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# NASA'S TRANSLATIONAL RESEARCH INSTITUTE FOR SPACE HEALTH

**2016-2028**

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## **STRATEGIC PLAN**

2021-2024



*April 6, 2021*

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FROM THE DIRECTOR

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**By solving some of NASA's most intractable health challenges in deep space, the Translational Research Institute for Space Health is challenging the boundaries in medicine, science, technology and engineering to advance humanity as a multi-planetary species.**

Humans exploring deep space will be physically, intellectually and emotionally challenged in ways beyond our current understanding. The Translational Research Institute for Space Health (TRISH) invests in health and human performance research and technology that will enable space explorers to successfully complete their mission. This Strategic Plan will guide the Institute's work over the next three years.

Partnered with and funded wholly by the NASA Human Research Program (HRP), TRISH relentlessly seeks and supports high-impact scientific, technological, clinical, and psychological advances that will enable any human to explore space safely.

NASA's deeply ingrained safety culture ensures steady advancement to concrete objectives maintaining a "failure is not an option" motto. TRISH, on the other hand, is an innovation institute. It exists to bring creativity, adaptability, risk taking, and ambitious thinking in sourcing and seeding emerging health and human performance investments. These investments are thoughtfully made in areas that are operationally relevant and yield solutions that are adaptable to meet NASA's needs.

TRISH leverages deep science, medicine, and technology ecosystems via its consortium members, a premier medical school (Baylor College of Medicine) and prestigious technical institutes on the east and west coasts (Massachusetts Institute of Technology and California Institute of Technology). TRISH has strong relations with many other universities, and with industry, particularly in the medical, biotechnology, and technology sectors. By engaging a wide and deep network of entrepreneurs, investors, start-ups, engineers, scientists and clinicians, TRISH is in a position to help NASA more

quickly and efficiently reduce the anticipated risks to human health and performance.

TRISH is inventive not only in the kind of science and technologies it sources and funds, but also in its grant procurement approaches and the diversity of partners engaged. Through creative programs and partnerships, and the dissemination of relevant scientific content, TRISH continues to draw in diverse problem solvers that are new to space biomedical research and enroll them in the mission of the Institute.

Bidirectional trust and good communication between TRISH and NASA are a large part of why the Institute has been successful. Both parties constantly iterate how they exchange information and transition products and knowledge. NASA's trust in TRISH partly manifests through the high degree of autonomy that the institute is afforded. NASA encourages TRISH to take chances and to embrace high-risk creative endeavors in keeping with lessons learned from successful entrepreneurs; i.e., the value of learning from failing fast and failing often and not being afraid of failure.

Few innovations successfully transition into the hands of users where they can truly impact and improve operations or health and performance. This "valley of death" is a common problem. TRISH is committed to helping NASA accept and integrate its products and new knowledge into its research road map or operations.

To land women and men on the Moon and Mars and return them home healthy, we must reinvent healthcare so it can be delivered off the planet. The positive consequences of our work in developing new capabilities will impact all of humanity.

Onward,

**Dorit Donoviel, Ph.D.**

April 6, 2021

# EXPLORING HEALTH'S NEW FRONTIERS

The Translational Research Institute for Space Health (TRISH) is a lean, virtual institute partnered with the NASA Human Research Program (HRP) to solve the challenges of human deep space exploration. We find and fund disruptive, breakthrough approaches that reduce risks to human health and performance.

The Institute's core components are the Translational Research Program, Scientist Program, and Supporting Program.

- *The **Translational Research Program** makes up the Institute's research portfolio. TRISH supports both high-risk, early-stage research as well as more mature, late-stage health technologies that can be modified for use by astronauts on the way to Mars.*
- *A **Scientist Program** educates and excites the nation's brightest minds about space health research. This program attracts researchers of all backgrounds and career strata with a special emphasis on bringing auspicious trainees into our community.*
- *The **Supporting Program** connects the general public to the mission of humans exploring deep space. TRISH engages space health enthusiasts to learn about astronauts' health delivery needs and the translation of space-related technologies to everyone on Earth.*

TRISH's programs all focus on providing exceptional research deliverables and human capital to NASA that will impact spaceflight for generations into the future. We also recognize that the next leap of space flight involves bringing people across the spectrum of health, backgrounds, sex/gender, etc. to venture into the unknown through both NASA and commercial spaceflight companies. The Institute advocates for and advances space health for the benefit of all future space travelers.

To develop the research and technologies that will help all of humanity, we must recruit new, diverse researchers and thinkers into our mission now. All people have a future in space if we make room for them today.

