A Simulation Base Investigation of High Latency Space Systems Operations

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NASA's human space program has developed considerable experience with near Earth space operations. Although NASA has experience with deep space robotic missions, NASA has little substantive experience with human deep space operations. Even in the Apollo program, the missions lasted only a few weeks and the communication latencies were on the order of seconds. Human missions beyond the relatively close confines of the Earth-Moon system will involve missions with durations measured in months and communications latencies measured in minutes. To minimize crew risk and to maximize mission success, NASA needs to develop a better understanding of the implications of these types of mission durations and communication latencies on vehicle design, mission design and flight controller interaction with the crew.

To begin to address these needs, NASA performed a study using a physics-based subsystem simulation to investigate the interactions between spacecraft crew and a ground-based mission control center for vehicle subsystem operations across long communication delays. The simulation, built with a subsystem modeling tool developed at NASA's Johnson Space Center, models the life support system of a Mars transit vehicle. The simulation contains models of the cabin atmosphere and pressure control system, electrical power system, drinking and waste water systems, internal and external thermal control systems, and crew metabolic functions. The simulation has three interfaces: 1) a real-time crew interface that can be use to monitor and control the vehicle subsystems; 2) a mission control center interface with data transport delays up to 15 minutes each way; 3) a real-time simulation test conductor interface that can be use to insert subsystem malfunctions and observe the interactions between the crew, ground, and simulated vehicle.

The study was conducted at the 21st NASA Extreme Environment Mission Operations (NEEMO) mission between July 18th and Aug 3rd of year 2016. The NEEMO mission provides ideal conditions for this study with crew in the loop, an active control center, and real-time flow of high latency communications and data. NEEMO crew and ground support will work through procedures including activation of the transit vehicle power system, opening the hatch between the transit vehicle and a Mars ascent vehicle, transferring simulated crewmembers between vehicles, overcoming

subsystem malfunctions, sending simulated crewmember on extra-vehicular activities, and other housekeeping activities.

This study is enhancing the understanding of high latency operations and the advantages and disadvantages of different communication methods. It is also providing results that will help improve the design of simulation interfaces and inform the design of Mars transit vehicles.