Further human exploration of the solar system will present significant new challenges to crew health including hazards created by traversing the terrain of lunar or planetary surfaces and the effects of variable gravity environments. The limited communications with ground-based personnel for diagnosis and consultation of medical events creates additional challenges. Providing health care capabilities for the moon and mars will require the definition of new medical requirements and development of technologies to ensure the safety and success of Exploration missions, pre-, in-, and post-flight. This SBIR Topic addresses some key medical technology and gaps that NASA will need to solve in order to proceed with exploration missions.

Subtopics

X12.01 Spaceflight Auscultation Capability

Lead Center: JSC
Participating Center(s): ARC

Analysis of body sounds for abnormalities is standard medical practice for diagnosing a medical condition. This call is for technology that can isolate internal body sounds (heart beating, breathing, etc.) in a potentially noisy ambient environment (up to 70 dBA) and capture the auscultation data to be managed and transmitted digitally to the appropriate destination for analysis.

Current commercially available systems have two main issues. Some systems pick up all sounds without filtering out the sounds of interest. Other systems use technology (e.g. doppler) that produce sounds that are not readily familiar to clinicians-thereby necessitating retraining.

Phase I Deliverable: Technical Feasibility Report; Draft Requirements Document
Phase II Deliverable: Prototype Hardware
X12.02 Quantifying Bone Degradation with High Resolution Ultrasound

Lead Center: GRC

Loss of bone strength, mass and density are known medical complications of space flight, where the static load of gravity is no longer present. The process of bone demineralization begins almost immediately upon an astronaut's arrival into a microgravity environment and appears to continue unabated. The losses occur particularly in weight bearing bone regions of the lower spine, hip and legs. NASA will eventually require diagnostics techniques that can perform in vivo quantitative evaluations of bone mineral density (BMD) and trabecular micro-architecture (i.e., porosity, trabecular size and geometry) during manned Exploration class missions. As an incremental step toward this end, a high-resolution diagnostic or imaging device is required for performing the quantitative evaluations identified above ex vivo with a technology that shows significant promise for adaptability to long duration human space flight. The device should be capable of resolving the trabecular micro-structure for analysis. The device should also demonstrate sufficient penetration depth in the body to eventually adapt the technology for in vivo evaluations of the calcaneus and lumbar spine, at a minimum. Efforts should be made to minimize the volume, mass, electromagnetic emissions and power draw of the device and its associated peripheral equipment. The use of ionizing radiation is not restricted, but its use is considered highly undesirable in a manned space flight environment and should, therefore, be minimized. This technology is desired for possible demonstration on ISS and for targeted deployment on future Exploration class vehicles supporting long duration missions.

X12.03 Lab to Marketplace: Commercializing Spaceflight Biomedical and Behavioral Research Tools

Lead Center: JSC

NASA and SBIR invest a significant amount of funds in the development of new technologies to study human physiology and behavior during spaceflight. This investment has produced a large number of technologies that include hardware (e.g., instruments, devices, etc.) and software (e.g., computational models, informatics tools, data analytic methods, etc.) While these technologies are put to good use by their developers, such non-commercial developers devote little attention to making their tools robust and easy to use by the broad research or clinical communities. Consequently, the promise of these advanced technologies is often realized only by the tool's developers and their close associates. Moreover, ongoing support to maintain and update technologies in non-commercial settings is difficult to obtain.

In contrast, tools that are commercially available need to be sturdy and easy to use, and commercial success often provides the means for continued maintenance and improvements of the underlying technology. This call is intended to formulate business plans that will move useful technologies from non-commercial laboratories into the commercial marketplace by inviting SBIR grant applications for further development of such technologies that are relevant to the missions of the NASA's Human Research Program. The supported research and development will likely include making the tools more robust and easy to use, advancing the Technology Readiness Levels (TRLs) from TRL 3-4 to TRL 6-7 and will likely require close collaboration between the original developers of these technologies and commercial partners.

Biomedical devices currently being developed that this will be focused on are: assisted medical procedure viewer, physiological and medical models, minimally invasive laboratory analysis capabilities, medical imaging techniques and procedures.
Phase I Deliverables: 5 business plans for current NASA/SBIR technology projects. These should include: market analysis; gap analyses reports between current state of 5 NASA biomedical technologies and what would be needed for commercialization/venture capital funding.

Phase II Deliverables: Updated business plans to include the following strategies: FDA regulatory; reimbursement; product adoption; competitive analysis; manufacturing costs; sales; use of proceeds; marketing; clinical trials.

X12.04 Batteries for Oxygen Concentrators

Lead Center: GRC

Advanced high energy battery systems are sought for use in Exploration Medical Capabilities mission applications such as power for mobile oxygen concentrators. There are only a few battery chemistries with a reasonable chance of achieving the target specific energies. Metal/air battery systems are the most likely candidates. The most common type of commercial metal/air battery utilizes zinc/air chemistry and has a practical specific energy of \( \approx 370 \) Wh/kg. While this battery chemistry has a theoretical specific energy of 1350 Wh/kg, it is not possible for this chemistry to meet the specific energy goals for these applications (\( >2000 \) Wh/kg). In addition to zinc/air batteries, aluminum/air batteries are also available in the commercial market, although only in a limited fashion. Aluminum/air batteries have a much greater theoretical specific energy (8140 Wh/kg) and although they currently have a practical specific energy of \( \approx 350 \) Wh/kg, the potential for significant near-term improvement exists. The highest theoretical specific energy for a metal/air battery chemistry is lithium/air at 11,500 Wh/kg giving it and aluminum/air batteries the best potential to realize the high specific energy values needed for Exploration Medical Capabilities mission applications.

The focus of this solicitation is on the development of a high specific energy battery that can meet the following goals:

- Specific energy (battery level) \( >2000 \) Wh/kg;
- Operating Temperature Range from 0°C to 35°C;
- Shelf life \( >2 \) years.

All classes of metal-air batteries (aqueous, non-aqueous, and solid state) as well as other battery chemistries will be considered if they fall within the guidelines of performance. Additionally, the battery system will be used inside a crewed space vehicle and must meet the requisite safety guidelines stated in ³Crewed Space Vehicle Battery Safety Requirements².
Phase I research should be conducted to demonstrate technical feasibility and deliver multiple cell-level demonstration units at the conclusion of the contract. Additionally, a path toward a Phase II hardware demonstration should be shown which leads to the delivery of multiple module-level demonstration units mid-way through the phase II contract and multiple TRL 4 battery-level demonstration units for TRL 5/6 validation and verification testing at the end of the phase II contract.