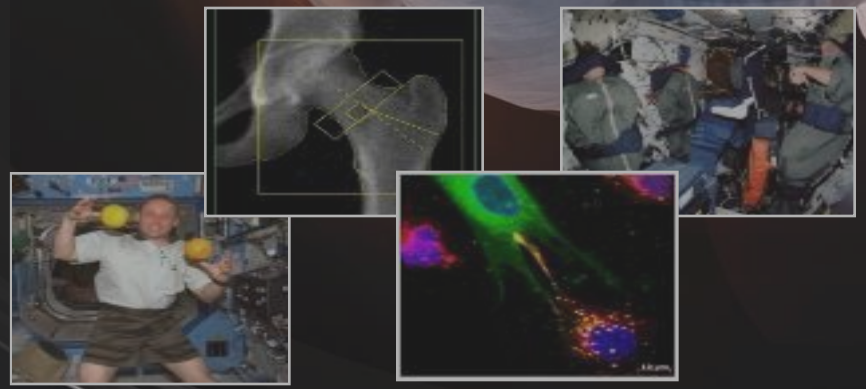
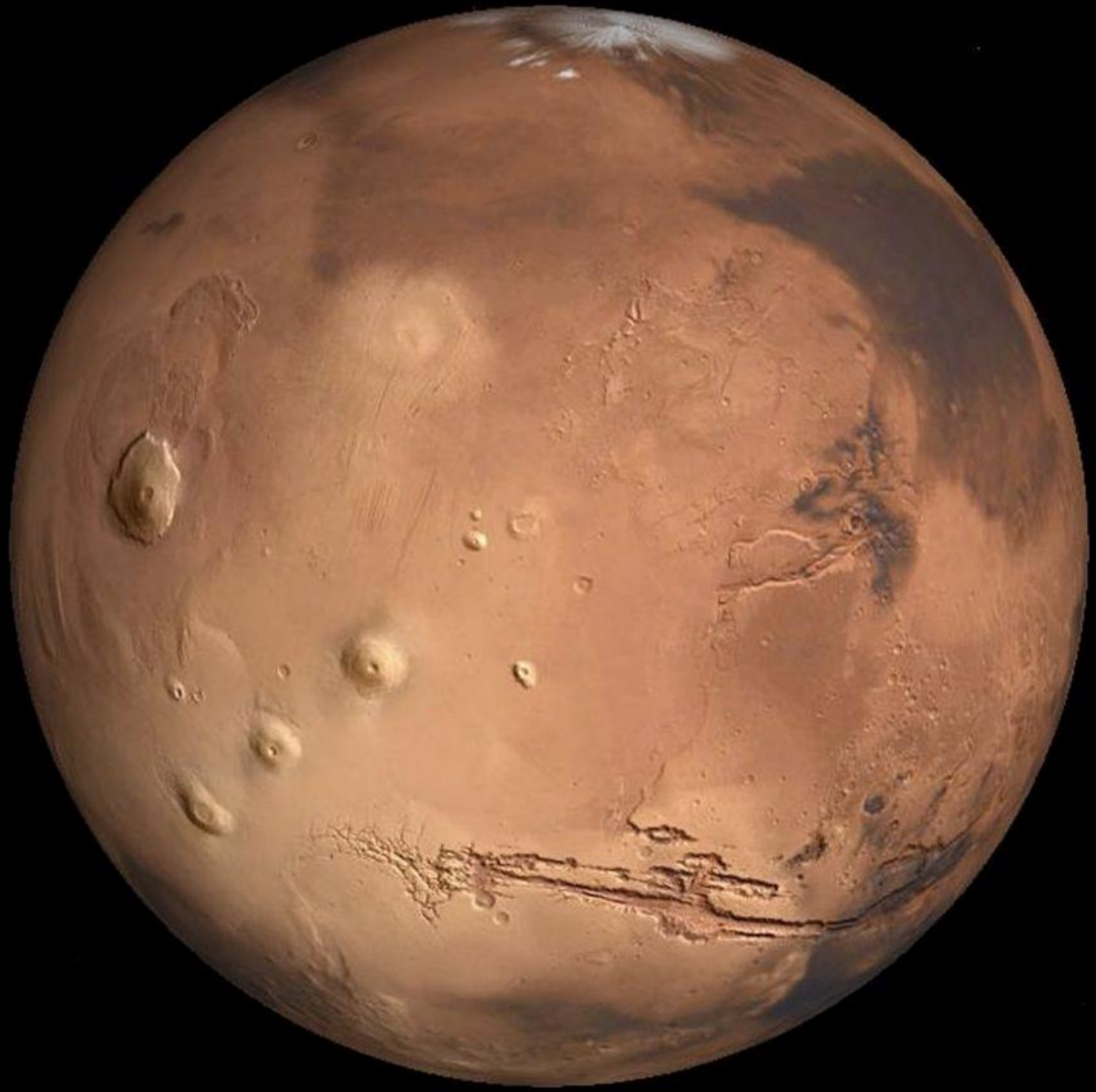
NASA Human Research Program

Human Health and Performance for Space Exploration



Jennifer Fogarty, PhD
Chief Scientist
NASA Human Research Program

01 April 2019
UND Space Studies Colloquium



Human Research Program Mission

To enable space exploration beyond Low Earth Orbit by reducing the risks to human health & performance through a focused program of:

- **Basic, applied, and operational research**

leading to the development and delivery of:

- **Human health, performance, and habitability standards**
- **Countermeasures and other risk mitigation solutions**
- **Advanced habitability and medical support technologies**

The Human Research Program (HRP) was established in 2007. It resides in the Human Exploration Operations Mission Directorate (HEOMD).

Research to Enable Space Exploration

Human travelers to Mars will experience unprecedented biological, physiological, and psychosocial challenges that could lead to significant health & performance decrements during and after the mission

NASA's Human Research Program is responsible for

Characterizing the effects of spaceflight and developing mitigation strategies

Human Research Program

Program Science Management Office

- Peer Review, Task/Risk Management, Data Archive
- Program planning, integration & control

Elements

Space Radiation

- Radiation exposure limits and health effects

Human Health and Countermeasures

- Physiology, nutrition, immunology, pharmacology, ocular impairment

Human Factors and Behavioral Performance

- Individual, interpersonal interactions, sleep, stress
- Interfaces between humans and vehicles/habitats

Exploration Medical Capability

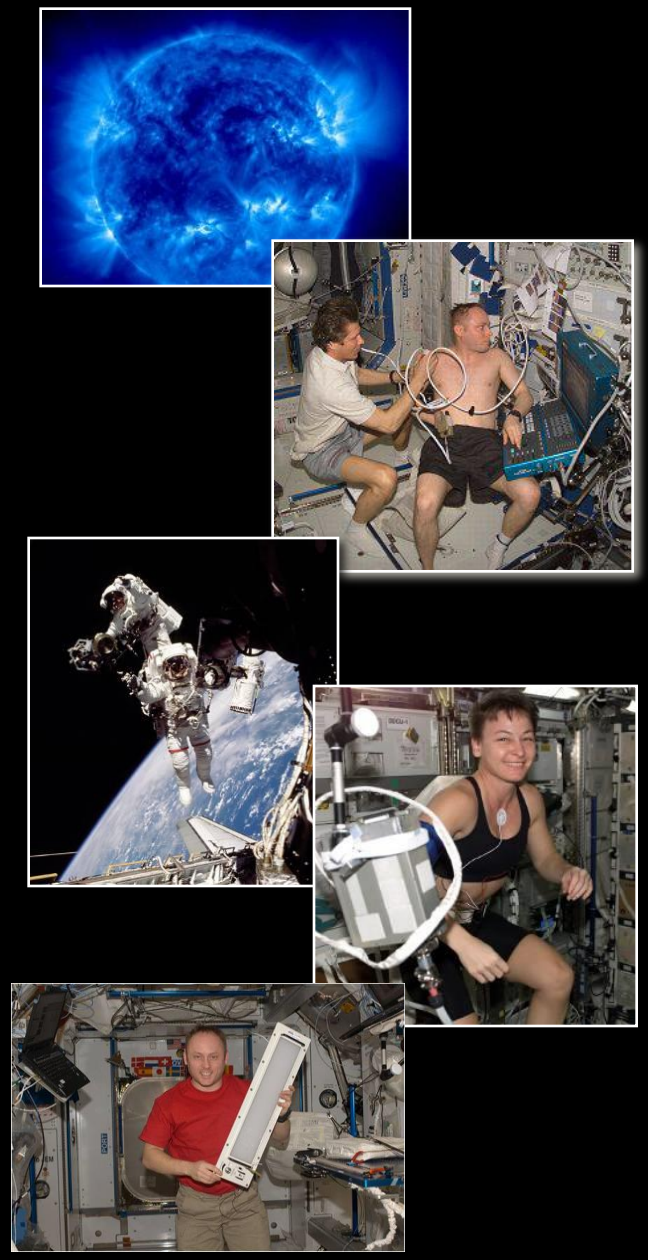
- Medical care for missions beyond low Earth orbit

