



NASA SBIR 2015 Phase I Solicitation

H12 Human Research and Health Maintenance

Lead Center: JSC

NASA's Human Research Program (HRP) investigates and mitigates the highest risks to astronaut health and performance in exploration missions. The goal of the HRP is to provide human health and performance countermeasures, knowledge, technologies, and tools to enable safe, reliable, and productive human space exploration, and to ensure safe and productive human spaceflight. The scope of these goals includes both the successful completion of exploration missions and the preservation of astronaut health over the life of the astronaut. HRP developed an Integrated Research Plan (IRP) to describe the requirements and notional approach to understanding and reducing the human health and performance risks. The IRP describes the Program's research activities that are intended to address the needs of human space exploration and serve HRP customers. The IRP illustrates the program's research plan through the timescale of early lunar missions of extended duration. The Human Research Roadmap (<http://humanresearchroadmap.nasa.gov>) is a web-based version of the IRP that allows users to search HRP risks, gaps, and tasks.

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The HRP is organized into Program Elements:Â

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- Human Health Countermeasures.
- Behavioral Health & Performance.
- Exploration Medical Capability.
- Space Human Factors and Habitability.
- Space Radiation and ISS Medical Projects.

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Each of the HRP Elements address a subset of the risks, with ISS Medical Projects responsible for the implementation of the research on various space and ground analog platforms. With the exception of Space Radiation, HRP subtopics are aligned with the Elements and solicit technologies identified in their respective research plans.Â Â

Subtopics

H12.01 Measurements of Net Ocular Blood Flow

Lead Center: GRC

Participating Center(s): JSC

The goal of this SBIR call is the development of rapid and accurate hardware to characterize the net blood flow to and from the eye. Due to limits on instrumentation, most of the literature on ocular blood flow to date has emphasized measurements that only partially characterize the net flow, such as minimum and maximum velocity in a single retinal arterial vessel or choroidal thickness in the vicinity of the fovea. However, there is significant spatial and interindividual variation in these ocular structures, for example, in choroidal and retinal thickness and in arterial and venous branching structures. Consequently, there are likely to be new insights to be gained from examining the choroid and retina from a bulk perspective. Recent advances in high-quality imaging, such as those based on wide-field Optical Coherence Tomography or high-resolution angiography, have allowed increased depth of penetration at high resolution for unparalleled accuracy in choroidal and retinal measurements that extend well beyond the posterior pole of the eye. The ready availability of computational resources renders it straightforward to capture and analyze the entire time history of ocular hemodynamics.

This SBIR solicits novel hardware that can quantify net ocular blood flow in the retina. Measurements of interest include the temporal history of the following:

- Maps of choroidal and retinal thickness, which include near- and far-field contributions.
- Net volume of the choroid and retina.
- Net volumetric blood flow to and from the choroid and retina.
- Pressures and net luminal areas at the entrance and exit of the choroid and retina.

Measurements must be presented in physical units, such as blood flow in milliliters per minute. The measurement system must also process the raw data, either in a real-time or post-processing mode. Data analysis capabilities should include the calculation of the overall time-averaged mean values, as well as the mean waveform over a cardiac cycle. It would be of significant interest if comparable measurements were made simultaneously of intraocular pressure, reference arterial pressure (systemic, brachial and/or ophthalmic artery), fundus pulsation amplitude, and/or heart rate.

Phase I Deliverables - Concept of hardware capable of producing some or all of the above measurements.

Phase II Deliverables - Prototype hardware and data from a pilot study.

H12.02 Unobtrusive Workload Measurement

Lead Center: JSC

Participating Center(s): ARC

Task design and associated hardware and software impose cognitive and physical demands on an operator and thus, drive the workload associated with a task. This solicitation is looking for technologies and methods to measure, assess, and predict astronaut workload unobtrusively, and to extend these technologies to measuring and predicting astronaut workload during long duration operations. Unobtrusive measures would be ones that do not require operators to specifically interact with a technology or provide inputs, and would not interrupt an operator's work.

Astronauts on long-duration missions will potentially have long periods of low workload and short bursts of high workload combined with reduced workload capacity that needs to be taken into account for system and mission design. Both high task demand and reduced workload capacity at any phase of a flight may lead to performance errors, which could potentially compromise mission objectives, and consequently the mission.

Astronauts, mission planners, and system designers require the capability to assess and predict when astronauts will be at a reduced capacity resulting from either work underload or from work overload. An unobtrusive workload tool could be used during development to ensure a system produces acceptable workload, or in real-time, to drive schedule modifications or to adapt interfaces based on the current workload the astronaut is experiencing. Unobtrusive objective measures such as video, voice, thermal infrared imaging or eye tracking methods may be

more appropriate when measuring long duration workload, so long as the technology's credibility is ensured.

Phase I of this SBIR is to complete a review of the current state of the art in automatically, unobtrusively measuring and tracking workload and informing astronaut of such workload levels in scenarios that are applicable to long duration missions. This Phase I effort will identify suitable unobtrusive measurement technologies and the parameters that need to be included in a candidate workload algorithm and subsequently generate the algorithm. NASA has already supported the development of wrist and arm-worn devices, therefore any unobtrusive wearables proposed should consider alternative concepts and/or new implementations of existing wearable technologies. Phase II of this SBIR is to take the current state of the art and recommendations from the Phase I effort to develop an unobtrusive workload measurement tool prototype, and test and validate the tool.

H12.03 Technology for Monitoring Muscle Protein Synthesis and Breakdown in Spaceflight

Lead Center: JSC

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Post flight decrements in skeletal muscle size and function are well documented, however, the true time course of muscle adaptations during long duration spaceflight have thus far been unaddressed. This information is of importance because it can help to identify:

- When the most critical stages of adaption to space are occurring.
- Whether changes are occurring at a constant rate or if they begin to plateau, and if so when.
- Targeted muscle countermeasures to mitigate true muscle loss.

Muscle protein synthesis and breakdown are typically measured via invasive biopsy which will not be feasible during space flight missions. Current terrestrial assays for protein synthesis involve use of stable isotopes to measure incorporation of amino acids into muscle and are determined in muscle biopsy samples. Markers for protein degradation (e.g., MuRF1, Atrogen-1) in muscle biopsy samples are often determined by real time PCR (mRNA expression) or Western blot analysis (protein expression), though these results are primarily qualitative. This subtopic seeks novel, non- or minimally-invasive technologies to measure muscle protein turnover for use in subsequent research studies. The most important measurement would be a synthesis: breakdown ratio indicative of the state of muscle balance (formation, breakdown or stability) as opposed to exact protein synthetic rates. However, absolute protein synthesis and breakdown rates are highly desirable.

This Subtopic addresses the following Human Research Program requirements:

- Risk of Impaired Performance Due to Reduced Muscle Mass, Strength and Endurance
- Gap M24. Characterize the time course of changes in muscle protein turnover, muscle mass and function during long duration space flight.

The technology developed should accurately be able to quantify protein synthesis, breakdown and total turnover.

A successful proposal will include the technologies being considered and detailed test plan for evaluating them during Phase I. A vision for miniaturizing the device and operating the device in microgravity is required.

Phase I Deliverables - Test results and plan for developing a low volume, low mass, easy-to-operate prototype. The expected TRL resulting from the Phase I effort should be 4.

Phase II Deliverables - Prototype in year 1 with minimal human testing in year 2 to demonstrate efficacy. Â Â