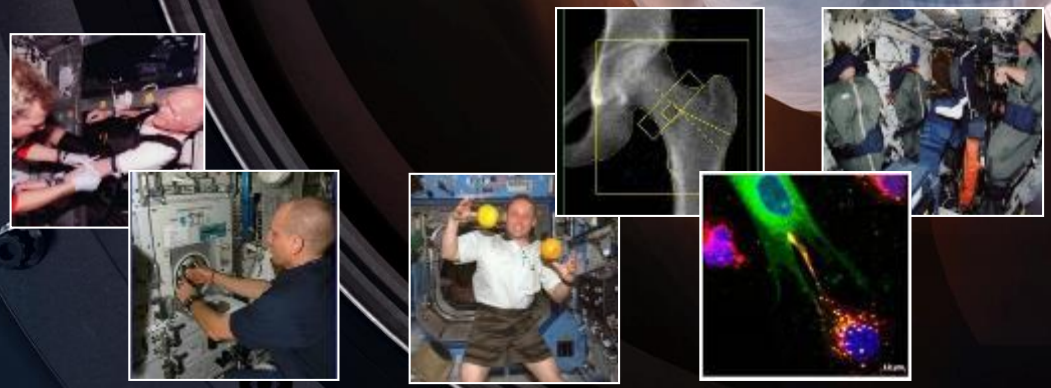
National Aeronautics and Space Administration

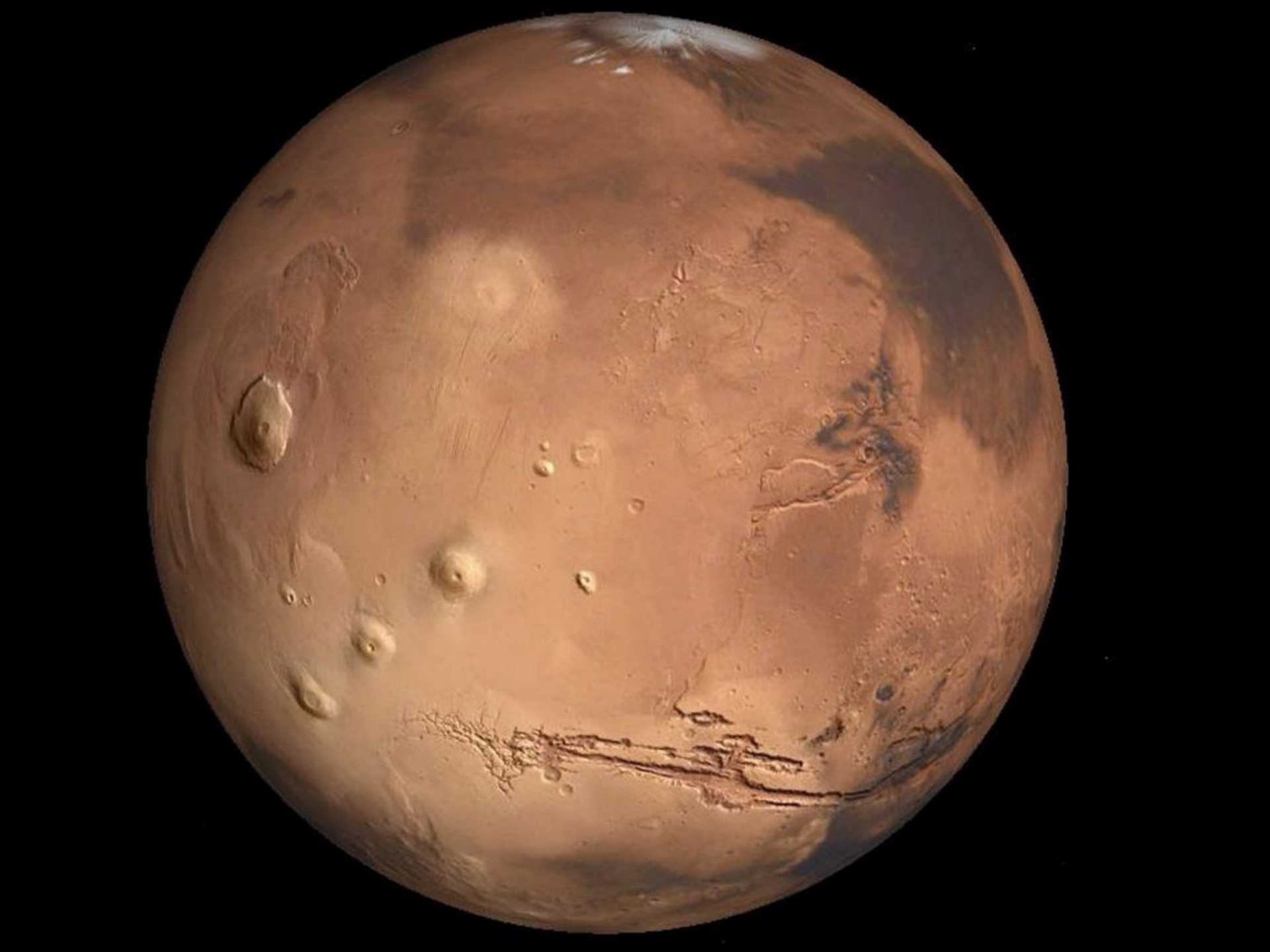
Recent US Space Biomedical Research Activities

WH Paloski, PhD
Director, NASA Human Research Program

05 December 2016

XVI Conference on Space Biology and Medicine
Russian Academy of Sciences
Moscow, Russia





