Fiscal Year:	FY 2013	**Task Last Updated:**	FY 01/31/2013
PI Name:	Sebok, Angelia M.S.		
Project Title:	S-PRINT: Development and Validation of a Tool to Predict, Evaluate, and Mitigate Excessive Workload Effects		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Space Human Factors Engineering		
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **SHFH**:Space Human Factors & Habitability (archival in 2017)		
Human Research Program Risks:	(1) **HSIA**:Risk of Adverse Outcomes Due to Inadequate Human Systems Integration Architecture (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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Zip Code:	80301-2560	**Congressional District:**	2
Comments:			
Project Type:	Ground	**Solicitation / Funding Source:**	2010 Crew Health NNJ10ZSA003N
Start Date:	04/01/2012	**End Date:**	03/31/2015
No. of Post Docs:		**No. of PhD Degrees:**	
No. of PhD Candidates:	1	**No. of Master' Degrees:**	
No. of Master's Candidates:		**No. of Bachelor's Degrees:**	
No. of Bachelor's Candidates:		**Monitoring Center:**	NASA ARC
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Flight Program:			
Flight Assignment:	NOTE: Risk/Gap changes per IRP Rev E (Ed., 1/24/14)		
Key Personnel Changes/Previous PI:	There are no key personnel changes to report in Year 1.		
COI Name (Institution):	Sargent, Robert (Alion Science And Technology Corporation) Wickens, Christopher (Self) Clegg, Benjamin (Colorado State University)		
Grant/Contract No.:	NNX12AE69G		
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Task Description:	This proposal describes a plan to research, develop, and validate a prototype human performance model-based tool for researchers, system designers, and mission planners to evaluate potential missions for their effects on astronaut fatigue, workload, and performance. The tool will enable analysts to identify, early in the design process, potential design, task allocation, or mission planning issues that could negatively impact astronaut performance. The proposed tool, S-PRINT, will leverage a human performance modeling environment, the Improved Performance Research Integration Tool (IMPRINT), and tailor it to space mission applications. IMPRINT was developed for the Army Research Laboratory, and is available, free of charge, to U.S. government agencies. IMPRINT includes algorithms to study performance shaping factors such as fatigue, training, and use of protective clothing with human performance models that include workload. SPACEPRINT will be based on an extensive literature review and meta-analysis, in which the team systematically evaluates human-in-the-loop research and lessons learned to identify and quantify factors in long-term space missions that affect astronaut workload, fatigue, and performance. The result of this meta-analysis will be used to update IMPRINT algorithms so they more accurately reflect space-specific conditions. The tool will be developed so it can be run in a predictive mode, to evaluate performance in missions that are being planned, and so it can run in a live mode, using real-time astronaut inputs on workload, fatigue, and wellness. The live mode will allow planners to identify potential problems as missions are being performed, and evaluate potential mitigation strategies. The team will identify scenarios of interest, perform task analyses with subject matter experts (SMEs), and develop models to reflect those situations. SMEs will review the models and their predictions an early validation study. The team will also perform an empirical, human-in-the-loop validation study. Results of the validations will be used to refine the models. Our scenario development and research efforts will focus specifically on situations that result in workload transitions (e.g., automation failures, other off-nominal events), placing the astronauts in potential overload situations. These conditions, when addressed by fatigued astronauts, constitute worst case scenarios and require specific, in-depth investigation. One particular goal of this project is to develop a prototype tool that is both usable and useful for analysts, allowing them to easily modify scenarios and evaluate the effects of different factors on mission performance. This tool will provide data entry screens that guide the user through the process of building a scenario. It will allow the researchers to specify numerous relevant factors, e.g., operators, tasks, equipment, environmental conditions, and sleep schedules. The output of the model run will include parameters of interest such as perceived workload, fatigue, time to initiate tasks, time to complete tasks, task accuracy, task failures (representing human error), results of task failures, and overall mission success.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The S-PRINT project includes research, modeling, and empirical investigations of human performance in unexpected workload transition situations. In particular, it examines performance under conditions in which operators are fatigued, and have previously experienced highly reliable automation. The tool will allow users (mission planners, automation system designers) to evaluate different conditions (of operator fatigue, or system design factors) that affect performance, to examine the impact of potential mitigation techniques. In developing models of operator workload and cognitive performance, we are conducting extensive meta-analyses investigating the effects on operator performance of the following factors: 1) fatigue and underload; 2) human automation interaction, including design factors that affect complacency; 3) overload and multitasking. These meta-analyses will be used to develop plug-ins to the underlying IMPRINT model. Because IMPRINT is a Department of Defense tool, the plug-ins developed for it can be used by Government entities to examine human performance in a variety of relevant conditions. Further, the empirical research will contribute to the state of knowledge in fields such as human-automation interaction and operator performance in complex operations.
