



Human Research Program

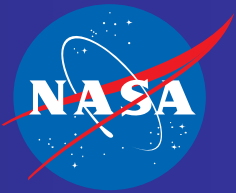
Steven H. Platts, Ph.D.

Chief Scientist

HRP-Johnson Space Center

Houston, TX

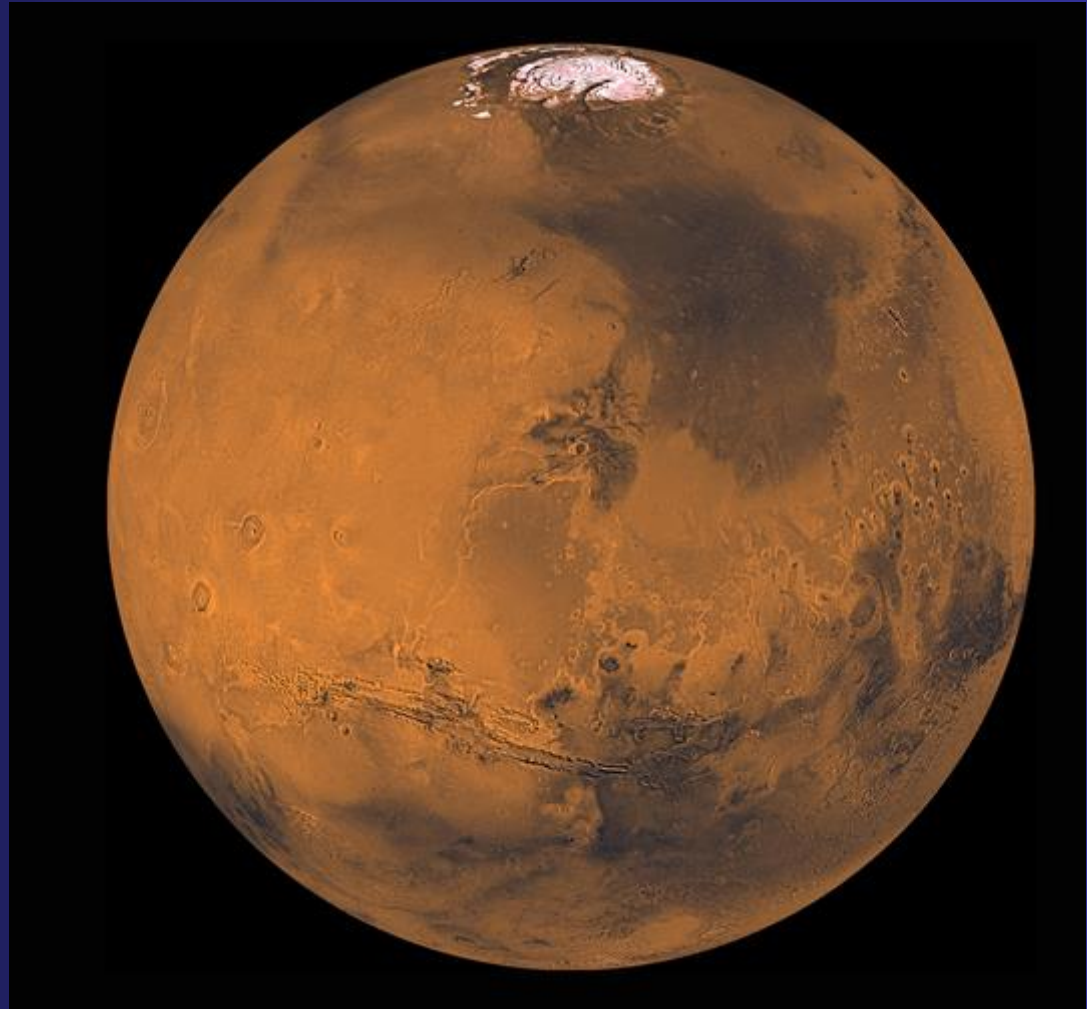
humanresearch.jsc.nasa.gov

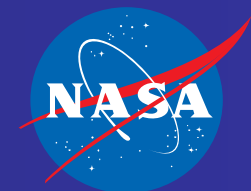


Human Research Program Mission Statement

Human Research Program

Mission: To enable
space exploration
beyond Low Earth Orbit
by reducing the risks to
human health &
performance

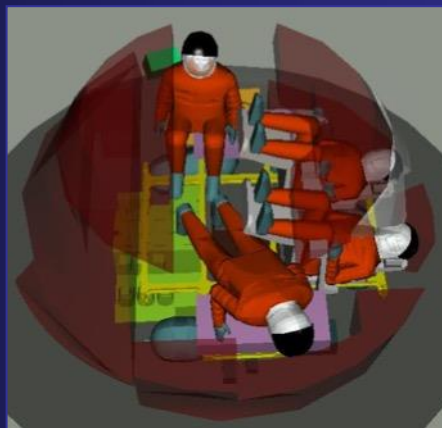




Human Research Program

Human Research Program

- The Human Research Program (HRP) focuses on applied research
- Program goals
 - Perform research necessary to understand and reduce spaceflight human health and performance risks in support of exploration
 - Enable development of human spaceflight medical and human performance standards
 - Develop and validate technologies that serve to characterize and reduce medical risks associated with human spaceflight