Human Research Program Mission

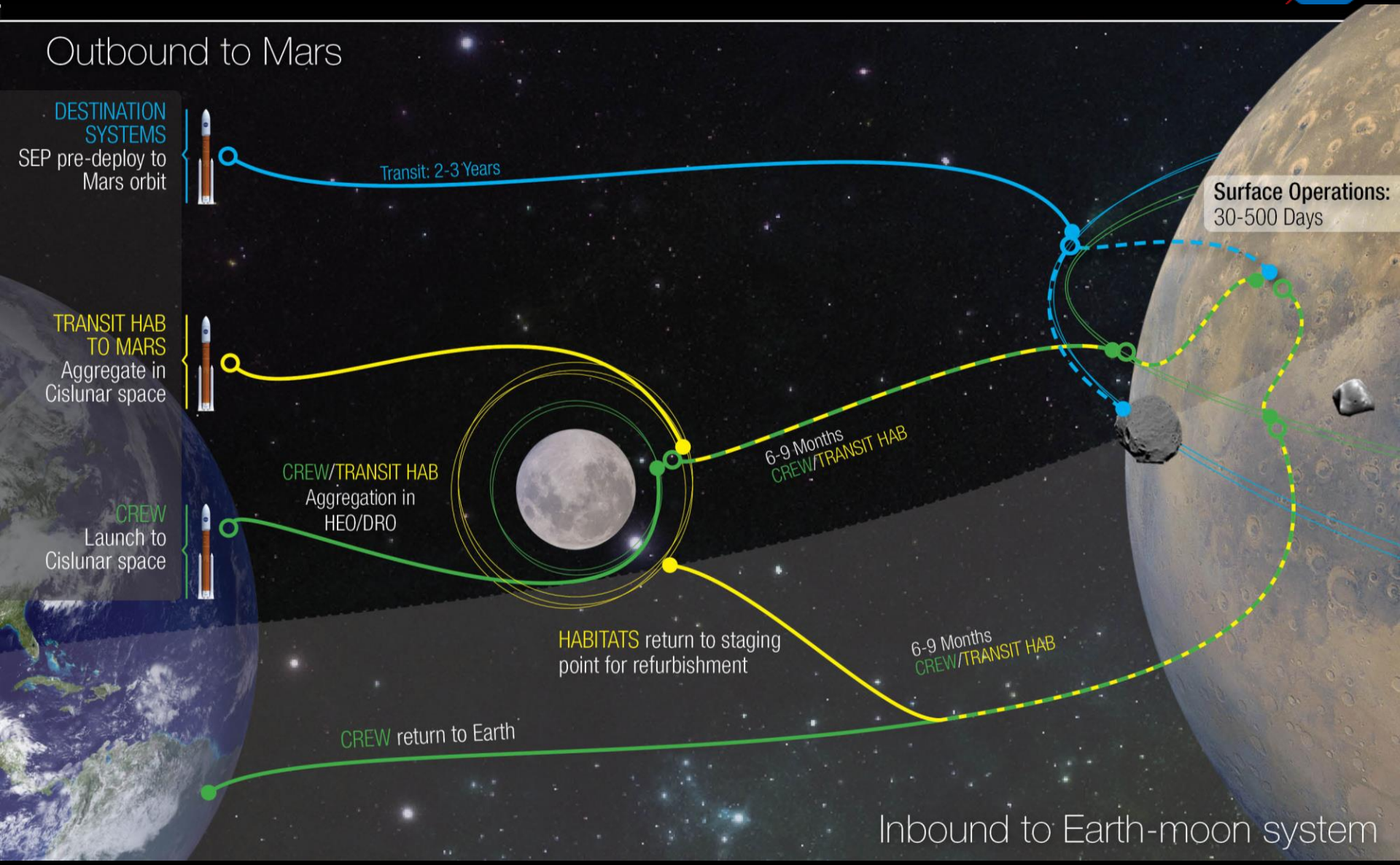
To enable space exploration beyond Low Earth Orbit
by reducing the risks to human health & performance
through a focused program of:

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

leading to the development and delivery of:

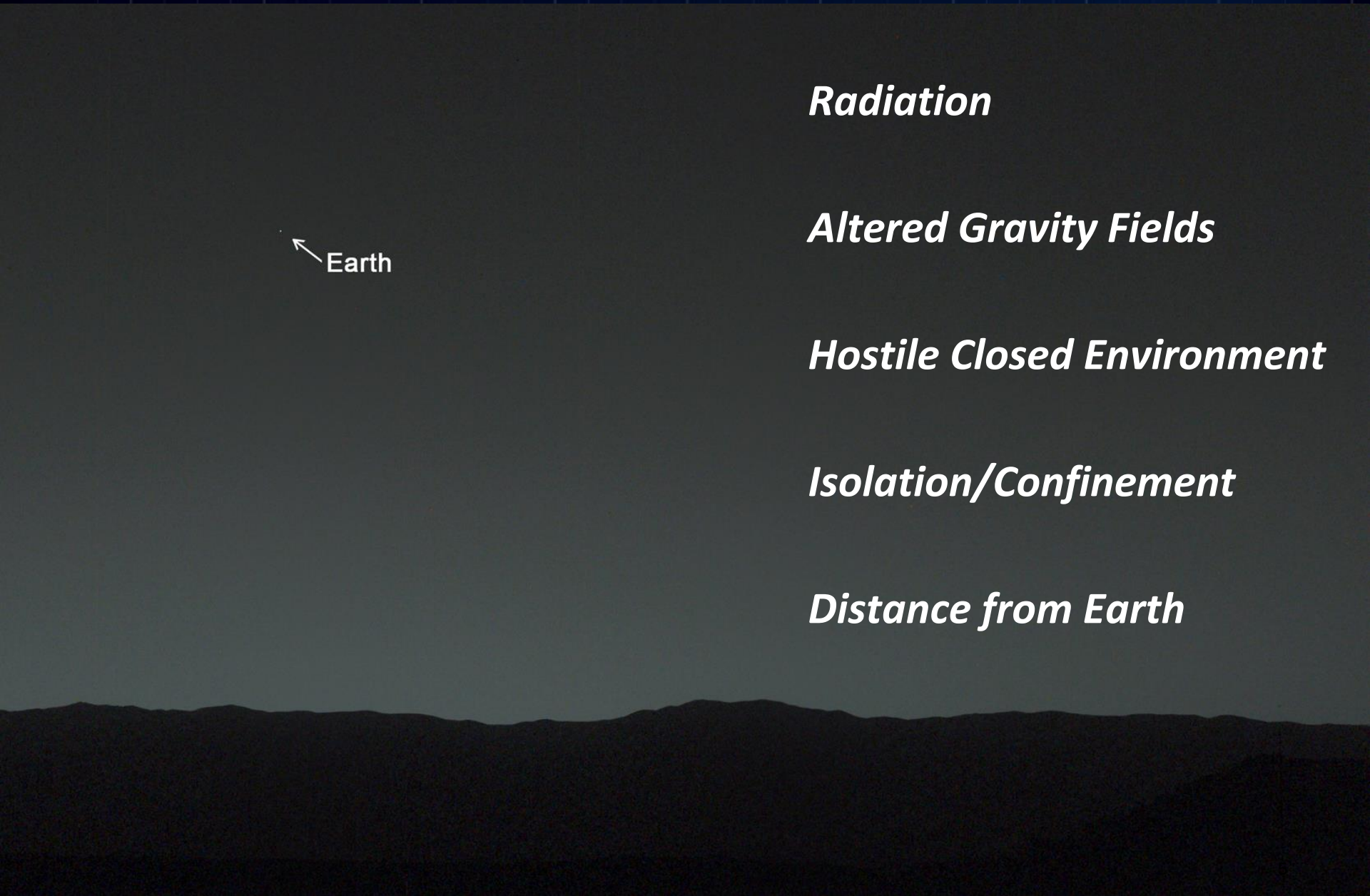
- **Human health, performance, and habitability standards**
- **Countermeasures and other risk mitigation solutions**
- **Advanced habitability and medical support technologies**

Human Missions to Mars



Unprecedented technological and human endurance challenges…

Crew Stressors in Deep Space Missions



Radiation

Altered Gravity Fields

Hostile Closed Environment

Isolation/Confinement

Distance from Earth

HRP Risk Mitigation Maturation Plan

~2035–20nn

Fine-tune mitigation approaches

- Exploration vehicles
- Planetary surfaces

~2021–2030

Validate mitigation approaches

- Orion
- Deep-space hab
- Lunar surface (?)

