Fiscal Year:	FY 2017	**Task Last Updated:**	FY 09/21/2017
PI Name:	Strangman, Gary E Ph.D.		
Project Title:	Sleep Electroencephalography and Near-Infrared Spectroscopy Measurements for Spaceflight and Analogs		
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline--Element/Subdiscipline:	NSBRI--Neurobehavioral and Psychosocial Factors Team		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H)		
Human Research Program Risks:	(1) **Bmed**:Risk of Adverse Behavioral Conditions and Psychiatric Disorders (2) **Sleep**:Risk of Performance Decrements and Adverse Health Outcomes Resulting from Sleep Loss, Circadian Desynchronization, and Work Overload (IRP Rev F)		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
PI Email:	strang@nmr.mgh.harvard.edu	**Fax:**	FY
PI Organization Type:	NON-PROFIT	**Phone:**	617-724-0662
Organization Name:	Massachusetts General Hospital		
PI Address 1:	Department of Psychiatry		
PI Address 2:	149 13th Street, Suite 2651		
PI Web Page:			
City:	Charlestown	**State:**	MA
Zip Code:	02129-2020	**Congressional District:**	7
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2014-15 HERO NNJ14ZSA001N-Crew Health (FLAGSHIP & NSBRI)
Start Date:	08/01/2015	**End Date:**	05/31/2017
No. of Post Docs:	2	**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:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:	NOTE: End date changed to 5/31/2017 per NSBRI (Ed., 8/30/16) NOTE: End date changed to 12/31/2016 per NSBRI (Ed., 5/24/16) NOTE: Period of performance corrected to 8/1/2015-7/31/2016, per NSBRI (Ed., 4/14/16) NOTE: End date change to 5/31/2017 per NSBRI (Ed., 9/16/15) NOTE: Change in Period of Performance to 8/1/2015-7/31/2016 (formerly 6/1/15-5/31/16), per NSBRI (Ed., 7/8/15)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Zhang, Quan Ph.D. (Massachusetts General Hospital)		
Grant/Contract No.:	NCC 9-58-NBPF04202		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Spaceflight is known to reduce sleep duration and negatively affect sleep quality. While actigraphy can be used to identify such sleep changes, the underlying physiology or causes of such disturbances remain to be understood. Brain assessments can be useful in this context, for sleep staging, sleep quality assessments, and identification of alterations in cerebral functioning related to sleep disturbance. However, the Earth-standard technologies for brain imaging—CT, MRI, PET—are not suitable for spaceflight. Electroencephalography (EEG) and near-infrared spectroscopy (NIRS) are amenable to packaging in small, lightweight and low power devices. Importantly, they provide complementary electrophysiological and hemodynamic windows into brain physiology. Dr. Strangman has been developing the NINscan series of devices for mobile (including 24-hour) brain assessment. The most recent such device, NINscan-M, is a multi-use brain imaging system that includes a 64-channel NIRS imaging system and has the potential to support 8-channel EEG, as well as device-chaining to enable 16 or more channels of EEG, plus the potential to support other analog and/or digital sensor inputs. Dr. Strangman has also recently completed a software platform project, called SpaceMED, which can provide integrated data collection, management, and real-time data viewing from biomedical and environmental devices. In this project, we enhanced our NINscan-M device to create NINscan-SE (a version specialized for sleep and EEG). The new NINscan-SE prototype provides 3-channel EEG, 2-channel EOG, 2-channel EMG, 1-channel ECG, accelerometry, and respiration monitoring, alongside the 64-channel NIRS imaging. We also developed a consolidated suite of data analysis tools to be used with the potentially large NINscan-SE datasets generated by sleep applications. This suite facilitates data format conversions to standard polysomnogrpahy formats (European Data Exchange, or EDF), as well as supporting standard preprocessing and analysis on the NINscan-SE datasets. To test NINscan-SE, we deployed the prototype in the Human Exploration Research Analog (HERA) facility, Campaign 3, Missions 1-4, to test the system in an operational environment. This work provides a a Technology Readiness Level (TRL)-6 prototype device plus software tools that significantly advance the brain- and sleep-assessment capabilities for spaceflight and analogous Earth-based settings.