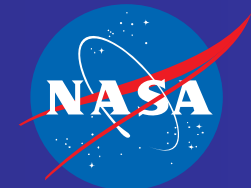


An Applied Research Program

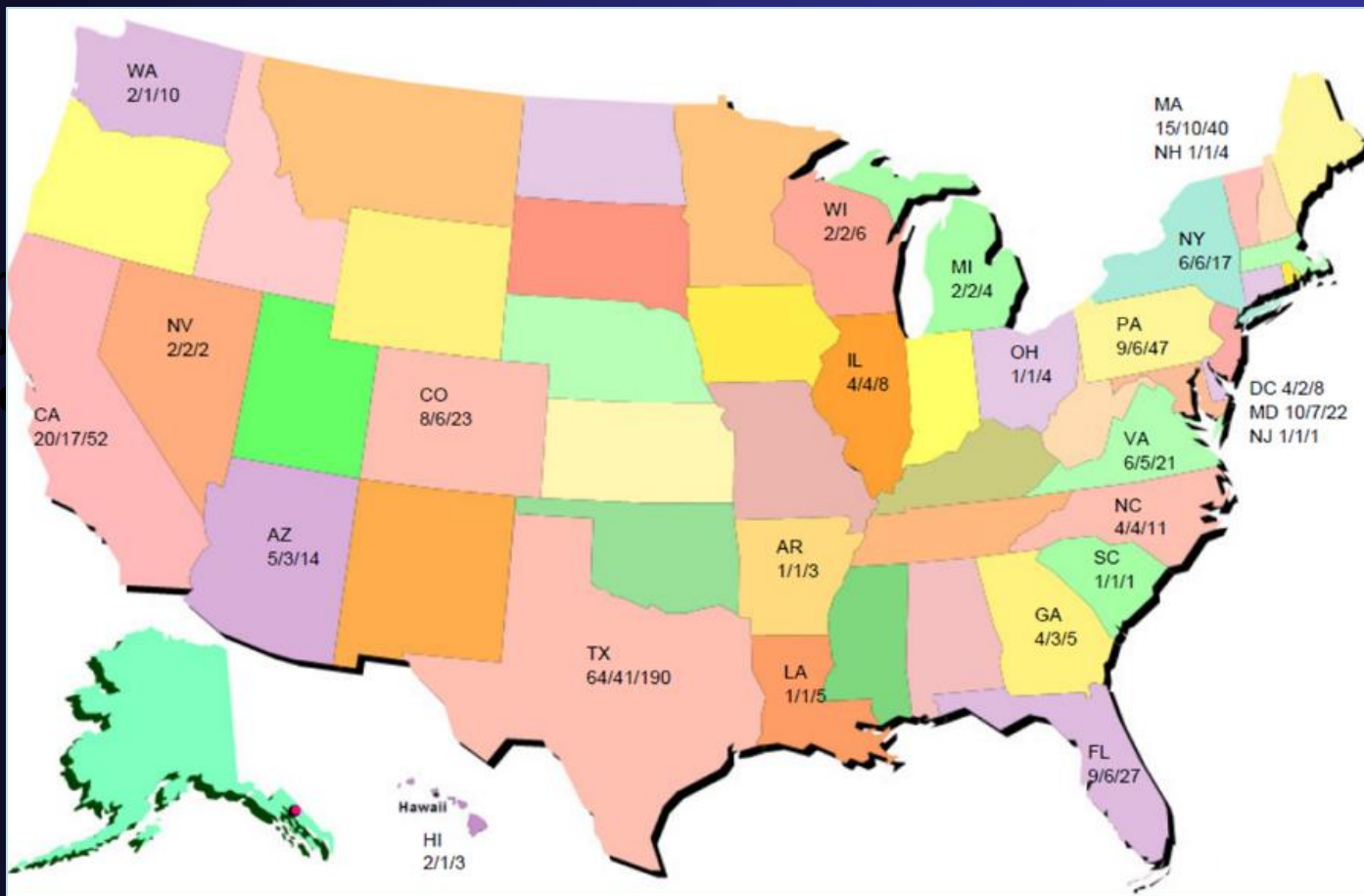


Nationwide Research Program

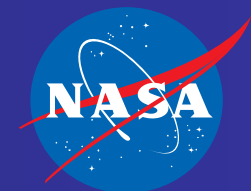
Projects/Principal Investigators/Co-Investigators by State



