Fiscal Year:	FY 2020	**Task Last Updated:**	FY 06/29/2020
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Project Title:	Human-centered Design Augmentation of the Vertical Flow Paper-based Health Monitoring Platform		
Division Name:	Human Research		
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Zip Code:	85004	**Congressional District:**	7
Comments:			
Project Type:	Ground	**Solicitation / Funding Source:**	TRISH--Synergy
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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:**	TRISH
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
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Key Personnel Changes/Previous PI:			
COI Name (Institution):			
Grant/Contract No.:	NNX16AO69A-SYN0005		
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Task Description:	Synergy Project This project aims to augment the current Translational Research Institute for Space Health (TRISH) Vertical Flow Paper-based Platform project (Principal Investigator: Frederic Zenhausern) through a human-centered design working in microgravity, including sample preparation modules for gene expression based health monitoring, that will be housed inside the CubeLabs from Space Tango.		
Rationale for HRP Directed Research:			

Research Impact/Earth Benefits:	A gene expression sample preparation module has been designed, and a ground module of Vertical Flow Paper (VFP) for automated biomarker detection in space has been demonstrated. This would allow point-of-care and sensitive detection of multiple types of biomarkers, not only proteins and antigens, but also nucleic acids, which allow astronauts to rapidly diagnose adverse health conditions in space exploration mission for correct treatment. It also has significant impact on Earth for rapid, sensitive, and multiplex detection of medical conditions in point-of-care setting, such as infectious disease and biothreat detection. Note that since the recent COVID-19 crisis, a panel of antibodies has been designed and could be implemented into the multiplex VFP device for possibly providing a more precise testing approach.
Task Progress:	This project aims to augment the current TRISH Vertical Flow Paper (VFP)-based Platform project (Principal Investigator: Frederic Zenhausern) through a human-centered design working in microgravity, including sample preparation modules for gene expression based health monitoring, that will be housed inside the CubeLabs from Space Tango to ensure safe operation and ultimate usability to the end users (astronauts). VFP is a novel point-of-care technology platform that can perform multiplexed detection of bio-agents and up to 100s of biomarkers in small or large volumes of bodily fluids for diagnosis in long space travel conditions. The platform is based on antigen capture by specific antibody pairs that generates colorimetric signals from nanoparticle labels, either for direct eye visualization, or connecting with a smartphone camera, in less than 10 min. We have already demonstrated the functionality of VFP with improved limit of detection > 25x vs. standard lateral flow assay (e.g., B. pseudomallei) showing VFP ability to detect microbial antigen, or more generally proteins. Our work will extend to other bacterial agents (e.g., gut bacteria or other environmental exposure on International Space Station), but also to nucleic acid detection to develop a hybrid platform able to multiplex different types of biomarkers for enabling the diagnosis of multiple conditions. It addresses the risks of Adverse Health Outcomes & Decrements in Performance due to Inflight Medical Conditions and Risk of Inadequate Design of Human and Automation/Robotic Integration within the NASA Human Research Program (HRP) roadmap to enhance capability for medical care during exploration missions, including gene expression based biodosimetry. The project has two specific aims. Aim 1 is to design an integrated VFP platform with sample preparation module for lymphocyte based gene expression assay with minimal end user intervention. Aim 2 is to design and construct a VFP ground module for future flight testing. For Aim 1, sample preparation for blood-based gene expression assay consists of multiple steps including RNA extraction, reverse transcription, and cDNA amplification. Among different assay approaches and chemistries, we have identified magnetic beads based RNA extraction for automation. Isothermal amplification of radiation sensitive genes was also demonstrated to simplify the automation process, and gene expression difference between irradiated and non-irradiated samples was successfully detected by our miniaturized VFP platform. Microfluidic cartridges for RNA extraction and reverse transcription plus isothermal amplification have also been designed and tested. For Aim 2, we worked with our subcontractor Space Tango, an expert in microfluidic automation for space applications, to develop an automated VFP system that can be housed inside a 6U CubeLab unit. A prototype unit has been completed, which includes a paper membrane holder, manifold and valving for fluid regulation, fluidic pumping system, a camera for signal imaging, and hardware and software for system control to conduct desired assay. We also successfully performed antigen immunoassay using the prototype. Our future work includes integration of the sample preparation module with the VFP module in CubeLab and testing of the system in microgravity environment.
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