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Author: Mr. Oscar Ojeda
Cydonia Foundation, Colombia

Mrs. Yael Natalia Méndez Chaparro
Cydonia Foundation, Colombia
Ms. Laura Margarita Rodríguez-Ortiz
University of America, Colombia
Mr. Tarek Rivas Granados
Cydonia Foundation, Colombia
Mr. Camilo Andrés Zorro
Cydonia Foundation, Colombia

DEVELOPMENT OF A MODEL OF A CONTROLLED ENVIRONMENT CROP PRODUCTION SYSTEM FOR OPTIMAL DISTRIBUTION DEFINITION IN DEEP SPACE MISSIONS AND ANALOG STATIONS

Abstract

In Situ production of plant based products such as food, medicine, and others, will be key for the success of future human spaceflight to deep space destinations. The lack of capacity for constant resupply will require for several of the resources to be generated during the mission, and development of controlled environment agriculture is an alternative for this. Moreover, developing the capacity to grow plants in extreme environments will allow for decentralized production of crops on Earth, aiding on food security of isolated or vulnerable population. This work presents the development of a virtual model of a crop-production system in the context of a remote location or space mission, aimed towards the definition of an optimal combination of plant growth methods, as well as plant selection. The model is conceived as an Agent Based Model(ABM) centered around the crop system and plants. Other constitutive elements of the model are the crew, the subsystems of the station, the food stock, crop collection and preservation systems, the external environment, and is flexible for additional systems. The developed model is a time-based step simulation aimed towards identifying not only a steady-state production, but also potential emergent behavior and response related to perturbations of the system towards evaluation of resiliency. The model uses a paremetrization of each one of the agents to establish relations between them in terms of analytical models for internal behavior and interactions. By providing the input variables of the crew characteristics and the desired percentage of diet replacement by crop production systems, the model generates an ideal distribution of crops and plant growth methods (aeroponics, hydroponics, substrate based), as well as an expected timeline of the operation of the system. Characteristics such as base environment and mission duration are also input variables, which allows the model to be used not only for space missions, but also Earth applications. The analytic description of the behavior of the agents as well as the interactions is based on available literature. Internal parameters can be tuned and stochastic variables can be included for non-deterministic simulations of the operation. Some of them include yield, calorie intake, energy and water requirements, efficiency coefficients for reclaim processes, external resource availability, maintenance time, conservation techniques, among other. Finally, empirical data to refine the performance is being collected with crops growing in substrate and vertical farming systems at the Analog Habitat for Simulated Space Exploration in Colombia, HAdEES-C.