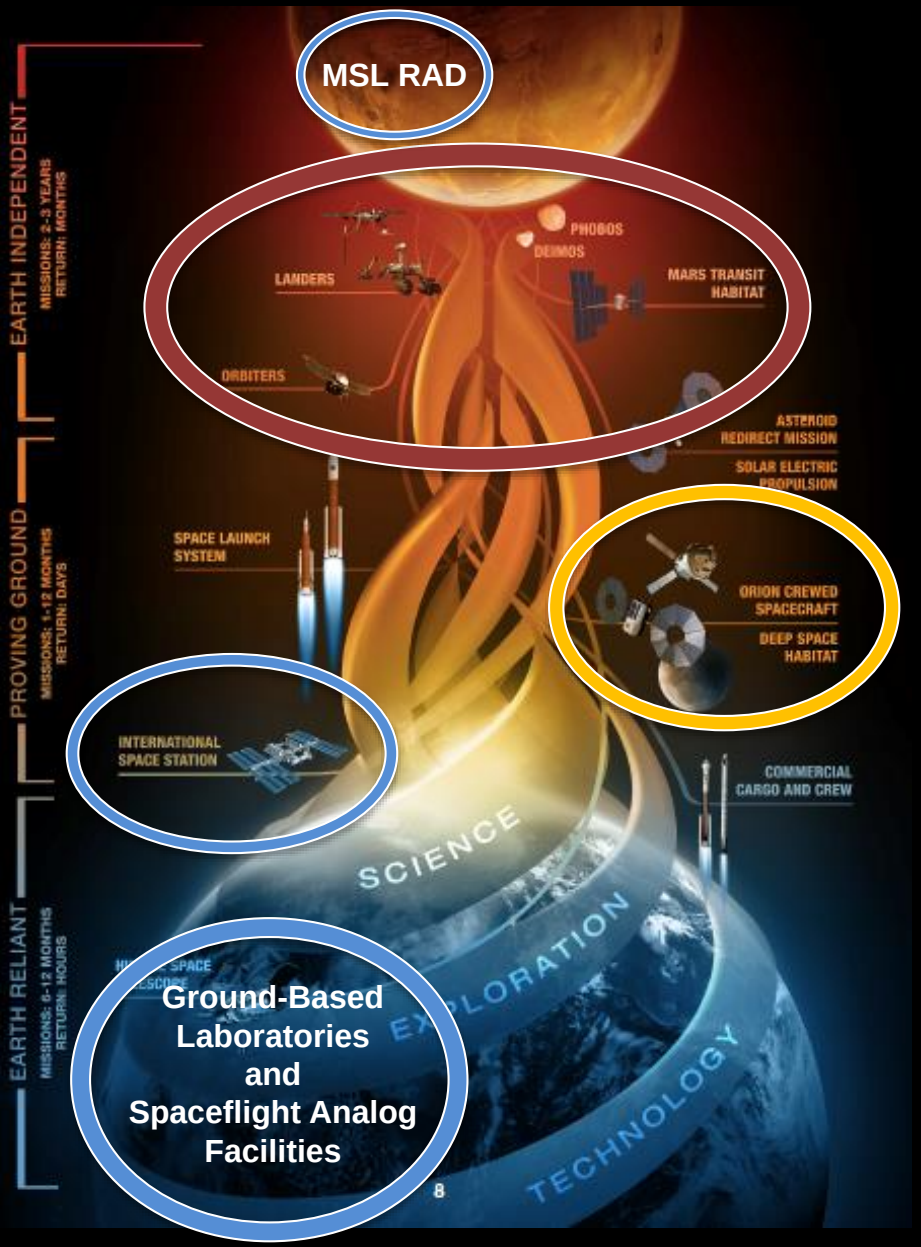
Inform exploration system designs

Now–2024 (+/-)

