Fiscal Year:	FY 2012	**Task Last Updated:**	FY 08/07/2011
PI Name:	Wood, Scott J. Ph.D.		
Project Title:	Effect of Sensorimotor Adaptation Following Long-Duration Spaceflight on Perception and Control of Vehicular Motion		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Biomedical countermeasures		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HHC**:Human Health Countermeasures		
Human Research Program Risks:	(1) **Sensorimotor**:Risk of Altered Sensorimotor/Vestibular Function Impacting Critical Mission Tasks		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	77058	**Congressional District:**	36
Comments:	NOTE: PI returned to NASA JSC in January 2017. PI was at Azusa Pacific University from August 2013 – January 2017; prior to August 2013, PI was at NASA JSC.		
Project Type:	FLIGHT	**Solicitation / Funding Source:**	2008 Crew Health NNJ08ZSA002N
Start Date:	10/01/2009	**End Date:**	02/29/2016
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	0	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
Contact Monitor:	Baumann, David	**Contact Phone:**	
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Flight Program:	ISS		
Flight Assignment:	NOTE: End date is now 2/29/2016 per HRP Master Task List dated 7/12/2011 (Ed., 8/4/2011)		
Key Personnel Changes/Previous PI:	August 2010. The rover simulation was Specific Aim 4 of the submitted proposal. Since the original Specific Aims 1-3 of this study were removed from this investigation, the investigator team members on Dr. Wood's proposal assigned to those aims are not participating in the revised integrated study with Dr. Moore.		
COI Name (Institution):			
Grant/Contract No.:	Internal Project		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	The central nervous system must resolve new patterns of sensory cues during movement in a novel gravitoinertial environment in order to maintain accurate spatial orientation awareness. We hypothesize that adaptive change in how inertial cues from the vestibular system are integrated with other sensory information leads to perceptual disturbances and impaired manual control during transition to a new gravity environment. The primary goals of this investigation are to quantify post-flight decrements in manual control performance during a rover simulation (both acute and recovery), and to examine the relationship between manual control errors and adaptive changes in sensorimotor function and motion perception. Eight crewmembers returning from 6 month stays onboard the International Space Station (ISS) will be tested on a six degree-of-freedom motion simulator during four pre-flight and three post-flight sessions on R+1, 4 and 8 days following landing. This rover simulation study has been incorporated into another post-flight manual control study titled “Assessment of operator proficiency following long-duration spaceflight” under the direction of principal investigator Dr. Steven Moore. Dr. Moore’s project includes a test battery to assess sensorimotor and cognitive function, including vestibular (head stabilization, pitch/roll vestibulo-ocular reflex, tilt motion perception), oculomotor (smooth pursuit, optokinetic nystagmus, dynamic visual acuity), manual dexterity, manual tracking, perspective taking, emergency response, sleepiness and fatigue. According to our hypothesis, we predict that decrements in sensorimotor function will be correlated with performance during the rover simulation. The rover simulation consists of serial presentation of discrete tasks that the crewmember attempts to complete within a scheduled 10 min block. The tasks are based on navigating around a Martian outpost that consists of a landing area, habitation area, power generator, science area and radio telescope spread over a 970 m2 terrain. Each task is subdivided into three components: (1) presentation of a perspective map detailing the current location of the rover and the location of the task to be performed; (2) navigation of the rover to the desired location as quickly as possible while avoiding obstacles, and (3) fine control of the rover to dock with another object. Metrics obtained from each component include time to completion and accuracy. At the completion of each task, a new perspective map will appear to initiate the next task in the series. The number of tasks the crewmember can complete during the 10 min time block will determine the overall operator proficiency. The order of task presentations will vary across sessions to minimize learning effects.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Sensorimotor function is critical for spatial orientation, gaze stabilization, and postural stability. This project examines how adaptive changes in sensorimotor and cognitive function may increase the risk of impaired ability to maintain control of vehicles and other complex systems. The goal is to map changes in physiological function with functional measures of manual control. Establishing these relationships will be relevant to how pathophysiological impairments in sensorimotor processing may affect other vehicular control tasks, such as driving with vestibular patients. Vehicle driving is one of the most complex tasks required of humans. A majority of vestibular-impaired patients report that driving is difficult or dangerous. Successful completion of this project will contribute to the development of assessment techniques to be used when determining fitness for driving duty. Specifically, the rover simulation utilizes a multiple degree-of-freedom motion base simulator to address aspects of vehicular control performance, including perspective taking, navigating a course safely, and fine positioning control. This approach can be easily adapted to a wide variety of simulated vehicle designs to provide similar assessments in other operational and civilian populations.
Task Progress:	Completion of Flight Definition Phase: During this past reporting year, the flight definition phase was completed and the integrated experiment was selected for flight in June 2011. The revisions to the integrated protocol involved a time reduction of the rover simulation from 15 to 10 min per session. The User Readiness Review was conducted to man-rate the Motion Control Simulator in January 2011. At this same time, the Test Readiness Review committee approved science verification man-in-the-loop testing for the rover simulation. A Delta TRR was conducted in May 2011 to approve the additional experiment components for the integrated study with Dr. Moore. Completion of Equipment Development: An overview of the experiment development status was presented at the 18th Humans in Space Symposium (Wood et al., April 2011). The simulator utilizes a Stewart-type motion base (CKAS, Australia), single seat cabin with triple scene projection covering 150° horizontal by 50° vertical, and joystick controller. This past year Tietronix completed the rover software using Unity3 with next-gen PhysX engine to synchronize simulation and motion platform commands tightly. Separate enhancements made to the C# applications to allow investigators to customize session sequences with different lighting and gravitational conditions, and then execute tasks to be performed as well as record performance data. The technical development of an operational simulation to assess how sensorimotor and cognitive function impact manual control performance will be presented at the 3rd International Symposium on Visual Image Safety (De Dios et al., September 2011). Normative data collection: Our flight study utilizes repeated measures pre- versus post-flight design, where each subject will serve as their own control. In order to determine learning effects resulting from our repeated measures, our initial control study is tracking performance in 20 control subjects across 5 test sessions separated by 2-4 days each. Five sequences of 8 tasks have been developed. One half of the control group will receive novel sequences during each session. The second half will receive the same sequence over the first four sessions, and then a novel sequence during the final session. The first and last sequence for both groups is identical, and will be compared to establish the effect of variable practice as well as establish the learning effects for each dependent variable. We predict that some measures, such as docking time, will show more learning effects that other variables. A description of each subtask is described below along with preliminary data for the first 7 subjects combined. Later reports will separate out performance for the variable and same sequence groups. (1) Perspective taking: Each of the docking tasks in a session begins with presentation of a map detailing the current location of the rover and the location of the docking task to be performed. Subjects point the joystick in the direction of the target from the perspective of the rover cockpit as fast and accurately as possible. This is similar to the perspective taking test in the Test of Basic Aviation Skills (TBAS) that is part of Dr. Moore’s protocol. However, one important difference is that subjects must then use this information from the map to navigate toward the target during the next subtask. Therefore, the longer reaction times in our simulation reflect the additional time that subjects use to study their initial and final locations before starting the navigation task. As described above, the primary dependent measures of the perspective taking are the reaction time to complete the task, and the accuracy of their joystick response. Another difference between this task the TBAS perspective taking task is that our accuracy is in resolution of degrees while the TBAS version has subjects use keypad arrows to indicate one of four directions. Our preliminary data show a clear trend in perspective taking accuracy over the first four sessions, with no significant change in reaction time. Thus, we