The Institute is a consortium led by Baylor College of Medicine and includes Caltech and Massachusetts Institute of Technology. These partners facilitate collaboration, amplify scientific learning and outreach, and provide a large network support.

This strategic planning document outlines the Institute's priorities through 2024.

*A SpaceX Falcon 9 rocket carries the company's Crew Dragon spacecraft on NASA's SpaceX Demo-2 mission to the International Space Station with NASA astronauts Robert Behnken and Douglas Hurley onboard on Saturday, May 30, 2020, at NASA's Kennedy Space Center in Florida. Image Credit: NASA/Bill Ingalls*



*Composite image of the moon created using Clementine data from 1994. Image Credit: NASA Goddard*

**VISION**  
HELPING HUMANS THRIVE IN DEEP SPACE

**MISSION**  
TRISH leads a National effort in translating cutting edge emerging terrestrial research into applied space flight human risk mitigation strategies for exploration missions.

**CORE VALUES**

**BOLDNESS**  
*Risk is necessary to achieve disruptive progress in space health. We find comfort in uncomfortable ideas and fund research that others consider unfundable.*

**COOPERATION**  
*Seeking great ideas also means learning from new people, our investigators, and the space health community. Innovation does not happen in silos; we move forward together.*

**CREDIBILITY**  
*Self-discipline manifests in the highest-quality science and complete commitment to rigor.*

**ENTREPRENEURSHIP**  
*The programs and research opportunities in place today are not monolithic. New funding mechanisms and techniques will lead the path toward the countermeasures and technologies of tomorrow.*

**IMPACT**  
*We understand that space health has similar issues as terrestrial health. Our goal to create thriving astronauts in space must also enhance life of Earth.*

**PLAYFULNESS**  
*Celebrate discovery of our universe, our planet, our bodies, and our infinite ability to explore and learn. Remain gleefully curious always.*



*The first high-resolution, color image to be sent back by the Perseverance rover in 2021. Image Credit: NASA/JPL-Caltech*

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# TRAJECTORY TO 2024

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## **STRATEGIC GOALS**

To execute the Institute mission and build towards our vision, TRISH will prioritize six strategic goals:

1. To deliver to NASA state-of-the-art innovations, knowledge, and capabilities that can safeguard the health and performance of humans in deep space based on NASA's highest priority risks – first Moon, then Mars.
2. To build confidence in our research findings, TRISH will **increase the "N"** by uncovering new opportunities to increase the available data points on space travelers.
3. To be inclusive with regards to considerations of sex, gender, age, socioeconomic status, orientation, race and ethnicity in our research results, researchers, and outreach activities.
4. To drive the future of health in space and on Earth, TRISH will raise awareness to attract a broad **coalition** of problem solvers for NASA's human exploration activities.
5. To offer learning opportunities that cultivate a future workforce for the space industry, and a diverse, multi-generational pipeline of New to NASA space health researchers and professionals.
6. To seek creative external funding opportunities that can further advance TRISH-funded projects through follow on funding for terrestrial health.

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## DELIVERING INNOVATION

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**GOAL 1.** *To deliver to NASA state-of-the-art innovations, knowledge, and capabilities that can safeguard the health and performance of humans in deep space based on NASA's highest priority risks – first Moon, then Mars.*

Achieving optimal health for astronauts in deep space requires both immediate and far-future innovations. To meet these distinct needs, TRISH funds early-stage, emerging research with a potential for high impact as well as more mature, late-stage technologies that can be more readily translated to spaceflight.

To support this approach, TRISH is pursuing game-changing research and technologies that can be used by astronauts currently preparing to go to the Moon or the travelers that will crew Mars missions in the 2030s.

TRISH priorities align with HRP's Red Risks that define the greatest challenges to tackle for safeguarding human health and performance in deep space.

The Institute will prioritize multi-pronged approaches to developing resilience to the combined stressors of spaceflight; and will remain vigilant to emerging or unaddressed medical and behavioral concerns in space.

**Key Institute priorities supporting Goal 1:**

### SYNTHETIC BIOLOGY & ADVANCED MATERIALS

A growing volume of research uses cellular and molecular tools to drive synthetic biology in areas relevant to space exploration, including functional foods, materials, pharmaceuticals and environmental enhancements. TRISH is seeking out the most cutting-edge research in synthetic biology for the development of 1) novel countermeasures including functional food, 2) therapeutics on demand and 3) augmented, living environments that can reduce multiple high-priority spaceflight health risks including radiation shielding and other mission protections.

