National Aeronautics and Space Administration

Human Research Program
Lunar Surface Research

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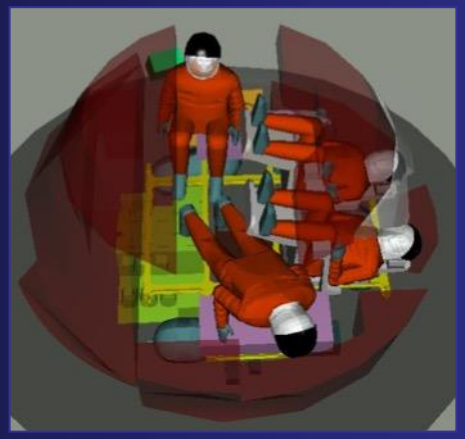
nasa.gov/hrp

Human Research Program Mission Statement

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

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

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Hazards of Human Spaceflight

Human Research Program

1 Space Radiation

Invisible to the human eye, radiation increases cancer risk, damages the central nervous system, and can alter cognitive function, reduce motor function and prompt behavioral changes.

2 Isolation and Confinement

Sleep loss, circadian desynchronization, and work overload may lead to performance reductions, adverse health outcomes, and compromised mission objectives.

3 Distance from Earth

Planning and self-sufficiency are essential keys to a successful mission. Communication delays, the possibility of equipment failures and medical emergencies are some situations the astronauts must be capable of confronting.

4 Gravity (or lack thereof)

Astronauts encounter a variance of gravity during missions. On Mars, astronauts would need to live and work in three-eighths of Earth's gravitational pull for up to two years.

5 Hostile/Closed Environments

The ecosystem inside a vehicle plays a big role in everyday astronaut life. Important habitability factors include temperature, pressure, lighting, noise, and quantity of space. It's essential that astronauts stay healthy and happy in such an environment.


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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
www.nasa.gov/hrp
NP-2020-11-020-JSC

Human System Risk Summary – Risks by Hazard

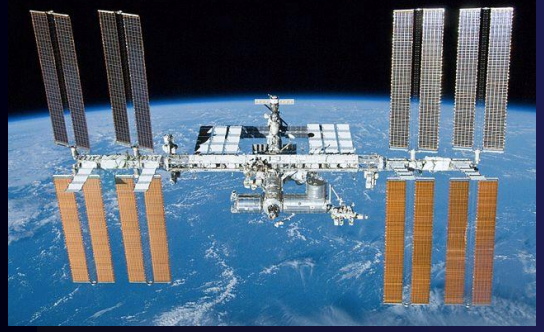
Human Spaceflight Risks	Low Earth Orbit (Long) 30 D - 1 Y	Lunar Orbital (Short) < 30 D	Lunar Orbital (Long) 30 D - 1 Y	Lunar Orbital + Surface (Short) < 30 D	Lunar Orbital + Surface (Long) 30 D - 1 Y	Mars (Preparatory) < 1 Y	Mars (Planetary) 730-1224D
Radiation							
Non-Ionizing Radiation	A	A	A	A	A	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

Venues for Conducting Research

International Space Station



Envihab

NSRL

Parabolic Flight

HERA

Antarctica

NEK

Use of Collaborations and Partnerships to Multiply Resources

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Artemis

Human Research Program

Artemis I: 2022

Uncrewed flight test

COMPLETE

SLS, Orion, EGS

Artemis II: 2025

Crewed flight test

SLS, Orion, EGS

Artemis III: 2026

Crewed surface expedition

SLS, Orion, EGS, HLS

Artemis IV

Gateway assembly, crewed sustaining lander expedition

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

Artemis V

Crewed mobile surface exploration, Gateway expansion

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

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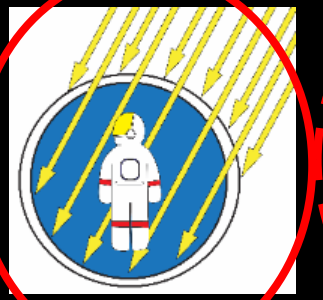
Why Artemis?

