Fiscal Year:	FY 2011	**Task Last Updated:**	FY 09/16/2011
PI Name:	Gore, Brian Ph.D.		
Project Title:	Workload Tools and Guidelines		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Space Human Factors Engineering		
Joint Agency Name:		**TechPort:**	No
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:	94035-0001	**Congressional District:**	18
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	Directed Research
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No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
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Flight Program:			
Flight Assignment:	NOTE: Change in Gaps per HRR information (Ed., 9/26/2011)		
Key Personnel Changes/Previous PI:	NOTE: Brian Gore became PI effective 10/01/2009, replacing Stephen Casner.		
COI Name (Institution):	Ahumada, Albert (NASA Ames Research Center)		
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Short-duration mission operations are designed to maintain workload levels that are neither too high nor too low. Long-duration mission tasks duplicate those of short-duration missions, however, the possible effects of the extended mission duration are poorly understood. In addition, the cumulative impact that workload-inducing tasks might have on the operator’s performance is ignored if one simply extends short-duration workload planning techniques to long-duration operations. When durations extend to days, weeks, months and years, social factors such as loneliness and isolation may increasingly influence performance, occasionally to the detriment of the system’s operation. This discrepancy between short and long duration perspectives contributes to the complexity of evaluating workload’s impact on operator performance and on mission success in space operations.
The first year of this Directed Research Project (DRP) achieved its two main goals: (1) to provide specific guidance on the selection of workload measurement techniques for particular human tasks and activities; and (2) to outline how

Task Description:	human workload can be best managed across a mission. This guidance, provided in the form of a NASA Technical Memorandum entitled "Measuring and evaluating workload: A primer" (Casner, & Gore, 2010; herein referred to as the Workload Primer, WP), considered the negative effects of high and low workload but also recognized the need for human operators to vigorously exercise critical skills in a balanced regime of work and rest. The techniques and guidance provided in the WP protocol section were tested in a practical spaceflight application by the Information Presentation DRP and refined in later phases of the Workload DRP. The research conducted in this first year was conducted to address the needs of spaceflight application designers to unobtrusively measure workload, and to create appropriate levels of human workload through the allocation of work between human spaceflight crew and automated systems. At the end of the first year, a gap on workload measurement and management was revealed, namely the need to identify research on workload during long duration operations and ways to measure it unobtrusively. The second and third year of the workload DRP applied the findings from the first year to consider specific system level concerns regarding workload's impact on the system performance over long duration operations. For example, in order to determine the acceptable system level of workload, an understanding of the effects of workload on repeated multitask performance, over extended operations, with additional crewmembers is required. The ultimate goal was to provide answers to the following human-system related workload questions: (1) how to measure workload from a system perspective; (2) how to maintain workload at levels that ensure robust human performance throughout the mission timeline; and (3) how can the human-system related workload guidance be used in future space flight operations. Five primary tasks were completed to provide answers to these questions: (1) identify Crewmembers' operational environment and workload considerations using Data Summaries regarding Architecture and Volume Design, Procedures, and Planning and Scheduling developed from the Flight Crew Integration (FCI) International Space Station (ISS) Life Sciences Crew Comments Database; (2) identify the commonalities between workload measured at the individual level and workload from the system level; (3) host a scales and measurement workshop; (4) conduct a Usability evaluation of the updated Primer's protocol section; and (5) develop a meaningful conceptual representation of the variables that influence workload management as applied to system performance and evaluation. These five tasks have culminated in the identification of system-related workload variables, in the development of two candidate conceptual models for measuring system workload over long duration operations, and in one new technology-based option to unobtrusively measure workload. The outcome of the Workload DRP lists several recommendations on the use of workload measurement approaches for long duration mission operations.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The Human Rating Requirement and Guidelines for Space Systems (2009) document contains the requirements and guidelines to develop the evaluation and validation methods of measuring crew workload during specific vehicle and system design cycles. This has been addressed for short-duration missions. However, applying short duration measures of workload measurement and management to long-duration missions may very well extend the workload measure beyond the context for which it was designed due to the unique stresses that a long-duration mission poses. Rather than itemizing sources of workload issues, the report completed by the Workload DRP concludes by emphasizing a system-level perspective of workload, with three levels or themes that emerge consistently over the course of studies. The first level can be thought of as the social dynamics impacted by long-duration stresses, and act as the psychological backdrop to all behaviors and performance. These social dynamics include stresses stemming from language barriers, cultural differences in leadership, and coping strategies. The second level pertains to workload as it is more traditionally conceived, involving usability, planning, procedures, and scheduling. The third level refers to workload that stems from institutional and organizational cultural practices. It takes the form of debriefs and practices in gradient dissent, but now must also incorporate a system-wide and standards perspective in the practice of human factors amongst NASA and its contractors. Results from the studies conducted and the methodical approach undertaken as part of the three year Workload DRP was the development of two conceptual models of the manner that workload impacts people over a longer duration mission. It is anticipated that the conceptual models of long duration operations be refined through additional research evaluations on extreme environment operations, particularly the manner that the individual workload considerations are raised to the system level. The effort taken to develop the conceptual models culminated in a set of requirements that has been provided to the Orion community to help in the design of workload requirements for long duration mission operations.
Task Progress:	The Workload DRP provided an overview of system, system operations, system engineering processes and presented a conceptual model, termed the Unified Theory of Cognition, that served as a framework for an initial conceptual representation of the manner that workload variables impact performance for long duration mission operations. A formal review of three crew debriefs was used to identify the likely long duration, workload-inducing variables that need to be considered when designing and using interfaces, procedures, and schedules in an integrated system perspective such that acceptable workload is maintained throughout a mission. A workshop that brought together a series of academics, government, and industry experts to discuss workload variables was used to support the crew debrief variables that were integrated into a conceptual model of long duration mission operations. The final chapter culminated in the development of two conceptual models rooted in Newell's Unified Theory of Cognition as it might pertain to long duration mission operations. It is anticipated that future research use these potential models as a starting point to further recommend considerations for unobtrusively measuring workload over a long duration mission through analogous environments, and to flesh out the primary, secondary, and tertiary variables that need to be considered for unobtrusively measuring workload over long duration missions. Technologies have also been highlighted in various developmental stages that may provide unobtrusive ways to measure workload, while providing feedback to astronauts who can use the information to manage their tasks with the ultimate goal of insuring safety of the entire system in order to achieve mission success. In terms of the technology-based option, a prototype mobile screening system that unobtrusively detects behavioral patterns and characteristics of individuals who perform specific actions will be required. Such a prototype system will track the homeostasis of an individual's pupil, skin/pore dilation, or other characteristic behavioral patterns and compare the baseline data to conditions when the operator experiences excessive workload. Sensor technology will be used to measure and monitor physiological, behavioral and auditory markers characteristic of individuals that experience performance decrements due to workload over a long duration mission. Research is needed to specify the markers and the thresholds that are characteristic of such

	performance changes. Data collection of physiological information (ocular measures, temperature, heart and breathing rates, perspiration, pore dilation, vocal measures), of behavioral information (physical movements/patterns, facial recognition measures), and of auditory information (pitch of voice) will be required so that baseline profiles can be created. These baseline profiles can then be compared against profiles of situations that are associated with performance decrements. These physiological, behavioral, and auditory markers will serve as the requirements specifications for systems developed for use in long duration mission missions. Research is required to identify the critical thresholds for the physiological, behavioral, and auditory markers over a longer duration space mission.
Bibliography Type:	Description: (Last Updated: 03/08/2018)
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