Conference: IEEE Aerospace Conference, Big Sky, Montana, March 2016

Target Session: **Session 12.4: Human Space Flight Development, Operations, and Processing**

Session Summary: This session focuses on all aspects of Human Spaceflight processing and operations across all mission regimes. Research topics including the design, and development of manned spacecraft hardware and support systems, as well as operations research focused on preflight, in-flight and postflight activities is encouraged. Additionally, research dedicated to specific areas such as flight operations including IVA and EVA, landing, and recovery of crewed spacecraft, and the physiological and psychological effects on human beings during all of these mission types and phases is also encouraged

Word Limit: <500

Authors: Steven P. Chappell, Andrew F. Abercromby, Matthew J. Miller, Christopher Halcon, Michael L. Gernhardt

Title: Analog Testing of Operations Concepts for Mitigation of Communication Latency during Human Space Exploration

OBJECTIVES: NASA Extreme Environment Mission Operations (NEEMO) is an underwater spaceflight analog that allows a true mission-like operational environment and uses buoyancy effects and added weight to simulate different gravity levels. Three missions were undertaken from 2014-2015, NEEMO's 18-20. All missions were performed at the Aquarius undersea research habitat. During each mission, the effects of varying operations concepts and tasks type and complexity on representative communication latencies associated with Mars missions were studied. **METHODS**: 12 subjects (4 per mission) were weighed out to simulate near-zero or partial gravity extravehicular activity (EVA) and evaluated different operations concepts for integration and management of a simulated Earth-based science backroom team (SBT) to provide input and direction during exploration activities. Exploration traverses were planned in advance based on precursor data collected. Subjects completed science-related tasks including presampling surveys, geologic-based sampling, and marine-based sampling as a portion of their tasks on saturation dives up to 4 hours in duration that were to simulate extravehicular activity (EVA) on Mars or the moons of Mars. One-way communication latencies, 5 and 10 minutes between space and mission control, were simulated throughout the missions. Objective data included task completion times, total EVA times, crew idle time, translation time, SBT assimilation time (defined as time available for SBT to discuss data/imagery after it has been collected, in addition to the time taken to watch imagery streaming over latency). Subjective data included acceptability, simulation quality, capability assessment ratings, and comments. **RESULTS**: Precursor data can be used effectively to plan and execute exploration traverse EVAs (plans included detailed location of science sites, high-fidelity imagery of the sites, and directions to landmarks of interest within a site). Operations concepts that allow for

presampling surveys enable efficient traverse execution and meaningful Mission Control Center (MCC) interaction across long communication latencies and can be done with minimal crew idle time. Imagery and information from the EVA crew that is transmitted real-time to the intravehicular (IV) crewmember(s) can be used to verify that exploration traverse plans are being executed correctly. That same data can be effectively used by MCC (across comm latency) to provide further instructions to the crew from a SBT on sampling priorities, additional tasks, and changes to the plan. Text / data capabilities are preferred over voice capabilities between MCC and IV when executing exploration traverse plans over communication latency. Autonomous crew planning tools can be effective at modifying existing plans if the objectives and constraints are clearly defined.