Human Research Program

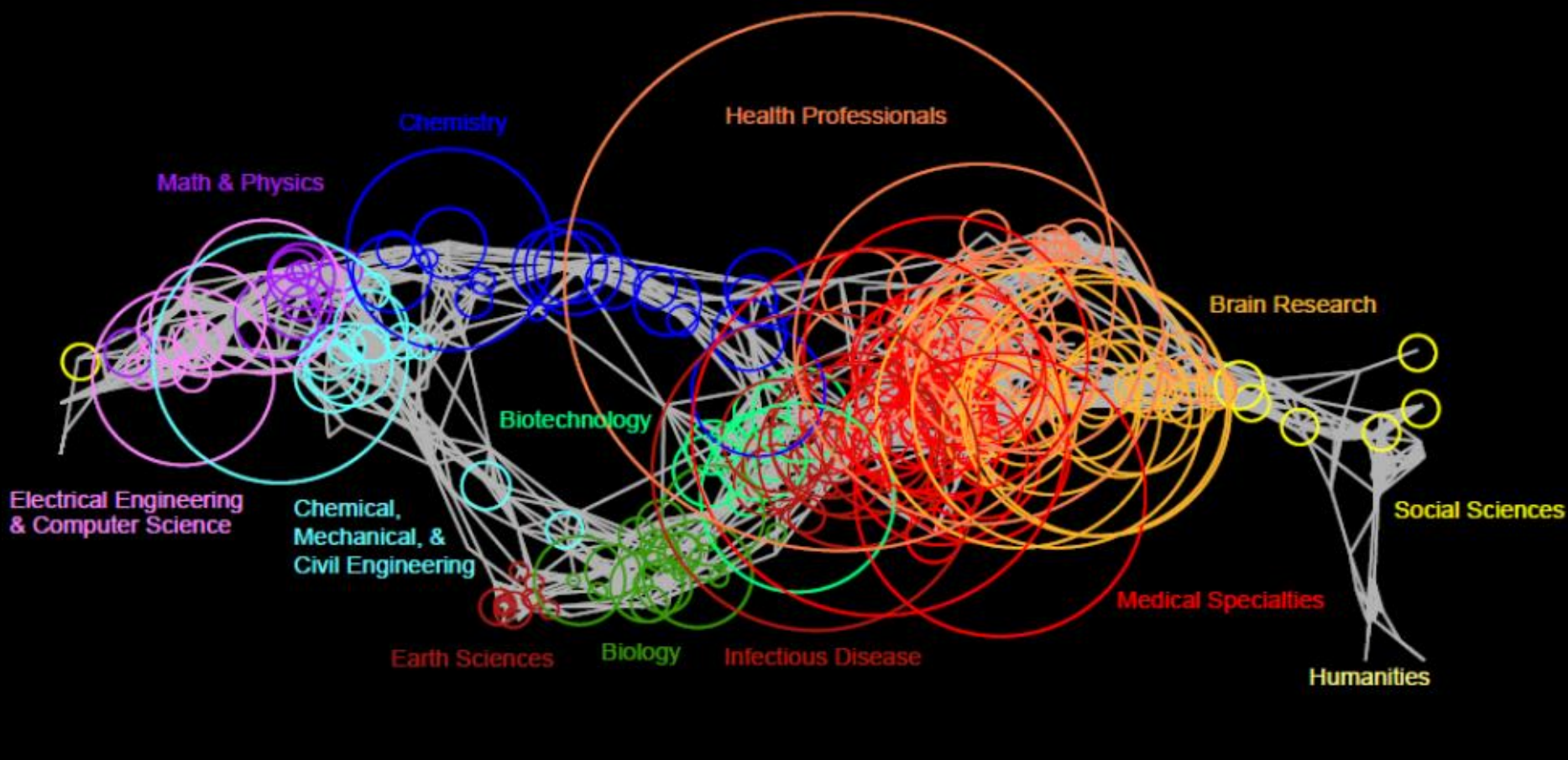


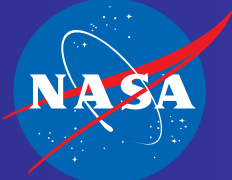
185 Research
135 Principal
529 Co-Invest
26 States