ISS Medical Project

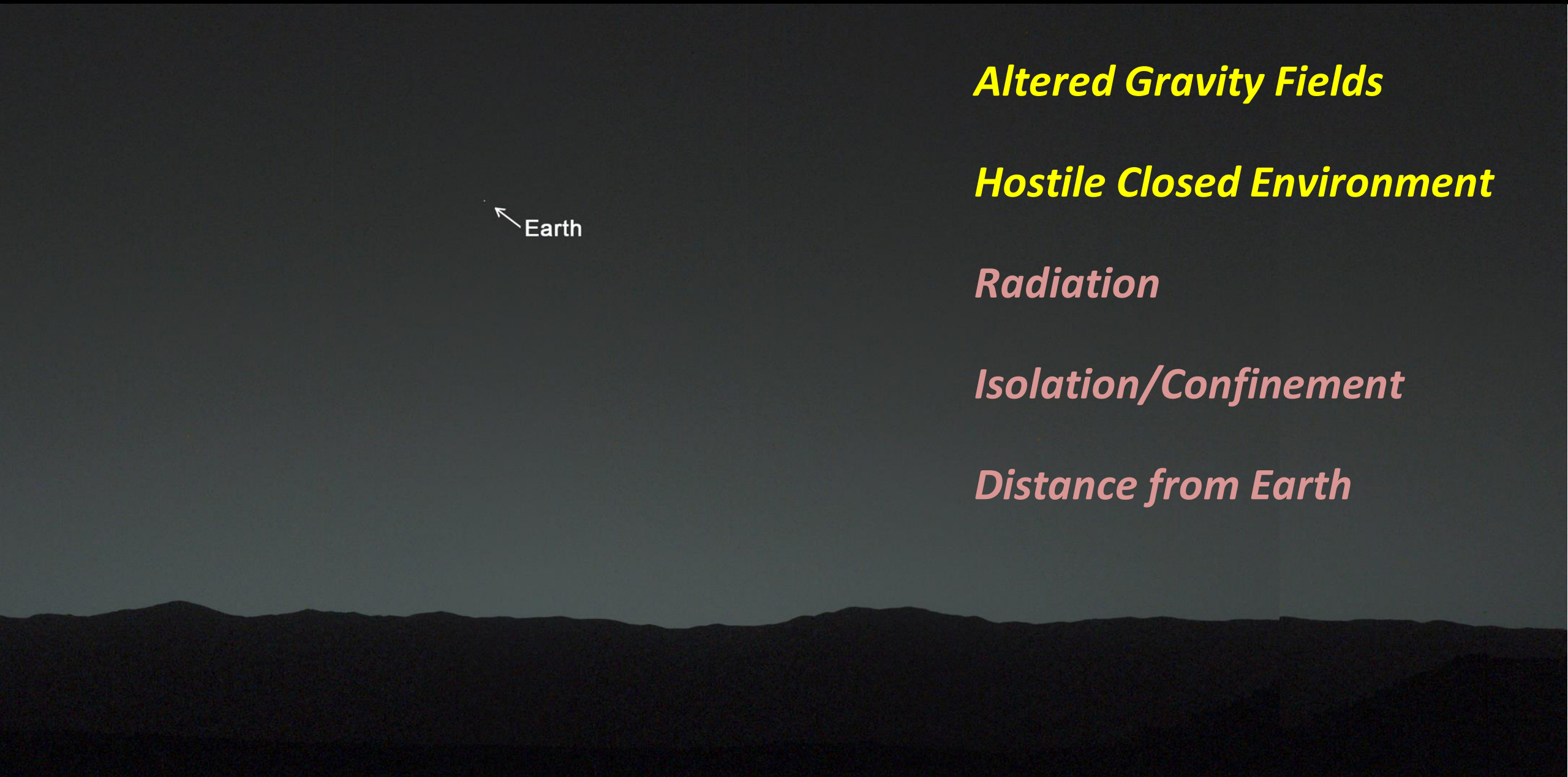
- Infrastructure for flight and analog experiments

Translational Research Institute for Space Health

Cooperative agreement to pursue R&T that disrupts the HRP portfolio



Deep Space Stressors to Human Health & Performance



Altered Gravity Fields

Hostile Closed Environment

Radiation

Isolation/Confinement

Distance from Earth


Altered Gravity Fields
Hostile Closed Environment
Radiation
Isolation/Confinement
Distance from Earth
Apollo 17 (1972)

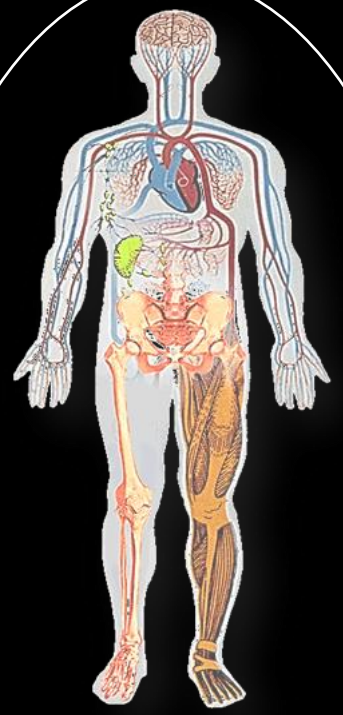
Human System Risks for Human Space Exploration

Altered Gravity - Physiological Changes

Spaceflight Associated Neuro-ocular Syndrome
Balance Disorders
Fluid Shifts
Cardiovascular Deconditioning
Muscle Atrophy
Bone Loss

Space Radiation

Acute In-flight effects
(controlled by vehicle design and operational constraints)
Long term cancer risk



Integrated Human Performance

Distance from earth

Drives the need for additional "self-reliant" medical care capacity – cannot come home for treatment

Hostile/ Closed Environment

Vehicle Design
Environmental – CO_2 Levels, Toxic Exposures, Water, Nutrition/Food
Decreased Immune Function, Microbiome Changes

Isolation & Confinement

Behavioral aspect of isolation
Sleep disorders

Exploration Health & Performance Risks – Mars DRM

Altered Gravity Field

1. Spaceflight-Associated Neuro-ocular Syndrome (SANS)
2. Renal Stone Formation
3. Impaired Control of Spacecraft/Associated Systems and Decreased Mobility Due to Vestibular/Sensorimotor Alterations Associated with Space Flight
4. Bone Fracture due to spaceflight Induced changes to bone
5. Impaired Performance Due to Reduced Muscle Mass, Strength & Endurance
6. Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity
7. Adverse Health Effects Due to Host-Microorganism Interactions
8. Urinary Retention
9. Orthostatic Intolerance During Re-Exposure to Gravity

Concerns

1. Concern of Clinically Relevant Unpredicted Effects of Medication
2. Concern of Intervertebral Disc Damage upon and immediately after re-exposure to Gravity

Radiation

1. Risk of Space Radiation Exposure on Human Health:
   - Acute solar events
   - Cancer
   - CNS impairment
   - Tissue degeneration (cardio)

Distance from Earth

1. Adverse Health Outcomes & Decrements in Performance due to inflight Medical Conditions
2. Ineffective or Toxic Medications due to Long Term Storage

Isolation/Confinement

1. Adverse Cognitive or Behavioral Conditions & Psychiatric Disorders
2. Performance & Behavioral health Decrements Due to Inadequate Cooperation, Coordination, Communication, & Psychosocial Adaptation within a Team

