Fiscal Year:	FY 2021	**Task Last Updated:**	FY 07/02/2021
PI Name:	Strangman, Gary E Ph.D.		
Project Title:	Operational Performance Effects and Neurophysiology in Partial Gravity (OPEN-PG)		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:			
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **HHC**:Human Health Countermeasures		
Human Research Program Risks:	(1) **Sensorimotor**:Risk of Altered Sensorimotor/Vestibular Function Impacting Critical Mission Tasks		
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:**	2019 HERO 80JSC019N0001-FLAGSHIP & OMNIBUS: Human Research Program Crew Health. Appendix A&B
Start Date:	09/01/2020	**End Date:**	08/31/2022
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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:**	NASA JSC
Contact Monitor:	Brocato, Becky	**Contact Phone:**	
Contact Email:	becky.brocato@nasa.gov		
Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Ivkovic, Vladimir Ph.D. (Massachusetts General Hospital) Zhang, Quan Ph.D. (Massachusetts General Hospital)		
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Task Description:	Background: Understanding human performance under various partial-gravity loadings is critical to NASA's crewed mission strategies. For example, current vehicle and mission designs for Mars landings require the crew to use robotic teleoperation within 24 hours of landing—unaided from Earth—to connect landing craft power systems with pre-positioned power generators. This design requires the crew to perform complex sensorimotor operations to maintain life support, as soon as possible after a gravitational transition, and in an unfamiliar partial-gravity setting. Unfortunately, there remains limited knowledge about how the sensorimotor system is affected by exposure to both partial gravity and gravity transitions. Addressing these gaps will in part require integrated assessment of operational and sensorimotor performance alongside neurovestibular and neurophysiological responses during exposure to various gravitational loads. Aim 1: Characterize and quantify changes in operationally-relevant sensorimotor and vestibular performance as a function of gravitational load. Aim 2: Characterize and quantify changes in physiology—particularly in brain function and autonomic activation during behavioral performance—as a function of gravitational load. Aim 3: Develop a model to predict behavioral performance and neurophysiological responses under different gravitational loads based on preflight ground testing data. Hypotheses: (Hyp1) We predict a monotonic but non-linear relationship between Robotics On-Board Trainer-r (ROBoT-r) performance and gravitational load, with larger departures from 1g leading to more impaired performance. (Hyp2) Behavioral alterations will be paralleled by physiological changes at different gravity loads, including activation of prefrontal and vestibular cortex, and autonomic nervous system activation. (Hyp3) Ground-based challenges to the vestibular system will induce detectable neurophysiological responses, and the amplitude of these responses (i.e., an indicator of individual "sensitivity" to these provocations) will help (3a) predict neurophysiological responses in-flight, and (3b) predict behavioral performance in flight. Deliverables: Overall, our project will characterize (1) operationally-relevant performance and (2) neurophysiological responses as a function of gravity load, as well as (3) providing models to predict performance and neurophysiological impacts of partial gravity based on preflight-data. This work has the potential to identify individuals who are particularly resilient to altered gravity, and will be key for planning future exploration-class missions where survival will depend on the operational capabilities of astronauts in partial-gravity environments.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The proposed parabolic flights will help fill critical knowledge gaps regarding human exposure to fractional-gravity conditions. Specifically, our project will address gaps regarding operational performance, neurophysiological status, individual sensitivity to different gravitational loads between 0-1g, as well as prediction of behavioral performance and physiological responses to partial gravity. In addition to filling key gaps surrounding human performance of operationally-relevant tasks in partial gravity, this work may provide a method to help identify crewmembers who are particularly resilient for performing particular tasks under novel gravity loadings. The results have the further benefit of providing a better understanding of the role of disorientation in Earth-based operational performance. This is relevant not only to fighter pilots, but to task performance by individuals with neurological or medical conditions that adversely affect the vestibular system (e.g., stroke, infections).
Task Progress:	Since project initiation, the project has been in definition phase, while Human Research Program (HRP)-Novespace negotiations continue. The primary efforts have therefore focused on adjusting the research plan based on requirements from the carrier. Changes to date are described below. • Flight campaign: The date of the parabolic flight campaign was tentatively set to the last half of 2022, and there will most likely be a single flight campaign of 3-4 days instead of two flight campaigns. • Experimental re-design: Due to the reduction in flight campaigns from our proposal's original plan, the experimental plan was re-designed to maximize statistical power. Changes included the following: o Flights & Parabolas: We had assumed 2 campaigns of 4-flights each (8 flights total), with 40 parabolas in each flight, or a total of 320 parabolas. This would have provided 10 parabolas at each of 0, ¼, ½, and ¾ g loadings (with blocks of 10 g loads pseudorandomly interleaved for counterbalancing). An amount of time equal to 10 parabolas would also be spent on the ground or in level flight to conduct 1g testing. To date, negotiations have indicated 4 flights of 30 parabolas each, or 120 parabolas total. This spurred various other changes (below). o ROBoT-r (Robotic On-Board Trainer (ROBoT)): To help recover statistical power, it was decided that ROBoT-r would be used exclusively, instead of half of the data from ROBoT-r and half from SpaceDock. This required the fabrication and assembly of multiple additional ROBoT-r workstations, including multiple sets of new hand controllers. The delivery time for these pushed the flight to sometime past the middle of 2022. o New Hand Controllers; Dr. Strangman worked closely with HRP and the DST Lab to finalize the design and performance characteristics of the new hand controllers, to be fabricated by DST lab personnel. o Ratio of Operational Performance Measures: Originally, due to the ROBoT-r recycle-time, we anticipated only being able to use every other parabola for ROBoT-r because the computers would be re-initializing for the next run during the intervening parabolas. However, Novespace pauses longer between parabolas—more so than other NASA/Zero-G flights—giving ROBoT-r just enough time to reset for every parabola. We therefore were able to re-assign the 10 parabolas such that ROBoT-r is used for 7 of them, and the balance force-plate is used for the remaining 3. This improves power on ROBoT-r, without having a significant negative impact on the postural stability assessments. o Ground Testing: Various plans for ground-based pretesting have been considered, given the constraints on availability of test subjects for training and assessment prior to flight. This issue is still under discussion, with a target of at least 4 days (ideally consecutive) for training/testing on the ground prior to the first flight-day. • Institutional Review Board (IRB) Protocols are well underway. These will be completed and submitted once the experimental design/logistics details above are finalized.

Bibliography Type:	Description: (Last Updated: 02/05/2025)
Abstracts for Journals and Proceedings	Ivkovic V, Shelhamer M, Kelly A, Reilly G, Zhang Q, Strangman GE. "Operational Performance Effects and Neurophysiology in Partial Gravity (OPEN-PG)." 2021 NASA Human Research Program Investigators' Workshop, Virtual, February 1-4, 2021. Abstracts. 2021 NASA Human Research Program Investigators' Workshop, Virtual, February 1-4, 2021. , Feb-2021