Fiscal Year:	FY 2012	**Task Last Updated:**	FY 07/03/2012
PI Name:	Sebok, Angelia M.S.		
Project Title:	Space Human Factors and Habitability MIDAS-FAST: Development and Validation of a Tool to Support Function Allocation		
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		
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:**	2008 Crew Health NNJ08ZSA002N
Start Date:	09/01/2009	**End Date:**	04/30/2013
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 JSC
Contact Monitor:	Wong, Douglas	**Contact Phone:**	
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Flight Program:			
Flight Assignment:	NOTE: Extended to 4/30/2013 per NSSC info (Ed., 1/8/2013) NOTE: End date changed to 12/31/2012 per NSSC information (Ed., 6/1/2012)		
Key Personnel Changes/Previous PI:	There are no PI or Co-I changes to report. One software developer specifically identified in the proposal, Shelly Scott-Nash, is now serving as an advisor instead of her originally-proposed role of software developer and MIDAS modeler. Mark Brehon and Dr. Marc Gacy will provide software development and MIDAS modeling expertise.		
COI Name (Institution):	Sarter, Nadine (University of Michigan) Gore, Brian (San Jose State University Research Foundation)		
Grant/Contract No.:	NNX09AM81G		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	This proposal describes a plan to develop and validate a computer-based tool to allow researchers to evaluate various function allocation strategies in space missions. The purpose of this tool is to enable researchers to evaluate novel human-automation systems early in the design process. The tool will leverage the Man-Machine Integration Design and Analysis System (MIDAS, developed for NASA Ames), and provide the MIDAS-FAST (Function Allocation Simulation Tool). In this project, the team will develop a research-based module of human-automation interaction. The team will develop human performance models of scenarios of interest. These models will be based on task analyses performed in cooperation with subject matter experts (SMEs). Various validation studies will be performed throughout this project. The team will validate the task analyses by talk-through sessions with SMEs. Human performance model and human-automation interaction module predictions will be validated in empirical, human-in-the-loop studies. Results of the validations will be used to refine the models. One particular focus of the project is on developing a prototype tool that is both usable and useful for researchers, allowing them to easily modify scenarios and evaluate different potential automation conditions. This tool will provide for 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, environmental conditions, and function allocation strategy. It will offer a visualization capability that provides a virtual video (or animation) of the scenario, showing operators interacting with equipment. The output of the model run will include, in addition to the video file, parameters of interest such as situation awareness, workload, time to initiate tasks, time to complete tasks, and task accuracy.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The research will provide (and empirically validate) a tool, MIDAS-FAST, to evaluate the effects of function allocation strategies and automation reliability on human performance in robotic tasks. While the tool is being developed specifically for space robotic tasks, we anticipate that the model predictions will also apply to Earth-based robotic tasks. MIDAS-FAST will allow analysts (e.g., researchers, system developers, and concept developers) to enter data regarding the proposed robotic system, allocation of tasks, and the potential for automation failures. The tool will use a variety of sub-models, called modules, to evaluate particular aspects of operator performance (e.g., focus of visual attention, situation awareness, disorientation and performance decrements due to control-response incompatibilities). The tool will then provide feedback on predicted operator performance (e.g., time to complete task; error such as reversals, collisions, rule violations), workload, situation awareness. This will help analysts evaluate and compare potential robotic systems in terms of their predicted effects on operator performance. Model predictions will be evaluated and refined with data collected during two human in the loop studies.
