

Fiscal Year:	FY 2023	Task Last Updated:	FY 01/25/2024
PI Name:	Robinson, Stephen K. Ph.D.		
Project Title:	HCAAM VNSCOR: Enabling Autonomous Crew Task Performance with Multimodal Electronic Procedure Countermeasure		
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:	(1) HSIA :Risk of Adverse Outcomes Due to Inadequate Human Systems Integration Architecture (2) Team :Risk of Performance and Behavioral Health Decrements Due to Inadequate Cooperation, Coordination, Communication, and Psychosocial Adaptation within a Team		
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:	2017-2018 HERO 80JSC017N0001-BPBA Topics in Biological, Physiological, and Behavioral Adaptations to Spaceflight. Appendix C
Start Date:	04/15/2019	End Date:	06/30/2025
No. of Post Docs:	0	No. of PhD Degrees:	
No. of PhD Candidates:		No. of Master' Degrees:	
No. of Master's Candidates:	1	No. of Bachelor's Degrees:	
No. of Bachelor's Candidates:	2	Monitoring Center:	NASA JSC
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Flight Program:			
Flight Assignment:	NOTE: End date changed to 06/30/2025 per A. Beitman/JSC (Ed., 8/23/23) NOTE: End date changed to 12/23/2023 per V. Lehman/JSC and NSSC information (Ed., 7/20/23) NOTE: End date changed to 12/31/2023 per A. Beitman/JSC (Ed., 4/17/23) NOTE: End date changed to 4/14/2023 per NSSC information (Ed., 1/26/21) NOTE: End date changed to 3/14/2020 per NSSC information (Ed., 1/22/2020)		
Key Personnel Changes/Previous PI:	February 2021 report: Jessica Marquez, Ph.D., is now CoInvestigator (CoI). Steven Hillenius and Richard Joyce are no longer CoIs on the project.		

