Translational Research Institute for Space Health
2450 Holcombe Blvd
TMCx
Houston, TX 77021

Translational Research Institute for Space Health (TRISH)

Translational Research Institute for Space Health (TRISH)

Broad Institute Announcement

Overview Information

The Translational Research Institute for Space Health (TRISH), hereafter generally referred to as "we, us, our, or TRISH" is an applied space health research institute that funds disruptive, high-impact scientific studies and technologies to equip astronauts for deep space exploration. Founded on October 1, 2016, TRISH works in partnership with NASA's Human Research Program (HRP) through Cooperative Agreement NNX16AO69A. Led by Baylor College of Medicine's Center for Space Medicine, TRISH's consortium leverages partnerships with Caltech and MIT. More details on TRISH, its mission and funding opportunities can be found on our website. Join TRISH's Orbit Rendezvous to stay connected with TRISH's community.

TRISH relentlessly pursues and funds novel research to deliver high-impact scientific and technological solutions that advance space health and help humans thrive wherever they explore, in space or on Earth. Since its inception, TRISH has funded projects that have advanced medical science especially for use in remote environments, a trait useful in space and on Earth. As an institute dedicated to promoting space health discoveries and technologies, TRISH is accelerating research that will benefit all people with a future in deep space and here on Earth.

To achieve TRISH's vision of helping humans thrive in deep space we know that we must solicit innovative research. TRISH utilizes many different procurement mechanisms that allow us to work effectively with both academic institutions and companies at different stages of maturity. This breadth allows us to award research funding to approach a problem in the most efficient way possible. In this Broad Institute Announcement, we will outline the TRISH science initiatives that govern the areas of interest for scientific research investment. This document does not include any specific solicitations for proposals but is a resource for those interested in proposing to TRISH to understand our vision. This is a living document that may be updated as necessary by TRISH. For open TRISH solicitations please refer to the following sites: https://www.bcm.edu/academic-centers/space-medicine/translational-research-institute/funding, Grant Research Integrated Dashboard (bcm.edu), NSPIRES - NASA Research Opportunities Online (nasaprs.com).

Table of Contents

Science ENterprise to INform Exploration Limits (SENTINEL)

NASA's Artemis missions will place astronauts in lunar orbit and on the lunar surface where they will experience deep space exposure on par with the Apollo missions. As the mission profiles progress, the Artemis exposure durations will far exceed the prior Apollo experience. Therefore, it is imperative that the space life science community have the tools to study the effects of long duration, deep space exposure and test ways to prevent and mitigate its potential negative effects. The upcoming Artemis missions provide an unprecedented opportunity to understand the risks of deep space exploration as well as approaches to manage those risks.

The Science ENterprise to INform Exploration Limits (SENTINEL) initiative is the TRISH effort to build automated microphysiological systems (MPS; also known as 3D tissue/organ chips) that also have in-line sensing capabilities to self-regulate and provide data to the astronaut crew as well as scientists on the ground thus overcoming the need to return samples to Earth for analysis. The MPS, tissue or organs-on–a-chip constructs have the potential to address several knowledge gaps in the impacts of the deep space environment. This will greatly improve upon the current primary methods of characterizing space exploration risks that use ground analogs and the International Space Station (ISS) providing limited or incomplete translatability and requiring sample return to Earth for analysis for the ISS research.

By using automated and self-reporting MPS, the lunar surface and vicinity can enable critical health and performance studies. These systems can also be built as single organs or as systems of organs allowing for interactions to simulate responses that might occur within the human body in space. Successful research and technology development in this area would improve the capability to test the effects of the realistic, deep space radiation environment on a tissue as well as the impacts of medications or other interventions. In addition, these systems are also being matured and validated with the goal of facilitating personalized and precision medicine. One can imagine the day when physicians can use cells acquired from a patient to diagnose and test treatments on that individual's engineered tissues and organs before ever having to introduce more risk to the patient. This is also the vision for space explorers given the remote, hostile, and austere environment in which they live and work that requires certainty and disciplined risk management. This approach during the Artemis missions and emerging commercial spaceflight opportunities will allow the MPS payloads to experience deep space exposures similar to those anticipated for exploration class missions and return data throughout the deep space exposure. Thus, these MPS would enable researchers to conduct time-course, mechanistic and countermeasure development studies while the MPS remain in space.

