

Human Research on the ISS

National Aeronautics and
Space Administration



Director, David Baumann
NASA's Human Research Program



Human Research Program

Mission:

To enable space exploration beyond low Earth orbit by reducing the risks to human health & performance





Office of the Chief Health and Medical Officer

Responsible for (among other things):

- Human Health and Performance Risks
- Spaceflight Human Health and Performance Standards



Human Research Program

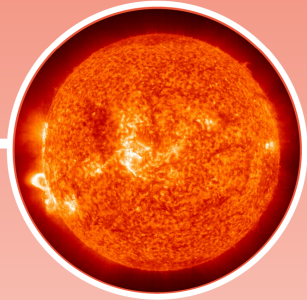
Responsible for mitigating and informing through research:

- Human Health and Performance Risks
- Spaceflight Human Health and Performance Standards

OCHMO is HRP's prime stakeholder



OCHMO and HRP Relationship - Functional Hazards and Risks of Human Spaceflight



Space Radiation

- Radiation Carcinogenesis
- Non-Ionizing Radiation



Isolation & Confinement

- Inadequate psychosocial adaptation within a team
- Adverse cognitive or behavioral conditions



Distance from Earth

- Inflight medical conditions
- Inadequate human systems integration architecture
- Inadequate food and nutrition
- Ineffective or toxic medications



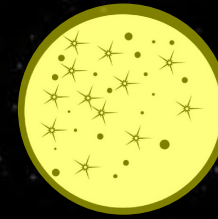
Lack of Gravity

- Reduced muscle size
- Bone fracture
- Sensorimotor alterations
- Host-microorganisms interactions
- Orthostatic intolerance
- Cardiac rhythm problems
- Renal stone formations
- Reduced aerobic capacity
- Cardiovascular adaptations
- Urinary retention
- Crew egress
- SANS



Hostile/Closed Environment

- Toxic exposure
- Hypoxia
- Decompression sickness
- Celestial dust exposure
- Carbon dioxide exposure
- Electrical shock
- Sleep loss
- Hearing loss
- Altered immune response
- Reduced EVA performance
- Injury from dynamic loads



A detailed photograph of the International Space Station (ISS) in orbit against the black background of space. The station's complex structure, including multiple modules, truss segments, and large solar panel arrays, is clearly visible. The lighting highlights the metallic surfaces and the intricate assembly of the station.

International Space Station

HUMANITY'S HOME IN ORBIT

Our State-of-the-art Microgravity Lab

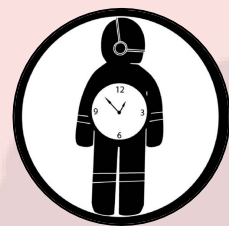
Remaining Research/Capability Gaps for LEO [and ground analogs]



Earth-Independent Human Operations



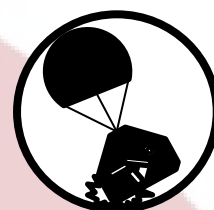
Mars Duration Food System



Mars Duration Effects on Human Physiology



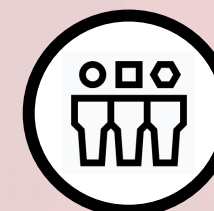
Risk Mitigations for Vehicle Atmospheres



Computational Injury & Anthropometric Models



Exploration Exercise Countermeasures



Understanding Individual Variability in Spaceflight

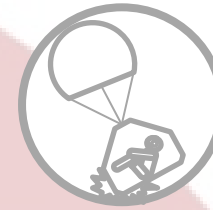


Sensorimotor Countermeasures

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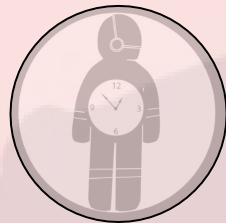
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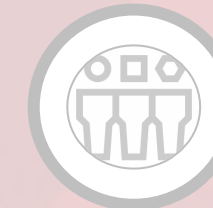
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Risk Mitigations for Vehicle Atmospheres



Sensorimotor Countermeasures

Risks Increases with Distance from Earth

International Space Station

Gateway

Lunar Surface

Mars Transit

CURRENT STATE

- 180-day to 360 -day mission duration
- Strong consumables resupply
- Real-time communications
- Regular sample returns to Earth
- Emergency evacuations possible
- Relatively large internal volume
- Limited onboard medical care (Earth -reliant)

EXPLORATION CLASS MISSION

- 650-day to > 900 -day mission duration
- Zero consumables resupply
- No real-time communications
- No sample returns to Earth
- No evacuations possible
- (Likely) much smaller internal volume
- Expanded onboard medical care (crew/vehicle -reliant)