Task Progress:	The goals of the MIDAS-FAST effort are to develop and empirically validate a model- and simulation- based tool to predict operator performance when interacting with robotics automation in different function allocation situations. The tool will allow researchers and designers at NASA to compare different robotics system designs in terms of their predicted effects on operator and system performance. In Year 3 of the MIDAS-FAST effort, the operator models have been refined to address more detailed aspects of performance, tool development has progressed, product demonstrations and meetings were held with the project stakeholders at NASA Johnson Space Center (JSC) and Ames Research Center (ARC), the first empirical study was conducted, and validation plans have been refined. The operator performance model includes aspects such as visual scanning, building and maintaining awareness of key task parameters, and executing robotic tasks in the Basic Operational Robotics Instructional System (BORIS) simulation. In Year 3 the models have been refined to include operator errors and corrections during trajectory control operations. In addition, the visual scanning model has been modified to address the scanning patterns typical of robotics missions. Robotics operators devote more attention to camera and window views of the robotic arm, rather than to other displays that provide additional information. Experienced operators employ a pattern of frequent, short scans to the supplementary information, where novices are more likely to fixate on camera and window view displays. In Year 3, the detailed models for operator situation awareness (SA) were also developed. Key parameters of importance for robotics missions were identified (e.g., hazard awareness, trajectory awareness, rate awareness, camera awareness), and the specific visual displays that provide data to support those types of SA were identified. These have now been incorporated into the model of operator performance. The MIDAS-FAST tool has been further developed, and it now provides an animation capability to show predicted operator performance during a model run. Because BORIS provides limited automation capabilities, the team developed and implemented a guided trajectory condition (where the automation shows a recommended "flight path") and an automated condition (different from the BORIS automated condition, that flies an arc trajectory, the MIDAS-FAST modification flies a 3-segment trajectory). Further, hazard alerting and hazard avoidance automation was included, to help prevent collisions and singularities. Finally, the team developed and implemented logic to provide camera control recommendations. The MIDAS-FAST interface has been modified to address the latest automation capabilities. The MIDAS-FAST team members met with NASA project stakeholders from NASA JSC and ARC. During these meetings we provided video demonstrations of the MIDAS-FAST tool, and gathered feedback on the usefulness of the tool. In one meeting, we attempted to conduct a "live" demo, using a version of BORIS installed at NASA JSC. Due to slight differences between that version of BORIS and the one used by the project team, we were unable to run the demo. We have since (with NASA contracts approval) purchased a dedicated laptop, and installed BORIS on it. This will be used for future demos, and provided to NASA at the end of the project. The first empirical study has been conducted at the University of Michigan. In this experiment, 36 participants performed 6 or 7 trajectory flight tasks with the BORIS simulation. Participants worked in either a manual, guided, or fully-automated condition, and they experienced either hazard alerting or hazard avoidance automation. In addition, some scenarios included camera recommendations, whereas others provided no camera recommendation. The final two scenarios included automation failures. Extensive data were collected to characterize operator performance in the different conditions. These included time to complete trajectory segments, errors made (collision alerts, singularity alerts), actual versus recommended trajectory, participant eye movements and fixations, camera selections, self-reported workload, as well as subjective preferences and comments regarding the automation. The data are currently being

	analyzed. A second experimental study is currently being planned. Finally, the team has updated the model validation plan to address the latest model improvements. This was used to help plan the experimental data collection. Using the validation plan, data gathered during model runs will be compared with empirical data to identify if the model accurately predicts operator performance. Discrepancies will be identified, investigated, and improved. These improvements will then be re-evaluated in the upcoming second experiment. A no-cost-extension has been requested and approved. The project is now scheduled to complete on December 31, 2012.
Bibliography Type:	Description: (Last Updated: 09/07/2020)
Abstracts for Journals and Proceedings	Sebok A, Wickens C, Gacy AM. "Using modeling and simulation tools to support performance in robotic automation systems." Invited talk. Presented at the 8th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human Machine Interface Technologies (NPIC&HMIT 2012), San Diego, CA, July 22-26, 2012. 8th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human Machine Interface Technologies (NPIC&HMIT 2012), San Diego, CA, July 22-26, 2012. , Jul-2012
Abstracts for Journals and Proceedings	Sebok A, Wickens CD, Gacy AM, Brehon M, Scott-Nash S, Sarter N, Li H, Gore BF, Hooey BL. "MIDAS-FAST: A Modeling and Simulation Based Tool to Predict Operator Performance in Human-Robotic Automation Systems." Presented at the 4th International Conference on Applied Human Factors and Ergonomics and 1st International Conference on Human Factors in Transportation, San Francisco, CA, July 21-25, 2012. 4th International Conference on Applied Human Factors and Ergonomics and 1st International Conference on Human Factors in Transportation, San Francisco, CA, July 21-25, 2012. , Jul-2012
Abstracts for Journals and Proceedings	Li H, Sarter N, Sebok A, Wickens C. "The Design and Evaluation of Visual and Tactile Warnings in Support of Space Teleoperation." To be presented at the 56th Annual Meeting of the Human Factors and Ergonomics Society, Boston, MA, October 22-26, 2012. To be presented at the 56th Annual Meeting of the Human Factors and Ergonomics Society, Boston, MA, October 22-26, 2012. , Jul-2012