HRP Map of Science

Human Research Program





Human Research Program

Radiation



Isolation & Confinement



Distance from Earth



Gravity fields



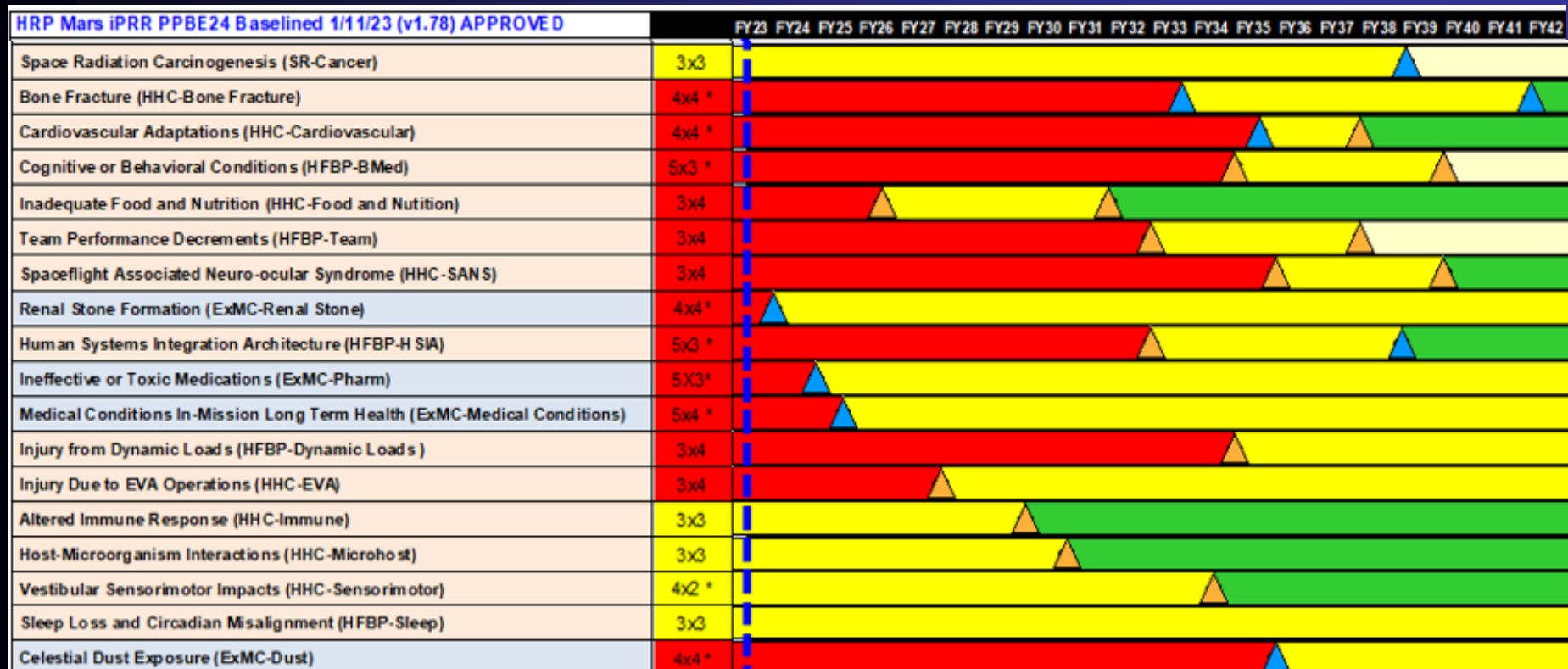
Environments



Path to Risk Reduction – Mars DRM

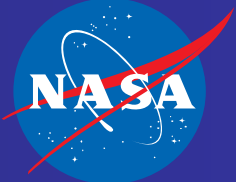
Human System Risks Requiring Research

Human Research Program





Human System Risk Summary – Risks by Hazard



Human Research Program

Human Spaceflight Risks	Low Earth Orbit (Long) 30 D - 1 Y	Lunar Orbital (Short) < 30 D	Lunar Orbital (Long) 30 D - 1 Y	Lunar Orbital + Surface (Short) < 30 D	Lunar Orbital + Surface (Long) 30 D - 1 Y	Mars (Preparatory) < 1 Y	Mars (Planetary) 730-1224D
Radiation							
Non-Ionizing Radiation	A	A	A	A	A	AO	AO
Radiation Carcinogenesis (LTH)	RC	A	RC	A	RC	RM	RM
Distance from Earth							
Inadequate Human Systems Integration Architecture	A	RM/SR	RM/SR	RM	RM	RM	RM
Inflight Medical Conditions	A	A	RM	RM	RM	RM	RM
Inadequate Food and Nutrition	A	A	RM	A	RM	RM	RM
Ineffective or Toxic Medications	A	A	A	A	A	A	RM
Isolation and Confinement							
Cognitive or Behavioral Conditions	RM	AM	RM	RC	RM	RM	RM
Psychosocial Adaptation within a Team	AM	AM	RM	AM	AM	RM	RM
Altered Gravity							
Bone Fracture	A	A	RC	A	RC	RC	RC
Cardiac Rhythm Problems	AM	AM	AM	AM	AM	RM	RM
Concern of Venous Thromboembolism (VTE)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Host-Microorganism Interactions	AM	AM	AM	AM	AM	AM	RM
Orthostatic Intolerance	A	A	A	A	A	A	A
Reduced Aerobic Capacity	AM	AO	AO	AO	AO	AO	AO
Reduced Muscle Size	AM	AO	AM	AO	AO	AO	AO
Renal Stone Formation	A	A	A	A	A	RM	RM
SANS	A	A	A	A	A	A	RM
Sensorimotor Alterations	RM/SR	AM	RM/SR	RM/SR	RM/SR	RM/SR	RM/SR
Urinary Retention	A	A	A	A	A	A	A
Crew Egress	AM	RC	RC	RC	RC	RC	RC
Cardiovascular Adaptations	AM	A	AM	AO	AO	AM	RM
Hostile Closed Environment							
Altered Immune Response	AM	AM	AM	AM	RM	RM	RM
Carbon Dioxide Exposure	A	A	A	A	A	RM	RM
Celestial Dust Exposure	N/A	A	A	A	RM	N/A	TBD
Decompression Sickness	A	RM	RM	RM	RM	RM	RM
Dynamic Loads	AM	AM	AM	RM	RM	AM	RM
Electrical Shock	A	A	A	RC	RC	RC	RC
EVA Risk	A	AO	AO	RM	RM	AO	RM
Hearing Loss (LTH)	AM	AM	RC	AM	AM	RC	RC
Hypoxia (LTH)	RM	A	RM	A	RM	RM	RM
Sleep Loss	AO	AO	AO	AO	RM	RM	RM
Toxic Exposure	AM	AM	AM	AM	AM	AM	AM

Notes:

- Risk ratings are approved at the Human System Risk Board
- Risk ratings are for In-mission operations unless otherwise noted for Long-Term Health (LTH)
- Risk text color:
 - Current risk ratings
 - Risk ratings under review
 - Proposed to be approved
 - To be transferred to another risk
- Risk colors:
 - High LxC
 - Mid LxC
 - Low LxC
- Risk Dispositions
 - A – Accepted
 - AM – Accepted with monitoring
 - AO – Accepted with optimization
 - RM – Requires Mitigation
 - RM/SR – Requires Mitigation/Standard Refinement
 - RC – Requires Characterization

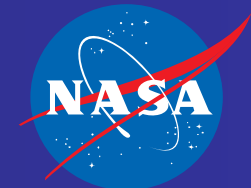


Characteristics of HRP

Human Research Program

- Composed of five Elements
 - Exploration Medical Capability
 - *Medical care for deep-space missions*
 - Human Factors and Behavioral Performance
 - *Interfaces between humans, vehicles & habitats*
 - *Individual and interpersonal*
 - Human Health Countermeasures
 - *Physiology*
 - Space Radiation
 - *Biological effects of radiation exposure*
 - Research Operations and Integration
 - *Infrastructure for flight and analog experiments*
- Funds Translational Research Institute for Space Health (TRISH) through cooperative agreement to pursue disruptive, breakthrough approaches that reduce risks to human health and performance
- Collaborates with NASA Space Biology to understand causal cellular and other mechanisms that underlie adaptation to fractional gravity levels in cells, microorganisms, plants, and animals





Human Research Program

STEPS TO MARS

EARTH:

Simulated spaceflight hazards
in Ground Analogs | :envihab |
Antarctic Stations | NEK | HERA |
Space Radiation Lab

LOW EARTH ORBIT:

International Space Station –
A unique testbed to study micro-
gravity and environment hazards,
with varying mission durations

LUNAR MISSIONS:

Decreasing Earth-dependence
around and on the lunar surface.
Provides insight into deep space
radiation; behavioral health, and
gravity transitions

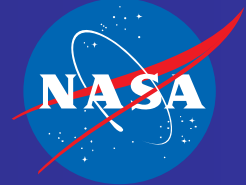


National Aeronautics and
Space Administration



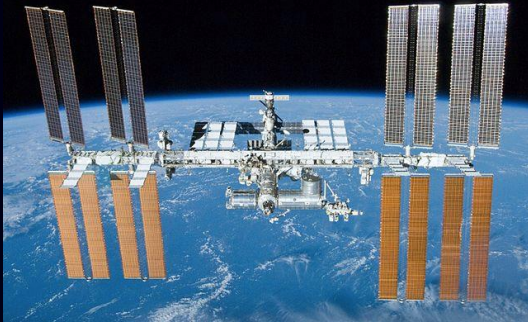


Venues for Conducting Research



Human Research Program

International Space Station



Envihab



Parabolic Flight



NSRL



HERA



Antarctica

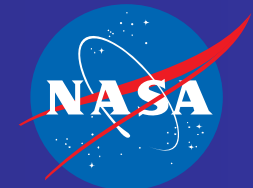


NEK





Use of Collaborations and Partnerships to Multiply Resources



Human Research Program

NASA Programs and Affiliates

- Biological & Physical Sciences (BPS)
- Health & Medical Technical Authority (HMTA)
- Advanced Exploration Systems (AES)