Tasks: Isolation, Confinement and Communications Delay Analogs

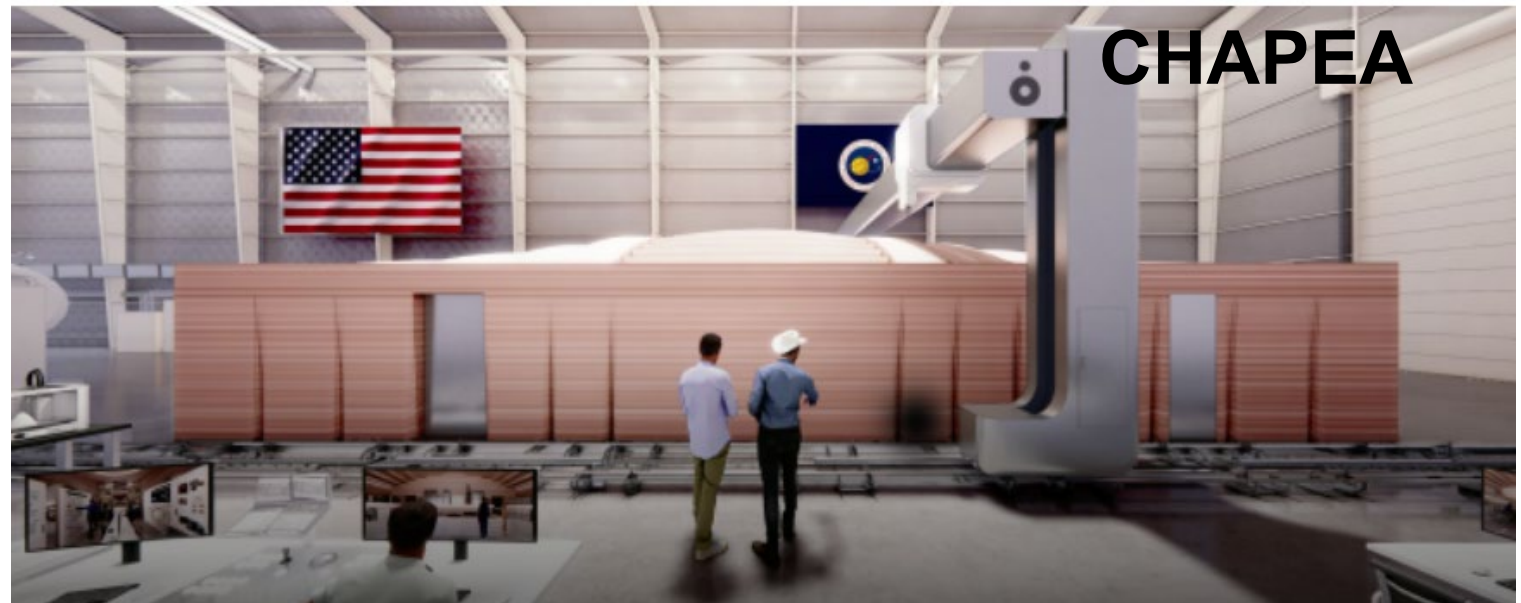


HERA

- Isolated, confined & controlled
- 45-day missions
- Variable crew autonomy
- Standard MCC-crew interactions

CHAPEA

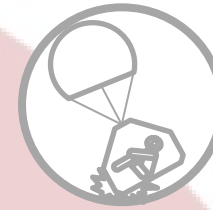
- Isolated & confined
- 378-day missions
- High crew autonomy
- Minimal MCC-crew



Remaining Research/Capability Gaps for LEO [and ground analogs]



