Fiscal Year:	FY 2022	**Task Last Updated:**	FY 05/18/2022
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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Zip Code:	95616-5270	**Congressional District:**	3
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:**	04/14/2023
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
Contact Monitor:	Whitmire, Alexandra	**Contact Phone:**	
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Flight Program:			
Flight Assignment:	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:	This task is part of the Human Capabilities Assessments for Autonomous Missions (HCAAM) Virtual NASA Specialized Center of Research (VNSCOR). 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.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	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. 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.
Task Progress:	Introduction: Astronaut crews on deep-space missions will not have real-time support from ground experts, so they must have access to procedures (especially for critical operations and malfunction recovery) that are enhanced beyond the traditional text-on-page, to reduce procedure deviations or execution errors. To address this important issue, University of California Davis (UC Davis) and NASA Ames Research Center have teamed up to form a unique and creative research collaboration. The Human Capabilities Assessments for Autonomous Missions (HCAAM) / Multimodal Electronic Procedures project is a collaboration between researchers in the Human/Robotics/Vehicle Integration and Performance (HRVIP) Lab at UC Davis and in the Human Systems Integration Division at NASA Ames Research Center. Astronauts currently complete tasks with PDF procedures and often with assistance from personnel at a Mission Control Center (MCC). Because of the increased distance from Earth in future long-duration exploration missions (LDEMs), there will be significant delays in communication. This leads to a need for increased autonomy which can be achieved by storing more information on board in such a way that it may be accessed by crewmembers in a timely and context-appropriate manner during routine and emergency procedures. Our aim is to use emerging technologies including the “Internet of Things” (IoT) and multimodal interactions such as augmented reality (AR) visual displays to generate interactive instructions that provide real-time feedback to astronauts when completing complex manual repair tasks. Project Objectives: We are experimentally testing the hypothesis that adding sensors to spacecraft systems to report procedure and system status to the astronaut will improve execution accuracy, and therefore enhance the safety of the long-duration crew. We eventually intend to enhance procedures by communicating information to the astronaut via sensory channels in addition to traditional reading of text; examples are visually enhanced procedures and augmented reality visual overlays. Progress as of April 2022: We are 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. So far, we have received and conducted preliminary efficiency analyses of the data from the first two crews of the NASA Human Exploration Research Analog (HERA) Campaign 6. Aggregating the data from HERA Campaign 6 Missions 1 and 2 crewmembers, we find that, in general, enhanced 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. 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 in performing the complex repair task will be assessed via manual analysis of videos collected during each subject’s repair activities.

Bibliography Type:	Description: (Last Updated: 01/29/2024)