SBIR-STTR



International

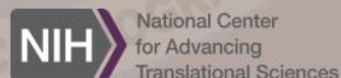
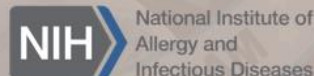


مرکز محمد بن راشد
للفضاء
MOHAMMED BIN RASHID SPACE CENTRE



Domestic OGA

- NSRL Outside Users



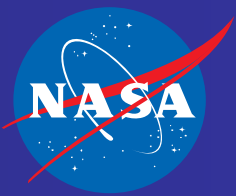
Industry / External

- Commercial Space Providers
- TRISH industry partners
- Others



National Council on Radiation Protection and Measurements

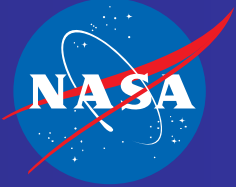
CURRENT PARTNERSHIPS



Decadal Survey

Human Research Program

- Based on the bold and encouraging recommendations from this report, future joint work, including solicitations, may include work in the following topic areas:
 - Tissue chips
 - Translational science
 - Plants/food system/synthetic biology
 - Systems biology (e.g. Gene lab)
 - Host/pathogen/microbiome
 - Radiation
 - CNS/Behavioral Medicine/Sensorimotor combinatorial effects
 - Spaceflight Associated Neuro-ocular Syndrome
 - Cardiovascular adaptation to spaceflight
 - Fluid Shifts



Tissue Chip Joint Solicitation

Human Research Program

Agency Partners



National Institutes of Health



National Center for Advancing Translational Sciences



National Institute of Allergy and Infectious Diseases



National Cancer Institute



U.S. FOOD & DRUG ADMINISTRATION

Extended Longevity of 3D Tissues and Microphysiological Systems for Modeling of Acute and Chronic Exposures to Stressors

NNH21ZDA015N NASA Research Announcement

Lisa Carnell, PhD, Program Scientist, Biological and Physical Sciences Division (NASA)

Steve Platts, PhD, Acting Chief Scientist, Human Research Program (NASA)

Lucie Low, PhD, Scientific Program Manager, National Center for Advancing Translational Sciences (NIH/NCATS)

Mary Homer, PhD, Chief, Radiological and Nuclear Countermeasures (BARDA)

Shannon Loelius, PhD, Biologist, Radiological and Nuclear Countermeasures (BARDA)

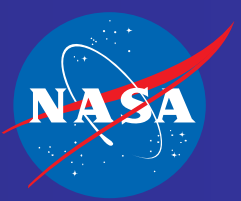
Jennifer Couch, PhD, Chief, NCI Structural Biology and Molecular Applications Branch, Division of Cancer Biology (NIH/NCI)

Brian Sorg, PhD, Program Director, Division of Cancer Treatment and Diagnosis (NIH/NCI)

Carmen Rios, PhD, Program Officer, Radiation and Nuclear Countermeasure Program, DAIT (NIH/NIAID)

Halonna Kelly, PhD, Program Officer, Basic Immunology Branch, DAIT (NIH/NIAID)

Tracy MacGill, PhD, Director, FDA Medical Countermeasure Regulatory Science, OCS, OCET



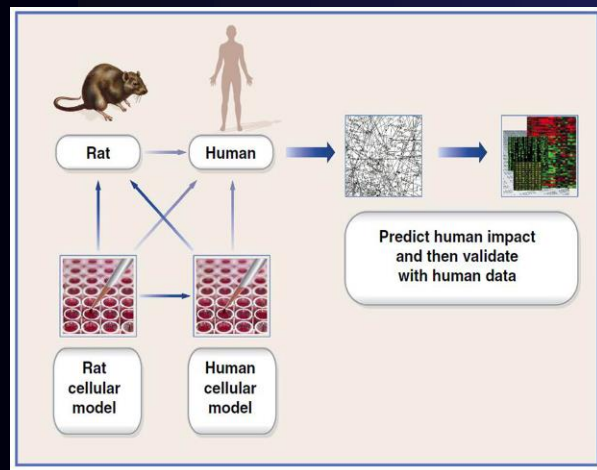
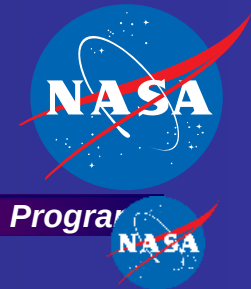
Translational Science

Human Research Program

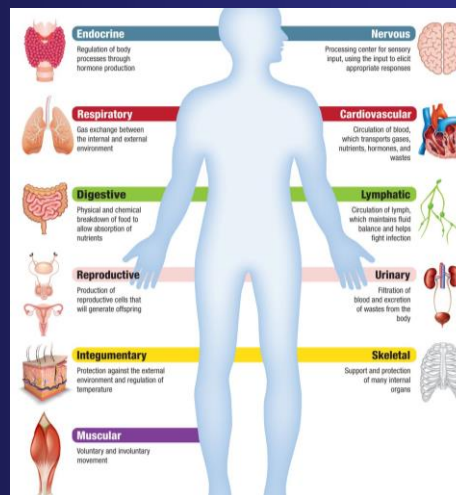
- HRP is more aggressively taking a multidisciplinary approach to addressing the identified risks and characterizing new and emerging risks
- Human Variability is large and our 'n' is small
 - Translating between individuals (population data and case studies)
 - Translating between populations (astronaut-like test subjects: HDBR; ICC; ICE)
 - Translating between species (rodent models for mechanistic studies): additional complexity of analogs (HLU)
- Time Course of exposure (CIPHER)
 - Extrapolating out to different durations
 - Characterizing exposures: Galactic Cosmic Rays versus....