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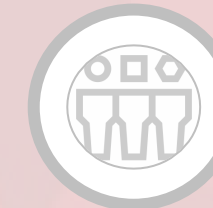
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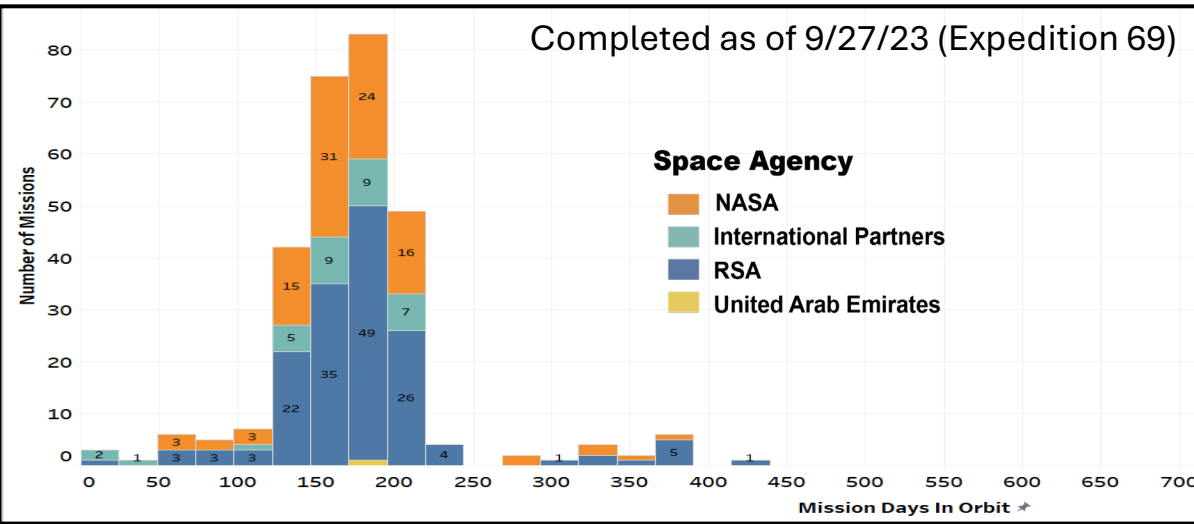
Limited Extended-Duration Data Creates Large Unknowns



LEO Conditions
(ISS/MIR/Salyut)

Number of Missions by Length

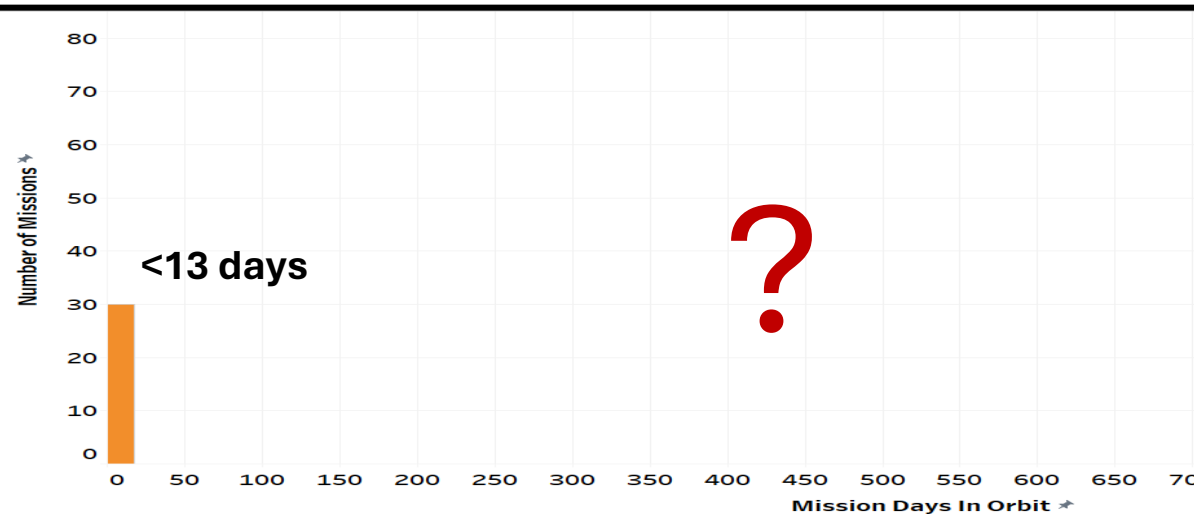
Completed as of 9/27/23 (Expedition 69)



Mars durations

?

Deep Space/Lunar Conditions
(Apollo)



?

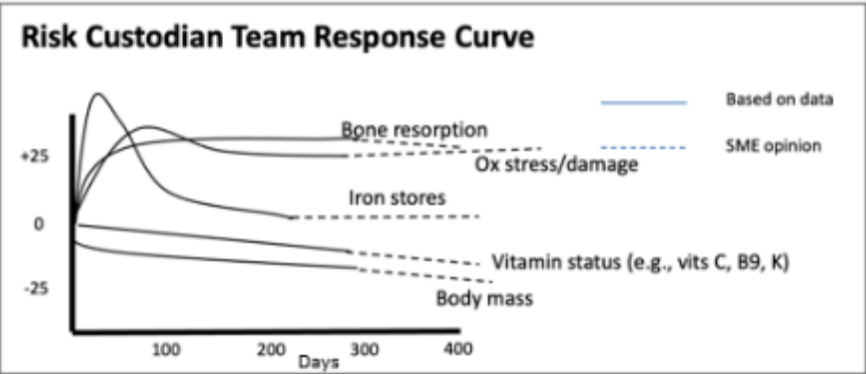
Time Course Spaceflight Changes Examples