	The overall objective of this research is to develop tools and empirically-based guidelines that support designers in mission planning. Specifically, the products from this research will help mission planners and monitors to (a) anticipate and avoid potential problems in astronaut workload and workload transitions by identifying the expected effects of automation system design and operator fatigue on performance, and (b) assure that systems can be designed in such a ways as to minimize transient or longer-term impacts on performance in space exploration missions. The proposed work contributes to the Program Requirements Document (PRD) by helping to mitigate both 1) risk of errors due to poor task design, and 2) risk of performance errors due to sleep loss, circadian desynchronization, fatigue, and work overload, especially in instances when high workloads are imposed by off-nominal events. The proposed work also directly addresses the Integrated Research Plan (IRP) Gap Usability, Workload, and Scheduling, UWS-1: How can workload measures and tools be developed to unobtrusively monitor and trend workload throughout the mission design and verification cycle in a consistent manner? To help NASA achieve these objectives, Alion Science and Technology, together with Dr. Christopher Wickens, Colorado State University, and Dr. Thomas Jones, proposed to develop and empirically validate the S-PRINT tool. S-PRINT is based on human-performance models, together with a usable interface, that allows system designers and mission planners to evaluate the effects of automation system design and fatigue on anticipated performance in automation failure scenarios. The following paragraphs identify the key project lines of work and summarize the progress to date or (where appropriate) briefly outline the plan for further research. Literature Review and Meta-Analyses During the literature review, we have identified factors likely to affect astronaut performance. Within this review, we have maintained focus on a few critical issues: task load (i.e., the number of tasks to be completed, the resources required, and the time pressure associated with those tasks), mental workload (the operator's perception of the burden associated with these tasks, and his/her residual capacity), the complexity of tasks, and the time available to complete tasks. Fatigue, due to sleep restriction, poor quality sleep, and circadian-rhythm desynchronization (potentially exacerbating fatigue effects) can also impact performance. In addition, emergency conditions that require operators to take control of automated systems and perform complex trouble-shooting tasks create substantial spikes in workload and are associated with slower responses and poorer operator decisions. This is especially true when operators assume that automation is reliable and do not maintain vigilance regarding system functioning (i.e., instances of operator complacency). Given the significant body of research

Task Progress:	(e.g., Harrison & Horne, 2000) indicating that operator performance (particularly attention and cognitive processing) degrades in fatigued conditions, it is highly likely that long-term fatigue and related physiological factors will also affect performance, especially when automation failures result in sudden workload spikes. Our particular interest in, and focus on, workload transitions (Huey & Wickens, 1993) is because this represents a “worst case” scenario. Astronauts are highly trained on routine tasks, as well as a wide variety of potential off-nominal conditions. However, the situation of fatigued operators and an unexpected event, such as an emergency or an automation failure, is one where operators are most likely to be vulnerable. In our literature review effort, we identified three primary areas of research: 1) fatigue and underload effects on performance; 2) human-automation interaction, including factors such as automation reliability and operator complacency; and 3) overload, multitasking, and operator strategies for performing tasks in these conditions. These three areas are being researched in parallel to provide a qualitative understanding of the issues (goal of the literature review), and to provide empirically-based data to inform human performance model development (goal of the meta-analyses). Progress: This task is currently ongoing, and expected to be completed at the end of Year 1. The S-PRINT research effort will continue for 2 additional years; if further relevant research is identified, we will update our analyses. However, the focus of the Year 2 and Year 3 research will shift to model and tool development, empirical data collection, and model validation. Model and Tool Development After the meta-analysis and literature review phase, we will develop a prototype version of the S PRINT performance assessment tool. This includes the data entry and interaction techniques, outputs, and the underlying human performance models. S-PRINT will rely on discrete event simulation, allowing users to model and evaluate novel situations to predict operator and system performance. This type of tool can be used to identify and redesign tasks to mitigate factors that are found to contribute to human error. Progress: This task is currently ongoing. The first step is to identify a scenario, and gather data to support model development. The scenario will include astronauts interacting with automation (potentially two different types of automation, one requiring active monitoring and controlling and one requiring intermittent monitoring) and an unexpected automation failure in one or both systems. Further, the effects of different fatigue-inducing conditions (e.g., sleep restriction, sleep deprivation, or poor quality sleep) will be modeled and evaluated. Empirical Data Collection and Validation Studies The validation studies we propose will be ground-based research performed at Colorado State University (CSU). A Year 2 study will provide data for model development, and the Year 3 study will be used for model validation. One critical issue is that the experiment is closely aligned with the model development effort, so both situations address performance in the same scenarios and using readily comparable measures. It is also necessary that the scenarios are relevant to NASA space operations. Possible scenarios include remote operation (robotic) tasks, or process control monitoring tasks, analogous to an astronaut’s task of monitoring spacecraft system status. Because a key focus of the research is in operator response to off-nominal events (i.e., situations causing sudden and unexpected workload transitions), particularly when the operators are fatigued, our experimental scenarios will include these aspects of performance. We will also evaluate operator interactions with automation, to examine the effects of fatigue on automation-induced complacency. Progress: This task is currently ongoing. We are planning the Year 2 experiment, with the intent of addressing gaps in the literature review and meta-analyses. Specifically, the intersection of the three areas of research investigated in the literature review – operator performance in the case of unexpected automation failures that result in high workload and require multitasking, with fatigued operators – is one requiring additional research.
Bibliography Type:	Description: (Last Updated: 09/07/2020)
Articles in Peer-reviewed Journals	Gutzwiller RS, Clegg BA, Blitch JG. "Part-task training in the context of automation: current and future directions." American Journal of Psychology. In press, February 2013. Expected publication November 2013. , Feb-2013