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CROP ENVIRONMENT FOR THE RESUPPLY AND EXTENSION OF SPACE MISSIONS (CERES) SYSTEM: DEVELOPMENT OF HORTICULTURAL TECHNOLOGIES FOR THE EXPLORATION SYSTEMS AND HABITATION (X-HAB) 2020 ACADEMIC INNOVATION CHALLENGE

Abstract

Deep-Space missions of 3-5 years are being considered for near-term exploration initiatives. A strong limiting factor in mission architecture is how to maintain crew health calorically and nutritionally without constant resupply or reliability on Earth. Systems as solutions for this should ideally: optimize volume, mass, and resource utilization; function without significant human-in-the-loop interactions; and scale to the mission's requirements. The **C**rop **E**nvironment for the **R**esupply and **E**xtension of **S**pace missions (CERES) Capstone team from the University of Miami (UM) will present their findings and proposed system solutions as developed through the eXploration Systems and Habitation 2020 Academic Innovation Challenge (X-Hab 2020 AIC) in collaboration with NASA and Made In Space. Through this opportunity, the team underwent an accelerated systems engineering analysis and rigorous workflow to explore the design space and understand the requirements for space horticulture. The resulting architecture was CERES: an automated growth volume with modular robotic racks that could be updated, modified, or repaired *in-situ*. This solution was a response to the blended requirements of public-private enterprise in space technologies. Undergraduates, faculty, industry engineers, and scientists, all contributed to the

design process as stakeholders, designers, and subject matter experts. CERES performs the function of greenhouse and caretaker for varying types of crops. Internal racks provide lighting, nutrient delivery, and sensing throughout the lifecycle of pre-selected plants. Taking the Outer Mold Line (OML) and inputs of a standard ISS EXPRESS Module, CERES is applicable for approaching projects such as Axiom, Artemis, and missions to the Moon and Mars. A subscale prototype of CERES will be completed and utilized to ground-validate capabilities of a space systems. Research and early experiments show the ability to grow dwarf crops from germination. The device validates robotic delivery of nutrients, lighting controls, thermal and power management, and sensors including cameras. A path forward is being constructed for gas management, TRL advancement of micro-gravity sensitive functions, and further plant research.