### DEEP SPACE MEDICAL SIMULATOR

As humans plan for space missions further and further from Earth, the increased distance from

Earth brings challenges of no resupply, no real-time communication, and no immediate return to Earth should a dire medical event occur. TRISH will lead the way in developing a simulated environment that will mimic a mission to Mars, in order to test our products, assumptions, and potential solutions. From the safety of Earth, this virtual tool that will allow NASA to anticipate the unknown in pursuit of protecting future human crew, update medical training and procedures, and continually test the medical capability of the future.

## **HARVESTING FROM HOTBEDS OF INGENUITY**

TRISH's consortium of BCM, Caltech, and MIT, engages the nation's hotbeds of ingenuity in medicine, science, and engineering in space health research. TRISH has already initiated successful seed space health innovation programs at Caltech and MIT. Overseen by the Lead Scientists at each of these institutions, modest investments are made in high-risk but potentially game-changing research through a competitive solicitation process. At BCM, TRISH headquarters scientists serve as faculty mentors to industrious Center for Space Medicine medical students who execute projects at no cost to TRISH and publish peer-reviewed papers on a variety space medicine topics.

## **TRANSITION TO NASA**

Close alignment between TRISH and NASA has led to great success in building a library of technology and research deliverables. We will work to ensure that the potential impact of all of TRISH's previous and current investments is fully understood and considered by NASA stakeholders.

Three initiatives will assist with this. One, TRISH will continue to work with HRP to identify the most promising advances in the TRISH portfolio. Two, TRISH will demonstrate value through transition grants which will further develop a nascent invention or test it in an analog or in spaceflight. Three, TRISH will create a visually vivid repository of its previous and current investments accessible to future NASA managers as mission needs arise.

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## INCREASING THE "N"

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**GOAL 2.** *To build confidence in our research findings, TRISH will increase the "N" by uncovering new opportunities to increase the available data points on space travelers.*

To date, humanity's space explorers can be described as the brave few. However, humanity is on the cusp of a new age of exploration, as commercial space partners rapidly expand the flight volume and decrease costs. In the near future, short-duration low-earth orbit experiences will be within reach for private citizens. TRISH is preparing for this future by advancing high-impact health research and products.

The rapid increase in spaceflight participants represents a unique opportunity to collect biometric data and rapidly vet healthcare technologies for use in zero-g. TRISH is building strategic partnerships with commercial space companies, the Australian Antarctic Division and more, to expand existing capabilities and grow the data points needed to design personalized health and performance solutions for everyone. What we learn from these additional points will inform future deep space mission concerns.

**Key Institute priorities supporting Goal 2:**

### **LEVERAGING PRIVATE SPACEFLIGHTS FOR SPACE HEALTH RESEARCH**

Humanity is on the cusp of opening human space travel to a "space rush". As commercial spaceflight programs advance their launch technologies, the cost for a trip to space will fall, thereby enabling more humans to break out of the confines of our planet. TRISH will lead a national initiative to collect, monitor, and securely store the health research data of these private space travelers. TRISH is building strategic partnerships with SpaceX, Blue Origin, Axiom, Space Adventures and more, to expand space transportation capabilities and support a safe, enjoyable voyage for all humans to the final frontier of space.

### **GLOBAL PARTNERSHIPS FOR NEW TERRESTRIAL ANALOGS**

Few high-fidelity spaceflight relevant analogs exist on Earth, thereby contributing to the sparse research pool available for use by the space health community. As a result, TRISH has bolstered its engagement of experts from the pharmaceutical industry to help the Institute address the low N

problem. In the area of rare diseases, the National Institutes of Health (NIH) and pharmaceutical companies have wrestled with similar challenges. TRISH will examine the possibility of applying lessons learned to improve analyses of limited spaceflight datasets. For example, existing terrestrial datasets may assist in developing predictive analyses for space-related research studies.

TRISH is also partnering with the Australian Antarctic Division (AAD) to conduct research in sparsely populated, extremely remote sites. The small teams are isolated for 9 months at a time with no possibility of evacuation. Non-medical crew must train and execute medical care autonomously much like on a deep space mission. TRISH will conduct studies in collaboration with AAD to test medical and mental health innovations in this operational setting which serves as an excellent analog for deep space exploration missions.

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## INCLUSIVE SPACE HEALTH

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**GOAL 3.** *To be inclusive with regards to considerations of sex, gender, age, socioeconomic status, orientation, race and ethnicity in our research results, researchers, and outreach activities.*

We go to space as a species. As we journey further and build habitats off our planet, we want to make sure every human – not just a group of select humans – can do so safely. Personalizing medicine is key to enabling humanity’s exploration of space.

TRISH is driving toward an inclusive future that recognizes the individual differences among our species and builds protections and countermeasures for all through personalized medicine. To accomplish this goal, TRISH encourages the study of differences in sex, gender, ethnicity and exposures in its funded research.

