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SYNERGETIC HYBRID LIFE SUPPORT SYSTEM FOR A MARS TRANSFER VEHICLE

Abstract

Future long-term space missions, such as a human mission to Mars, will require a regenerative life support system (LSS) whether it be to the moon Phobos or a visit to the planet's surface. A mission duration of about two years and the large distance from Earth to Mars are the main drivers in LSS development. The M (Modular Mars Mission) concept suggests the development of an Earth-to-Orbit transportation system, a Mars Transfer Vehicle (MTV), and a Mars Excursion Vehicle. The MTV will consist of a pressurized module for the crew and contains the LSS during transit time. To meet the requirements of long-term missions a combination of physico-chemical and biological components is needed. A synergetic hybrid LSS with integrated proton exchange membrane (PEM) fuel cells and algae photobioreactors (PBR) is investigated that contributes to partially closing the main life support media loops of oxygen, water, and carbon and enables the crew self-sufficiency and less dependence on resupply. It takes advantage of a high-level technology integration approach so that a common use of media by the different MTV subsystems is possible. The integration approach is realized by a media specific infrastructure. Thus air or oxygen supply is directly connected with the crew cabin and the fuel cell. The photobioreactors for algae cultivation are a high-controllable biological component that allows for converting the carbon dioxide exhaled by the crew into oxygen and edible biomass under illumination. Besides oxygen the algae emission gas contains organic and inorganic contamination in low concentrations that are dispersed in the gas infrastructure of the space system if no filtration is provided. The Mars transit scenario is modeled and simulated with the ELISSA software (Environment for Life Support Systems Simulation and Analysis) developed at the Institute of Space Systems at the University of Stuttgart. At the same time ELISSA serves as simulator in a hardware-in-the-loop (hil) test environment. The hardware components in the hil simulation are a PEM fuel cell and an algae PBR of flat plate type. The system behavior (mass and energy flows) with integrated hardware components afford essential cost results. The advantages of a hybrid LSS with use of electrochemical and biochemical processes in comparison to a regenerative physico-chemical LSS are determined, initial thoughts on system reliability are discussed and evaluated.