Fiscal Year:	FY 2021	**Task Last Updated:**	FY 08/04/2021
PI Name:	Duda, Kevin R Ph.D.		
Project Title:	Real-Time Estimation of the Effects of a Simulated Long-Duration Exploration Mission on Flight Performance, Workload, and Situation Awareness		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Behavior and performance		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H)		
Human Research Program Risks:	(1) **BMed**:Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders (2) **Sleep**:Risk of Performance Decrements and Adverse Health Outcomes Resulting from Sleep Loss, Circadian Desynchronization, and Work Overload		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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City:	Cambridge	**State:**	MA
Zip Code:	02139-3539	**Congressional District:**	7
Comments:			
Project Type:	Ground	**Solicitation / Funding Source:**	2015-16 HERO NNJ15ZSA001N-ILSRA. Appendix F: International Life Sciences Research Announcement
Start Date:	07/19/2016	**End Date:**	01/31/2021
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:	1	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	1	**Monitoring Center:**	NASA JSC
Contact Monitor:	Gore, Brian	**Contact Phone:**	650.604.2542
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Flight Program:			
Flight Assignment:	NOTE: End date changed to 1/31/2021 per NSSC information (Ed., 7/10/2020) NOTE: End date changed to 4/30/2020 per NSSC information (Ed., 1/29/2020) NOTE: Extended to 1/18/2020; in addition, start date should be 7/19/2016, per K. Ohnesorge/JSC HRP (Ed., 5/24/18) NOTE: Change in period of performance to 7/01/2016-12/31/2018 (previously 7/22/16-10/21/18 and then 7/19/2016-10/18/2018), per NSSC information (Ed., 12/15/17) NOTE: Change in period of performance to 7/19/2016-10/18/2018 (previously 7/22/16-10/21/18), per K. Ohnesorge and D. Risin/JSC (Ed., 3/29/17) NOTE: Element change to Human Factors & Behavioral Performance; previously Behavioral Health & Performance (Ed., 1/18/17)		

Key Personnel Changes/Previous PI:	June 2021: Program Manager J. West left Draper and no longer has a role with the project. April 2017: Original CoInvestigator D. Handley left Draper Laboratory for a position with another company and no longer has a role with the project.
COI Name (Institution):	Stankovic, Aleksandra Ph.D. (Charles Stark Draper Laboratory)
Grant/Contract No.:	NNX16AO29G
Performance Goal No.:	
Performance Goal Text:	
Task Description:	Human spaceflight often requires long-term isolation of crewmembers in extreme environments. These environments introduce stressors to both crewmember physiology and psychology. Specific human-factors stressors include long-duration isolation, sleep loss, circadian desynchronization, and high workload. These stressors present a real risk of performance decrement during a spaceflight mission. Research done in spaceflight analogs such as the NASA Human Exploration Research Analog (HERA) provide a unique opportunity to study these effects and develop essential metrics to identify and prevent performance decrements in an operationally-relevant setting. In the field of human spaceflight, real-time performance metrics, and quantification of performance during operationally-relevant tasks and scenarios has the potential for making existing operations safer and more efficient, as well as for improving the design of future vehicles. The identification of critical performance decrements, either in measures of task performance, workload, or situational awareness, may be used to alter the human-automation task allocation or suggest changes to crew resource management. These metrics have been previously developed for the following operationally relevant tasks: • Piloted lunar landing using a generic lunar lander design. • Manual control of SAFER (simplified aid for EVA rescue) during an inspection of a solar panel by an EVA (extravehicular activity) crewmember. • Manual control of SAFER during a simulated self-rescue flight back to the International Space Station (ISS). • Manual control of the MPCV/Orion vehicle during docking with the ISS. Future missions may be operating with delayed communication, or in extreme cases, without communication to Earth for ground-based support. In addition, all of the environmental parameters likely will not be known in advance (e.g., asteroid spin rate). A simulation capability that can be used to assess operational performance can be used to inform temporal function allocation (e.g., performance benefit/cost of human performing all the tasks vs. auto to start and then allow human to takeover at the end). This can help to inform mission design and crew resource management as a function of mission duration, sleep state, circadian synchronization, and workload. Real-time performance metrics are a valuable tool for quickly identifying performance decrements, and for determining the performance impact of delayed or sparse communication. We integrated the Draper-developed configurable and portable simulation platform within the HERA facility for use during the Campaign 4 and Campaign 5 simulated long-duration space exploration missions. This platform can simulate multiple operationally-relevant scenarios—a generic piloted lunar landing task, ISS EVA SAFER inspection of a solar array, ISS EVA self-rescue, and MPCV/Orion docking with the ISS. During Campaigns 4 and 5, the simulation platform was used to characterize piloting metrics including flight performance, workload, and situation awareness during a simulated piloted lunar landing and ISS EVA SAFER solar array inspection tasks. The results from these two Campaigns were correlated with mission timeline events and the NASA Behavioral Health and Performance (BHP) Standard Measures.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The integration of flight performance, workload, and situation awareness metrics in a real-time estimation algorithm and combining those metrics with several operationally relevant spaceflight piloting scenarios is impactful for spaceflight operations and has many Earth-based benefits. A novel aspect of this project is real-time situation awareness estimation, which does not require simulation freezes/pauses or post-simulation questionnaires. This method could be applied to any land, sea, or space-based systems where there is a need to continually assess operator performance, workload, and situation awareness over time, and use those metrics to alert them to deviations. We continue to work closely with the NASA Behavioral Health and Performance community to ensure that these metrics are relevant to the cohort of Standard Measures that are part of their ongoing and planned future studies.