Human Research Program



Radiation

Deep space ionizing radiation dose rate and composition different than ISS and NASA Space Radiation Laboratory

Isolation & Confinement

Habitation modules smaller than ISS and ground-based analog habitats; times without view of the Earth

Distance from Earth

Limited resupply, multi-day return to Earth, near real-time communication, more crew & vehicle autonomy

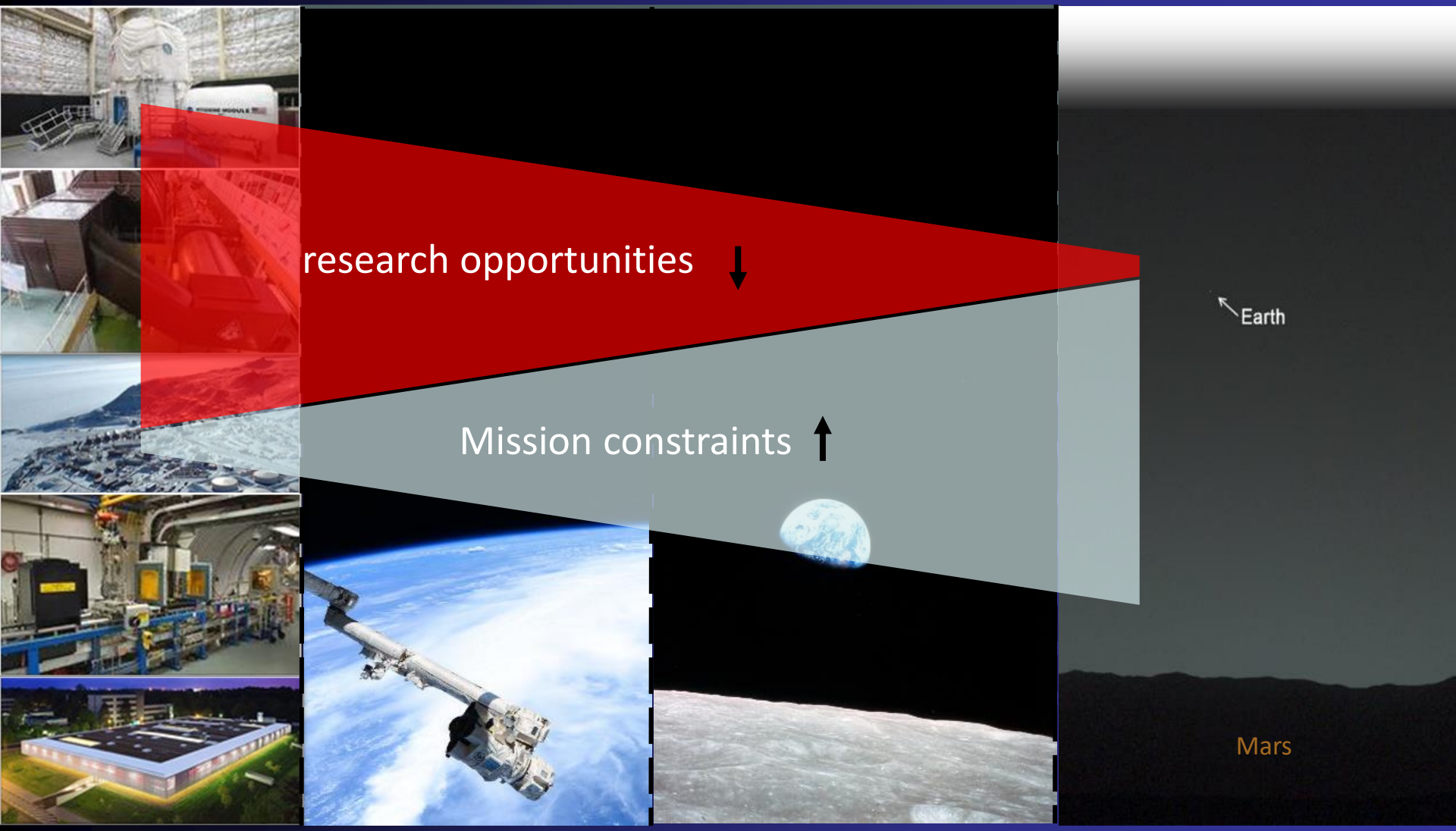
Altered Gravity

Ability to study effects of microgravity/partial gravity transitions and multi-day exposure to partial gravity of lunar surface (pre/post surface measurements)

Hostile/Closed Environments

Different atmospheric pressure/partial pressure of oxygen (TBD), different microbial environment, limited food system, different exercise capability

Synergistic interaction of all five hazards acting on human body simultaneously


research opportunities
Mission constraints
Earth
Mars

HRP Study Candidates

Sensorimotor Assessment Pre-EVA:
Cardiovascular monitoring (HR), ultrasound, balance testing, videos of crew, surveys

Manual Control In-Flight Training
Hand controller, sim software, data collection

Artemis Standard Measures (ASSM):
Sleep, movement (actigraphy), individual/team performance, cognitive assessment, surveys

Lunar Descent/Ascent Injury Assessment:
Dynamic loads/accelerometer, videos, survey

Immune Biomarkers:
Dry saliva booklets, dried blood spot cards

Alterations of Multi-Sensory Integration:
Dosimetry, videos

Potential long range Lunar goals

Human Research Facility Lunar Laboratory

Possible payloads:

- Tissue Chips (precision health)
- Pharmaceuticals
- Plants (crops)
- Dosimetry
- Analytical lab

Conclusions

NASA's Human Research Program is dedicated to discovering the methods and technologies to support safe, productive human spaceflight.

