Paper ID: 63531
student

IAF HUMAN SPACEFLIGHT SYMPOSIUM (B3)
Advanced Systems, Technologies, and Innovations for Human Spaceflight (7)

Author: Mr. Curt Holmer
Department of Space Studies, University of North Dakota, United States

BIO-REGENERATIVE LIFE SUPPORT SYSTEMS FUNCTIONAL STABILITY INDICATORS USING THEORETICAL MODELING

Abstract

Experiments such as Russia's BIOS series, NASA's BIOPlex, ESA's MELiSSA, and Japan's CEEF have shown that microalgae and higher plants combined with physical-chemical material converters can be a successful part of a Biological Life Support System or a Closed Ecological Life Support System. BIOPlex, MELiSSA, CEBAS experiments, and commercial Ecosphere products have proven stability at small-scale with direct dependence, closed-loop systems for both short and extended time periods. This shows that when the dependencies and factors are known and understood, creating a small-scale stable environment with known measuring points can be easily accomplished. However, the more extensive experiments, such as Biosphere2 or Bios3, have shown that the more complex environment, the more stability issues arise and give way to critical transitions. These transitions are sudden and often irreversible, leading to the collapse of the system. Generalized models can achieve this and may even reduce the amount of time series data required to validate the stability of a given system. Computer systems can now create simulations with enough fidelity to accurately model the interactions between plants, humans over extended periods. This ability allows for low-cost and rapid iteration of environment and habitat components. Using this ability also allows the examination of monitoring and analysis techniques to monitor the stability of individual features and the overall system. After constructing and validating a model of the 1990's Lunar Mars Life Support Test Project (LMLSTP), the components were used to conduct long-term simulations to examine overall stability. This paper summarizes the initial attempts to leverage these simulations for data, construct a generalized framework model to detect early warning signals of critical transitions using sub-system eigenvalues, and demonstrate the overall stability or instability of the system under observation. Analysis of the data for possible signs of critical transitions was unfortunately inconclusive. Although a clear signal of system failure was not seen in these models overall, the compensation created in the water system for a simulation anomaly demonstrated that part of the lack of a strong signal could have been due to a lack of adequate system buffers. Further simulation execution with increased buffers did show a stabilized system for some system values. Further study is needed to clarify eigenvalue factors and define the generalized model's expected required parameters for proper execution. Keywords: life support, stability, modeling.