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Impact: Successful development of the NINscan-SE device will provide four key advantages. The most important of these is an easy-to-use mobile/wearable system for EEG+NIRS monitoring suitable for spaceflight sleep research. Essentially all prior PSG systems were either too large, heavy and/or complex for spaceflight, or lack adequate functionality to be useful for sleep researchers. In addition, NINscan-SE will be the first to integrate NIRS-based functionalities for brain and tissue hemodynamic imaging with EEG in a form factor suitable for spaceflight analog use. Third, we will provide a customized software toolkit for managing and analyzing the NINscan-SE data. Finally, the laboratory and HERA tests will demonstrate usability with minimally trained users, as well as operational feasibility and acceptability of deploying such a system in spaceflight analogs. Earth Benefits: No current NIRS, EEG, or PSG device has both the portability and the multi-use features we propose; thus NINscan-SE could have substantial novel Earth applications. Hospital monitoring applications could include long-duration, non-invasive brain monitoring in the NeuroICU following stroke or traumatic injury, for which no similar technology exists. In-office brain function assessment could also be enabled, for assessment of psychiatric states, for monitoring the neural effects of cardiovascular or psychoactive drugs or other therapies, or for brain monitoring during rehabilitation. Mobile monitoring could perhaps have an even larger impact outside the hospital setting. With a wearable monitor, ambulatory syncope monitoring, or multi-parameter ambulatory epilepsy monitoring become possible. If deployed in emergency vehicles, NINscan-SE could potentially be used to detect cerebral or abdominal hemorrhage, ischemia and/or cortical spreading depression by first responders. Home monitoring uses include sleep apnea, as well as a variety of commercial possibilities.
Task Progress:	This project sought to develop and test NINscan-SE, a multi-use system for its ability to support self-deployable polysomnography (PSG) along with hemodynamic brain imaging. The effort also sought to develop a data analysis toolkit for handling NINscan-SE datasets, including reading, preprocessing, filtering, format converting, and analysis for use in NASA sleep and related physiological monitoring research. The project achieved five major deliverables: (1) completion of NINscan-SE prototype system for self-deployable, research-grade polysomnography; (2) completed and delivered to National Space Biomedical Research Institute (NSBRI) a second NINscan-SE prototype system for use by NSBRI investigators and Center for Space Medicine personnel; (3) completed a software suite for data management and format conversion so the NINscan-SE data files can be used with standard polysomnography review and analysis software; (4) completed detailed feasibility and usability testing for NINscan-SE self-deployment during four separate missions in Campaign 3 at the NASA HERA analog; (5) demonstrated strong feasibility, usability, and data reliability for American Academy of Sleep Medicine (AASM) sleep scoring despite minimal training and self-deployment of the system. The system is thus considered suitable for detailed physiological sleep monitoring in operationally-relevant settings.
Bibliography Type:	Description: (Last Updated: 08/05/2022)
Articles in Peer-reviewed Journals	Hu G, Zhang Q, Ivkovic V, Strangman GE. "Ambulatory diffuse optical tomography and multimodality physiological monitoring system for muscle and exercise applications." Journal of Biomedical Optics. 2016 Sep;21(9):091314. https:// ; PubMed PMID: 27467190 , Sep-2016
Articles in Peer-reviewed Journals	Strangman GE, Ivkovic V, Zhang Q. "Wearable brain imaging with multi-modal physiological recording." J Appl Physiol (1985). J Appl Physiol (1985). 2018 Mar 1;124(3):564-72. https:// ; PubMed PMID: 28705994 [reported originally in late 2017 as "2017 Jul 13:jap.00297.2017. Epub ahead of print"] , Mar-2018