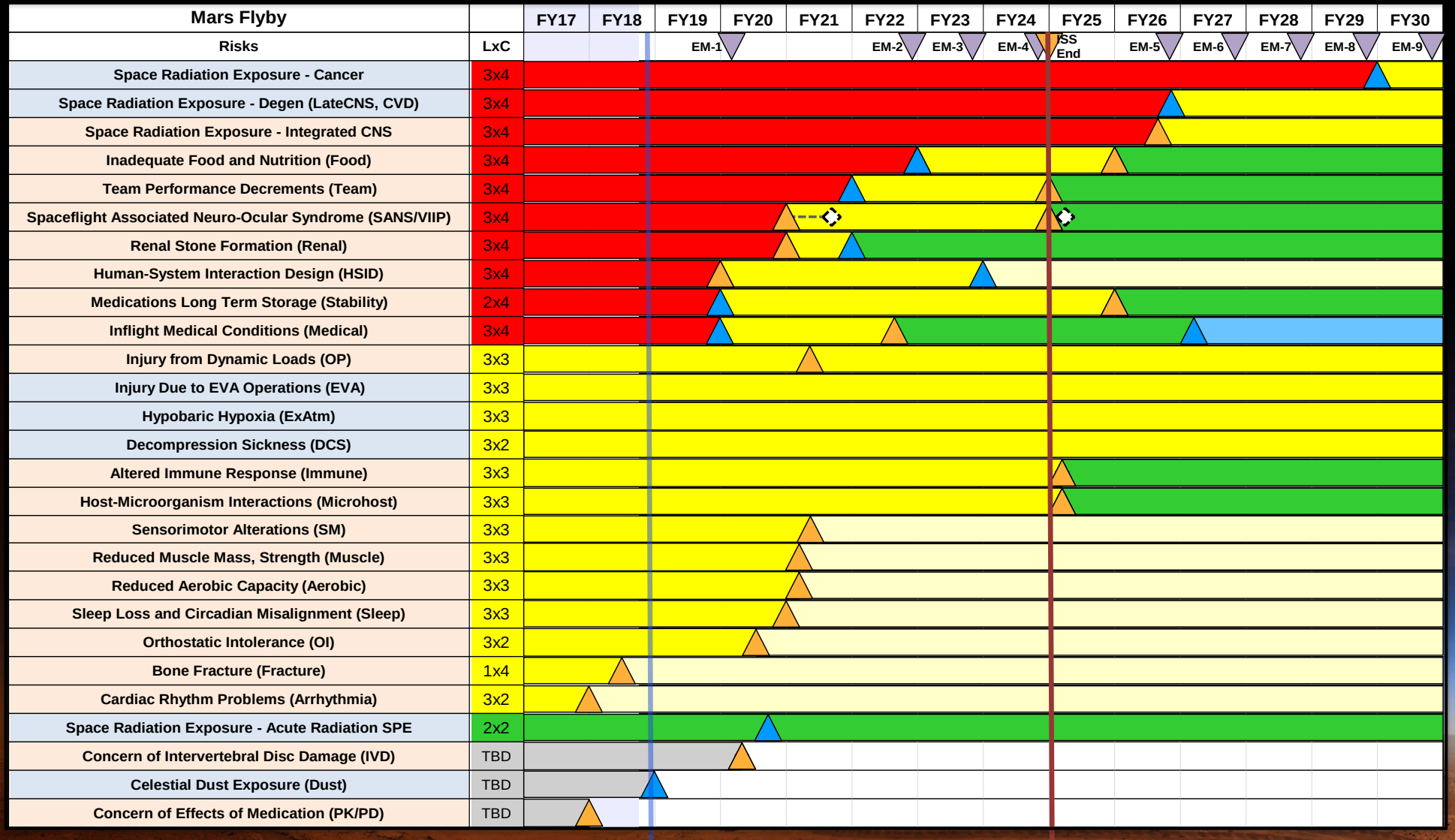
Hostile Closed Environment

1. Acute and Chronic Carbon Dioxide Exposure
2. Performance decrement and crew illness due to inadequate food and nutrition
3. Injury from Dynamic Loads
4. Injury and Compromised Performance due to EVA Operations
5. Adverse Health & Performance Effects of Celestial Dust Exposure
6. Adverse Health Event Due to Altered Immune Response
7. Reduced Crew Performance Due to Hypobaric Hypoxia
8. Performance Decrements & Adverse Health Outcomes Resulting from Sleep Loss, Circadian Desynchronization, & Work Overload
9. Reduced Crew Performance Due to Inadequate Human-System Interaction Design
10. Decompression Sickness
11. Toxic Exposure
12. Hearing Loss Related to Spaceflight

Key: High LxC Medium LxC Low LxC TBD LxC

Managed/configuration-controlled by NASA Human Systems Risk Board

HRP Integrated Path to Risk Reduction



ISS Mission Milestone

Exploration Mission Milestone

High LxC

Mid LxC: Requires Mitigation

Mid LxC: Accepted

Low LxC

Optimized

Insufficient Data

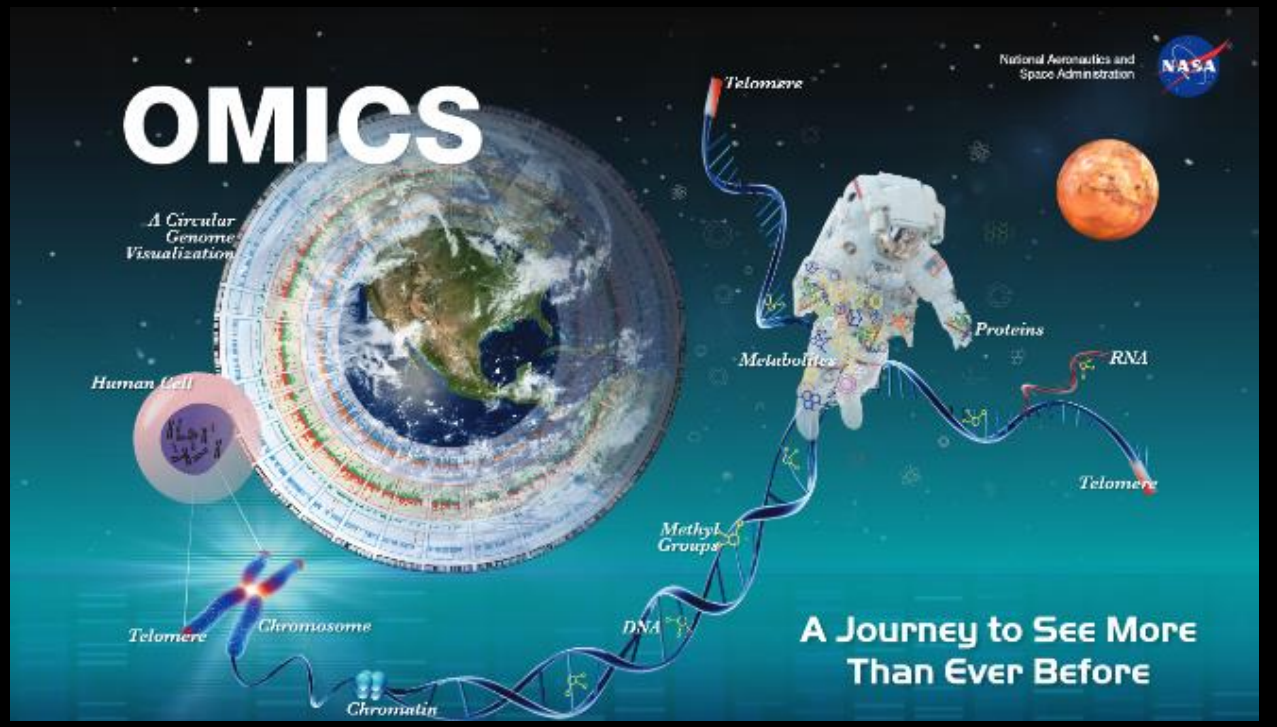
Milestone Requires ISS

Ground-based Milestone

PPBE20 Baseline+FY18Q3
8 Aug 2018

ISS: Space Platform for HRP Studies

ISS: Year in Space/Twins Study



Planning Exploration-Simulation Missions Aboard ISS

- **Extend Increments to 1 Year**
  - Validate effectiveness of microgravity countermeasures for longer missions
- **Enable More Crew Autonomy**
  - Limit interactions with ground control and family
  - Delay communications
  - Reduce the number of visiting vehicles and re-supply
  - Use hardware and procedures that do not rely on ground contro