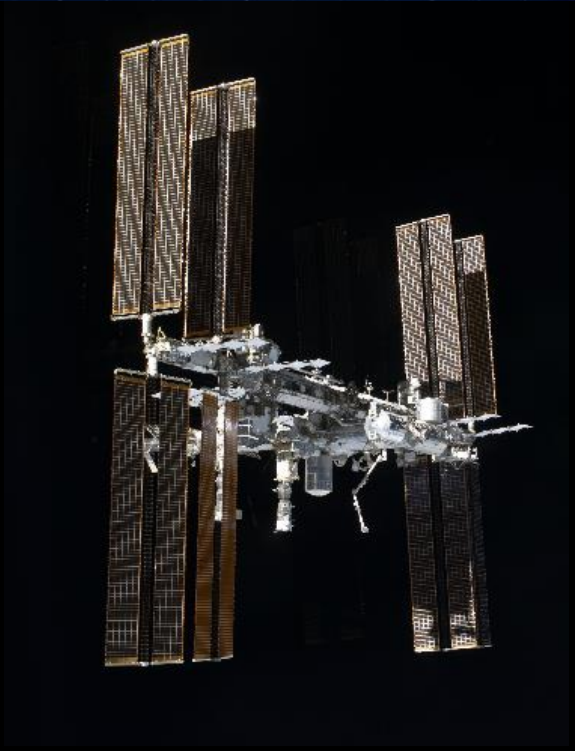
Develop/test mitigation approaches

- ISS
- Spaceflight analog facilities
- Ground-based laboratories

Inform deep-space hab designs



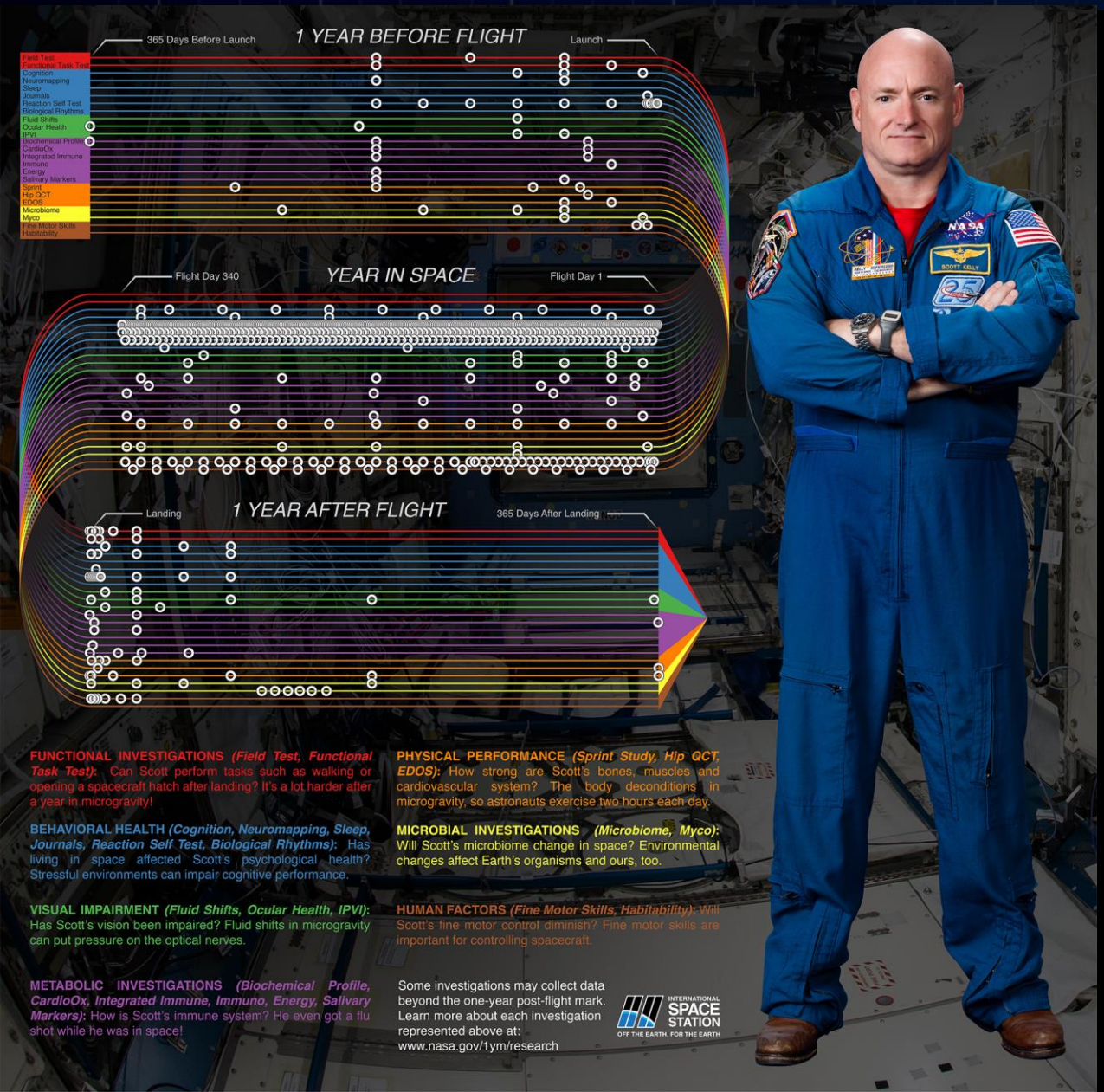
ISS: Space Platform for HRP Studies

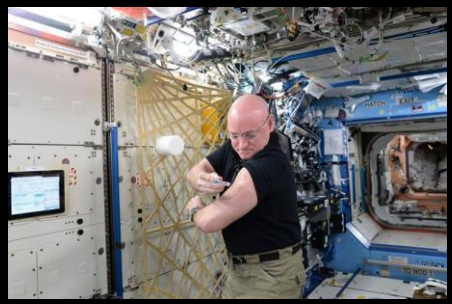


HRP studies receive highest priority for NASA science payloads aboard ISS.

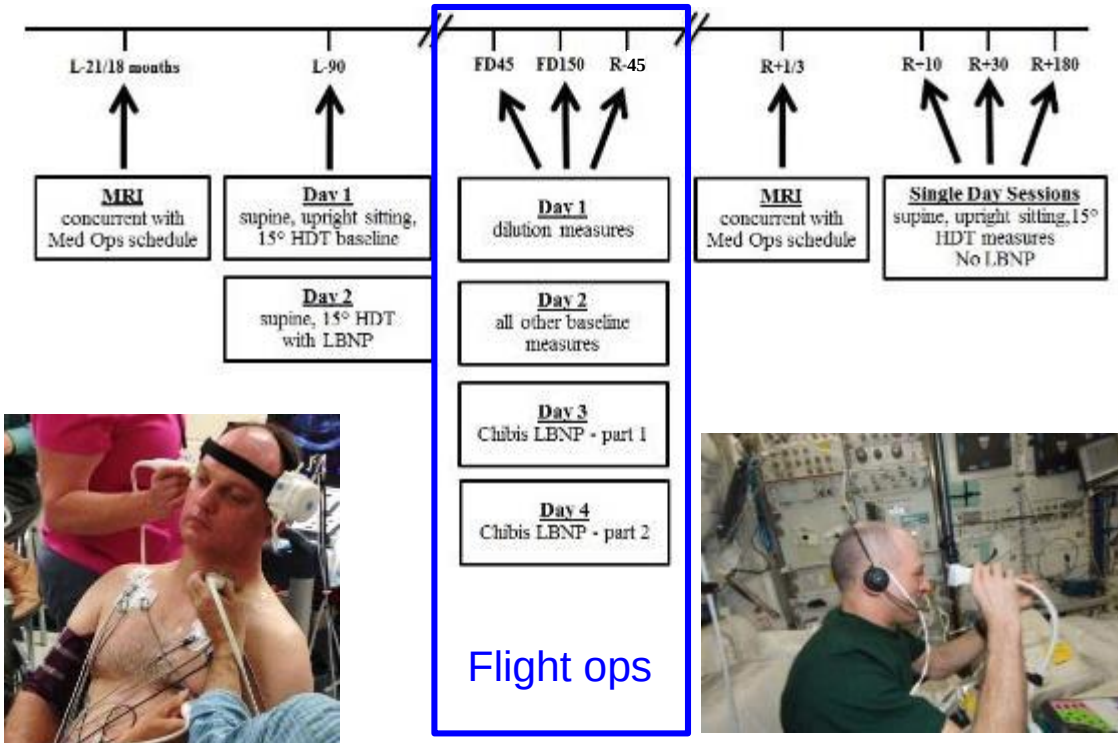
Each USOS crewmember participates in 10-15 separate HRP experiments.

