Fiscal Year:	FY 2018	**Task Last Updated:**	FY 03/24/2018
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		
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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
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No. of PhD Candidates:	0	**No. of Master' Degrees:**	0
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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		

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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 are evaluating how well individuals perform during repeated cycles of chronic sleep restriction in the Human Exploration Research Analog (HERA). Crews of four complete the psychomotor vigilance task (PVT) up to five times every third day during the 45-day mission. They also collect information on their sleepiness and mood and baseline information about their personality and general fatigue levels. Our goal is to determine how well bio-mathematical models designed to predict performance impairment correlate to the objective measures of performance that we are collecting in each mission. In addition, we have added graphics of model predictions to the crew scheduling tool in order to determine how useful crewmembers find the model information for making planning decisions in real time. We are also evaluating how well pre-mission personality characteristics predict in-mission mood. To date, we have collected data from three complete missions (n = 12), and have a partial dataset from a mission that was evacuated due to an environmental hazard surrounding the habitat (n = 4). We plan to collect data from one final crew in this campaign, during the spring of 2018, for a total of n =16 participants. We have not analyzed any of the data as the study is ongoing. Specific information about our data analysis approach is listed below for each of our aims. Specific Aim 1 is focused on determining how well the proposed model(s) estimate sleep deprivation and circadian outcomes traditionally assessed by the clinical gold standard, PVT. To address this aim, our study biostatistician will compare the gold standard PVT data to the model predictions. The PVT includes several outcome metrics; however, our primary focus will be two of the PVT's most common performance indicators--lapses > 500 ms and the inverse mean reaction time (1/RT). Each of the candidate models also estimates these to outcomes, making it possible to compare the gold standard measures to each candidate surrogate measure. More specifically, we will compute root mean square error (RMSE) values and calculate Spearman correlations to determine how well the model predictions fit the observed data. We will repeat our analysis using the outcomes from a robotic trainer task in order to evaluate whether the model predictions are linked with decrements in operational performance. A sub-aim of Specific Aim 1 is to evaluate the potential impact of individual characteristics generated during screening to PVT performance. In order to accomplish this aim, we will regress incorporate the individual subject characteristics collected at screening (sex, age, morningness-eveningness score, fatigue severity scale score, Epworth Sleepiness Score, Tiredness Symptom Scale (TSS) domain, personality traits, and anxiety traits) on our primary PVT performance outcomes using mixed-effects regression methods that incorporate within-subjects variance components. In addition, we will calculate the squared semi-partial correlation coefficients in order to evaluate the independent variance contributions

	(after removing shared covariance among other predictors) of each of the subject characteristics. Specific Aim 2 is aimed at qualitatively evaluating the usability, acceptability, and feasibility of using the models within an operational environment. In order to accomplish this aim, we will test the effectiveness of providing modeling software to the crewmembers by conducting user interface sessions while crewmembers describe their understanding of the model and interface using a think-aloud approach. We will evaluate the usefulness of providing modeling information to crewmembers by collecting usability ratings following each model usability session. Specific Aim 3 is aimed at incorporating the models into Playbook, the crew's self-scheduling tool. In order to qualitatively evaluate this aim, we will use a Wizard-of-Oz user testing approach to integrate the model predictions into the scheduling software. In addition, we will compare the usability, feasibility, and acceptability of using Playbook to using existing model software by comparing the usability metrics that we obtain during the implementation of the existing model software to the usability metrics that we obtain during the Wizard-of-Oz implementation of the Playbook software.
Bibliography Type:	Description: (Last Updated: 07/11/2025)