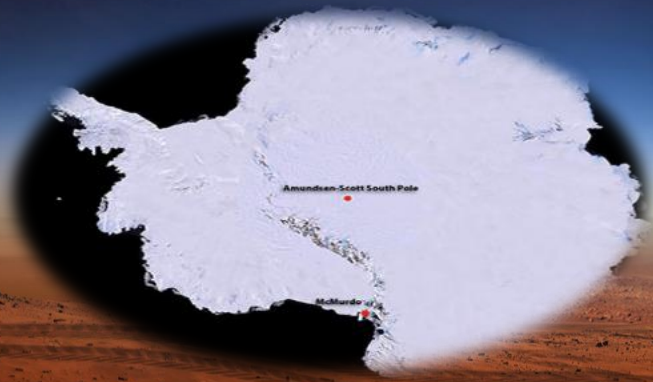
Simulating Exploration Stressors on Earth

Radiation

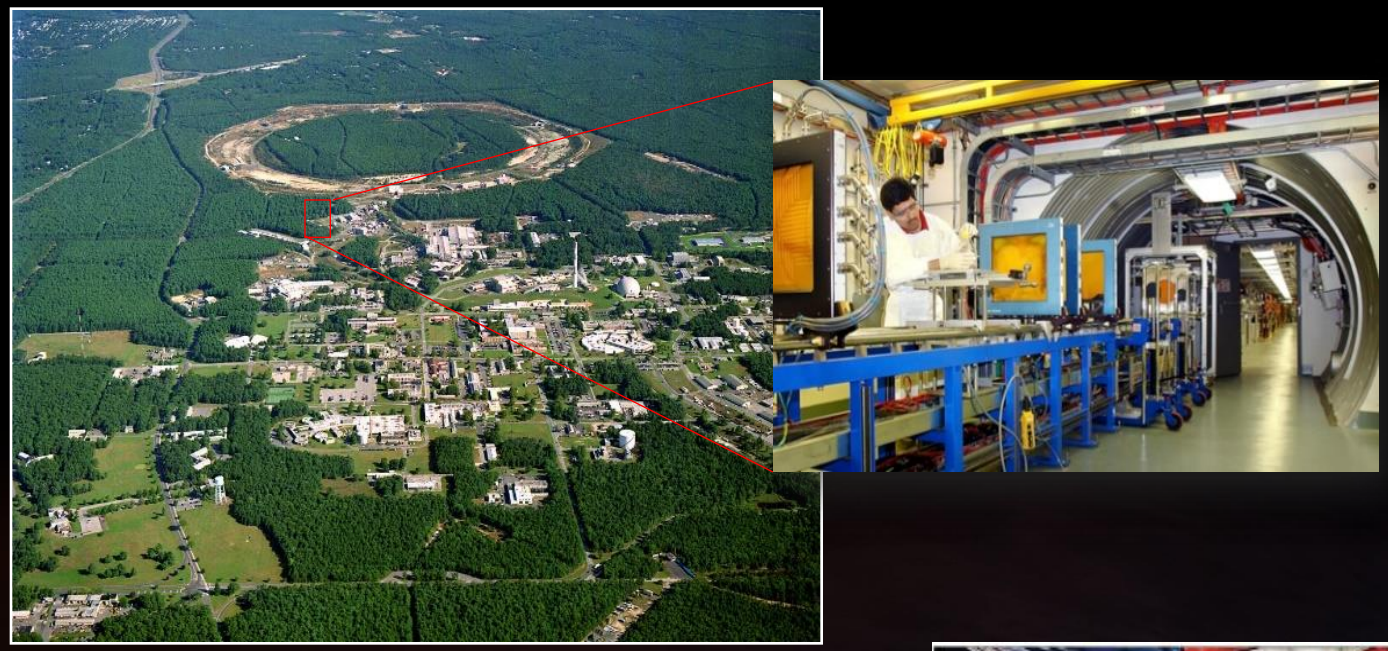
Isolation & Confinement

Altered Gravity

Hostile Environment

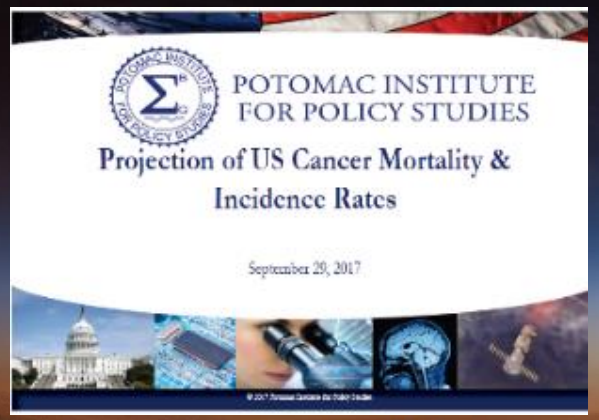


NASA Space Radiation Laboratory (NSRL)



NASA Space Radiation Lab (NSRL) DOE/BNL

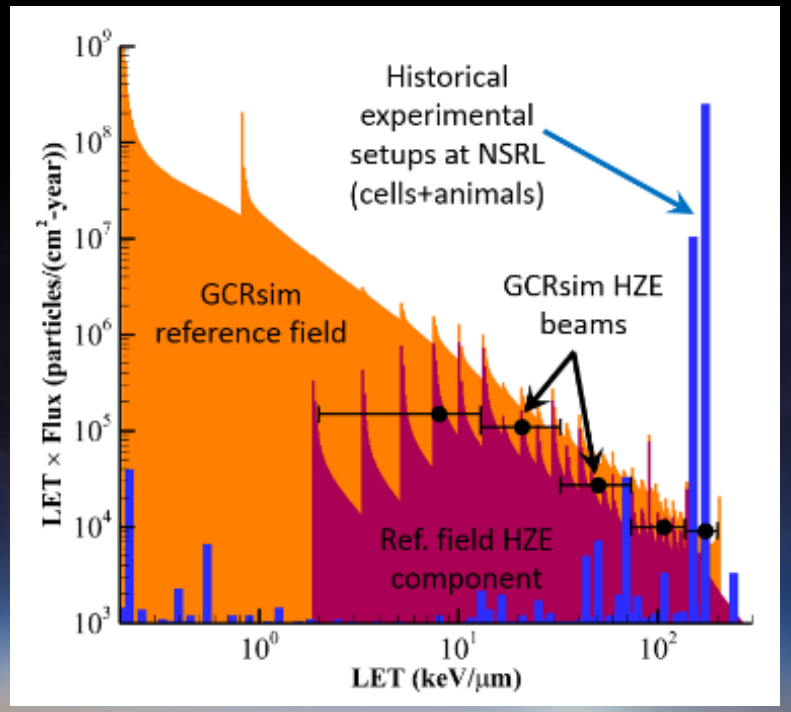
- Simulates the space radiation environment- high energy ion beams (H^+, Fe, Si, C, O, Cl, Ti, etc.)
- Beam line, target area, dosimetry, biology labs, animal care, scientific, logistic and administrative support



Standardized GCR Simulation at NSRL

GCR Simulation Beam consists of

- *5 proton energies plus degrader*
- *5 helium energies plus degrader*
- *5 Heavy ions: C, O, Si, Ti, Fe*



Chronic exposure over 2-6 weeks:

- Full GCRsim 15 ion beam delivered daily
- Beam delivered 6 days per week to allow for contingencies

