Moon, by simplifying mission architectures and allow for the development of a sustainable space architecture.