Fiscal Year:	FY 2011	**Task Last Updated:**	FY 06/30/2011
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		
PI Email:	asebok@alionscience.com	**Fax:**	FY
PI Organization Type:	INDUSTRY	**Phone:**	720-389-4562
Organization Name:	Alion Science and Technology		
PI Address 1:	4949 Pearl East Cir		
PI Address 2:	Suite 100		
PI Web Page:			
City:	Boulder	**State:**	CO
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:**	12/31/2012
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:	Woolford, Barbara	**Contact Phone:**	218-483-3701
Contact Email:	barbara.j.woolford@nasa.gov		
Flight Program:			
Flight Assignment:	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 of the scenario, showing operators interacting with equipment and each other. 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 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:	This report describes the goals and progress of the project MIDAS-FAST : A Tool for Evaluating Function Allocation. The main overall objective of the proposed research is to develop tools and empirically-based guidelines that support designers in developing new technologies. Specifically, the products from this research will help designers and mission planners (a) anticipate and avoid potential problems in function allocation strategies in system design before new systems are introduced, and therefore (b) assure that these systems and their function allocation strategies can be implemented seamlessly and in a way to minimize transient or longer-term impacts on performance in space exploration missions. The proposed work contributes to the Program Requirements Document (PRD) Risk Associated with Poor Task Design (20.0 – D X I), and specifically addresses Integrated Research Plan (IRP) Gap Space Human Factors Engineering SHFE4: Guidelines are needed for appropriate task automation as well as for effective allocations of tasks between humans and automation to increase performance, efficiency, and safety. To help NASA achieve these objectives, Alion Science and Technology, together with Dr. Christopher Wickens, the University of Michigan, the San Jose State University Research Foundation, and Dr. Thomas Jones, proposed to develop and empirically validate the MIDAS-FAST simulation tool. MIDAS-FAST is based on human-performance models, together with a robotic simulation environment, to allow system designers and concept developers evaluate the effects of function allocation strategies, varying types of automation (e.g., fixed, adaptive, and adaptable automation), and automation reliability on operator and system performance. In developing this tool, our plan of work consists of six key tasks, identified below. The following paragraphs identify the task, describe the progress to date, and briefly outline the plan for further research. 1.1 Identify an appropriate domain and simulation environment Progress: This task is complete. The team, with input from NASA personnel, has identified the space robotics domain. We have obtained from NASA the necessary set of software tools to simulate robotics tasks, in particular, the Basic Operational Robotics Instructional System (BORIS). We have installed these tools at Alion and University of Michigan. In the summer of 2010, five team members attended the NASA General Robotics Training (GRT) at NASA Johnson Space Center (JSC). We are currently working with the BORIS tools. The BORIS simulation at Alion has been integrated with the MIDAS human performance modeling environment and other performance modules, as described in other tasks below. The simulation at the University of Michigan is being customized to provide the task environment for the human in the loop simulation studies. 1.2 Conduct a literature review of human automation interaction Progress: This task is complete. An extensive literature review has been conducted: 1) to assess the effects of automation at varying stages (i.e., information acquisition, information analysis and integration, choosing and deciding, and executing an action) and levels (i.e., high, moderate and low degrees of automation) on operator performance, 2) to identify the effects of unreliable automation on performance, and 3) to evaluate context sensitive (adaptive and adaptable) automation. The “stages and levels” and “reliability” aspects of the literature review have been further refined to identify and extract the data that are relevant for module development. Further, the effects of context-sensitive automation have been briefly summarized. 1.3 Develop and validate modules of human performance Progress: This task is currently ongoing. We have identified a number of relevant modules to include in MIDAS-FAST. Modules are reusable computational models that predict specific aspects of human performance. These interact with the MIDAS human performance model to predict operator behavior and outcomes for the user-specified conditions. We

leverage existing models developed under other NASA efforts. These include the Salience, Expectancy, Effort, and Value (SEEV) model of visual attention, and the Frame of Reference Transformation (FORT) model of human error due to control action – robotic arm movement incompatibility in robotic tasks. These are being customized for use in MIDAS-FAST. Other modules under development include operator performance in different stages and levels of automation, in varying conditions of automation reliability, and in different conditions of context-sensitive automation.