By conducting human research on the early lunar surface crews, results will help inform the missions of tomorrow.

Thank you for Listening

Questions?

Thank you for Listening!

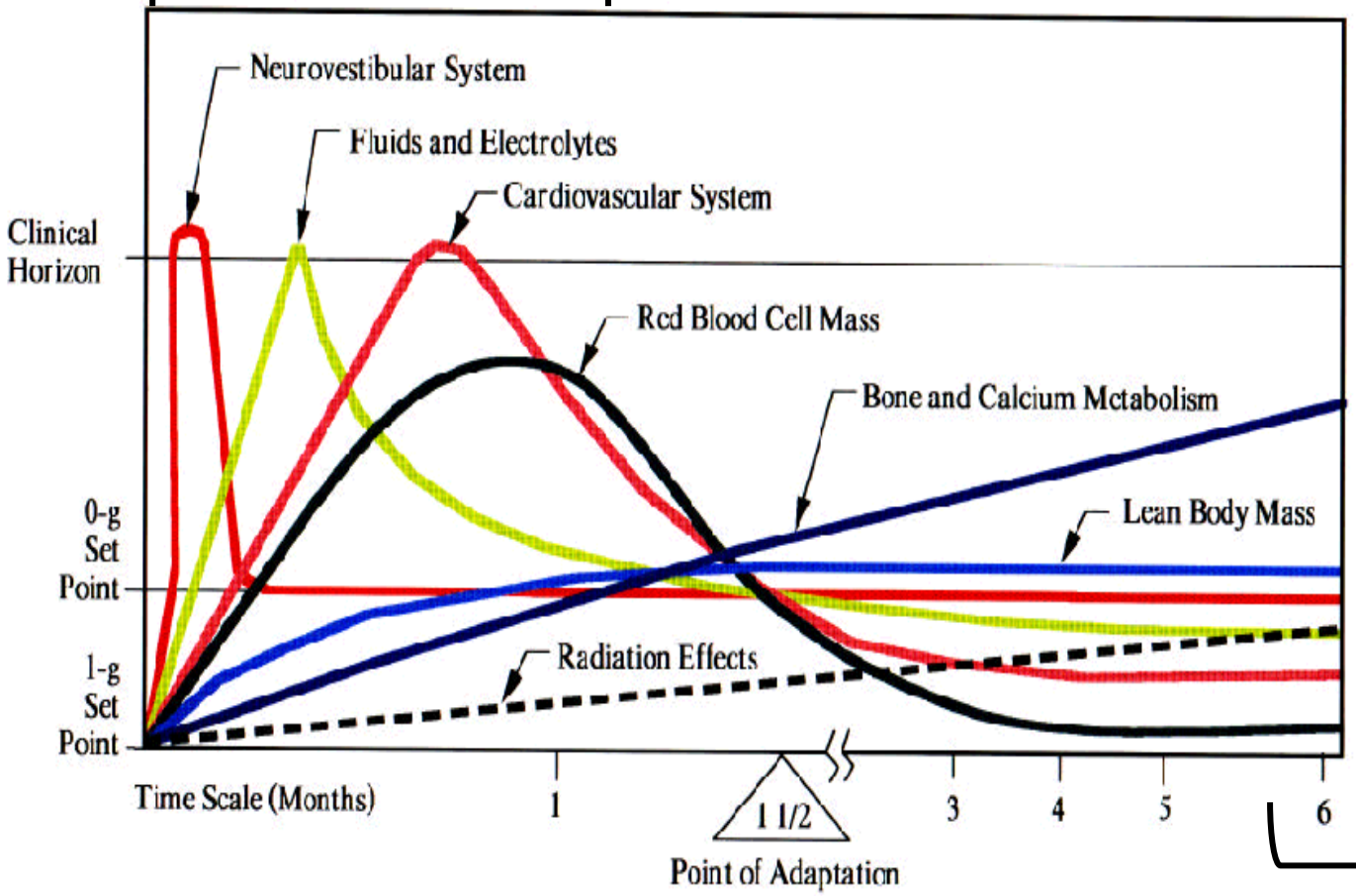
Questions?

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

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HRP enabling Artemis missions

HRP solving problems for today's vehicle Programs.

Human Research Program

New for PP
New Initiativ

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

- Acceleration/Vibration Requirements
- Autonomy Standards

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

- Emergency CO_2 limits
- In-suit Nutrition Requirements

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

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

HRP Goal & Objectives for Artemis

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.

Characteristics of HRP

- 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