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IMPORTANCE OF A MODELING APPROACH FOR BIOREGENERATIVE LIFE-SUPPORT SYSTEMS

Abstract

Bioregenerative Life-Support Systems (BLSS) are key for long-duration space exploration missions, as they enable the recycling of crucial consumables such as water, oxygen, and food. As such, the MELiSSA (Micro-Ecological Life-Support System Alternative) loop is designed as a closed artificial ecosystem divided into 5 compartments, each ensuring a vital function of the ecosystem. A deterministic control is a prerequisite of robust performance but cannot be developed without a thorough understanding of each part of the system and of the interrelations between the different subparts. In order to develop a precise multi-criteria and multi-factorial control of each compartment, a first step was to develop mechanistic models for each process of the loop.The second step is to develop a global simulator of the recycling loop accounting for the different layers of control and for the fulfillment of the constraintsassociated to the BLSS. These activities mainly took place at the Institut Pascal (University Clermont Auvergne, France) and this presentation summarizes this effort. A stoichiometric description enables to account for an average behavior of the first compartment (anaerobic degradation). The efforts for a mechanistic description of the second compartment - conversion of Volatile Fatty Acids (VFA) to CO2 using microbial electrochemical cells – are currently ongoing. Modeling of the nitrification compartment has allowed its connection to the microalgae compartment. The two photoautotrophic compartments – photobioreactor and higher plant compartment– have been described mechanistically and the photobioreactor predictive model was validated on the ISS. The gas phase of the consumer reactor is modeled and can predict O2 consumption and CO2 production of a group of rats. The overall analysis of the degrees of freedom of the entire recycling loop is done, enabling the development of the interface with the Advanced Life Support System Evaluator (ALiSSE). This work was supported through ESA MELiSSA MoU 4000100293/10/NL/PA and funded via ESA Optimal System in System Control and Architecture 4000133102/20/NL/KML.