NASA SBIR 2021 Phase I Solicitation

H12.03 Portable Spatial Disorientation Simulator - Trainer

Lead Center: JSC

Scope Title:

Portable Spatial Disorientation Simulator - Trainer

Scope Description:

Astronauts are at risk of spatial disorientation due to vestibular alterations during and following g-level transitions, such as landing on Earth. This disorientation has previously been simulated using a bilateral bipolar Galvanic vestibular stimulation (GVS) delivered in a suprathreshold range (2 to 5 mA) over the mastoid processes independent of head orientation. NASA needs a portable GVS-based system that can be coupled to head orientation and movements to enhance the simulation of the g-transition induced spatial disorientation effect astronauts experience.

This system will be used for astronaut crewmembers to simulate performing landing and recovery type tasks while experiencing head-tilt contingent vertigo due to vestibular alterations. This simulator will also be used by recovery operations personnel to validate nominal and contingency procedures with a simulated deconditioned crewmember. Finally, this disorientation simulator will be used experimentally to develop sensorimotor standards related to fitness to perform critical mission tasks.

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The requirements include:

- Phase 1A head-worn inertial measurement unit (IMU) sensor that can measure natural head rotation (position and velocity) and linear acceleration in all three planes.
- A GVS that is head-coupled and proportional to head tilt orientation as well as pitch and roll velocity, with the ability to adjust the algorithms to alter the IMU sensor combinations that drive the GVS signal.
- The system should also allow a user-adjustable manual gain to allow for individual sensitivity, with minimal two-fault current limit at 5 mA and emergency on/off

switch.
- The system should allow a two-channel multiple electrode configuration that can provide illusory motion in both head roll and pitch axes.
- The system should be self-powered for minimally 1 hr with user switchable rechargeable batteries.
- The system should include nonvolatile memory (onboard data storage) to record IMU sensor data, GVS current delivery, and external trigger and/or manual synch event push-button timing.
- This system should be able to be worn while performing nonsuited crew landing and egress type activities without interfering with other crew-worn equipment.

Expected TRL or TRL Range at completion of the Project:Â 2 to 6Â
Primary Technology Taxonomy:Â
Level 1: TX 06 Human Health, Life Support, and Habitation SystemsÂ
Level 2: TX 06.6 Human Systems Integration**Â**
Desired Deliverables of Phase I and Phase II:

- Prototype

Desired Deliverables Description:

Phase I deliverable is a laboratory version of the disorientation trainer that successfully demonstrates the proof of concept for the requirements listed under scope description have been met.

Phase II deliverable is a portable wearable version of the disorientation trainer that can be deployed in field settings.

State of the Art and Critical Gaps:

While there are GVSÂ available, there are no GVS devices on the market that are portable or that can be coupled to head movement. This capability would provide the ability to train astronauts on what to expect with regards to spatial disorientation in a realistic mission simulation.

Relevance / Science Traceability:

This is relevant to Human Exploration and Operations Mission Directorate (HEOMD), because of its applicability in human research and exploration. For example, this technology would assist in the success of theÂ sensorimotor standards project, sponsored by NASA's Human Research Program.

References:

Moore ST, Dilda V, MacDougall HG. Galvanic vestibular stimulation as an analogue of spatial disorientation after spaceflight. Aviat Space Environ Med. 2011;82(5):535-542. (download fromÂ https://www.ingentaconnect.com/content/asma/asem/2011/00000082/00000005/art00006)

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