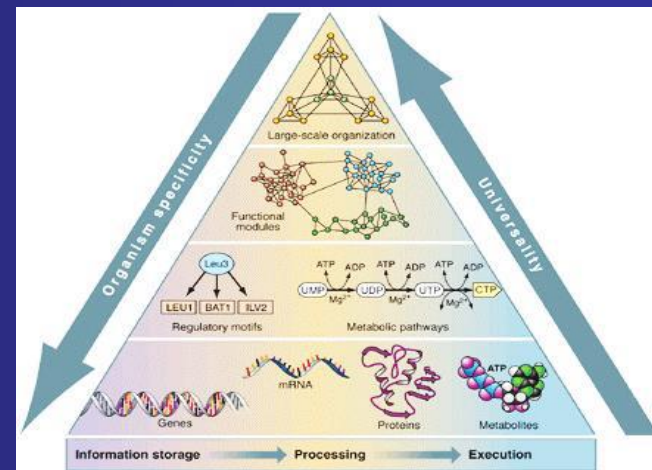
Systems Biology Project



CROSS
SPECIES



CROSS
SYSTEMS



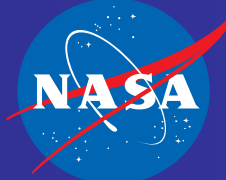
CROSS LEVELS

Cross-Cutting
Computational
Modeling Project (CCMP)

Precision Health Initiative



Artemis



Human Research Program

Artemis I: 2022

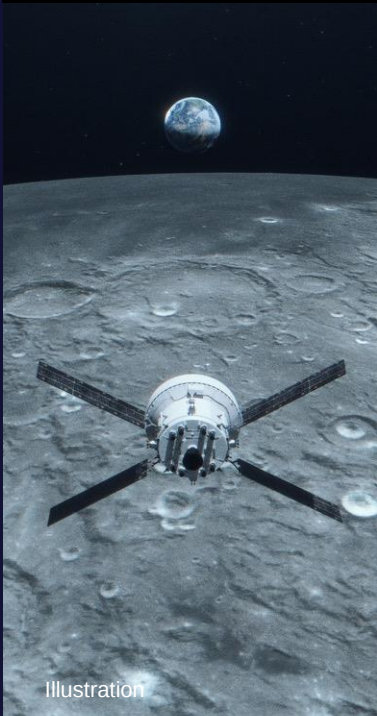
Uncrewed flight test
COMPLETE



SLS, Orion, EGS

Artemis II: 2024

Crewed flight test



Illustration

SLS, Orion, EGS

Artemis III: 2025

Crewed surface
expedition



Illustration

SLS, Orion, EGS, HLS

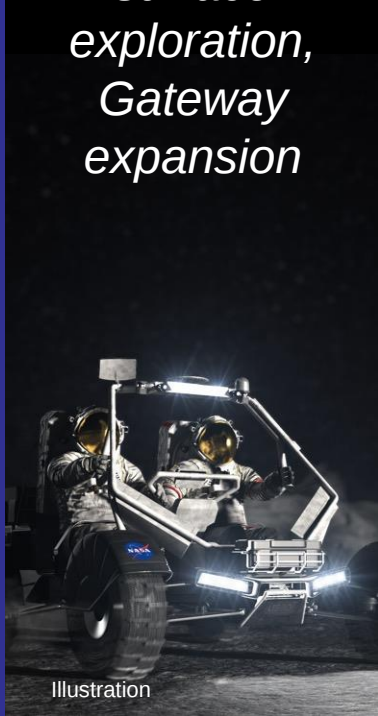
Artemis IV
Gateway
assembly,
crewed
sustaining lander
expedition



Illustration

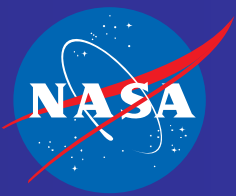
SLS, Orion, EGS,
HLS, Gateway
(PPE/HALO, I-HAB)

Artemis V
Crewed mobile
surface
exploration,
Gateway
expansion



Illustration

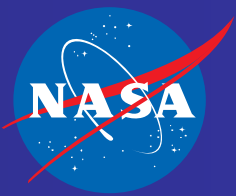
SLS, Orion, EGS,
HLS, LTV, Gateway
(ESPRIT, Canadarm3)



Why human research on Artemis?

Human Research Program

- This mission represents an **opportunity** to gather data to **characterize the effects of the deep space and operational environment** on astronauts that has not been available or experienced since Apollo.
- This unprecedented mission will have **both females and males** living and working in isolated and confined vehicles with a high mission tempo focused on Artemis objectives such as lunar landing and surface extravehicular activities.
- The performance objectives create a rich scenario in which to **understand how the human adapts to the hazards of spaceflight and maintains high level mission performance in a constrained environment.**



Collaborative Opportunities

Human Research Program

HRP HERO Solicitations

Flagship

Omnibus

New Investigator

Early career

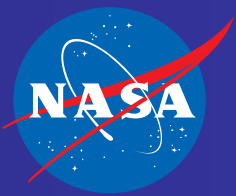
TRISH

EPSCoR

MUREP

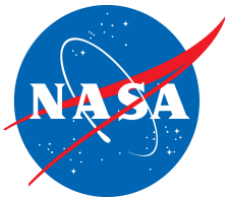
SBIR

Joint activities with BPS



Thank you for Listening!

Questions?

