Fiscal Year:	FY 2019	**Task Last Updated:**	FY 08/07/2020
PI Name:	Flynn-Evans, Erin E. Ph.D.		
Project Title:	Evaluation of the Validity, Acceptability and Usability of Bio-mathematical Models to Predict Fatigue in an Operational Environment		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Behavior and performance		
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H)		
Human Research Program Risks:	(1) **BMed**:Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders (2) **HSIA**:Risk of Adverse Outcomes Due to Inadequate Human Systems Integration Architecture (3) **Sleep**:Risk of Performance Decrements and Adverse Health Outcomes Resulting from Sleep Loss, Circadian Desynchronization, and Work Overload		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
PI Email:	erin.e.flynn-evans@nasa.gov	**Fax:**	FY
PI Organization Type:	NASA CENTER	**Phone:**	650-279-3459
Organization Name:	NASA Ames Research Center		
PI Address 1:	Fatigue Countermeasures Group		
PI Address 2:	Human Systems Integration Division, Code 262-4		
PI Web Page:			
City:	Moffett Field	**State:**	CA
Zip Code:	94035	**Congressional District:**	18
Comments:			
Project Type:	FLIGHT,GROUND	**Solicitation / Funding Source:**	2015-16 HERO NNJ15ZSA001N-ILSRA. Appendix F: International Life Sciences Research Announcement
Start Date:	11/01/2016	**End Date:**	04/02/2019
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:	1	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
Contact Monitor:	Williams, Thomas	**Contact Phone:**	281-483-8773
Contact Email:	thomas.j.will1@nasa.gov		
Flight Program:	ISS		
Flight Assignment:	NOTE: End date changed to 4/02/2019 per D. Arias/JSC (original end date was 4/30/2018 and then was extended to 10/1/2018) (Ed., 12/21/18) NOTE: End date change to 10/01/2018 (original end date was 4/30/2018) per D. Arias/JSC (Ed., 3/22/18)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Hillenius, Steven M.S. (NASA Ames Research Center) Marquez, Jessica Ph.D. (NASA Ames Research Center) Pecena, Yvonne Ph.D. (Deutsches Zentrum Fuer Luft- Und Raumfahrt E.V.) Young, Millennia Ph.D. (NASA Johnson Space Center)		
Grant/Contract No.:	Internal Project		

Performance Goal No.:	
Performance Goal Text:	
Task Description:	Bio-mathematical models hold promise as tools that can be used to manage fatigue risks in an operational setting. There are numerous models available to predict fatigue-related performance impairment arising from sleep loss, circadian misalignment, and sleep inertia. It is imperative that any model considered for use during spaceflight missions be validated in an operational setting in order to ensure that predictions are reliable and consistent. Given the complexity of the underlying causes of fatigue, there are wide individual differences in response to mission stressors; however, the majority of candidate models provide predictions based on average human responses, making it difficult to use the models to make operational decisions for individuals. In addition, there are no published reports on the acceptability, usability, and feasibility of any of the current models. Effective incorporation in a spaceflight environment requires model-based software systems that are easy to use by a wide-range of operators and are integrated with other scheduling constraints that are relevant in spaceflight operations. We will work with NASA to identify which model(s) are the best candidates for inclusion in 4 Human Exploration Research Analog (HERA) studies. Once complete, our evaluation will provide operational personnel with an understanding of 1) the validity of the model predictions in an operational setting, including how predictions may vary by individual; 2) the acceptability, usability, and feasibility of using the software in an operational setting; and 3) a preliminary assessment of the utility of integrating the model predictions into existing scheduling tools. Specific Aim 1: Validate model predictions in a spaceflight analog. To accomplish this aim, we will conduct two analyses. First, we will evaluate the performance of the selected model against gold-standard and operational estimates of fatigue among participants (n=16) during four HERA missions. Second, we will assess individual characteristics. We will use a battery of astronaut selection tests in order to collect characteristic parameters and evaluate how well they improve our ability to estimate resiliency and vulnerability to fatigue. The results of this analysis should help crew and support personnel to better understand and estimate performance based on individual as well as situational factors. Specific Aim 2: Evaluate acceptability, usability, and feasibility of the selected sleep-wake model software user interface. The current candidate models available for consideration in a spaceflight environment utilize a variety of platforms and it is unclear whether such tools are feasible for implementation in a spaceflight environment. Often, these software tools require significant expertise in modeling sleep-wake activity and experience using such platform. To accomplish this aim, we will conduct think-aloud usability user tests, post-debrief surveys, and in mission short surveys to measure subjective acceptability ratings and number of usability issues. Specific Aim 3: Incorporate model predictions into Playbook and assess usability and acceptability of model in the context of scheduling & planning. Although each fatigue model has been incorporated into a stand-alone interface, it may be difficult for crew to apply the performance predictions generated by the selected model(s) to operational demands due to the need for two separate software interfaces (i.e., one for performance predictions and one for scheduling decisions). The complexity of such a task may deter crew from accepting or using the bio-mathematical predictions. Therefore, it is desirable to incorporate the model predictions into scheduling tools used by crew. In order to accomplish this aim, we will conduct a nested pilot study, whereby we integrate the model predictions into Playbook, NASA's self-scheduling tool, and evaluate which interface is preferred by crew.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Bio-mathematical models are useful tools for predicting when an individual may be too sleepy to complete tasks. The information gained from this project should provide insight into how well these models predict performance impairment in an operational environment. There are many other occupational groups that could benefit from this information, including shiftworkers, military personnel, and individuals working in high pressure occupations, such as medicine, aviation, and the oil industry.
Task Progress:	We studied crews of four individuals during 4.5 missions in the Human Exploration Research Analog (HERA; n = 20). Crewmembers were allowed five hours of sleep during the week and eight hours of sleep on weekends. Crewmembers completed a reaction time test and fatigue ratings five times a day approximately every three days over 45 days. We compared objective performance on the reaction time test to the predictions of biomathematical models designed to predict fatigue. We found that performance deteriorated over the course of the mission on average; however, there were wide individual differences in performance trajectories between crewmembers. Self-reported fatigue did not change over the mission. Biomathematical models were able to predict average performance, but not performance at the individual level.
Bibliography Type:	Description: (Last Updated: 11/10/2020)
Articles in Peer-reviewed Journals	Flynn-Evans EE, Kirkley C, Young M, Bathurst N, Gregory K, Vogelpohl V, End A, Hillenius S, Pecena Y, Marquez JJ. "Changes in performance and bio-mathematical model performance predictions during 45 days of sleep restriction in a simulated space mission." Sci Rep. 2020 Sep 24;10(1):15594. https://doi.org/10.1038/s41598-020-71929-4 ; PMID: 32973159; PMCID: PMC7515915 , Sep-2020