Fiscal Year:	FY 2016	**Task Last Updated:**	FY 01/26/2017
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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Organization Name:	The Charles Stark Draper Laboratory, Inc.		
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City:	Cambridge	**State:**	MA
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:	2	**No. of Master' Degrees:**	1
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**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 (extravehicular activity) 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 3, our final project year, we completed the development of the simulation capability by		

Task Description:

integrating the piloted lunar lander, EVA SAFER return to the International Space Station (ISS), EVA SAFER ISS solar array inspection, and MPCV/Orion docking with the ISS vehicle models. The simulation software, along with an operations manual, was made freely available to those who agree to the Draper software licensing agreement. A copy of the Draper simulation station was delivered to NSBRI (National Space Biomedical Research Institute), and is fully capable of executing all the experimentation and demonstration use cases that were developed. In this final project year, an automated flight instructor was designed by our collaborators at University of California (UC) Davis to investigate the effects of three variations of an instructor-model performance-feedback strategy on human performance in a novel SAFER inspection task. Thirty subjects flew SAFER to perform an inspection of the ISS solar arrays. Subjects were initially placed 40 ft away from the array, and were asked to close to 30 ft and hold this distance while inspecting 4 damage" points using a guidance display for navigation to the waypoints. In order of priority, the task included: 1) maintaining the 30 ft distance, 2) minimizing their roll angle to a relative angle of 0 degrees, and 3) navigating the waypoints as quickly and accurately possible. Subjects were also asked to respond to a secondary task in the form of a comm light" as a proxy for workload. Finally, the subjects also made verbal callouts about their fuel level every 5% as a measure of situational awareness.

Subjects were placed into one of three groups. Group 1 acted as a control group, and had an analog distance error display that read from -10 to 10 ft, and digital displays with one significant figure. Group 2 had an analog distance error display that read from -5 to 5 ft, and digital display with two significant figures. Group 3 had the same analog and digital distance error displays as Group 1, and experienced real-time feedback in the form of displays that changed color. Results suggest Groups 2 and 3 both perform better than the control group on the primary and secondary flight tasks. The data also suggests that the real-time performance feedback immediately provided a performance improving effect, even with novice operators. While both Groups 2 and 3 showed performance improvements over the control group, Group 2's workload was increased, as was their time to complete the task.

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 vehicle models, 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. In project year 3, through conducting the experiment investigating the effects of an instructor-model performance-feedback strategy on human performance in a novel Simplified Aid for EVA Rescue (SAFER) inspection task revealed many interesting aspects. Not surprisingly, providing real-time performance feedback immediately provided a performance improving effect, even with novice operators. However, as the sensitivity of the feedback was increased (i.e., tighter performance criteria), the time to complete the task increased as well as the reported operator workload. The significance of this is that there is likely an optimum set of feedback sensitivity parameters that balance the operators task completion performance with their workload. The installation of a copy of our simulation station at NSBRI Headquarters is a valuable tool for collaborative use by researchers. Our team's continual pursuit of scientific investigation into the dynamic interaction between a pilot and their spacecraft led to a workshop on Piloted Spacecraft Guidance & Control Systems and Human Performance.

4. Proposed research plan for the coming year: This was the final year of the project. There is no proposed research plan for the coming year.

Rationale for HRP Directed Research:

Research Impact/Earth Benefits:

This project delivered 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.

In project year 3, our final project year, we completed the development of the simulation capability by integrating the piloted lunar lander, EVA SAFER return to ISS, EVA SAFER ISS solar array inspection, and MPCV/Orion docking with the ISS vehicle models. The simulation software, along with an operations manual, was made freely available to those who agree to the Draper software licensing agreement.
In this final project year, an automated flight instructor was designed by our collaborators at UC Davis to investigate the effects of three variations of an instructor-model performance-feedback strategy on human performance in a novel SAFER inspection task. Thirty subjects flew SAFER to perform an inspection of the ISS solar arrays. Subjects were tasked with: 1) maintaining the 30 ft distance, 2) minimizing their roll angle to a relative angle of 0 degrees, and 3) navigating the waypoints as quickly and accurately possible. Subjects were also asked to respond to a secondary task as a proxy for workload, and made verbal fuel percentage callouts as a measure of situational awareness. Group 1 had an analog distance error display that read from -10 to 10 ft, and digital displays with one significant figure. Group 2 had an analog distance error display that read from -5 to 5 ft, and digital display with two significant figures.

Task Progress:	Results suggest Groups 2 and 3 both perform better than Group 1 on the primary and secondary flight tasks. The data also suggests that the real-time performance feedback immediately provided a performance improving effect, even with novice operators. While both Groups 2 and 3 showed performance improvements over Group 1, Group 2's workload was increased, as was their time to complete the task. The development of the integrated simulation platform for running vehicle models, 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 and addressing the HRP TASK-01 Gap. 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 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 installation of a copy of our simulation station at NSBRI Headquarters is a valuable tool for collaborative use by researchers. Our team's continual pursuit of scientific investigation into the dynamic interaction between a pilot and their spacecraft led to a workshop on Piloted Spacecraft Guidance & Control Systems and Human Performance.
Bibliography Type:	Description: (Last Updated: 04/05/2019)
Abstracts for Journals and Proceedings	Duda KR, Robinson SK, Prasov Z, York SP, Handley P, Karasinski J, Paddock E, West JJ. "Metrics and Methods for Real-Time Task Performance Assessment." 2016 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 8-11, 2016. 2016 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 8-11, 2016. , Feb-2016
Abstracts for Journals and Proceedings	Duda KR, Handley PM, "Metrics and Methods for Real-Time Task Performance Assessment," Invited presentation to the NSBRI External Advisory Council Meeting. Houston, TX, 13 April 2016. NSBRI External Advisory Council Meeting. Houston, TX, 13 April 2016. , Apr-2016
Articles in Peer-reviewed Journals	Johnson AW, Duda KR, Sheridan TB, Oman CM. "A closed-loop model of operator visual attention, situation awareness, and performance across automation mode transitions." Human Factors. 2017 Mar;59(2):229-41. Epub 2016 Sep 2. http://dx.doi.org/ ; PubMed PMID: 27591207 [Note: reported originally in Jan 2017 as 2016 Sep 2. (Epub ahead of print)] , Mar-2017
Awards	Duda KR. "Elected to Associate Fellow of the American Institute of Aeronautics and Astronautics (AIAA), November 2016." Nov-2016
Awards	Duda KR. "Elected to the Steering Committee for the International Conference on Environmental Systems (ICES), August 2016." Aug-2016
Awards	Duda KR. "Promoted to Group Lead, Human Systems Integration, at The Charles Stark Draper Laboratory, Inc., April 2016." Apr-2016
Awards	Duda KR. "Promoted to Principal Member of the Technical Staff at The Charles Stark Draper Laboratory, Inc., January 2016." Jan-2016
Awards	Robinson SK. "Elected to Chair of the Mechanical and Aerospace Engineering Department at University of California Davis, May 2016." May-2016
Papers from Meeting Proceedings	Karasinski JK, Robinson SK, Prasov Z, Duda KR. "Development of Real-Time Performance Metrics for Manually-Guided Spacecraft Operations." 2016 IEEE Aerospace Conference, Big Sky, MT, March 5-12, 2016. In: 2016 IEEE Aerospace Conference Proceedings, 2016. p. 1-9. http://dx.doi.org/ , Mar-2016