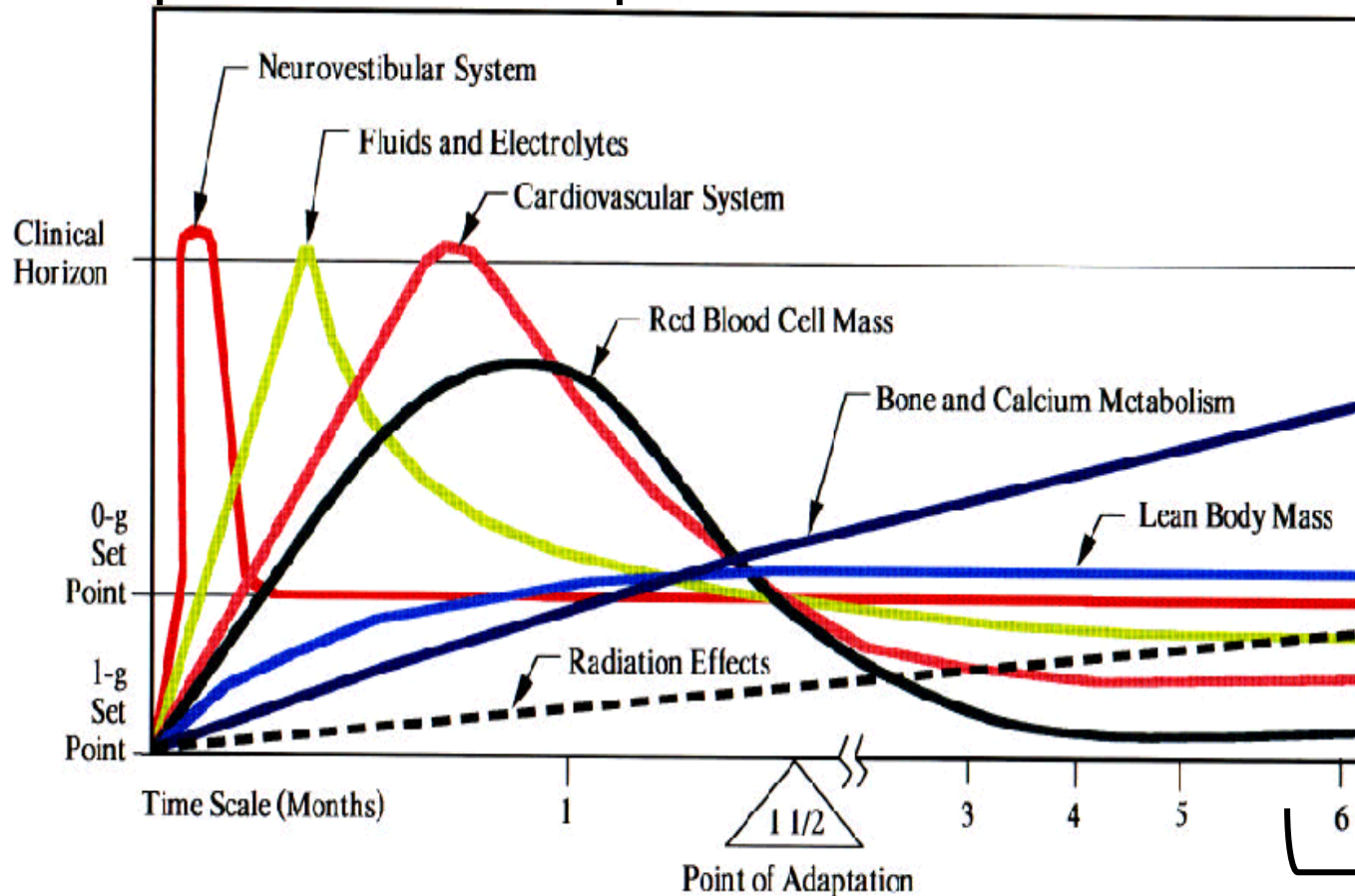


Time Course of Physiological Changes During Weightlessness

This is notionally how the body adapts to Spaceflight, most notably microgravity

Note that there are acute and chronic processes at work

Still unclear if there are bimodal responses



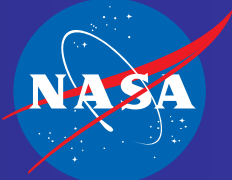
A. Nicogossian et al, Space Physiology and Medicine

Therefore, the body has a process by which it readapts to gravity. These processes will have acute and chronic elements as well



HRP enabling Artemis missions

HRP solving problems for today's vehicle Programs.



Human Research Program
New for PP
New Initiative



ORION

- WMS requirements validation
- Cabin imagery system
- Flywheel exercise device collaborations



GATEWAY

- Crew Health and Performance Integrated Data Architecture (CHP-IDA) – collaboration with AES/Enabling Capabilities



HUMAN LANDING SYSTEM

- Acceleration requirements
- Caloric requirements for high tempo EVA missions
- Autonomy Standards



LUNAR TERRAIN VEHICLE

- Acceleration/Vibration Requirements
- Autonomy Standards



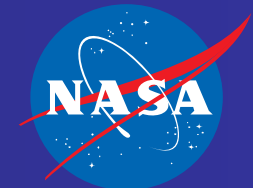
EVA SUITS

- Emergency CO₂ limits
- In-suit Nutrition Requirements



EXPLORATION CAPABILITIES

- Food System Trade Study
- No-Treadmill ISS study Integration
- CHAPEA one year analog support and research collaborations



HRP Goal & Objectives for Artemis

Human Research Program

Advance knowledge to support safe, productive human space travel, and perform systems testing to reduce risks for future human exploration

1. Exploration Medical Operations Advancement

Evaluate and validate progressively Earth-independent crew health & performance systems and operations.

2. Integrated Human System Research

Evaluate changes to the human system and validate countermeasures to mitigate impacts to overall crew health & performance with human subject research.

3. Living Environment

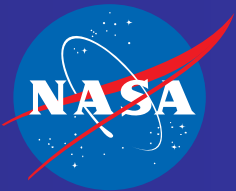
Evaluate the interaction of exploration habitation systems and spaceflight hazards and validate crew health & performance.

4. Special Task-Related Issues

Evaluate and validate operational implementation of critical tasks and human factors for adequate crew health & performance.

5. Extended Mission Durations

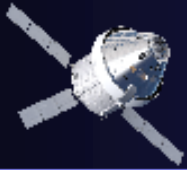
Test crew health & performance with the hazard environments, mission durations, and systems representative of Mars-class missions.



