

## NEO – MARS ADAPTIVE TRAINING INTEGRATIVE KNOWLEDGE SYSTEM (MATRIKS) TO IMPROVE OPERATIONAL PERFORMANCE AND ITS NEURAL BASIS FOR SPACEFLIGHT

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With prolonged mission durations, spaceflight crews will become increasingly dependent on onboard technologies for knowledge acquisition and maintenance. It is expected that not all skills and knowledge required for these missions can be retained and retrieved based on pre-mission training alone. Limited and delayed communication will significantly constrain support from Mission Control and crews will increasingly rely on autonomous onboard technologies to successfully perform post-landing operations. With the present project we will target NASA's particular interest in developing and assessing an adaptive, just-in-time countermeasure that will consolidate and improve skills that are most relevant to space flight operations. To achieve this aim, NASA established a Virtual NASA Specialized Center of Research (VNSCOR) referred to as "Mars Adaptive Training Integrative Knowledge System (MATRIKS)", comprising the following three projects: (1) "*Trinity* – Multi-Environment Virtual Training for Long Duration Exploration Missions", PI: A. Anderson (UC Boulder); (2) "*Morpheus* – A Haptic Sensory Supplement to Optimize In-Flight Adaptive Training for Human Control of Spacecraft Robotic Arms", PI: S. Robinson, UC Davis); and the present project "*Neo* – Adaptive Training integrative knowledge System to Improve Operational Performance and its Neural Basis for Spaceflight" (UPenn, PI: A.C. Stahn).

*Neo* leverages a validated workstation called 6DF that simulates a rendezvous and docking maneuver using real spacecraft flight dynamics. It is designed to (1) train and improve sensorimotor skills relevant for inflight and post-landing operational tasks; (2) feature an autonomous and adaptive training approach that does not rely on feedback from flight operations on the ground; (3) maximize the transfer of mission-relevant motor skills; (4) allow the assessment of the neural circuitry underlying the task; and (5) deliver the training in a motivating and meaningful way to astronauts. *Neo* comprises two overarching aims: First, we will identify the neural circuitry underlying spaceflight relevant tasks by performing a subset of the 6DF task during functional magnetic resonance imaging (MRI) in a total of up to N=30 subjects with varying levels of 6DF training experience. Second, as part of the above-mentioned VNSCOR MATRIKS the proposed 6DF autonomous intelligent tutor system will be integrated in an additive manner with a haptic feedback intervention (*Morpheus*), and a multi-environment virtual trainer (*Trinity*). It is expected that *Neo*, *Morpheus* and *Trinity* mutually complement each other to facilitate an effective countermeasure tool to acquire and retain operational skills that are critical for exploration class missions. To assess the efficacy of this combined effort, the VNSCOR MATRIKS will collect data in N=16 crew members in one HERA campaign of 45 days duration with N=16 crew members (four missions with N=4 crewmembers each). The primary goal is to identify changes in operational performance as assessed by NASA's simulator of Canadarm2 operations, i.e., Robotic On-board Trainer (ROBoT-r) in response to MATRIKS. As part of *Neo* we will also identify if, and to what extent MATRIKS will promote transfer to general cognitive performance (*Cognition* battery), distinctive visuo-spatial tasks critical for telerobotic tasks (*Spatial Cognition* battery), and affect brain structural changes and the neural circuitry of key brain networks expected to be relevant for spaceflight-related performance.

At the conclusion of the research, we will have defined and demonstrated the use of a neuroscience-based, adaptive training integrative knowledge system to potentially mitigate visuo-spatial and sensorimotor brain changes associated with prolonged isolation and confinement to reduce the likelihood or impact of potential decrements in human performance capabilities during long-duration space missions. The expected significance of this 4-year project relates to its relevance for facilitating effective countermeasure tools to acquire and retain operational skills that are critical for exploration class missions. This will support the development of necessary countermeasures and technologies in support of human space exploration, focusing on mitigating operational performance risks.

### SUPPORT

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