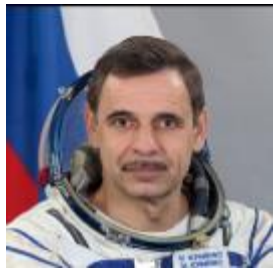
Year in Space/Twins Study





Visual Impairment–Fluid Shifts Experiment





Challenge: Russian Segment Ops

- Obtaining Agency-level Int'l Agreements
- Coordinating activities across NASA/Roscosmos
  - Hardware certification and testing activities
  - Simulation development planning
  - Real-time crew scheduling of US and Russian crew
- Consenting and training Russian crewmembers for NASA-sponsored science activities
- Procedure/Remote Guidance translation capability an unknown commodity

U.S./Russian Field Test Studies

Omics/Personalized CMs–Twins Study

Twins Study (Scott and Mark Kelly)

- ISS Sample Collection Completed
- Post Flight Sample Collection Completed

Objective

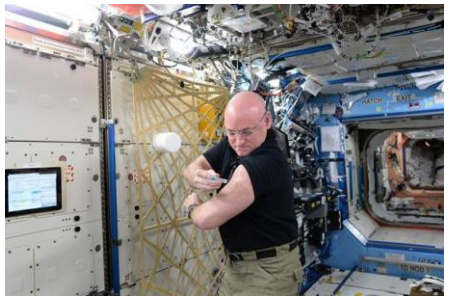
- Begin to examine next generation genomics solutions to mitigating crew health and performance risks: Personalized countermeasures

Twins Study National Research Team Examined

- Genome, telomeres, epigenome
- Transcriptome and epitranscriptome
- Proteome, Metabolome, Microbiome
- Physiology and Cognition

Significant Privacy and Ethics Issues

NASA is developing new genomics policy (modeled after NIH policy) that addresses informed consent, data privacy approaches, and genetic counseling on consequences of discovery (individual, family)



Preliminary Results Expected at HRP IWS (January 2017)

Circadian Regulation via Lighting

“Real Work Underway To Keep Mars Travelers Alive”

The clock is running on ISS testing for Mars missions

Oct 19, 2016 Frank Morring, Jr. | Aviation Week & Space Technology

Astronaut Kate Rubins recently installed new lighting in the International Space Station (ISS) crew quarters that could help her successors in space survive a mission to Mars. Known as a solid-state lighting assembly (SSLA), the device emits light in wavelengths that can be tuned to help space travelers get a better night’s sleep. The SSLA is a simple example of the complex testing underway on the ISS as NASA and its international partners prepare for eventual human travel to Mars.

Michael Fincke holding a General Luminaire Assembly (GLA) in Node 2.

Solid State Lighting Assembly (SSLA)

- Energy efficient, longer life span, no toxic mercury vapor.
- Excellent, bright light for visual performance and color discrimination.
- Suppresses melatonin to better manage circadian rhythms.
- Provides spectral adjustments to aid sleep and circadian disruption.
  - Blue shifts for the morning
  - Red shifts for the evening

Flight unit Solid State Lighting Module (SSLM)

Delivery and Testing Aboard ISS

- 7/8/16: 1st 4 SSLAs launched on SpX-9
- 10/5/16: Kate Rubins installed 3 SSLAs in Crew Quarters
- 11/15/16 Lighting Effects Flight Study begins on 49S
- 12/?/16: Next 11 SSLAs launch on HTV6

Brainard GC, et al. Solid-state Lighting for the International Space Station: Tests of Visual Performance and Melatonin Regulation. Acta Astronautica. 2012 November; 92(1): 21-28. DOI: 10.1016/j.actaastro.2012.04.019.

Renal Stone Formation Risk Mitigation

Risk of renal stone formation/development is elevated during and early after flight

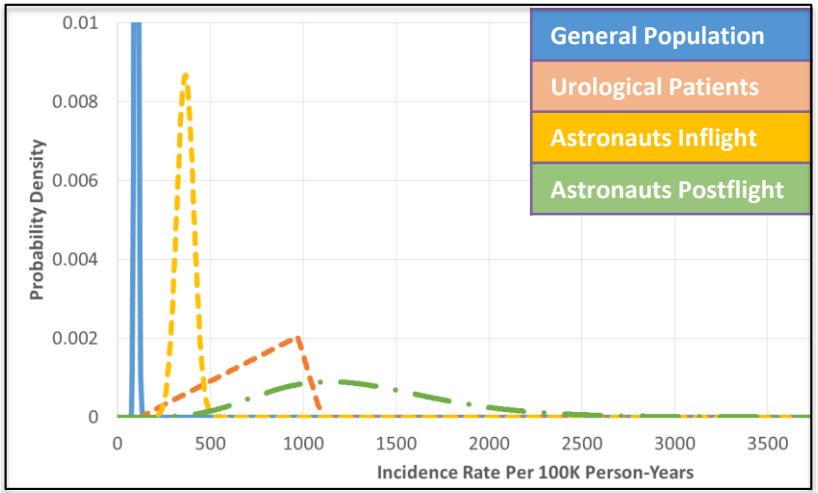
- Fluid redistribution, bone loss, muscle atrophy, diet

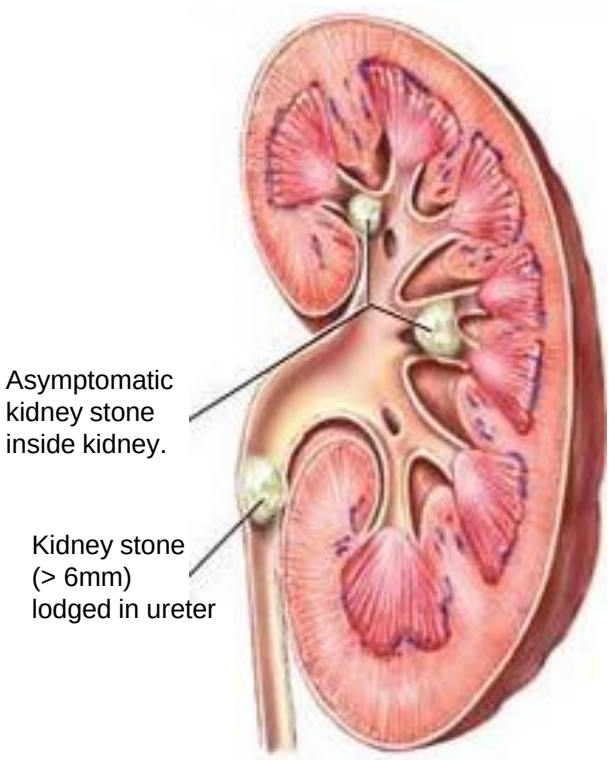
Current Risk Mitigation Strategy:

