Fiscal Year:	FY 2015	**Task Last Updated:**	FY 07/16/2015
PI Name:	Duda, Kevin R Ph.D.		
Project Title:	Metrics and Methods for Real-Time Task Performance Assessment		
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline--Element/Subdiscipline:	NSBRI--Human Factors and Performance Team		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **SHFH**:Space Human Factors & Habitability (archival in 2017)		
Human Research Program Risks:	(1) **HARI**:Risk of Inadequate Design of Human and Automation/Robotic Integration		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	02139-3539	**Congressional District:**	7
Comments:			
Project Type:	GROUND	**Solicitation:**	2012 Crew Health NNJ12ZSA002N
Start Date:	07/01/2013	**End Date:**	09/30/2016
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	0	**No. of Master' Degrees:**	1
No. of Master's Candidates:	1	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	1	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:	NOTE: End date changed to 9/30/2016 per NSBRI (Ed., 4/5/16)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Robinson, Stephen (University of California, Davis)		
Grant/Contract No.:	NCC 9-58-HFP03401		
Performance Goal No.:			
Performance Goal Text:			
	1. Original Project Aims/Objective: The project objective is to produce a configurable and portable simulation capability for developing and validating real-time metrics for assessing flight performance, workload, and situational awareness. There are three integrated specific aims: (1) Define the system architecture for integrating vehicle and environmental models with the simulation environment. (2) Perform a critical analysis of four piloted tasks: MPCV/Orion docking, MPCV/Orion entry, Lunar Landing, and EVA SAFER self-rescue. Simulator data will be analyzed to identify candidate metrics for performance, workload, and situational awareness as well as operationally relevant options for presenting feedback to the operator. (3) Conduct a series of experiments using the simulated spaceflight tasks and real-time metrics engine to baseline performance, workload, and situational awareness in each task in order to develop algorithms and methods for alerting the operator to deviations from nominal. 2. Key Findings: In project year 2, we furthered the development of the simulation capability through integration of		

Task Description:	additional vehicle models, and testing the calculation of pilot flight performance, workload, and situation awareness metrics in real-time, without adding additional hardware to the simulator or requiring interrupts to the flight task. The baseline piloted lunar landing simulation was modified to include real-time estimation and plotting of flight performance (entropy of the hand controller inputs, root mean square error of the difference between the actual and guidance recommended pitch attitude), response time to the two-choice secondary task for workload estimation, and an estimate of situation awareness via the accuracy of required key system state callouts through an automatic speech recognition engine. These metrics were calculated in real-time throughout the trial, and are displayed through an engineering-level view. A human subject experiment (n = 26) was conducted using the lunar landing simulation in an effort to validate the performance of the automatic speech recognition (ASR) engine, as well as to collect data to develop unobtrusive workload estimation metrics that do not require a two-choice secondary task. The ASR analysis found that the system performed well (the ASR algorithm correctly recognized 838 of the 1035 valid callouts, for a precision of 0.81), and also identified several areas for further development to improve performance. We also developed a new real-time statistical approach to estimating flight performance by computing the percentage of pitch axis error in relation to pre-set bounds (comparison of actual vs. guidance recommended). The real-time performance metrics (flight, workload, and situation awareness) infrastructure was integrated with an extravehicular activity (EVA) simplified aid for EVA rescue (SAFER) jetpack International Space Station (ISS) self-rescue simulation in our portable ground station for future experimentation. The baseline Orion/MPCV piloted simulation for docking with the ISS was also implemented and tested in the portable ground station. It is these simulations and the data that we collect from the experiment that will enable the development of robust metrics that can be presented to the pilot for making operations more safe and efficient. 3. Impact of Key Findings on hypotheses, technology requirements, objectives and specific aims of the original proposal: The development of the integrated simulation platform for running the vehicle models, recording/logging data, unobtrusively estimating workload and situation awareness, and providing visualizations and feedback to the pilot has significantly enhanced the capabilities for developing real-time performance metrics. By using typical spacecraft command and control tasks, such as piloted lunar landing, SAFER self-rescue, and Orion/MPCV docking, we have several operational scenarios to test our metrics. The Human Research Program (HRP) Integrated Research Plan gap (SHFE-TASK-01) states, in part, that, …The successful management or evaluation of workload must include a consideration of the nature of individual tasks that operators must perform, the combinations of tasks that are performed during a work period, priorities among tasks, and individual differences among operators. The development and evaluation of real-time performance metrics in representative operational settings—which include task performance, workload, and situational awareness, and are measured objectively as well as subjectively—will provide valuable data for the validity assessment. 