TRISH will deploy funding mechanisms, programs, outreach and leverage NASA EPSCoR funding to grow a diverse space health universe.

**Key Institute priorities supporting Goal 3:**

### **HUMAN PERSONALIZATION & RADIATION COUNTERMEASURES**

TRISH is driving towards an inclusive future that recognizes the individual differences among our species and builds protections and countermeasures for all through personalized medicine. Further enhancements in human-based tissue engineering will allow us to better understand the impact of space hazards, such as radiation exposure on human physiology and provide a human model for countermeasure development. By taking advantage of inducible pluripotent stem cells in these engineered platforms, a component of this goal is to learn how sex, gender and ethnicity plays a role in spaceflight risk susceptibilities. These “tissue chips” will help us understand how our individual differences can confer resilience under extreme conditions, and how to identify the most effective and safe personalized countermeasure regimen in the event that an adverse medical scenario were to occur. A near-future bold next step would be to leverage tissue chip technology to place diverse human cell samples on the moon in a unique environment for radiation studies.

TRISH will invest in a plethora of novel and unusual radiation countermeasures which will be tested

in a deep space radiation environment (lunar orbit or equivalent) on samples from a variety of humans to determine the extent and universality of efficacy.

### **CREATING SPACE FOR DIVERSE INVESTIGATORS**

TRISH will design new programs and funding mechanisms to support diverse researchers and enhance minority representation. TRISH is using a three-part strategy to close the diversity gap. In Phase One, TRISH and a partner will conduct a survey and market analysis to determine how TRISH can be more attractive to specific populations as well as produce a strategic roadmap and implementation plan, including success benchmarks. In Phase Two, TRISH will create an outreach strategy and propose partnerships with organizations recommended in the first phase. Phase Three will involve creating opportunities that enable diverse engagement.

To assist the Institute in increasing diversity in space health research, TRISH will convene a small Diversity Advisory Board that evaluate allocations, spending, and evaluate progress, and efficacy.

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## BUILDING A COALITION

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**GOAL 4.** *To drive the future of health in space and on Earth, TRISH will raise awareness to attract a broad coalition of problem solvers for NASA's human exploration activities.*

Enhancing health for astronauts intrinsically means enhancing health on Earth. NASA has an extensive history of taking originally space-related advancements and applying them in everyday life. TRISH recognizes that its research and technologies have a role to play in increasing quality and access of Earth-based healthcare.

TRISH invests in terrestrial products that can meet a need for space, and in doing so, is advancing those products for Earth as well. In addition, we break down and simplify NASA's research needs and the latest space health results for the general public. Through multimedia and communication capabilities, we aim to increase the number of researchers working on the challenges to astronaut health and performance.

**Key Institute priorities supporting Goal 4:**

### VIRTUAL PORTFOLIO

TRISH will stand up a virtual research portfolio to educate, inform and inspire a variety of audiences. This fully immersive virtual experience will allow NASA stakeholders, potential proposers and public audiences to engage with the future of human health and performance, which will take place beyond our planet. Befitting a virtual institute, this platform will serve to educate and effectively tell a compelling story of health, space travel, and future moon and Mars expeditions.

### SPACE HEALTH RESEARCH DOCUMENTARY

Creative and meaningful storytelling can inspire. We are in a pivotal moment for space exploration, and now is the time to reignite human passion for exploration and biomedical research. TRISH has a unique perspective on this exciting period in human history, and has the experience and credibility necessary to inform and engage the public. TRISH will partner with filmmakers and a collection of space health researchers on a documentary exploring the need for and challenge to

keep humans healthy and productive in deep space.

## **WORKSHOPS**

Designed to spur innovation, TRISH places an emphasis on Workshops and Conferences. We hold topic-specific workshops annually that enable participants to evaluate the maturity of a research area or new methodology for use in space. TRISH also supports NASA's annual Human Research Program (HRP) Investigators Workshop (IWS) where the latest human space research and new directions are often conveyed. Conferences also often enable collaborations between distinct groups and investigators for the benefit of NASA. Occasionally, NASA may request a specific workshop to meet emerging needs.

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## NEW TO NASA

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**GOAL 5.** To offer learning opportunities that cultivate a future workforce for the space industry, and a diverse, multi-generational pipeline of New to NASA space health researchers and professionals.

Tackling the challenges of health delivery on the way to Mars requires a robust community united in sending humans further than ever before. To grow this space health community, TRISH will continue to expand its reach and attract non-traditional space health researchers.

TRISH recognizes that diversity in skill sets, scientific training, ethnicity, sex and gender, and age brings about more diverse ideas.

