Fiscal Year:	FY 2015	**Task Last Updated:**	FY 04/03/2015
PI Name:	Dentinger, Aaron Ph.D.		
Project Title:	Non-Invasive Monitoring of Intracranial Pressure (ICP) with Volumetric Ophthalmic Ultrasound		
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline--Element/Subdiscipline:	NSBRI--Smart Medical Systems and Technology Team		
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **HHC**:Human Health Countermeasures		
Human Research Program Risks:	(1) **Medical Conditions**:Risk of Adverse Health Outcomes and Decrements in Performance Due to Medical Conditions that occur in Mission, as well as Long Term Health Outcomes Due to Mission Exposures (2) **SANS**:Risk of Spaceflight Associated Neuro-ocular Syndrome (SANS)		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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City:	Niskayuna	**State:**	NY
Zip Code:	12309-1027	**Congressional District:**	21
Comments:			
Project Type:	Ground	**Solicitation / Funding Source:**	2011 Crew Health NNJ11ZSA002NA
Start Date:	10/01/2012	**End Date:**	09/30/2016
No. of Post Docs:	0	**No. of PhD Degrees:**	1
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 9/30/2016 per NSBRI (Ed., 4/26/16) NOTE: End date changed to 3/31/2016 per NSBRI report submission (Ed., 5/8/14) NOTE: Risk/Gap changes per IRP Rev E (Ed., 3/18/14)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Jagannathan, Srinivasan (GE Global Research) Sargsyan, Ashot (Wyle Laboratories, Inc.) Patwardhan, Kedar (GE Global Research) Ebert, Douglas (Wyle Laboratories, Inc.) Melton, Shannon (Wyle Laboratories, Inc.) Garcia, Kathleen (Wyle Integrated Sciences and Engineering Group) Mills, David (GE Global Research)		
Grant/Contract No.:	NCC 9-58-SMST02803		
Performance Goal No.:			

Performance Goal Text:	
Task Description:	Further research is needed to understand the role elevated intracranial pressure (ICP) plays in visual impairment observed during and following space missions. This project will lead to the development of tools to non-invasively monitor changes in ICP and the body's ability to compensate for increases in ICP. A simplified ocular scan and new ocular metrics will provide the ability to track the short-term and long-term time course of ICP with minimal burden on the crew, to determine the correlation of ICP with visual acuity changes in response to microgravity, and to investigate effectiveness of potential treatments. In addition to in-flight monitoring of crew health during space missions, these techniques are applicable to many clinical applications where ICP plays a key role, such as monitoring patients with head trauma. The objective of this research is to non-invasively monitor ICP using 3-D ultrasound imaging by detecting changes in ocular structures and functioning of the eye that are correlated with elevated ICP. The new volumetric ultrasound imaging capability will provide user independent views of the entire ocular anatomy in a single scan with minimal crew time and ground guidance during image capture. Volumetric ultrasound data taken pre-flight, post-flight, and in-flight will be aligned with pre-flight and post-flight magnetic resonance (MR) scans allowing in-flight changes in the ocular anatomy to be tracked over time. In the first two years of the grant, hardware was developed for 3-D ophthalmic imaging on the GE Vivid q ultrasound system with prototype mechanical 3-D ultrasound probes and in vivo studies started. Several 2-D imaging and Doppler modes were implemented on the Vivid q for imaging with the prototype 3-D probes below the FDA's (Food and Drug Administration) acoustic output limits for ophthalmic scanning. Safety tests were completed on the 3-D acquisition hardware at an external lab and the protocol for the human subjects study approved by NASA's Institutional Review Board (IRB). The ultrasound acquisition on the Vivid q was optimized for ocular scanning and computer algorithms developed for visualizing the 3-D ultrasound data. An in vivo human subject study is being conducted at Wyle Integrated Science and Engineering in Houston. In the first phase of the study magnetic resonance and 3-D ultrasound data were acquired on 5 subjects. In the second phase of the study, 3-D ultrasound data will be acquired on 10 subjects during head-down tilt experiment during the final month of the current grant year. Additionally, a plan for integrating the prototype 3-D ophthalmic probe with NASA's next generation flexible ultrasound system was developed and reviewed with NASA and National Space Biomedical Research Institute (NSBRI). In the final year of the research