Fiscal Year:	FY 2009	Task Last Updated:	FY 09/15/2009
PI Name:	Small, Ron M.S.		
Project Title:	Modeling and Mitigating Spatial Disorientation in	Low G Environments	
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline Element/Subdiscipline:	NSBRISensorimotor Adaptation Team		
Joint Agency Name:		TechPort:	Yes
Human Research Program Elements:	(1) SHFH :Space Human Factors & Habitability (a	archival in 2017)	
Human Research Program Risks:	(1) HSIA:Risk of Adverse Outcomes Due to Inade	equate Human Systems Integrat	ion Architecture
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
PI Email:	rsmall@alionscience.com	Fax:	FY 303-442-8274
PI Organization Type:	INDUSTRY	Phone:	303-442-6947
Organization Name:	Alion Science & Technology Corp.		
PI Address 1:	MAAD Operation		
PI Address 2:	4949 Pearl East Circle		
PI Web Page:			
City:	Boulder	State:	СО
Zip Code:	80301-2577	Congressional District:	2
Comments:			
Project Type:	Ground	Solicitation / Funding Source:	2007 NSBRI-RFA-07-01 Human Health in Space
Start Date:	09/01/2007	End Date:	08/31/2011
No. of Post Docs:	1	No. of PhD Degrees:	0
No. of PhD Candidates:	0	No. of Master' Degrees:	0
No. of Master's Candidates:	2	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:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Young, Laurence (Massachusetts Institute of Tech Oman, Charles (Massachusetts Institute of Tech Wickens, Christopher (Alion Science & Technol	chnology) nology) logy Corp.)	
Grant/Contract No.:	NCC 9-58-SA01302		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Original Aims The goal of this industry-university research and development project is to extend Alion's spatial disorientation mitigation software – originally developed for aeronautical use – to NASA's space applications including the Shuttle, CEV, Altair, and Mars exploration missions. Alion's Spatial Disorientation Analysis Tool (SDAT) is designed for post too analyses of aircraft tracetory data from US. Navy, Air Force and NTSB mishaps to determine the presence or absence of vestibular SD. SOAS (Spatial Orientation Aiding System) is a real-time cockpit aid that has been evaluated in simulators with rated pilots. Both tools incorporate models of the vestibular system and assessor heuristics to predict the epoch and probability of an SD event such as Leans, Coriolis, or Graveyard Spiral Illusions, as well as any other significant disparities between actual and perceived pitch attitude (somatogravic), noll rate, SOAS assesses multi-sensory workload to determine the types of countermeasures to trigger and when to trigger them. This project will: 1) Enhance the utility of SDAT/SOAS by including appropriate mathematical models for vestibular and visual assory uces, and CNS gravito-interial force resolution into perceived tith att translation estimates from MIT's Observer model, and revalidating it using existing aeronautical data sets. 2) Extend the models for vestibular SDAT/SOAS to consider multiple visual frames of reference, the effects of visual attention and sensory workload, and the cognitive costs of mental rotation and reorientation. The enhanced SDAT/SOAS from Aims 1-3 will be validated via simulator and/or flight experiments1) SOAS will be tailored for a lunar landing, using multi-sensory workload, and the cognitive costs of mental rotation and reorientations. SDAT could assist flight surgeons with post-flight medical debriefings. Key Findings During the project's second year, we focused on: understanding the separate Alion & MIT perception models; assessing how to combine them; obtaining vehicle d
	may be Shuttle landing data outlier analyses (compared to non-outliers), and data sets from Altair simulators.
	4) Help VMS engineers tune their washout algorithms to better account for lunar gravity.
	5) Plan in detail for simulator and possible flight validation experiments in the second half of Year 3 and in Year 4.