Disparities in science, technology, engineering, and mathematics (STEM), have manifested in the space research community. TRISH understands that by demystifying space health, we can engage non-traditional space researchers today and inspire future generations of space biomedical scientists, physicians and engineers.

### **Key Institute priorities supporting Goal 5:**

## **ACADEMY OF BIOASTRONAUTICS**

To support the mentorship of its postdoctoral fellows, TRISH established the Academy of Bioastronautics, a virtual forum for the fellows to share experiences and ask questions to seasoned spaceflight experts. Postdoctoral fellowships enable early career scientists to design, develop and conduct their own space-related research projects under the guidance of experienced faculty mentors. These two-year fellowships provide an allowance for healthcare and travel.

## **GO FOR LAUNCH**

A September 2020 survey published in the journal Nature demonstrated that the COVID-19 pandemic has made the road from postdoctoral fellow to independent researcher more rocky. As research laboratories closed and academic positions were trimmed from the budget, two-thirds of postdoctoral researchers surveyed felt that their career prospects had worsened. If the future class

of space health researchers were unable to transition successfully into independent positions, the space sector would feel the loss of a generation of talent. TRISH's "Go For Launch" program is our collective investment in the future, by empowering senior TRISH fellows to advance their own career and gain independence. The Institute welcomes projects from current TRISH fellows with unique and creative aims that support both the professional development of an early career scientist and add significant additional value to NASA, TRISH, and the space health community.

### **VISITING SCIENTIST PROGRAM**

TRISH's Visiting Scientist program provides external scientists the opportunity to work directly with NASA. These scientists work directly with NASA scientists and personnel to design programs and experiments in a short-term engagement.

### **FACULTY EXCHANGE PROGRAM**

TRISH's Faculty/Scientist Exchange, or Space Health Swap, stimulates new collaborations, ideas and approaches for space biomedical research. This is an opportunity for external scientists, researchers, engineers, and physicians to spend time at a NASA center; and NASA scientists to spend time at an external laboratory, company or university.

### **SCIENCE COMMUNICATIONS INTERNSHIP**

Skillful science communication will build support for space health research and human exploration missions. TRISH will build a science communications internship to engage communications and STEM professionals in the critical work of promulgating research advances for education and outreach.

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## FUNDING THE MISSION

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**GOAL 6.** To seek creative external funding opportunities that can further advance TRISH-funded projects through follow on funding for terrestrial health.

While TRISH is wholly supported by NASA's Human Research Program through a Cooperative Agreement, aligning TRISH funding with additional funding sources will amplify the impact of each taxpayer dollar. Creativity and strategic alignment will open up new channels for progress in biomedical research that can be applied to terrestrial health and space health. In addition to enhancing Institute research activity, new funds can be deployed to rapidly advance novel yet high-potential technologies from TRISH investigators on Earth as well as through NASA's operations.

**Key Institute priorities supporting Goal 6:**

### ATTRACTING ALIGNED PARTNERS

Additional partnership models will be explored with other agencies, strategic investors, focused traditional investors, and philanthropy. The TRISH SHERPA Program is ideal to fund partnerships focused into all TRISH interests including disruptive innovation, translative innovation, transition or follow on projects, and completely unique initiatives. Partners such as space focused investors such Starbridge, Space Fund or SP8CE VC, aligned other government agencies such as In-Q-Tel, and deep science focused investors such as IndieBio are all currently funding new knowledge and technologies that can apply to NASA's needs. There are strong overlap areas with philanthropy in areas of need such as longevity being championed by the Methuselah Foundation. These partnerships can further amplify TRISH's outreach, drive traffic to our funding mechanisms, or amplify our funding to make NASA's dollars go further. Follow on funding can keep projects alive past TRISH funding or during uptake into NASA. Through investments in early stage companies via the TRISH Industry Solicitation and business development activities, TRISH aligns in new directions to ensure that multiple stakeholders are engaged in bringing nascent innovations to market. Transition awards can help projects become flight certified.

## **PRIMING THE PIPELINE OF DIVERSE SPACE HEALTH RESEARCHERS**

Additional sources of funding will be explored in order to invest in early education (middle school age) so that the future pipeline of space health scientists, engineers, and physicians is well primed.

## **EPSCoR: ESTABLISHED PROGRAM TO STIMULATE COMPETITIVE RESEARCH**

TRISH will add value by leveraging the NASA EPSCoR program, so that future EPSCoR proposers in states with low-NASA presence are aware of the Human Research Program's research needs. By using this existing program and available federal funds, TRISH can amplify health and human health performance research happening nationwide.