- Preflight ultrasound screening
- In-flight prevention: resistive exercise, increased fluid intake, appropriate diet
- Oral Calcium citrate

Future Risk Mitigation Research Goals:

- Flexible Ultrasound System (FUS) to provide clinical grade imaging of asymptomatic stones.
- FUS to provide therapeutic modalities:
  - Moving a kidney stone away from the ureters
  - Moving a kidney stone lodged in the ureter
  - Non-invasively breaking-up a kidney stone.





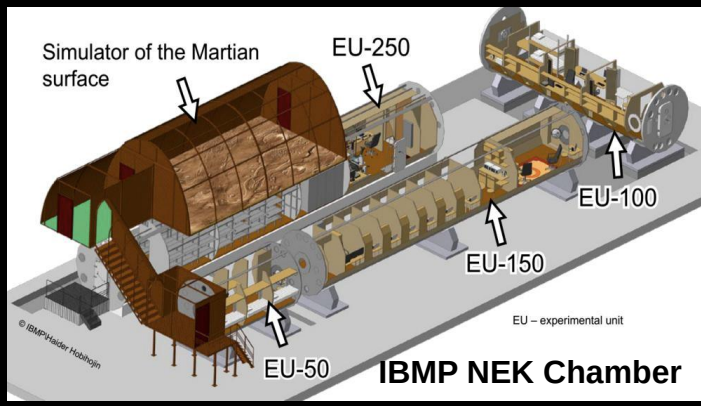

Misery


Agony

FUS moving stone in ER patient.