Three multiweek research campaigns each calendar year

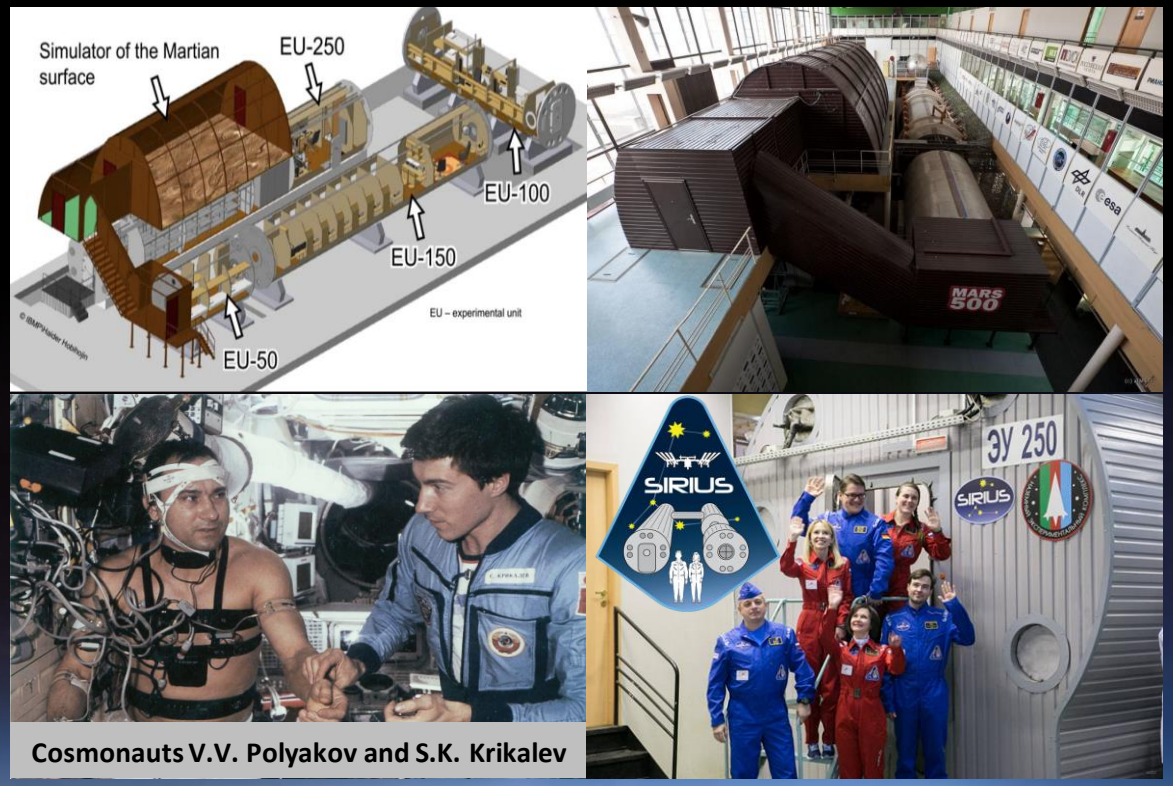
Isolated/Confined/Extreme (ICE) Environments

- **Partnership between NASA and the US National Science Foundation (NSF)**
  - Data collection at both McMurdo (88 subjects) & Admunsen-Scott South Pole (21 subjects) Stations complete. Analysis underway.
  - New Team study at McMurdo Station underway (April 2018)
  - More studies planned for future winter-overs
- **Partnership between NASA and ESA**
  - Immune study complete at Concordia
- **Partnership with DLR**
  - Cognitive function study at Neumayer Station

At least one study manifested each winter-over season.

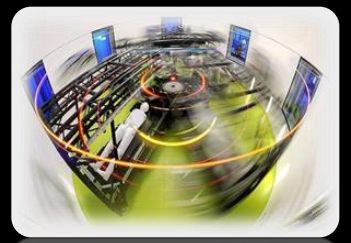
Isolated/Confined/Controlled (ICC) Environments

Human Exploration Research Analog (HERA)
(4 x 45 days missions per year)



NEK Facility (RAS/IMBP, Moscow, Russia)
(SIRIUS: 4, 8, 12 month missions planned)

Altered Gravity Analogs



Parabolic Flight
(Fractional Gravity mission completed with DLR)

:enviHab Facility (DLR, Cologne, Germany)
(Artificial Gravity missions planned jointly with ESA)

:envihab (DLR) Altered Gravity Analog Status

VaPER (VIIP and Psychological :envihab Research) Study

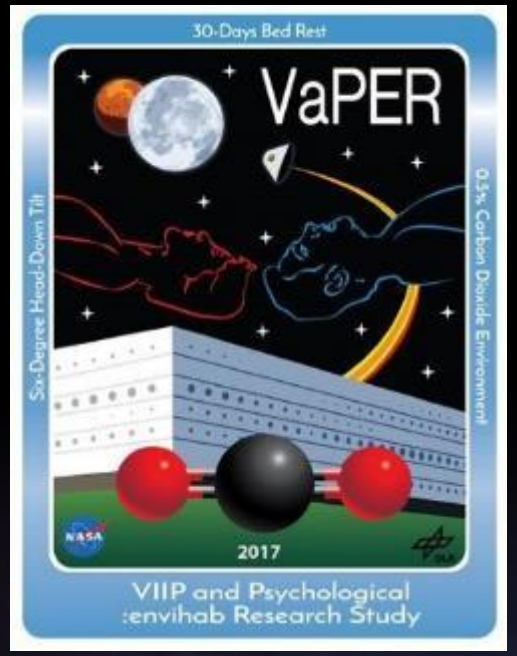
(5 HRP studies)

Study design:

- 11 astronaut-surrogate volunteers (both sexes)
- 30 days duration
  - simulated microgravity (6° head-down tilt bed rest)
  - hostile, closed environment (elevated CO_2)
- physiological and psychological outcome measures (pre/in/post)

Schedule:

- 2 October: Subjects began 2-week pre-bed rest BDC studies
- **17 October: Mission ingress began (staggered)**
- 4 December: Mission egress ends

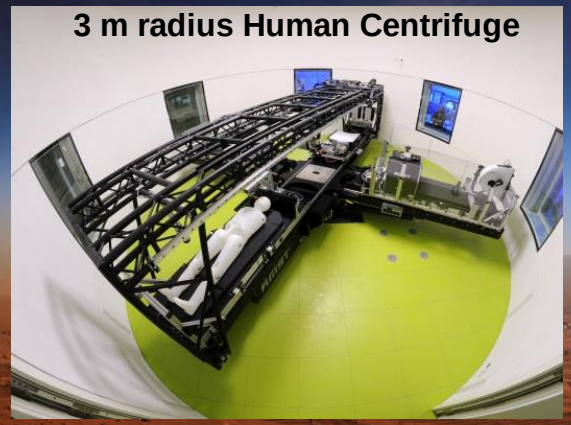


Artificial Gravity Bed-Rest study (2018-2019)

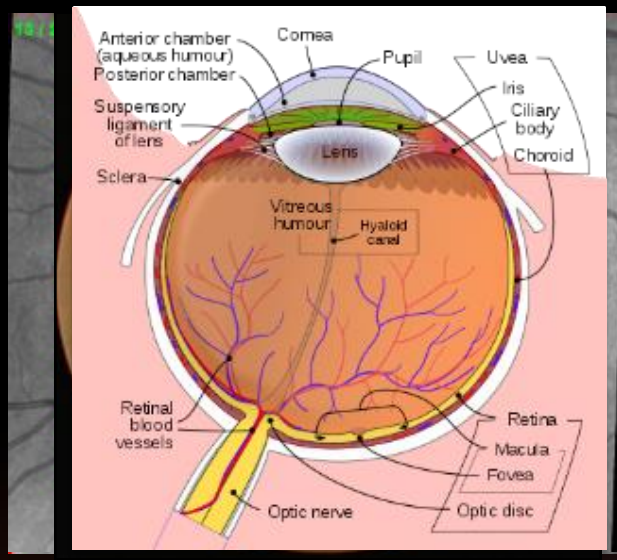
(4 HRP studies, 7 ESA studies + BR standard measures)