Task Progress:	Year 4 (our final year) of our project was primarily comprised of tasks related data analysis from Campaign 4 and Campaign 5. In addition to the development and crew training efforts, extensive testing on the robustness has continued to be conducted to ensure simulation stability and the data was properly and reliably logged. We have also developed a set of data analysis routines to support in the verification of the automatic speech recognition (ASR) algorithm. The Draper- and University of California (UC) Davis-developed configurable and portable simulation platform was integrated with the HERA facility for the Campaign 4 and Campaign 5, 45-day, simulated long-duration space exploration missions (LDEMs). Lunar lander simulation flight performance data was collected every two days for the duration of each mission, for each of the four crewmembers, over the entirety of Campaign 4 Missions 1, 3, 4, 5, 20 days in Mission 2 (mission terminated early due to Hurricane Harvey), and the entirety of Campaign 5 Missions 1, 2, 3, and 4. Lunar lander metrics jointly developed by Draper and UC Davis, were assessed as a function of mission time in HERA, the presence of a Landing Point Redesignation (LPR), the landing site Map orientation, and crew sleep duration derived from actigraphy data collected during Campaign 4. Analysis of trials that include the presence of a LPR show an impact on most performance metrics consistent with past results. Assessment of performance and workload over time indicate crew improvement over mission time. The observed flight performance in Campaign 4 was assessed with crew sleep duration. With data pooled by mission, results indicate greater variation in Average Pitch RMSE (root mean square error) for all subjects on days following reduced sleep (5 hours or less) than on days following unrestricted sleep, indicating performance was more consistent after unrestricted sleep. Additionally, we worked with the University of Pennsylvania – who also has a copy of the Draper Real-Time

	Performance Metrics (RTPM) workstation -- to support the data collection activities as part of the Chronobiology Laboratory. Lastly, Draper has invested internally in making the RTPM a laptop version that was deployed and operated in remote locations such as NASA Extreme Environment Mission Operations (NEEMO) 23 mission.
Bibliography Type:	Description: (Last Updated: 09/04/2023)
Abstracts for Journals and Proceedings	Duda KR, Stankovic A, York SP, Robinson SK, West JJ. "Real-Time Estimation of the Effects of a Simulated Long-Duration Exploration Mission on Flight Performance, Workload, and Situation Awareness." Presentation at 2020 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 27-30, 2020. Abstracts. 2020 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 27-30, 2020. , Jan-2020
Abstracts for Journals and Proceedings	Pryputniewicz AS, Holder SA, Stankovic A, York SP, Robinson SK, Duda KR, West JJ. "Real-Time Estimation of the Effects of a Simulated Long-Duration Exploration Mission on Flight Performance, Workload, and Situation Awareness." Presentation at 2021 NASA Human Research Program Investigators' Workshop, Virtual, February 1-4, 2021. Abstracts. 2021 NASA Human Research Program Investigators' Workshop, Virtual, February 1-4, 2021. , Feb-2021
Articles in Other Journals or Periodicals	Stankovic AS, Pryputniewicz AS, Holder SA, York SP, Handley PM, Karasinski, JA, Robinson SK, West JJ, Duda KR. "An assessment of operationally-relevant human performance measures using an unobtrusive, real-time simulation platform in simulated long-duration space exploration missions." Submitted to the Human Factors Special Issue: Human Factors and Ergonomics in Space Exploration, April 2021. , Apr-2021
Articles in Peer-reviewed Journals	Stankovic AS, Pryputniewicz A, Holder S, York SP, Handley PM, Karasinski JA, Robinson SK, West JJ, Duda KR. "Longitudinal impacts of simulated long-duration spaceflight missions on operationally relevant measures of human performance using a portable simulation platform." Hum Factors. 2023 Sep;65(6):1130-41. https://doi.org/10.1177/00187208221113629 ; PMID: 35927966 , Sep-2023