Ultrasound testing aboard ISS

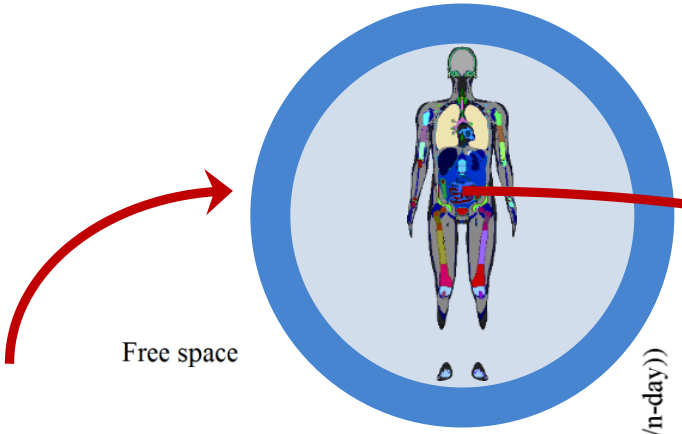
Spaceflight Analog Facilities

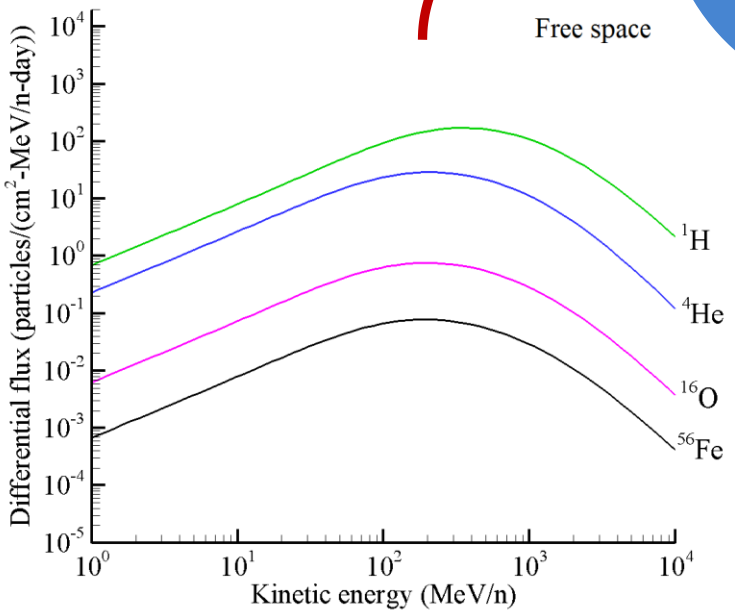


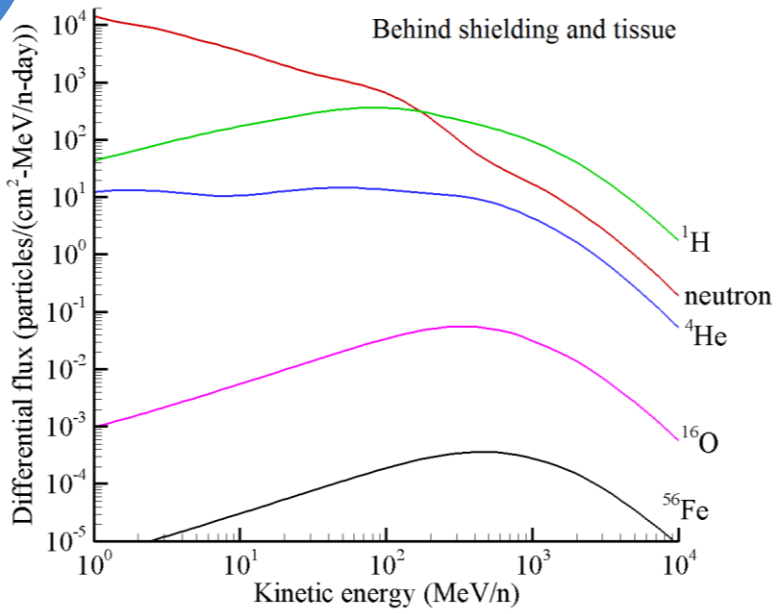
External and Internal Fields

The external field is modified as it passes through shielding and tissue

- Slowing down due to atomic processes
- Attenuation and breakup of heavy ions due to nuclear collisions
- Secondary particle production (especially neutrons)



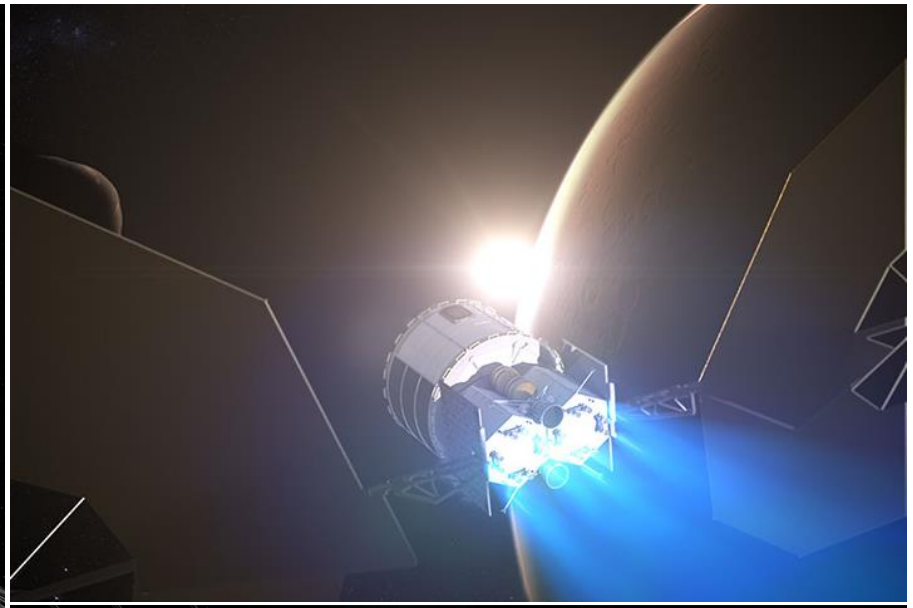




Selected particle spectra in free space (left) and behind 5 g/cm² of aluminum and 30 g/cm² of water (right) during solar minimum.

Preparing for cis-Lunar Space

THE JOURNEY CONTINUES



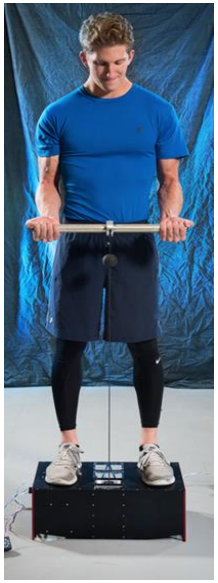
Advanced Exercise Countermeasures

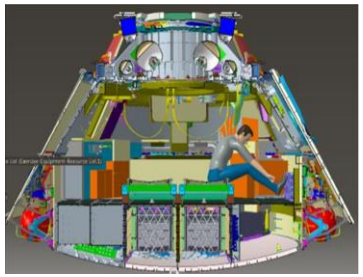
MPCV Exercise Device (ROCKY)

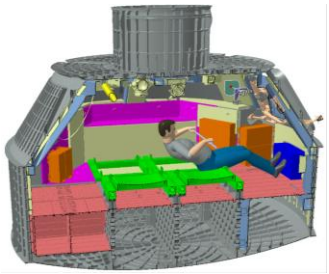
Servo-motor controlled, single cable exercise system

- Provides resistive loads up to 400 lbf at velocities up to 2 m/s
- Software-modifiable exercise loading profiles
  - Inertial characteristics of free weights for resistive training
  - Oar/boat loading dynamics for aerobic (rowing) training
  - Custom profiles for eccentric overloading, weight racks, etc.
- Capacitor bank allows unpowered operation in rowing mode

ROCKY = Resistive Overload Combined with Kinetic Yo-yo







Deep Space Exercise Device (ATLAS)

Servo-motor controlled, double cable exercise system

- Leverage the MPCV/ROCKY, MMED2, and SBIR efforts
- Demonstrate/validate on ISS asap (NET 2019)
- TTO to augment/replace ARED after initial valid

Design Goal: ATLAS will exceed ARED capabilities at 1/10 of its mass and volume.

ATLAS = Advanced Twin Lifting and Aerobic System

HRP: Research to Enable Space Exploration

Human travelers to Mars will experience unprecedented physiological, environmental, and psychosocial challenges that could lead to significant health & performance decrements in the absence of effective mitigation strategies.

Success of any human mission to Mars will hinge on the mission designers' ability to develop and implement such strategies.

NASA's Human Research Program is responsible for identifying those strategies.


NASA