Fiscal Year:	FY 2023	**Task Last Updated:**	FY 02/14/2023
PI Name:	Fanchiang, Christine Ph.D.		
Project Title:	HCAAM VNSCOR: Using a Human Capabilities Framework to Quantify Crew Task Performance in Human-Robotic Systems		
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		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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City:	Centennial	**State:**	CO
Zip Code:	80122-1801	**Congressional District:**	6
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:**	04/14/2024
No. of Post Docs:	0	**No. of PhD Degrees:**	
No. of PhD Candidates:	2	**No. of Master' Degrees:**	1
No. of Master's Candidates:	1	**No. of Bachelor's Degrees:**	
No. of Bachelor's Candidates:		**Monitoring Center:**	NASA JSC
Contact Monitor:	Whitmire, Alexandra	**Contact Phone:**	
Contact Email:	alexandra.m.whitmire@nasa.gov		
Flight Program:			
Flight Assignment:	NOTE: End date changed to 4/14/2024 per A. Beitman/JSC (Ed., 2/20/23) NOTE: Start date changed to 4/15/2019 per NSSC information (Ed., 5/18/21) NOTE: End date changed to 4/14/2023 per NSSC information (Ed., 1/22/2020)		
Key Personnel Changes/Previous PI:	March 2020 report: Change to PhD graduate student for upcoming semester. August 2021 report: Added a MS graduate student (Kaitlyn Hauber) for the 2021-2022 academic year to help deploy subject testing July 2021 report: Added a Postdoc Dr. Katya Arquilla (volunteer) to help with data analysis May 2022 report: Removed a MS student (Kaitlyn Hauber) because she graduated July 2022 report: Postdoc upgraded to Professor (Dr. Katya Arquilla) at MIT Sept 2022 report: Added a PhD student (Amelia Gagnon) at MIT to help with HERA fNIRS data analysis because of her background in brain biosignals (EEG)		
COI Name (Institution):	Klaus, David Ph.D. (University of Colorado, Boulder) Shelhamer, Mark Sc.D. (Johns Hopkins University)		
Grant/Contract No.:	80NSSC19K0655		

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). Effective space exploration will require proper task coordination between humans and robotic systems. These systems can be characterized in a variety of ways, from level of autonomy to the number of functions provided. At the most basic level a robotic system can be considered a hand tool while something more complex could be a humanoid companion. To ensure the robotic system is effective, the crew must trust that the system performs its intended function(s), or retain enough Situation Awareness (SA) and capability to find another way to execute the required task. Currently, there are no comprehensive standards for measuring, monitoring, and evaluating task performance with regard to crewmember capabilities, the design of the task, and the dynamic spacecraft environment. This work seeks to address this missing performance infrastructure by providing a conceptual framework for measuring task design quality and developing a path for validation using a task performance metric through experimentation both in university labs and using NASA's analog missions.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Leveraging wearable technologies for monitoring human health and performance is beneficial for a range of people here on Earth whether it is for elite athletes to rehabilitation patients in the hospital. Currently, there are limitations to the use and integration of data from various wearable sensors. The work done for this project will help to provide some guidance regarding wearable data integration and effectiveness of the data for predicting performance degradation. The ability to predict changes in performance can be useful for a number of scenarios here on Earth.