Rationale for HRP Directed Research	:
Research Impact/Earth Benefits:	Over 15 % of all aircraft accidents are attributable to spatial disorientation, with particularly high prevalence in night military and general aviation operations. Better understanding of the motion patterns leading to SD and potential in-flight warnings and improved displays could reduce this danger. All lessons learned and enhancements to SDAT and SOAS from this NSBRI project will be applied to aviation. In particular, the addition of otolith models to SDAT and SOAS will be useful in analyzing rotary wing SD events and devising appropriate countermeasure strategies within SOAS for this class of vehicles. MIT's Observer model has aided investigators of aircraft accidents (e.g., 2004 Flash Air 737 fatal crash).
	The new FORT tool is intended as a design aid for all vehicle control-display engineers. The tool will help designers objectively assess the costs of frame-of-reference transformations in terms of increased workload, slower response times, and more control reversal errors.

	Our four specific aims are to: 1) Extend SDAT by incorporating MIT's Observer models. Enhance SDAT with pilot head movement data, and visual attention cues. Validate enhancements with existing and new flight data sets.
	Progress: SDAT is ready to incorporate MIT's Observer algorithms. SDAT can also accept head movement data, and Observer includes visual orientation cues for perception calculations. We have obtained new data sets (Shuttle, Altair simulator, helicopter simulator, VMS), but were unable to obtain Apollo data, as those data sets were apparently not archived, according to our sources.
	2) Extend SDAT assessments to include typical space vehicle illusions: Inversion, Visual Reorientation, Tilt Gain, and Otolith Tilt-Translation Reinterpretation. Validation will include assessment of Shuttle landing data, and Altair simulator data.
	_Progress: See above. When Observer is incorporated into SDAT, SDAT will be able to assess all the illusions listed above.
Task Progress:	3) Further extend SDAT by examining alternative visual reference frames. The FORT model is used to predict the cognitive cost of transitioning between reference frames. Validation of Aims 1-3 for SDAT will include parabolic flight experiments.
	_Progress: We designed and prototyped a FORT tool to help designers calculate the cognitive costs of FORT. It is a stand-alone tool, not included in either SDAT or Observer. FORT costs include the increased potential for control errors, response time delays, and increased cognitive workload. We analyzed and applied the tool to Shuttle-ISS docking, and to Shuttle-Hubble rendezvous and robotic arm tasks. We have begun to plan flight and simulator experiments to validate all enhancements to SDAT, although parabolic flight experiments may not be included.
	4) To further enhance SDAT/SOAS assessor performance, pilot multi-sensory workload is considered in countermeasure selection. Validation experiments are not detailed, but will involve evaluations in ground-based simulators.
	_Progress: Once we have verified and validated our models, we will assess the efficacy of various countermeasures triggered by SOAS during years three or four.
Bibliography Type:	Description: (Last Updated: 09/08/2020)
Abstracts for Journals and Proceedings	Oman CM, Newman MC. "Observer model for spatial orientation research and accident investigation." 80th Annual Meeting of the Aerospace Medical Association, Los Angeles, CA, May 3-8, 2009. Aviat Space Environ Med. 2009 Mar;80(3):208. , Mar-2009
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Dissertations and Theses	Newman MC. "A multisensory observer model for human spatial orientation perception." Dissertation, Massachusetts Institute of Technology, May 2009. , May-2009
NASA Technical Documents	Small RL, Wickens CD, Keller JW, Oman CM, Young LR, Jones TD, Newman M, Brehon M. "Modeling and mitigating spatial disorientation in low g environments: Year 1 report." Alion Science and Technology Corp. Year 1 report, November 2008. , Nov-2008
Significant Media Coverage	Jacobs PJ. "Alion to Research Spatial Disorientation Faced by Astronauts in Flight under \$1.73M National Space Biomedical Research Institute Grant." Alion press release, January 2009., Jan-2009
Significant Media Coverage	Small R, Jones T, Oman C. "The Space Show, online show." The Space Show, online show, March 2009., Mar-2009
Significant Media Coverage	Thomas B. "Space researchers developing tool to help disoriented pilots." NSBRI press release, December 2008., Dec-2008