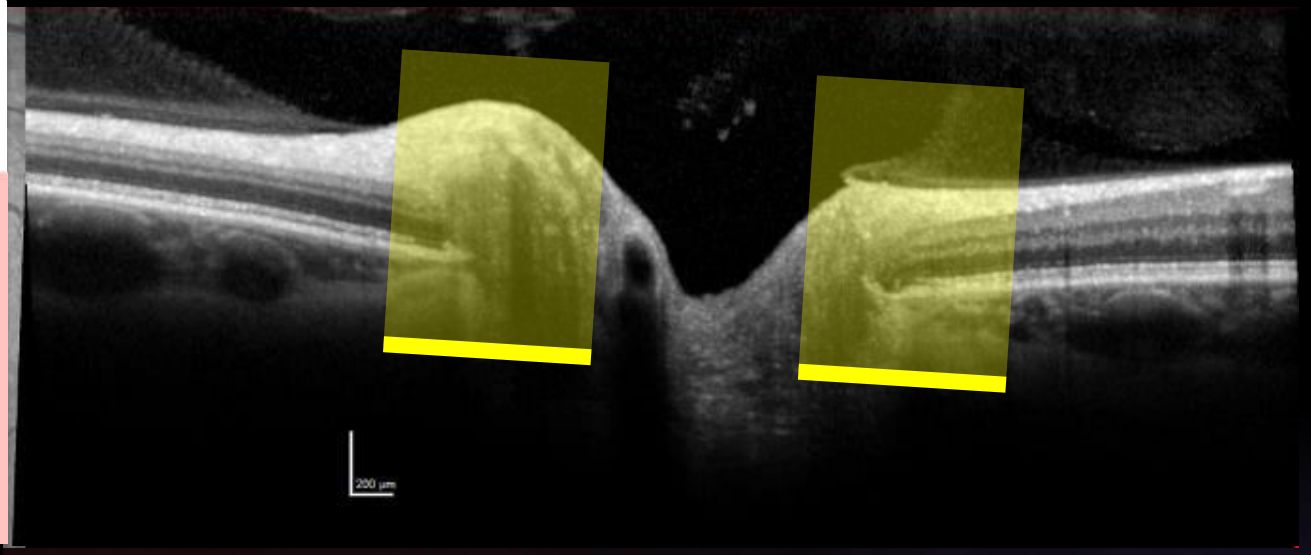
Study design:

- 2 x 12 astronaut-surrogate volunteers (both sexes)
- 2 x 60 days duration
  - simulated microgravity (6° head-down tilt bed rest)
  - short-duration continuous and intermittent centrifugation as a countermeasure
- physiological, neurological, and behavioral outcome measures (pre/in/post)



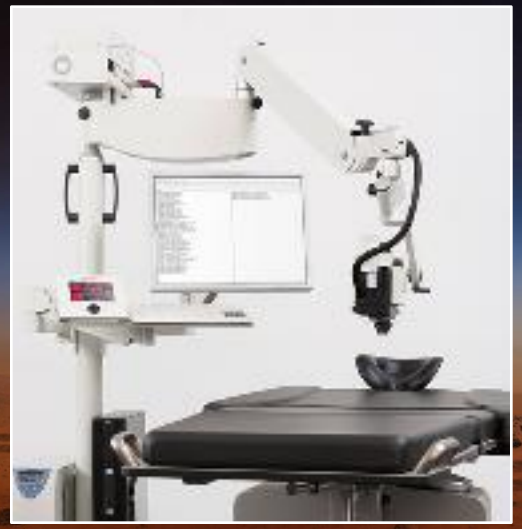
:enviHab VaPER Study: 1st Ground-based SANS Model

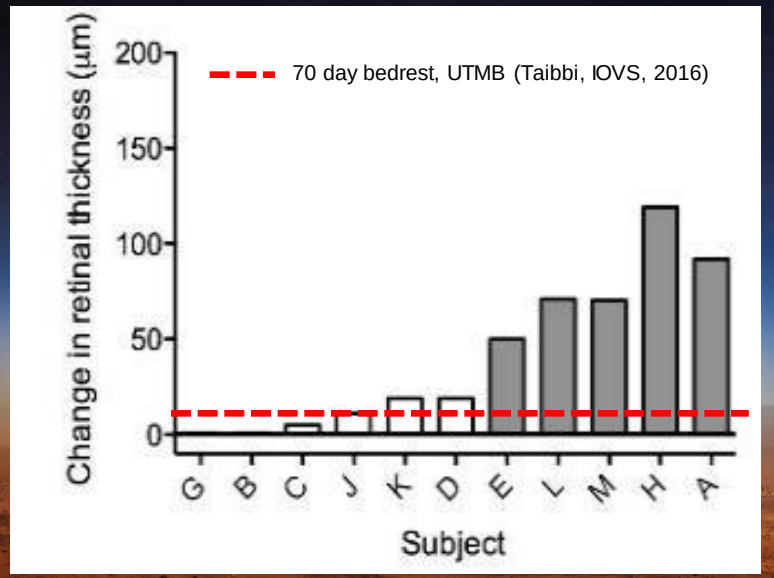




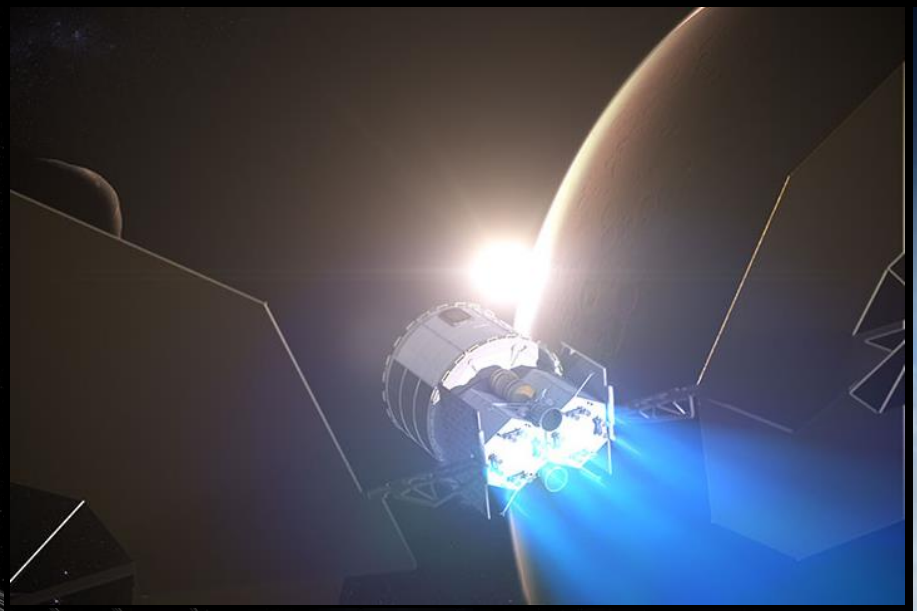
PI: S Laurie (NASA/JSC/KBRWyle)

- 11 volunteer test subjects (6 male, 5 female)
- 30-day strict HDT bed rest in 0.5% CO_2 (3.8 mmHg) environment
- Pre/post retinal thickness via Optical Coherence Tomography (OCT)





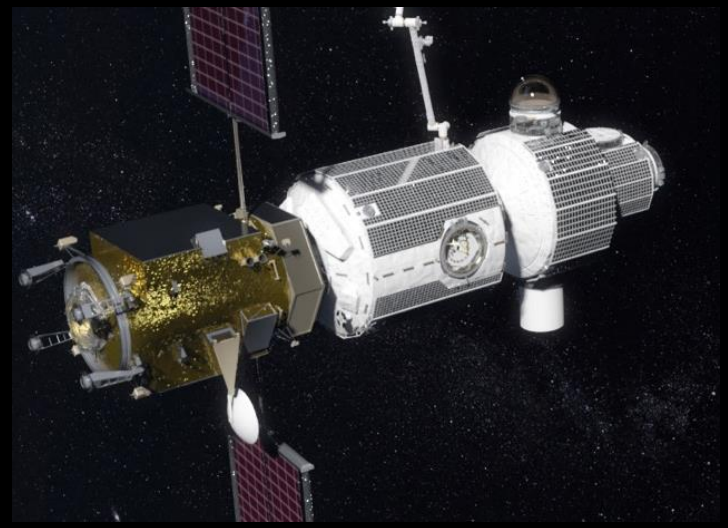
Next: cis-Lunar Space and Return to the Lunar Surface



THE JOURNEY CONTINUES

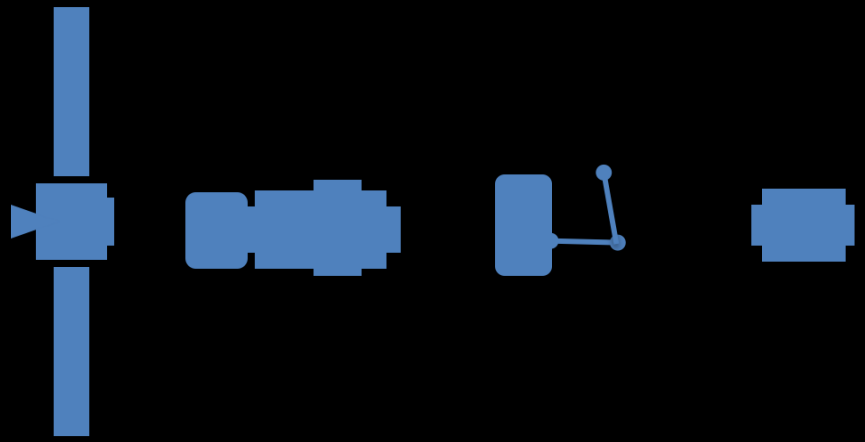
GATEWAY DEVELOPMENT

Establishing leadership in deep space and preparing for exploration into the solar system



FOUNDATIONAL GATEWAY CAPABILITIES

2022	2023	2024+



50 kW-class Power & Propulsion Element

Habitation and Utilization

Logistics and Robotic Arm

Airlock

These foundational gateway capabilities can support multiple U.S. and international partner objectives in cislunar space and beyond.

