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DESIGN OF SENSORY INFORMATION NETWORK FOR ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM SELF-AWARENESS

Abstract

An Environmental Control and Life Support System (ECLSS) meets the environmental and metabolic needs of the crew. However, regenerable ECLSS subsystems have required continuous monitoring and frequent maintenance and repair. For the International Space Station (ISS), ground control monitors these subsystems and directs maintenance and repair operations using replacement components and assemblies sent from Earth via resupply. While this has been sustainable for the ISS, habitats for crewed Moon and Mars missions will need to be less dependent on Earth, requiring the ECLSS to be more self-sustaining. For "self-awareness", the ECLSS will be expected to detect and diagnose component and system health in real time. To do so, the possible failure modes of each ECLSS subsystem and their effects on operability and performance, habitability and crew health must be known. This then informs the data that must be collected via instruments and sensors, and then synthesized for meaningful projections of ECLSS health. An on-going study has identified ECLSS common failure modes and created a framework for implementing self-awareness into the ECLSS architecture. Additionally, the study revealed shortcomings with current ECLSS health monitoring systems, which often failed to detect a fault through lack of information or conversely, indicated a false positive.

Therefore, an important step for self-awareness is to identify those data necessary to monitor and predict ECLSS health, especially with respect to the common failure modes. This paper summarizes ECLSS failures that have occurred on ISS and the benefit of implementing self-awareness based on a Failure Modes and Effect Analysis. We describe instruments, sensors and protocols currently in place to monitor ECLSS and will discuss their limitations. The paper will then discuss the sensory information that should be obtained for ECLSS self-awareness, possible strategies to reliably detect system, subsystem and component faults, and limitations of both. From these results, we will baseline an approach for implementing self-awareness into ECLSS.