Task Progress:	Based on our findings from Block 1 data analysis we were confident that the wearable sensor suite would yield interesting results even with a more demanding experimental design. Therefore, the focus for this grant year was to develop an ambitious testing regime for our Block 2 testing that provided a more comprehensive and pseudo-random counterbalanced trials that would provide more extensive coverage of the task types that we had initially envisioned for Block 1. For the physical load, we retained the same biking set-up but chose a more challenging n-back task for the cognitive load. Additionally, from the lessons learned from Block 1, we decided to employ a pseudorandom counter-balancing experimental design. Since it would be difficult to achieve full counter balancing with 16 different task types, we focused on developing a protocol that allowed us to isolate the physical levels per test session, where each test session was to be done at only one level of physical load throughout. Therefore, each subject would come in for four different test sessions for the four different physical loads. Each test session had a different sequence of cognitive loads. For this grant year, we were able to run 8 subjects under this Block 2 testing regime. While the data collection is still underway and will continue through the spring of 2023, preliminary analysis indicates some utility in using a random forest classifier for identifying the 16 task types. Additionally, the previous year we had begun a variety of engineering tests with the Biosignalsplux fNIRS systems to compare the expected results regarding different cognitive tests. A protocol for investigating the quality of the fNIRS sensor from Biosignalsplux was developed. The study was designed to determine if we can discern differences in data quality collected during cognitive activity between two functional near-infrared spectroscopy (fNIRS) systems: the NIRx NIRSport2 and the biosignalsplux fNIRS Pioneer. The NIRx NIRSport2 is a widely used but invasive and operationally infeasible sensor package while the biosignalsplux Pioneer is non-invasive and operationally feasible but has a limited presence in research studies. This protocol was submitted and approved by the Institutional Review Board (IRB) with potential data collection to start in the spring and summer of 2023. And lastly, initial analysis from the first three missions of the HERA Campaign #6 has begun and indicated that the fNIRS measures collected over a 20-minute task may provide a different perspective of task performance than our in-lab five-minute cognitive tasks, in that there may be indicators of mental fatigue present. Additionally, the fNIRS data from HERA indicates that it can clearly identify when the subject is switching from one cognitive task to the next. More thorough analysis will be done as the final Human Exploration Research Analog (HERA) mission concludes.
Bibliography Type:	Description: (Last Updated: 05/05/2023)
Abstracts for Journals and Proceedings	Arquilla K, Zero M, Hauber K, Klaus D, Shelhamer M, Fanchiang C. "Detection of task type through unobtrusive physiological monitoring." International Conference on Environmental Systems, St. Paul, Minnesota, July 10-14, 2022. Abstracts. International Conference on Environmental Systems, St. Paul, Minnesota, July 10-14, 2022. , Jul-2022
Abstracts for Journals and Proceedings	Zero M, D. Klaus M, Arquilla K, Shelhamer M, Fanchiang C. "Assessing crewmember operational state and task performance effectiveness to guide space habitat design and mission operations." International Conference on Environmental Systems, St. Paul, Minnesota, July 10-14, 2022. Poster. International Conference on Environmental Systems, St. Paul, Minnesota, July 10-14, 2022. , Jul-2022
Abstracts for Journals and Proceedings	Zero M, Klaus DM, Arquilla K, Shelhamer M, Fanchiang c. "Development of a task-design framework for quantifying crew performance." Human Factors and Ergonomics Society Conference, Atlanta, Georgia, October 10-14, 2022. Conference Proceedings. Human Factors and Ergonomics Society Conference, Atlanta, Georgia, October 10-14, 2022. , Oct-2022
Abstracts for Journals and Proceedings	Fanchiang C, Klaus DM, Zero M, Arquilla K, Gagnon A, Shelhamer M. "Using a human capabilities framework to quantify crew task performance in human-robotic systems – Year 4." NASA Human Research Program Investigators' Workshop. Galveston, Texas, February 6-9, 2023. Abstracts. NASA Human Research Program Investigators' Workshop. Galveston, Texas February 6-9, 2023. , Feb-2023

Abstracts for Journals and Proceedings	Zero M, Klaus DM, Arquilla K, Gagnon A, Shelhamer M, Fanchiang C. "Monitoring cognitive and physical workload changes alongside task performance using a suite of non-invasive wearable sensors." NASA Human Research Program Investigators' Workshop, Galveston, Texas, February 6-9, 2023. Abstracts. NASA Human Research Program Investigators' Workshop, Galveston, Texas, February 6-9, 2023. , Feb-2023
Abstracts for Journals and Proceedings	Gagnon A, Klaus DM, Zero M, Arquilla K, Shelhamer M, Fanchiang C. "Monitoring cognitive workload and performance impacts through functional near-infrared spectroscopy (fNIRS) in a human spaceflight analog mission." NASA Human Research Program Investigators' Workshop, Galveston, Texas, February 6-9, 2023. Abstracts. NASA Human Research Program Investigators' Workshop, Galveston, Texas, February 6-9, 2023. , Feb-2023