CAPABILITIES

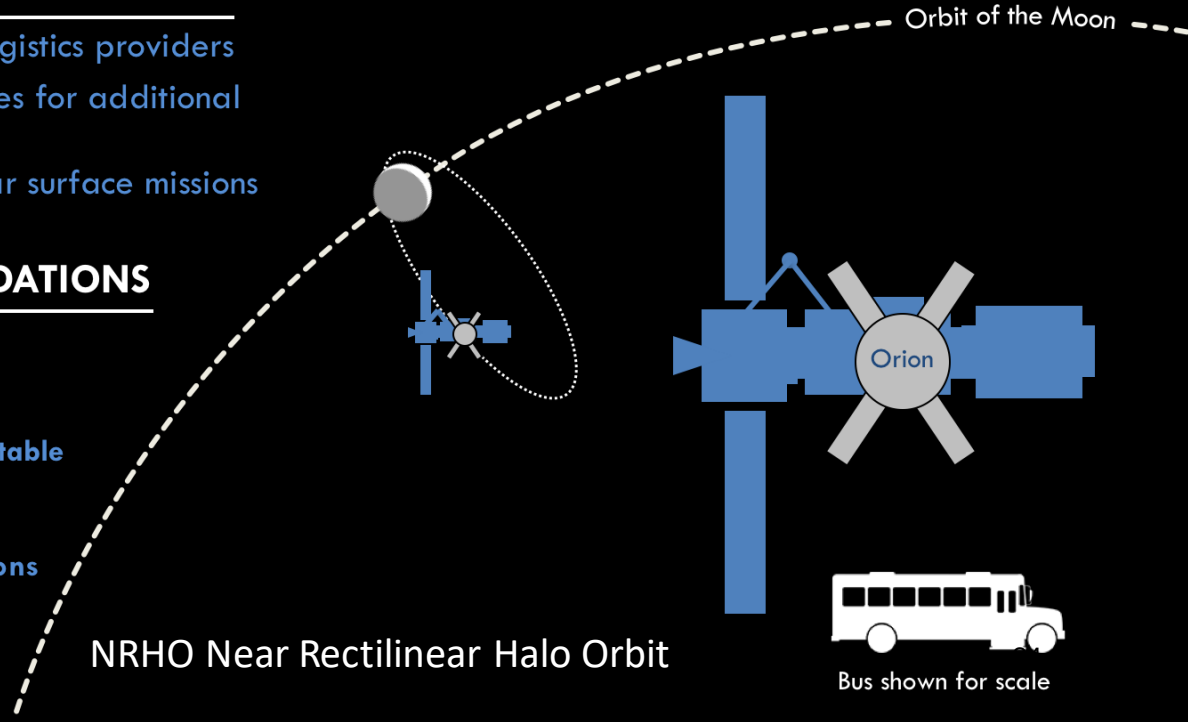
- Supports exploration, science, and commercial activities in cislunar space and beyond
- Includes international and U.S. commercial development of elements and systems
- Provides options to transfer between cislunar orbits when uncrewed
- External robotic arm for berthing, science, exterior payloads, and inspections

OPPORTUNITIES

- Logistics flights and logistics providers
- Use of logistics modules for additional available volume
- Ability to support lunar surface missions

INITIAL ACCOMMODATIONS

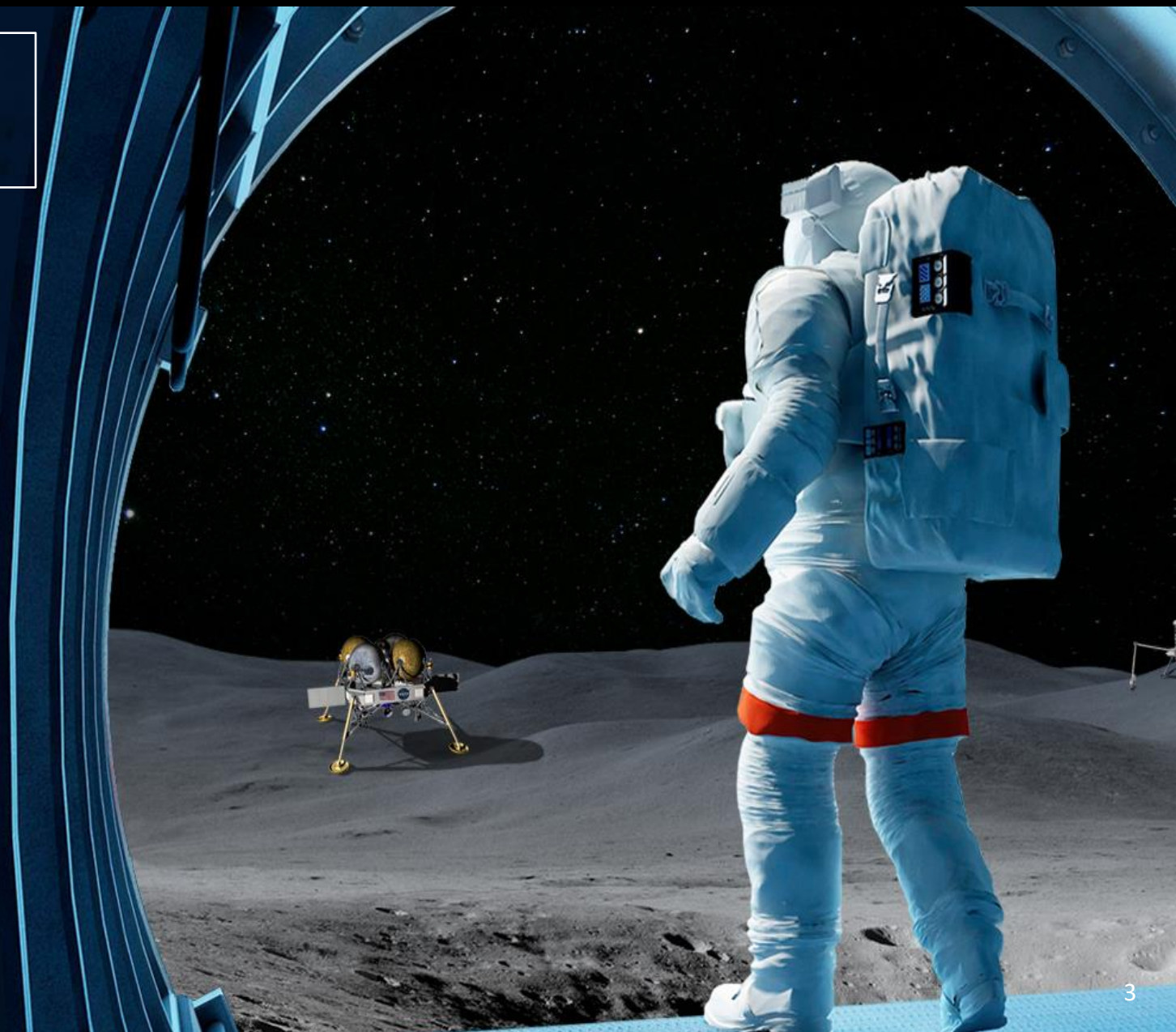
- 4 Crew Members
- At least 55 m^3 Habitable Volume
- 30 Day Crew Missions



Lunar Surface Research Operations

Depending on mission design and duration, Lunar Surface Operations Missions could add significantly to our understanding/mitigation/validation of human health and performance risks during future Mars surface missions.

