



## NASA SBIR 2016 Phase I Solicitation

### H12 Human Research and Health Maintenance

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 exploration 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.

The HRP is organized into Program Elements:

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

Each HRP Element addresses a subset of the risks, with ISS Medical Projects responsible for the implementation of the research on various space and ground analog platforms. The HRP subtopics in this year's solicitation address risks from the Behavioral Health and Performance, Exploration Medical Capability, and Space Human Factors and Habitability Elements.

NASA is investing in technologies and techniques geared towards advancing the state of the art of spacecraft systems through the utilization of the ISS as a technology test bed. For technologies that could benefit from demonstration on ISS, proposals should be written to indicate the intent to utilize ISS. Research should be conducted to demonstrate technical feasibility and prototype hardware development during Phase I and show a path toward Phase II hardware and software demonstration and delivering an engineering development unit or software package for NASA testing at the completion of the Phase II contract that could be turned into a proof-of-concept system which can be demonstrated in flight.

## Subtopics

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## **H12.01 Task Analysis Visualization and Data Management Tool**

**Lead Center:** JSC

**Participating Center(s):** ARC

Task analysis (TA) is a method within the Human-Centered Design process that represents tasks as sequences or concurring steps and actions that are necessary to accomplish goals. It is used to understand and document the sequence of tasks, steps, and the relationship among these in order to indicate how the user or uses performing them. Furthermore, most major NASA programs, such as Orion, call for TA in the verification process. The output of the TA is a Master Task List (MTL) that feeds into design, models, and databases. Designers use the MTL to design systems, subsystems, and components to accommodate crew tasks. Operations personnel use the MTL for operations concepts and crew procedures development. This solicitation invites proposals intending to develop methods and technologies to manage and visualize TA information.

Although recognized as a critical function in design, task analysis is often erroneously overlooked until final design phases when hardware, system, and software designs are too costly to change. It is essential that task analysis be conducted as early in the design process as possible. Task analysis should be conducted iteratively and should be frequently evaluated throughout the design and development process to allow for proper verification of crew task and system design. Furthermore, task analysis should be performed to identify the "critical" tasks, i.e., those tasks that are necessary to successfully accomplish operations and mission objectives. Function allocation is also an important part of task analysis: deciding whether a particular function will be accomplished by the human or the system, or by some combination of humans and systems.

Task analyses for long-duration missions will result in a complex structure of tasks and sub-tasks. Master task lists can contain thousands of tasks that have complex temporal and sequential relations among them that need to be visualized. In order to use the results of a complex task analysis efficiently, there is a need for a robust visualization tool that helps with overviewing, sorting, and interpreting the results. Available commercial tools are not able to deal with the complexity of long-duration mission task analysis data due to the following limitations: cannot easily show simultaneous tasks and tasks performed by multiple operators, difficult to track changes, difficult to search for tasks, few/no summary options, and few/no file export options.

The tool should improve task design and system design by relating tasks and sequences of tasks in an efficient way, making the data more usable and ultimately improving overall design.

Phase I Deliverables - Conceptual prototype of a task analysis data management and visualization tool and final report detailing the conceptual prototype and software development plan including feature and display requirements.

Phase II Deliverables - Completed, usability-tested software tool along with the source code, user's guide, and final report on the development and testing of the tool.

## **H12.02 Passive Vital Sign Monitoring**

**Lead Center:** ARC

**Participating Center(s):** JSC

Human exploration missions beyond low earth orbit (LEO) require physiologic monitoring of the crew. These highly mass, volume, and power constrained missions require significant leveraging of resources by all vehicle subsystems. To date, research and development resources involving physiologic monitoring have been allocated to crew worn devices to measure these physiologic parameters. NASA recognizes that there are numerous worn devices that provide monitoring, but all of these devices still require mass, volume, power, and crew time to operate. The exploration vehicle, however, will already provide a variety of technologies that could potentially be used to extrapolate human physiologic data in a more passive and continuous manner that does not require additional mass, volume, power, and crew time to operate. Examples of technology embedded within the vehicle include, but are not limited to, high quality video and audio, wireless networks, radio frequency identification, and other electromagnetic (EM) sources/detectors.

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NASA requires new technologies that will exploit vehicle infrastructure to passively and continuously monitor the crew's physiologic parameters. NASA is amenable to improving existing vehicle technologies to extract crew data, but also for incorporating novel and innovative technologies that could be added to the vehicle or the crew. Examples of technology developments can include, but are not limited to, heart and respiration rate detection via HD video, temperature detection via infrared camera, or circadian rhythm phase detection via automated urine analysis. Some of the parameters that would be desirable for monitoring include:

- Heart Rate.
- Oxygen Saturation Level.
- Respiration Rate.
- Blood Pressure (diastolic/systolic).
- Core and/or Skin Temperature.
- Urinary 6-sulfatoxymelatonin.