1.4 Build and verify human performance models

Progress: This task is currently ongoing. The team is evaluating the robotic task domain, and implementing modules to simulate operator performance. MIDAS modeling efforts will focus on progressively more detailed issues as the team identifies relevant scenarios and automation effects. Models address operator performance in a variety of conditions. Specifically they focus on decision making, trajectory control, camera selection, rate of robotic arm movement, and operator visual attention.

1.5 Plan, conduct, and evaluate empirical studies

Progress: This task is currently ongoing. During the past year, the UM team developed and set up the apparatus and procedures (including hardware and software) that will be used for training participants and for conducting the planned experiments. This includes the BORIS simulation with associated data collection routines and equipment, eye-tracking data analysis software, the two hand controllers, training tools (e.g., a model of the robotic arm, coordinate frames), and, importantly, the design and implementation of automation functions (including modifications of the original BORIS GUI). The team developed a training plan and tutorials. Also, the protocol for a pilot study and the first experiment has been submitted to, and approved by, the UM Institutional Review Board (IRB). The pilot study was recently completed. Its purpose was to compare the effectiveness of different notifications and alerts in case of undesirable arm configurations. Its findings also helped refine the experiment setup and training plan, and they informed the design of automation schemes and scenarios for the two subsequent experiments. Experiment 1 which focuses on a comparison of performance effects of fixed automation schemes will be conducted during Summer/Fall 2011. Subsequently, and based in part on findings from experiment 1, experiment 2 will examine possible benefits and limitations of employing context-sensitive (adaptable and adaptive) automation schemes.

1.6 Integrate the software tools to develop MIDAS-FAST

Progress: This task is currently ongoing. During this year the team has effectively integrated the BORIS simulation environment and MIDAS modeling tool, where the MIDAS (or MORRIS) simulated operator control actions drive the robotic arm, and the feedback from the robotic environment affects simulated operator attention and decision making. Further work will include identifying the simulation data to collect and developing the capabilities to store this data and present it in a readable, usable format.

One challenge this year has been identifying and developing workaround solutions to limitations in the BORIS environment. BORIS provides an excellent robotic simulation, but it offers limited automation conditions. Because our modeling and research efforts focus specifically on the effects of varying automation strategies and failures on operator and system performance, we need to be able to simulate different automation situations. This year we have identified and developed implementation strategies for trajectory control automation, hazard alerting and avoidance, camera control recommendations, and rate control.

Bibliography Type:	Description: (Last Updated: 09/07/2020)
Abstracts for Journals and Proceedings	Sebok A, Wickens CD, Sarter N, Gore B, Hooey B, Li H, Gacy M, Brehon M, Santamaria A. "MIDAS-FAST: Development and Validation of a Tool to Support Function Allocation." Presented at the 18th IAA Humans in Space Symposium, Houston, TX, April 11-15, 2011. 18th IAA Humans in Space Symposium, Houston, TX, April 11-15, 2011. , Apr-2011
Abstracts for Journals and Proceedings	Sebok A, Wickens C, Gacy M. "Automation for Human-Robotic Interaction: Modeling and Predicting Operator Performance" Presented at and published in the Proceedings of the 16th International Symposium on Aviation Psychology, Dayton, OH, May 2-5, 2011. Proceedings of the 16th International Symposium on Aviation Psychology. Dayton, OH : Wright State University, 2011. p. 621-626. , May-2011
Articles in Peer-reviewed Journals	Gacy AM, Wickens CD, Sebok A, Gore BF, Hooey BL. "Modeling operator performance and cognition in robotic missions." Proceedings of the Human Factors and Ergonomics Society Annual Meeting. 2011 Sep;55(1):861-5. (55th Annual Meeting of the Human Factors and Ergonomics Society, Las Vegas, NV, September 19-23, 2011.) http://dx.doi.org/10.1177/1071181311551179 , Sep-2011