4. Proposed research plan for the coming year: In project year 3, we aim to conclude the analysis of the piloted lunar landing study. This analysis will produce a quantitative assessment of the ASR engine performance as a real-time situation awareness metric, as well as an unobtrusive workload estimation metric based on flight performance analysis (compared against the two-choice secondary task a as the gold standard). The presentation of the results to affect flight and mission performance will be prototyped in the simulator in a manner that seamlessly integrated with the existing displays. In collaboration with our team members at the University of California (UC) – Davis and the NASA Johnson Space Center (JSC) Virtual Reality Laboratory, we aim to conduct an experiment using the SAFER self-rescue simulation to develop and test our metrics engine, and to compare its robustness to novel scenarios through data collected during JSC VR Lab simulations. We will also complete the development of the Orion/MPCV docking simulation for human subject testing that is planned for later in project year 3. Lastly, we will deliver and install a copy of our simulation station at National Space Biomedical Research Institute (NSBRI) Headquarters to provide a foundational capability for subsequent test and evaluation with operators and subject matter experts.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	This project aims to deliver a research capability for evaluating the applicability and robustness of metrics for quantifying operator performance in real-time. Although our case studies are specific to piloted spacecraft, the innovations and implementation approach are generally applicable to any vehicle that requires a human in the loop. This re-configurable, portable simulation and test station provides a capability for integrating and testing real-time performance metrics for assessing operator effectiveness continually throughout a trial, as opposed to a single mission effectiveness metric. In addition, temporal operator performance can then be assessed against system-level metrics such as fuel consumption vs. time. Regardless of the domain, the interaction between vehicle/operation performance, operator workload, and operator situation awareness is complicated. Prior approaches to quantify these metrics have relied on post-hoc analyses or measurement approaches that affect the parameter of interest. This project aims to reduce to practice in-situ real-time performance, workload, and situation awareness metrics that can be objectively and unobtrusively collected. We are doing this through a flexible and module architecture that allows researchers to develop their own modules (either vehicle/system models or metrics modules) that can be integrated with our simulation framework. Through rigorous testing and integration with operationally relevant tasks and scenarios, our goal is that this platform be adopted by the human-system integration and research community as the gold standard in crew performance benchmarking through open-source integration of algorithms for metrics development and validation.
Task Progress:	In project year 2, we furthered the development of the simulation capability through integration of additional vehicle models, and testing the calculation of pilot flight performance, workload, and situation awareness metrics in real-time, without adding additional hardware to the simulator or requiring interrupts to the flight task. The baseline piloted lunar landing simulation was modified to include real-time estimation and plotting of flight performance (entropy of the hand controller inputs, root mean square error of the difference between the actual and guidance recommended pitch attitude), response time to the two-choice secondary task for workload estimation, and an estimate of situation awareness via the accuracy of required key system state callouts through an automatic speech recognition engine. These metrics were calculated in real-time throughout the trial, and are displayed through an engineering-level view. A human subject experiment (n = 26) was conducted at UC Davis using the lunar landing simulation in an effort to validate the performance of the automatic speech recognition (ASR) engine, as well as to collect data to develop unobtrusive workload estimation metrics that do not require a two-choice secondary task. The ASR analysis found that the system performed well (the ASR algorithm correctly recognized 838 of the 1035 valid callouts, for a precision of 0.81), and also identified several areas for further development to improve performance. We also developed a new real-time statistical

	approach to estimating flight performance by computing the percentage of pitch axis error in relation to pre-set bounds (comparison of actual vs. guidance recommended). The real-time performance metrics (flight, workload, and situation awareness) infrastructure was integrated with an extravehicular activity (EVA) simplified aid for EVA rescue (SAFER) jetpack International Space Station (ISS) self-rescue simulation in our portable ground station for future experimentation. The baseline Orion/MPCV piloted simulation for docking with the ISS was also implemented and tested in the portable ground station. It is these simulations and the data that we collect from the experiment that will enable the development of robust metrics that can be presented to the pilot for making operations more safe and efficient. A copy of the portable ground control station was assembled. In year 3, we aim to complete the integration and test of the components, transfer the software to the new system, and develop the operational procedures in advance of delivering it to NSBRI Headquarters.
Bibliography Type:	Description: (Last Updated: 04/05/2019)
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Awards	Duda KR. "Chair of the AIAA Life Sciences & Systems Technical Committee, May 2015." May-2015
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Dissertations and Theses	Handley PM. "A Pilot Model for the NASA Simplified Aid for EVA Rescue (SAFER) (Single-Axis Pitch Task)." M.S. Thesis, University of California Davis, June 2014. , Jun-2014
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