A list of anticipated medical conditions that would require monitoring can be found on the Exploration Medical Condition list (EMCL), which may be found on NASA's Human Research Wiki:

(<https://humanresearchwiki.jsc.nasa.gov/index.php?title=ExMC>).

Phase I Deliverables - Conceptual prototype of a monitoring device/algorithm and final report detailing the conceptual prototype and hardware/software development plans.

Phase II Deliverables - Completed monitoring device/algorithm, and final report on the development, testing, and validation of the tool.

## **H12.03 Novel Imaging Technologies for Space Medicine**

**Lead Center: GRC**

**Participating Center(s): JSC**

NASA is seeking novel medical imaging techniques in two areas: software-based ultrasound and portable x-ray.

### **Software-Based Ultrasound**

Ultrasound has been, and will continue to be for the foreseeable future, NASA's workhorse modality for internal imaging in space. Ultrasound's smaller footprint, lower power consumption and lower emissions across the electromagnetic spectrum make it particularly well-suited for space medicine. Ultrasound also provides additional medically useful capabilities outside the realm of imaging, such as quantitative ultrasound diagnostic techniques, and therapeutic techniques that utilize the energy in the ultrasound signal itself. NASA's commitment to ultrasound has led to the development of the Flexible Ultrasound System (FUS), which is a software-based, state of the art clinical scanner specially adapted to support the development of novel research in ultrasound. The FUS may be thought of as an "ultrasound development platform". It features software-based beam forming, scanning and receiving on up to 192 channels, dual-probe operation, high power support, and full access to the radio frequency (RF) data. Developers using the FUS may implement their algorithms and techniques in an Application Programming Interface (API) that supports both Matlab and C++.

The ground-based demonstration of the FUS will begin in April of 2016 and will potentially last for several years. NASA requires novel ultrasound-based diagnostic and therapeutic techniques for diagnosing and/or treating conditions on the Exploration Medical Condition List (EMCL), which can be found on NASA's Human Research Wiki at – (<https://humanresearchwiki.jsc.nasa.gov/index.php?title=ExMC>).

NASA is amenable to improving existing uses of ultrasound for both diagnostic and therapeutic purposes, but also for completely novel and innovative uses of ultrasound for diagnosis or treatment of any conditions on the EMCL. These novel techniques, which can include both hardware and software, should be developed with integration onto the FUS in mind, either by direct development on a system loaned to the developer by NASA or by

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porting the application from another system to the FUS at a later stage in the grant. Current examples of FUS integration include novel probe and algorithm development to quantify bone density and efforts to move/break up renal stones.

### **Portable X-Ray**

Although ultrasound remains NASA's workhorse modality for internal imaging of body parts on spaceflight missions, there are gaps in ultrasound's ability to diagnose certain medical conditions that might arise during spaceflight, particularly to deep space destinations. Ultrasound is not as well suited to diagnosing dental conditions and certain musculoskeletal (MSK) injuries as traditional radiographic (x-ray) techniques. A set of limiting factors have precluded the use of x-ray devices on-orbit. These limitations include the relatively higher volumetric footprint, higher power requirements and higher electromagnetic (EM) emissions (particularly ionizing radiation, both in terms of dosage delivered to the crew and stray emissions) of x-ray devices and other imaging devices.

NASA needs new technology developments to overcome these limitations and ensure the diagnosis of dental and MSK conditions are more compatible with human spaceflight. NASA is amenable to improvements in existing x-ray devices and/or other novel and innovative imaging technologies. Example technology developments include, but are not limited to, those leading to more efficient x-ray sources, more sensitive detector technologies, improving image quality, reducing delivered EM dosage, and expanding the usefulness of handheld portable x-ray devices and other imaging devices to address dental and MSK conditions. A complete list of dental and MSK conditions can be found on the Exploration Medical Condition list (EMCL), which may be found on NASA's Human Research Wiki -

<https://humanresearchwiki.jsc.nasa.gov/index.php?title=ExMC>).

Proposals should address one of the two aforementioned technology areas.

The expected deliverables for Phase I for the software-based ultrasound are:

- Conceptual prototype of a novel device/algorithm.
- Final report detailing the conceptual prototype and hardware/software development plans.

The expected deliverables for Phase II are:

- Completed FUS device/algorithm.
- Integrated testing on FUS platform.
- Final report on the development, testing, and validation of the tool.

The expected deliverables for Phase I for the portable x-ray are:

- Conceptual prototype of an imaging device.
- Final report detailing the conceptual prototype and hardware/software development plans.

The expected deliverables for Phase II are:

- Completed imaging device.
- Final report on the development and testing of the tool.