COI Name (Institution):	Karasinski, John M.S. (NASA Ames Research Center) Marquez, Jessica Ph.D. (NASA Ames Research Center)
Grant/Contract No.:	80NSSC19K0657
Performance Goal No.:	
Performance Goal Text:	
Task Description:	<p>This task is part of the Human Capabilities Assessments for Autonomous Missions (HCAAM) Virtual NASA Specialized Center of Research (VNSCOR).</p> <p>Future long duration exploration missions (LDEM) conducted by NASA will have an increased need for crew autonomy during routine and emergency procedures, due to the increased distance from Earth causing time delays in communications. Presently, many procedures are completed with constant communication between the crewmembers and mission control personnel. This need for increased autonomy will lead to a need for more information being stored on board and accessed by crewmembers in a timely and context appropriate manner during procedural execution. Emergent technologies in multimodal interaction such as augmented reality (AR) visual displays, spatial audio, and tactile feedback are likely to play a role in mitigating this need, leading to what we define as "enhanced electronic procedures." In this proposal we outline a research study which will use a multimodal enhanced electronic procedure to determine the best tasks and cues to pair with sensory channels for procedural execution tasks. Past efforts by our group have investigated procedural tasks using new technologies such as augmented reality and haptic cues. A ground-based research study will determine the effects of crew performance, situational awareness, and trust with the use of multimodal enhanced electronic procedures compared to traditional unimodal electronic procedures. The results of the ground-based study will lead to deployment in an analog mission for validation in a flight-like environment. From the lab and analog results, we will formulate recommendations for updated standards and guidelines for multimodal interaction and electronic procedures.</p>
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	<p>This research aims to re-define the meaning of "procedures" for astronauts performing complex task in space. Traditionally, procedures are static, non-responsive documents that serve as passive instructions or recipes for astronauts to follow while performing a pre-planned task. The current research adds sensors and responsive procedure-viewer technology to allow a dynamic feedback loop to aid the astronaut in being certain that the procedures are being executed correctly.</p> <p>Since procedures are very common in safety-critical tasks here on Earth (operating rooms, nuclear power plants, airliners, etc.), the results of this NASA research are likely to benefit a broad range of society on Earth.</p>
Task Progress:	<p>Summary of Progress: The HCAAM Enhanced Procedures research team has spent Year 4 supporting NASA's Human Exploration Research Analog (HERA) Campaign 6, with Mission 4 (of 4) just completed in March 2023. Accomplishments during this period include:</p> <ul style="list-style-type: none"> • We are utilizing a commercial-off-the-shelf (COTS) electrical generator as a spacecraft subsystem analog which subjects are asked to partially disassemble and then reassemble using both traditional and experimentally-enhanced procedures. During Year 4, we continued using our experiment system architecture in HERA with the Campaign 6 crews. Our experiment system is designed to serve, display, and provide interaction options for HERA crews to execute the enhanced procedures. Raspberry Pi and sensors are now built into the customized Honda generator to monitor the state of the system and feed step-specific data to the enhanced procedures. • Enhanced Procedure Viewer - We have developed a novel Enhanced Procedure Viewer (EPV). This EPV integrates dynamic data from sensors directly into the procedure in real-time, providing the crewmember enhanced situational awareness and progress tracking. The green and red sensor data statements allow the participant to know when a step has been completed correctly, avoiding the need for them to go back later to fix a missed step. Other enhancements include on-when-needed laser indicators to highlight items on the physical generator, caution/warning statements in the procedures, and videos on complex steps to provide additional context and support for the crewmember. Navigation of the procedure via up and down arrow buttons and a moving blue step indicator help to keep track of procedure progress and reduce errors from missed steps. • The Enhanced Procedure Viewer's numerous features are meant to aid the user during the completion of their mechanical repair tasks. • During the run-up to HERA Campaign 6, our project team (led by UC Davis graduate student Katie Homer) worked closely with HERA personnel to install and test our research equipment hardware and software, and then train each 4-person crew as they prepared for their 45-day mission. As tribute to the professionalism and effectiveness of the HERA engineers, our research has been very successfully deployed without a single visit to NASA Johnson Space Center (JSC) by the research team. <p>Results:</p> <p>We are currently quantifying two primary measures of subject performance – efficiency and accuracy, comparing standard vs. enhanced procedures for the complex repair task being administered in the experiment. As of March 2023, we have completed all four Missions of HERA Campaign 6.</p> <p>Subject efficiency during system-repair procedure execution is assessed by logging the time spent during each step of the procedure. A significant learning effect is evident in the difference between the timescales of the first and final run-throughs. Also evident is a slight effect of improved execution time for the enhanced procedures compared to the standard procedures.</p> <p>Aggregating the data from the HERA Campaign 6 Missions 1 and 2 crewmembers, we find that in general, enhanced</p>

	<p>procedures seem to result in a slight efficiency advantage over traditional procedure presentation. However, since enhanced procedures present so much additional information to the subject, we may anticipate that time savings may be minimal – what we are really looking for is enhanced accuracy with enhanced procedures, and that analysis is just starting.</p> <p>Although overall conclusions cannot yet be drawn, it can be observed that subjects do not always perform more efficiently with the enhanced procedures. But for safety-critical tasks in space, accuracy is often a higher priority than efficiency – “do it once, do it right” is a common refrain in the astronaut world. For the HERA data, subject accuracy as they perform the complex repair task will be assessed via manual analysis of videos collected during each subject’s repair activities.</p> <p>These data (with a limited N of subjects) suggest that both levels of procedure enhancement increase operational accuracy by significantly reducing the number of errors made during execution of the complex procedure.</p>
Bibliography Type:	Description: (Last Updated: 04/23/2025)
Abstracts for Journals and Proceedings	<p>Robinson S et al. "2023 Update for the Virtual NASA Specialized Center of Research (VNSCOR) – “Human Capabilities Assessments For Autonomous Missions (HCAAM)”." 2023 NASA Human Research Program Investigators’ Workshop, “To the Moon: The Next Golden Age of Human Spaceflight”, Galveston, TX, February 7-9, 2023.</p> <p>Abstracts. 2023 NASA Human Research Program Investigators’ Workshop, “To the Moon: The Next Golden Age of Human Spaceflight”, Galveston, TX, February 7-9, 2023. , Feb-2023</p>