project, the performance of 3-D ocular metrics for tracking changes in ICP will be evaluated using the in vivo data being collected and ultrasound parameters related to cerebral dynamics will be explored. The data collected during the in vivo human studies will be used to further develop automated image analysis algorithms for registering MR and ultrasound volumes and 3-D measurements of optic nerve sheath size and globe flattening. For the 3-D ultrasound ocular measurements, the repeatability with ultrasound probe position and the sensitivity to changes in ICP will be quantified on the data collected during the in vivo studies. In addition to the ocular structural metrics, new ultrasound-derived parameters of cerebral dynamics will be investigated as part of an in vivo animal study in the final year of the research project.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The primary Earth-based clinical application of the technology is non-invasive ICP monitoring of traumatic brain injury patients. Portable ultrasound systems provide the opportunity for frequent non-invasive monitoring directly at the point of care without the need to transport patients to an imaging suite. Additionally, the use of the technology to quantify the 3-D ocular shape has applications to the diagnosis and treatment monitoring of patients with disorders affecting the ocular structure, such as high-myopia and staphyloma. Further research is required to translate the technology into the clinical setting, including automating and testing the reliability of the ultrasound-based 3-D measurement on clinical populations. Clinical validation of the technology will require partnering with a clinical collaborator to secure external funding, such as through an NIH (National Institutes of Health) grant.
Task Progress:	The progress on this research project during the last funding period focused on optimizing the ultrasound acquisition for 3-D ophthalmic imaging, visualizing 3-D ocular structures, developing automated algorithms for detecting and measuring the optic nerve and posterior surface of the globe, and completing the data collection for the in vivo human study. Image Quality – The acquisition parameters for the prototype mechanical 3-D probes were optimized for ophthalmic imaging through several in vivo scanning sessions with the engineering team at GE Global Research and the clinical team at Wyle Integrated Science and Engineering. A down-selection between two prototype probe designs was performed resulting in the probe with a slightly smaller aperture and shallower focus providing better imaging performance and being selected to be used for the subsequent in vivo evaluation. Visualization – The 3-D ultrasound data collected with the volume acquisition hardware is generated by first extracting separate volume sweeps from standard DICOM (Digital Imaging and Communications in Medicine) files stored on the Vivid q ultrasound system and then converting the ultrasound volume data into multiple files formats compatible with different rendering software. Several rendering and display methods were investigated for visualizing the 3-D ocular data. These methods included orthogonal cuts through the 3-D data, parallel slices aligned with and perpendicular to the optic nerve, arbitrary slices through the volume, and surface rendering of the retinal boundary. Image Analysis – Image analysis algorithms have started to be developed to automatically identify ocular landmarks, such as the optic nerve centerline and retinal boundary, for registering multiple ultrasound and MRI (magnetic resonance imaging) volumes acquired on a single subject. These landmarks will be used to generate consistent slices through the ultrasound volume data for making standard measurements of the optic nerve sheath and globe shape, as well as providing inputs for automatic algorithms for 3-D measurement of the same ocular structures. In Vivo Data Collection – A protocol and supporting design and safety documentation were submitted to NASA's IRB and approval obtained for a human study to evaluate the performance of the 3-D ophthalmic acquisition and ocular measurements. The in vivo human subject study is currently being conducted at Wyle Integrated Science and Engineering in Houston. In the first phase of the study magnetic resonance and 3-D ultrasound data were acquired on 5 subjects. In the second phase of the study, 3-D ultrasound data will be acquired on 10 subjects during head-down tilt experiment during the final month of the current grant year.

Bibliography Type:	Description: (Last Updated: 09/05/2020)