Artemis Utilization Planning

HRP Leading International complement planning for Human Life Sciences

Human Research Program



1. Dry Saliva Books
2. Crew/Team Perf. Measures
3. Actigraphy



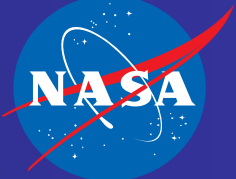
1. Crew/Team Perf Measures
2. Actigraphy, Cognition, Sleep Questionnaires
3. Dry Saliva Books
4. Blood Analysis (TBD)
5. Ultrasound
6. Pharm Samples
7. Ophthalmic Measurements
8. IN-SITU (ESA/ASI led)
9. Thermosensor (ESA/DLR led)
10. TIME (ESA led)
11. EveryWear application (ESA/CNES led)



1. Ultrasound
2. Crew/Team Perf Measures
3. Actigraphy, Cognition, Sleep Questionnaires
4. Dry Saliva Book
5. Heart rate monitor
6. Alterations of Multi-Sensory Integration from Combined Hazards
7. Blood Analysis
8. Crew Health Data Mnmgt
9. Lunar Ascent/Descent Dyn Loads Injury Assess.

Coordinated Roadmaps across NASA

Integration of agency investments to reduce human health risks from Exploration Missions



Human Research Program

HEOMD Cross Cutting Deliverable

HEO Capability Gap Closure

Agency Investments in Human System Risk Mitigation

Habitation Systems Capability Leadership Team

Integrates among teams developing crew health & performance, environmental monitoring, and life support systems and develops agency-level roadmaps

**CREW HEALTH and
PERFORMANCE SYSTEMS**



EVA Physiology



Counter-measures



Food + Nutrition



Radiation



Exploration
Medical

Biological and Physical Sciences

Solicits and conducts research to understand how biological and physical systems respond to spaceflight environments, particularly reduced gravity and radiation

Human Research Program

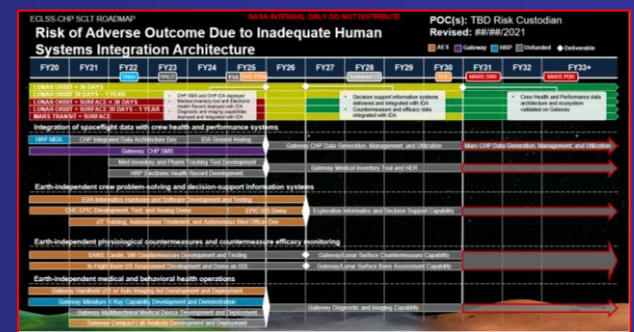
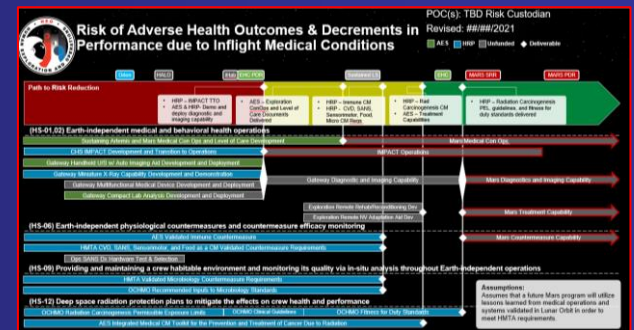
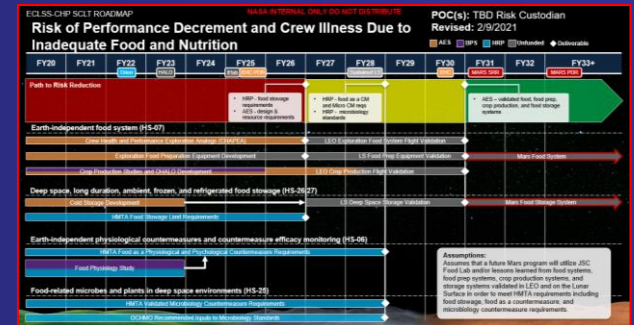
Enables human space exploration beyond LEO by reducing risks to astronaut health & performance through a focused program of applied research and technology development

AES Enabling Capabilities

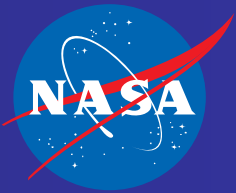
Develops prototype systems, advances key capabilities, and validates operational concepts for human missions outside of LEO

Crew Health & Safety

Provides a comprehensive astronaut occupational health program and agency capabilities for human health risk modeling and human health data collection, aggregation, and analysis



Integration across all Programs addressing Human System Risks



Agency Progress on Selected Risks

Human Research Program



- 50+ years of spaceflight medical evidence integrated with resource requirements in a probable risk assessment decision support tool.
- HRP recommending moving risk to “yellow” in next 2 years



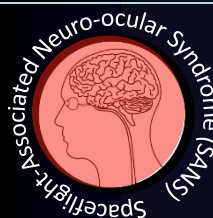
- Exercise standards validated for maintaining muscle and aerobic capacity
- HRP now focusing on exercise hardware



- Renal Stone mitigations (hydration, exercise, etc.) in place
- HRP recommending moving risk to “yellow” in next year



- Antarctica validated as a spaceflight analog.
- Ground countermeasure validation concluding soon.



- Strict head-down-tilt bedrest validated as a spaceflight analog
- Countermeasure concepts being tested now in analogs and in spaceflight



- New dose-based standard in place. Mitigations largely dependent on advances in terrestrial detection and treatment capabilities
- HRP working on characterizing unique GCR effects and individual susceptibility to provide informed consent and decision making



- New evidence indicates that DXA Bone Density measurement not adequate to characterize fracture risk
- HRP working to develop bone microarchitecture scans as more predictive tool



- Compression suit and fluid loading countermeasures validated
- HRP risk work completed, optimization potential