TRISH plans to advance these state-of-the-art platform capabilities and move towards autonomous systems in upcoming solicitations and projects. In the future, these tissue chips could be utilized for personalized medicine: with a customized tissue chip of an individual astronaut, sent into deep space before or with an astronaut, thus assisting in the overall assessment of the risks of the space environment on that individual's physiology. The end goal of the SENTINEL initiative is to provide the space life science research community and ultimately NASA space medicine with effective and reliable tools to preserve astronauts' health span and ensure a performance-ready state during and after the mission.

Topics or Focus Areas of Interest

Automated Tissue Chips

The development of autonomous MPS systems that do not require human tending. This effort will enable studies to be conducted on uncrewed missions or those with limited crew time. Once autonomous capabilities are engineered, and a platform developed, the vision would be to integrate any tissue of interest into the platform for testing in concert with others.

Automated Analysis in Tissue Chips

The development of automated in-line sensing and in-situ analysis capabilities that can be broadly applied to various types of MPS systems. These capabilities would eliminate the need for a human in the loop analysis and sample return by only transmitting data back to Earth.

Countermeasure Development and Testing

Following the successful development of the first two topics/focus areas listed above it will become important to use this platform to test countermeasures to well understood spaceflight risks that might be useful to space travelers in the future.

Medical System Architecture

The Medical System Architecture initiative's goal is to enable space and ground-based medical teams and systems to monitor and access crew health status and research study progress even when the astronaut is far from Earth's surface. Future missions to the moon and beyond will require multiple vehicles, built and operated by various companies with astronauts transitioning between them on a regular basis, making it challenging to leverage biomedical data management requirements across all vehicles. Continuity of access to health and performance data is key for safeguarding the astronaut, assessing immediate health and performance risks, and making informed and timely decisions. The Medical Systems Architecture initiative involves the development of a data acquisition, data ingestion, data management, and data usability framework to support network infrastructure, biomedical peripherals, and end users of the collected data.

The Medical System Architecture will be developed in phases starting with the Human and Environmental Research Matrix for Exploration of Space (HERMES) solicitation to design and build the networking infrastructure to facilitate the movement, storage, and distribution of biomedical data from source to user. The HERMES funding opportunity solicited for the predominantly software based, semi-autonomous platform that seamlessly intakes, manages, and moves biomedical data gathered for research and clinical purposes and enables the data to follow the astronaut to any spaceflight venues they visit, whether that be a spacecraft or any other future space destination.

The envisioned platform, when fully complete, will allow continuity across missions and space vehicle operators as astronauts adapt to new space environments. By aggregating medical, research, environmental, and mission data together and having it follow the crewmember, all the necessary data is aggregated proximal to the astronaut and available to develop and test autonomous medical systems of the future and allow more seamless remote medical care until autonomy is established.

Topics or Focus Areas of Interest

Human and Environmental Research Matrix for Exploration of Space (HERMES)

Develop a robust, scalable, and interoperable network platform that can be used in different spaceflight vehicles that will enable usability and access to a spaceflight participant's data by algorithmic users, human users on Earth (including clinicians), researchers and the individual themselves.

Build an Evidence Base

Develop the evidence base to feed into future algorithmic users such as artificial intelligence and machine learning tools that use the data collected in HERMES and can aid in remote diagnosis of future health concerns of space travelers. Evidence base will be especially helpful during missions where communication delays are lengthy.

Develop AI and ML Tools

Develop artificial intelligence and machine learning tools to begin interpretation of health status information gained through HERMES and made available to crew and doctors on the ground to aid in remote diagnosis of future health concerns of space travelers. This approach will be especially helpful when astronauts are far from Earth and communication delays exist.

