Fiscal Year:	FY 2023	**Task Last Updated:**	FY 10/17/2022
PI Name:	Stahn, Alexander Ph.D.		
Project Title:	Mars Adaptive Training Integrative Knowledge System (MATRIKS) to Improve Operational Performance and Its Neural Basis for Spaceflight		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:			
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H)		
Human Research Program Risks:	None		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2020-2021 HERO 80JSC020N0001-HHP, OMNIBUS3 Human Research Program: Human Health & Performance Appendix E; Omnibus3-Appendix F
Start Date:	12/17/2021	**End Date:**	03/31/2026
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	0	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
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Flight Program:			
Flight Assignment:	Note: End date changed to 03/31/2026 per NSSC information (Ed., 5/16/22).		
Key Personnel Changes/Previous PI:	CoInvestigators changed since writing of the proposal as follows; Pete Roma and Sara Whiting changed positions and were therefore deleted from the team. Dr. Suzanne Bell (NASA Johnson Space Center) was added as the lead for the HERA study. Drs. Christian Mühl and Darius Gerlach (German Aerospace Agency) were in support of the study conducted at DLR :envihab.		

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Performance Goal Text:	
Task Description:	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.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	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. 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. Together, these data will data will help mission planners to ensure safe and successful space exploration class missions. It is possible that the results from this project also translate to situations on Earth where fine motor skills are essential such as robot-assisted surgery.
Task Progress:	The primary objectives for Year 1 were to continue the preparation of the integrated Mars Adaptive TRaining Integrative Knowledge System (MATRIKS) Human Exploration Research Analog (HERA) campaign, and to validate and optimize the task functional imaging protocol simulating a spaceflight maneuver, which will leverage a subtask of the proposed 6DF training system. The following project milestones were achieved in the first year of the study: 1. Institutional Review Board (IRB) approval for in-lab study was granted by the University of Pennsylvania. Since the study is conducted at the German Aerospace Agency (Deutsches Zentrum für Luft- und Raumfahrt / DLR) additional IRB approval was required by local German authorities. The local German IRB approval was granted in August 2022. 2. The experimental design for the functional imaging was optimized to maximize scientific return, costs, subject burden, and technical limitations. 3. Completion of experimental design and software integration for delivering the task in the scanner. 4. Design of hardware setup and its demonstration for administering the task in the scanner. 5. Identification/delivery of hardware to DLR. 6. Standard operating procedures (SOP) / Familiarization of DLR staff: Statements of procedures or other materials have been prepared to prepare and assist DLR with the correct implementation of all measures, including magnetic resonance imaging (MRI) acquisition, and the administration of the test batteries: Cognition and Spatial Cognition. 7. Subject recruitment has started. The target sample size comprises N=30 subjects, including individuals naïve to the training system, and those characterized by a history of extensive training with the spaceflight task. It was planned that the groups would be represented in an equal ratio, but if that cannot be reached, a ratio of 1:2 (N=10 for the expert subjects and N=20 for the naïve subjects) will also be acceptable. Currently,

	a total of N=10 experts, i.e., subjects with significant experience of the task, and N=20 naïve subjects have been successfully recruited. 8. Data collection: The data collection is expected to start at the end of 2022.
Bibliography Type:	Description: (Last Updated: 02/16/2022)