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ABSTRACT: HESTIA Phase I Test Results: The Air Revitalization System

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In any human spaceflight mission, a number of Environmental Control & Life Support System (ECLSS) technologies work together to provide the conditions astronauts need to live healthily, productively, and comfortably in space. In a long-duration mission, many of these ECLSS technologies may use materials supplied by In-Situ Resource Utilization (ISRU), introducing more interactions between systems. The Human Exploration Spacecraft Test-bed for Integration & Advancement (HESTIA) Project aims to create a test-bed to evaluate ECLSS and ISRU technologies and how they interact in a high-fidelity, closed-loop, human-rated analog habitat. Air purity and conditioning are essential components within any ECLSS and for HESTIA's first test they were achieved with the Air Revitalization System (ARS) described below.

The ARS provided four essential functions to the test-bed chamber: cooling the air, removing humidity from the air, removing trace contaminants, and scrubbing carbon dioxide (CO_2) from the air. In this case, the oxygen supply function was provided by ISRU. In the current configuration, the ARS is a collection of different subsystems. A fan circulates the air, while a condensing heat exchanger (CHX) pulls humidity out of the air. A Trace Contaminant Removal System (TCRS) filters the air of potentially harmful contaminants. Lastly, a Reactive Plastic Lithium Hydroxide (RP-LiOH) unit removes CO_2 from the breathing air.

During the HESTIA Phase I test in September 2015, the ARS and its individual components each functioned as expected, although further analysis is underway. During the Phase I testing and in prior bench-top tests, the energy balance of heat removed by the CHX was not equal the cooling it received. This indicated possible instrument error and therefore recalibration of the instruments and follow-up testing is planned in 2016 to address the issue. The ARS was tested in conjunction with two other systems: the Human Metabolic Simulator (HMS) and the Electrolyzer. They behaved as anticipated as well. The HMS added humidity, CO_2, and heat to the chamber while removing oxygen, and the Electrolyzer (an ISRU technology) added oxygen.

The objective for HESTIA in 2015 was achieved: the creation of a high-fidelity test-bed for ECLSS and ISRU technologies. With the 'backbone' technologies installed, more technologies will be added to increase the analog habitat's fidelity over the next few years. The ARS was designed with this in mind, and as new technologies develop and mature, the strategic installation of the existing components will allow for them to be replaced with the new technologies.