Advance Remote Medical Tools

Advance medical technology tools that can easily integrate into the HERMES system. Multi-use tools are of great interest. Small footprint, low burden tools (low mass, power, volume, and training needs) that are capable of producing clinical quality data for diagnostic and therapeutic capabilities.

Biology Engineered for Exploration of Space (BEES)

TRISH has identified the importance of a robust food system to support future exploration missions. This is a broad initiative that encompasses food but also includes other scientific capabilities like synthetic biology and engineering biology which has much to offer in terms of solution space, and we know that this could impact other risks besides food itself. For this initiative TRISH is actively gathering information on ideal focus areas and road-mapping to inform future solicitations.

The current food paradigm for the ISS requires resupply of fresh and non-perishable food. Astronauts receive fresh foods, such as fruits and vegetables, whenever there is a vehicle sent to the ISS with new crew members or a resupply of needed materials. These fresh foods are not preserved, dehydrated or pre-packaged. The diversity and freshness of this food positively impacts nutritional needs and behavioral health for crew. Future missions are beyond the possibility for resupply, and unless augmented with new solutions, the current approach will rely on a food system based on pre-packaged meals. While the exact plans for exploration crewed missions to Mars have not been finalized, it is likely that due to the mass of food needed to sustain several crew members for an approximately 3 year mission, food and other supplies may be sent in a separate pre-supply vehicle prior to the launch of the crewed vehicle. It is likely that such a vehicle would be sent prior to the crewed mission to avoid the risk of astronauts arriving on the surface of the planet to find that their food supply vehicle did not arrive. In this potential scenario the pre-supplied pre-packaged food may have been sitting on planet for up to 5 years before the crew is there to eat it. In this situation, food may not retain its nutritional value beyond the expected mission duration. Gaps remain in the knowledge of how to manage this potential loss in nutritional value to ensure the best health and performance of astronauts on long-duration missions.

Without the possibility of resupply from the ground, future long duration missions would need to grow crops in order to have “fresh food”. Mental health benefits of raising plants and then eating these fresh foods have been documented. However, growing plants on the ISS in Low Earth Orbit (LEO) thus far has proven to be costly in terms of supplies, physical space and energy. These are all things that will be at a premium on future long duration missions. While growing food in space or on a planetary body other than Earth is of interest, there are many advancements required in not only engineering but possibly genetic modification and synthetic biology to make it realistic and feasible for long duration missions. It is worth considering that if growing plants is beneficial beyond the actual food it produces, (i.e. mental health), then there might be other beneficial things that plants can provide. One example of previous research TRISH funded in this area is “A Plant-Based Platform for “Just in Time” Medications” by Dr. Karen McDonald focused on growing biologics for medications in lettuce. This project is an example of taking advantage of an existing capability, in this case growing lettuce in space, that could be used to bolster other capabilities, in this case growing new biologics during a mission.

Novel food systems and scientific capabilities are necessary to enable space exploration on late Artemis missions and beyond. To address this goal, TRISH understands that out–of-the-box thinking will be needed to maintain healthy nutrition for astronauts at the lowest mass, power, and volume trade-off. Delivering new solutions may help to bridge the existing gap in the food system. This effort could be linked to other systems throughout the spacecraft, such as bioregenerative life support. Virtual workshops held by the Institute in 2023 and 2024 will begin the conversation about innovative approaches to food and nutrition. Recordings of these workshops can be found here.

Topics or Focus Areas of Interest

Figures of Merit Analysis

Many food and nutrition tools, alternatives, uses and innovations have been developed over the years by both NASA funding as well as other academics and companies around the world. Many of these technologies have a proven evidence base of the technical credibility or proof-of-concept of their capability. However, there is often no clear understanding of the Figures of Merit (FOM). The FOM refers to the mass, power, volume, time, money/cost and risk in terms of successful usage that would be required to actually bring a particular technology into use in spaceflight. TRISH sees the undertaking of such assessments as a beneficial first step to enable the adoption of new solutions in future spaceflight mission architecture.