anticipate achieving a stable preflight baseline by the final (fourth) preflight data collection.

(2) Path navigation: Once the perspective taking phase is complete, the subject is brought into the virtual scene in the same location and orientation as presented by the preceding map. The subject must then use the hand controller to navigate the rover to the desired location as quickly as possible while avoiding obstacles. If needed, the subject can recall the map at any time to display the current rover location relative to the docking target. Two metrics from the navigation phase are the time to move within the docking location boundary and total path length. If subjects do not reach the target boundary within two minutes, the task "times out" and they are automatically forwarded to the docking phase. Based on preliminary data to date, there are no consistent learning trends for the navigation time. A trend for the path length to increase may be attributed to the fact that subjects are more consistently reaching the docking boundary, i.e., traveling more efficiently and therefore farther in later sessions. However, path length does not currently factor the distance away from the docking boundary if the subject times out after 2 min. Revisions to the analysis are underway to add parameters that factor both distance and time to the docking boundary.

(3) Docking: Once within the docking boundary, the subject must dock a side hatch of the rover to a visually guided target. Each target has a specific orientation that is defined by a projection of a cone on the ground in front of it. As the subject brings one of the side hatches within closer proximity to the docking target, crosshairs are displayed on the side camera view to be used in aligning the hatch with the docking target. Subjects are allowed 60 sec to complete this task. There is clear trend in time to dock decreasing over the first four sessions, with no significant change in docking accuracy. (4) Other measures: At the completion of each task, subjects provide subjective comments and report any motion sickness symptoms. Preliminary tests resulted in low incidence of symptoms (<15% unable to complete first session), with only negligible after effects after the initial session. During the flight study, overall operator proficiency will also be based on how many tasks the crewmember can complete during the 10 min time block.

Near term plans: The first opportunity for pre- and post-flight data collection will be Expedition 33/34 with pre-flight data collection commencing in the summer 2012 timeframe. Following the current study examining learning effects, additional factors of influence ground studies are planned. One study will examine the influence of vestibular impairment on operator proficiency with the rover simulation using Galvanic Vestibular Stimulation (GVS). A second study will examine the influence of fatigue on operator performance. When astronaut data has begun, another ground control study will utilize age and gender matched control subjects that will be tested using the same test session timing and sequence.

Bibliography Type:	Description: (Last Updated: 03/08/2024)
Abstracts for Journals and Proceedings	Wood SJ, Dean SL, De Dios YE, MacDougall HG, Moore ST. "Assessment of spatial navigation and docking performance during simulated rover tasks." 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	De Dios YE, Dean SL, Davis N, Rosenthal J, MacDougall HG, Moore ST, Wood SJ. "Development of a rover simulation to assess operational proficiency following long duration spaceflights." To be presented at the 3rd International Symposium on Visual Image Safety, Las Vegas NV, September 22-23, 2011. 3rd International Symposium on Visual Image Safety, Las Vegas NV, September 22-23, 2011. http://www.vims2011.org/index/pdf/DeDios.pdf , Sep-2011