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DEVELOPMENT OF THE HUMAN FACTORS SUBSYSTEM FOR THE RXEVA MODEL FOR PRESCRIBING SURFACE EVA OPERATIONS

Abstract

Artemis astronauts are facing an unprecedented expected EVA frequency that will place significant demands on their cognitive and physical workload, thereby increasing their risk of injury. In a conceptual paper published at the 2020 IEEE Aerospace Conference, Dr. Kobrick et al. proposed to satiate this problem via the RxEVA model, which outputs mission planning recommendations based on individual astronaut performance limitations established by environmental parameters (terrain slope, gravity forces, duration, and consumables), mental and physical workload, and EVA task intensity. This paper discusses the preliminary development of the human factors subsystem of the RxEVA model, which is responsible for characterizing, quantifying, and mapping human performance data (i.e. physical and mental workload) to EVA task difficulty.

Given the lack of available personal performance data on Artemis astronauts, a literature study was conducted on elite endurance athletes of comparable astronaut age, height, weight, gender and physical fitness level, to determine approximate metabolic rate ranges. These generic operating limits were compared against energy expenditure data from the Apollo missions to ensure consistency with prior Lunar EVA performance and that they accurately reflect the general limitations of modern astronauts.

High-fidelity pilot data collection and method validation were conducted during the Sensoria mission at the Hawaii Space Exploration Analog and Simulation (HI-SEAS) habitat in January 2020. To quantify the ambiguous biomedical differences between individuals, the Hexoskin Smart shirt was used to monitor key biometric variables (heart rate, breath rate, lung capacity, and cadence) that characterize physical workload. To collect cognitive workload data, the NASA Task Load Index, Karolinksa Sleepiness Scale, Rate of Fatigue Scale, and Comfort Affected Labeled Magnitude Scale were utilized.

The causal link found between variations in key biometric variables and the strenuousness of the EVA task encourages the possibility of creating an individual performance map per crewmember that quantifies their physical workload during disparate EVA tasks. Additionally, many of the analogue astronauts reported feeling invigorated by strenuous EVAs rather than overwhelmed by their physical fatigue, an important discovery when considering the influence of cognitive workload versus physical workload on perceived stress and ability.

Future work includes creating the performance map to disparate EVA tasks per Sensoria crewmember, establishing a robust method of characterizing general EVA task difficulty, and standardizing the pre and post-EVA protocol. This work will continue within several analogue missions to help refine the human factors subsystem and make optimized recommendations for safe manned exploration of the Moon.