Enhancing eXploration Platforms and ANalog Definition (EXPAND)

TRISH developed a program enabling space health research through partnerships with commercial space providers and their customers. Initiated with the Inspiration4 mission in 2021, TRISH launched Enhancing eXploration Platforms and ANalog Definition (EXPAND), the first-of-its-kind research program to study human health and performance in private spaceflight participants. TRISH's EXPAND Program collects pre-, in-, and post-flight data from private spaceflight missions and houses it in a centralized database.

In 2023, TRISH continued to build upon this new program by (1) harmonizing NASA's Standard Measures and TRISH's Essential Measures, (2) supporting the AX-2, and Polaris Dawn missions, (3) developing a TRISH EXPAND Database in which to store all data from commercial spaceflights, (4) developing a Space Omics program and biobank in collaboration with Baylor College of Medicine's Human Genome Sequencing Center, and (5) establishing a Data Privacy and Release Board (DPRB).

The EXPAND program also works with spaceflight analogs to conduct ground-based testing on countermeasures and technologies in remote and austere environments that have similarities to space travel. These analogs are also used to develop ground-based control samples that, like those that go to space, have experienced stressful extreme environments. We see the EXPAND program as a testing ground for mature technologies that have proven themselves in earlier testing and are ready to be tested in analog and spaceflight environments. Successful technologies, countermeasures and other solutions developed through TRISH's initiatives as well as via other funding sources could be tested through the EXPAND program once they have proved themselves in a laboratory environment.

In future years TRISH plans to continue to grow its relationships with commercial spaceflight companies and offer EXPAND as a complement of scientific studies that can help to bring benefit not only to support future Artemis goals but also to enable better healthcare on Earth as well.

TRISH Essential Measures

TRISH has developed a complement of projects that are to be deployed in all commercial spaceflight missions to standardize and ensure that essential research data is collected. This complement has been designed to maximize the collection of valuable information while minimizing the crew time and up-mass requirements. Given that all current commercial spaceflight missions are short in duration, these projects have been selected based on physiologic changes expected in missions less than one month. TRISH Essential Measures also collects data, samples, and medical data pre- and post-flight in addition to including environmental and mission data from the spacecraft. While this complement of research is designed to remain the same between missions and thus new studies to it will be rare, the data and samples collected and stored in the EXPAND database and will be available for hypothesis driven research as reviewed by the DPRB, both described below.

Space Omics Project Assays

The Space Omics project, part of EXPAND Essential Measures and enabled by Baylor College of Medicine's Human Genome Sequencing Center, includes state-of-the-art assays and clinical grade CLIA (Clinical Laboratory Improvement Amendments) pharmacogenomics and pathogenic variants analyses. All data collected for Space Omics will be stored in the TRISH EXPAND Database.

The EXPAND Database

TRISH's goal is to provide a state-of-the-art integrated medical, research, and environmental knowledge bank as well as a repository for biological samples. EXPAND captures research, medical data and biospecimens from all volunteering commercial spaceflight participants. Requests to use this data or acquire bio-samples for hypothesis driven research will be reviewed by the DPRB, described below, on a case-by-case basis.

Data Privacy and Release Board

The EXPAND Data Privacy and Release Board (DPRB) was established to ensure that spaceflight data and rare samples are used in the most appropriate way possible while maintaining the privacy of the spaceflight participants themselves. The DPRB has five members with institutional and scientific discipline diversity to ensure a well-rounded board. The purpose of the DPRB is to review data and bio-sample requests made through the EXPAND data/sample request process.

Analogs

TRISH has an existing relationship with the Australian Antarctic Division, one of the more austere Antarctic stations which does not have any access to resupply or evacuation for many months and uses a one health care provider model. TRISH is also building relationships with other analog destinations.