- **Autonomous egress/ post-landing operations:**
  - sensorimotor, orthostatic intolerance
  - occupant protection
  - team performance
  - human-systems interaction design
  - EVA, DCS, exploration atmospheres
- **Long-term habitation/exploration:**
  - bone, muscle, aerobic, sensorimotor, orthostatic intolerance
  - medical system
  - team performance, bmed
  - human-systems interaction design
  - EVA, DCS, exploration atmospheres
  - radiation: acute, degen, CNS
  - dust, immune, microhost



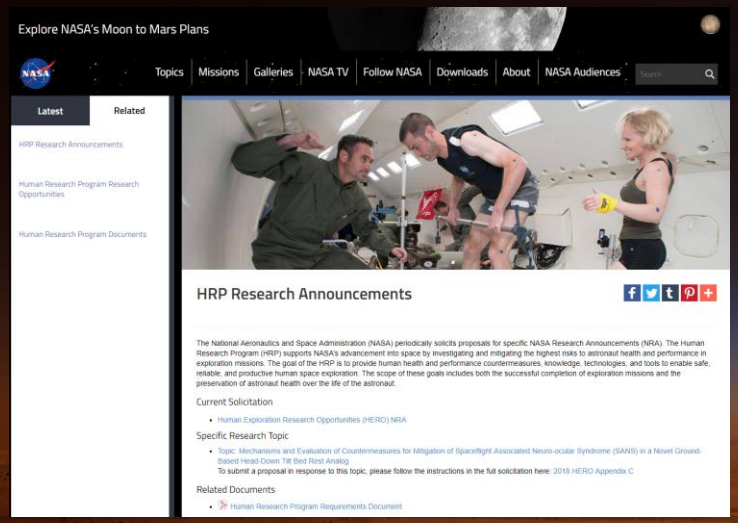
Human Exploration Research Opportunity (HERO)

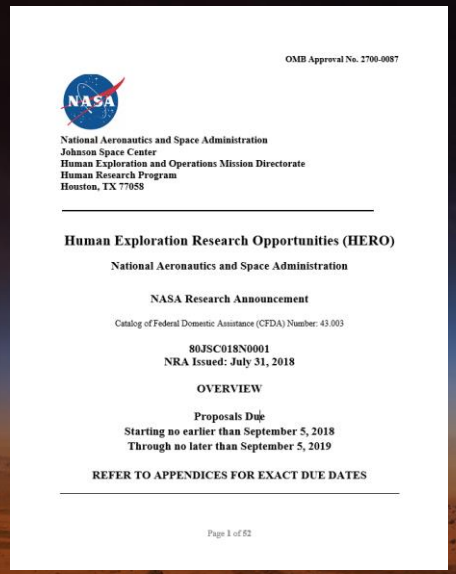
July – Annual Flagship and Omnibus Opportunity

November and March - Topic Specific Appendices

Working with HRP: https://www.nasa.gov/hrp/research

Current Research Announcements: https://www.nasa.gov/hrp/research/announcements





OMB Approval No. 2700-0087

National Aeronautics and Space Administration
Johnson Space Center
Human Exploration and Operations Mission Directorate
Human Research Program
Houston, TX 77058

Human Exploration Research Opportunities (HERO)

National Aeronautics and Space Administration

NASA Research Announcement

Catalog of Federal Domestic Assistance (CFDA) Number: 43.003

80JSC018N0001
NRA Issued: July 31, 2018

OVERVIEW

Proposals Due
Starting no earlier than September 5, 2018
Through no later than September 5, 2019

REFER TO APPENDICES FOR EXACT DUE DATES

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Ambidexterity: Translational Research Institute

Mission: To lead a national effort in translating cutting edge emerging terrestrial biomedical research and technology development into applied space flight human risk mitigation strategies for exploration missions.

TRANSLATIONAL RESEARCH INSTITUTE FOR SPACE HEALTH™

TRISH: *Funding human health research for space.*

Partnering with NASA through a cooperative agreement, the Translational Research Institute for Space Health (TRISH) funds transformative human health technologies to predict, protect, and preserve astronaut physical and mental wellness during deep space exploration missions. We fund high-risk, high-reward, human health and performance solutions that can be adapted for use in space. Focused on early stage (proof of concept) and late stage (market-ready) research, TRISH stands apart from other funding organizations due to our high-risk tolerance, our flexible grant mechanisms, and our ability to connect researchers with NASA scientists and space analogs.

https://www.bcm.edu/centers/space-medicine/translational-research-institute

Game-Changers: TRISH plus CIMIT Solicitation

CIMIT®

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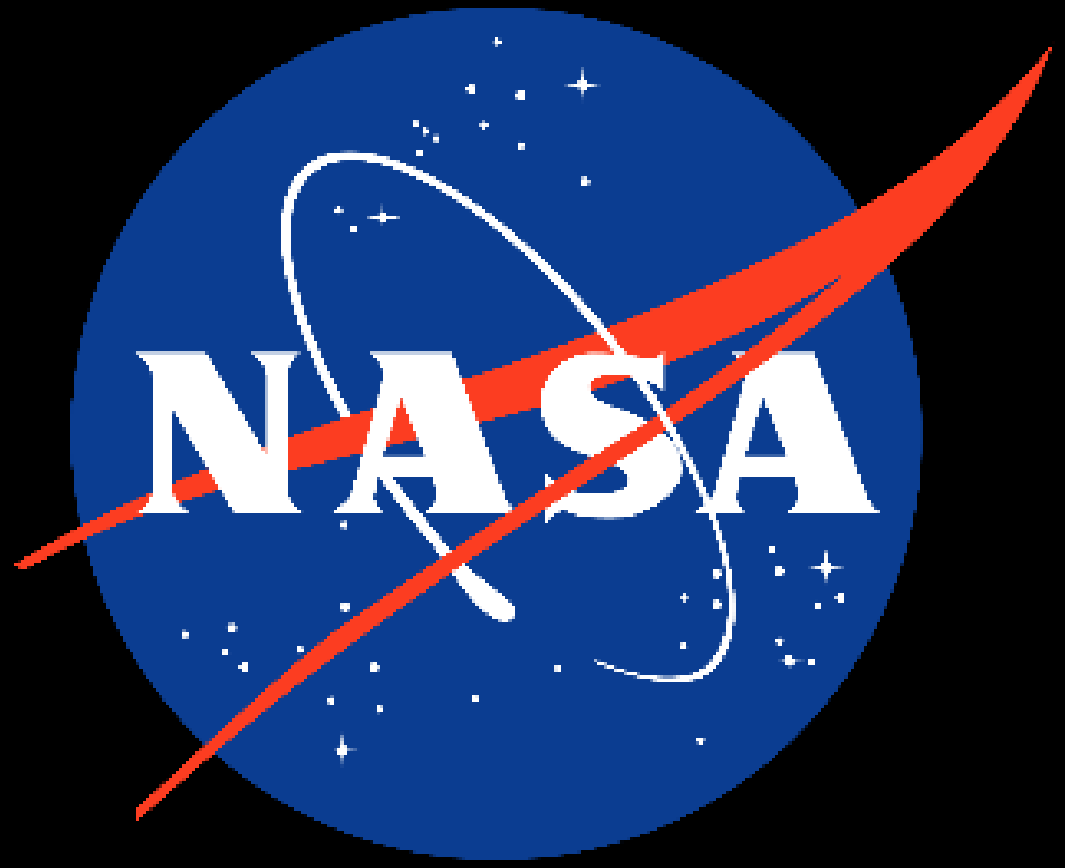
Consortia for Improving Medicine with Innovation & Technology

Accelerating Healthcare Innovation

CIMIT is a network of world-class academic and medical institutions partnering with industry and government. Our mission is to foster collaboration among clinicians, technologists, and entrepreneurs to accelerate innovation and catalyze the discovery, development, and implementation of innovative healthcare technologies.


NASA