Appears to generally plateau by 6 months

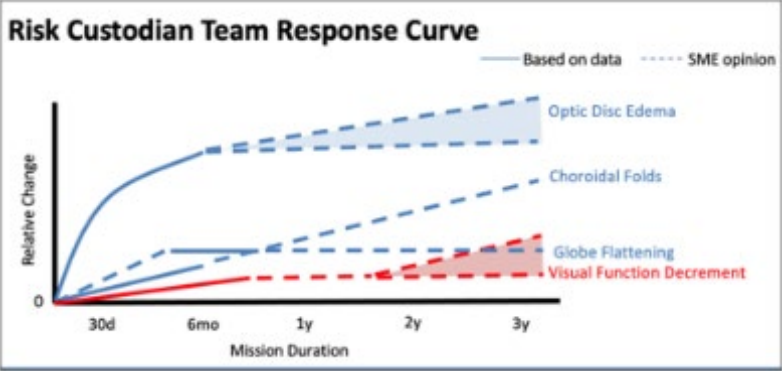
Does not appear to plateau by 6 months in some crewmembers

Unknown

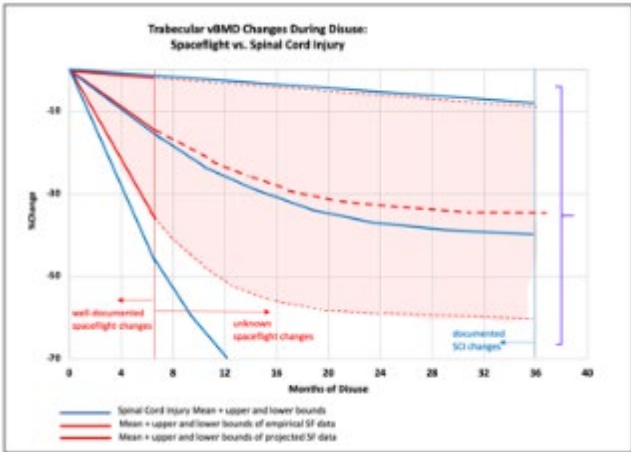
Nutrition/Biochemistry



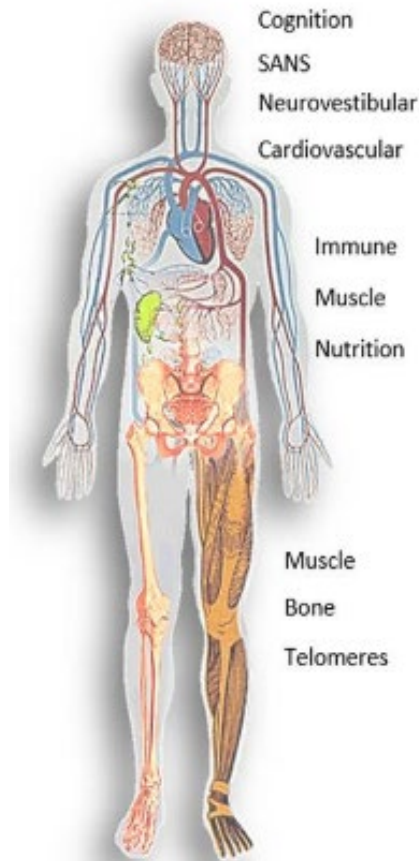
Spaceflight Associated Neuro-ocular Syndrome (SANS)



Bone Quality



Complement of Integrated Protocols for Human Exploration Research



The CIPHER **integrated** protocol is composed of **14 multi-disciplinary, multi-national investigations** that have been integrated into a **single research complement** that addresses over **20 Human System Spaceflight Risks**.

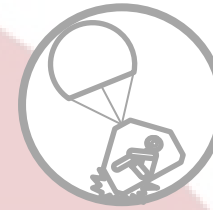
Designed to be conducted on crew members of varying mission durations, but categorized into three subject pools:

- **Standard:** 106 to 239 days
- **Extended:** 240+ days

Remaining Research/Capability Gaps for LEO [and ground analogs]



Earth-Independent Human Operations



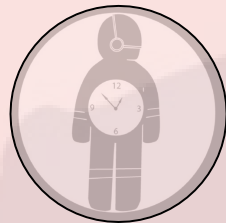
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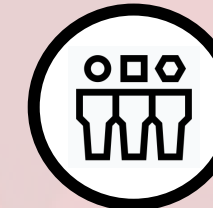
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Understanding Individual Variability in Spaceflight

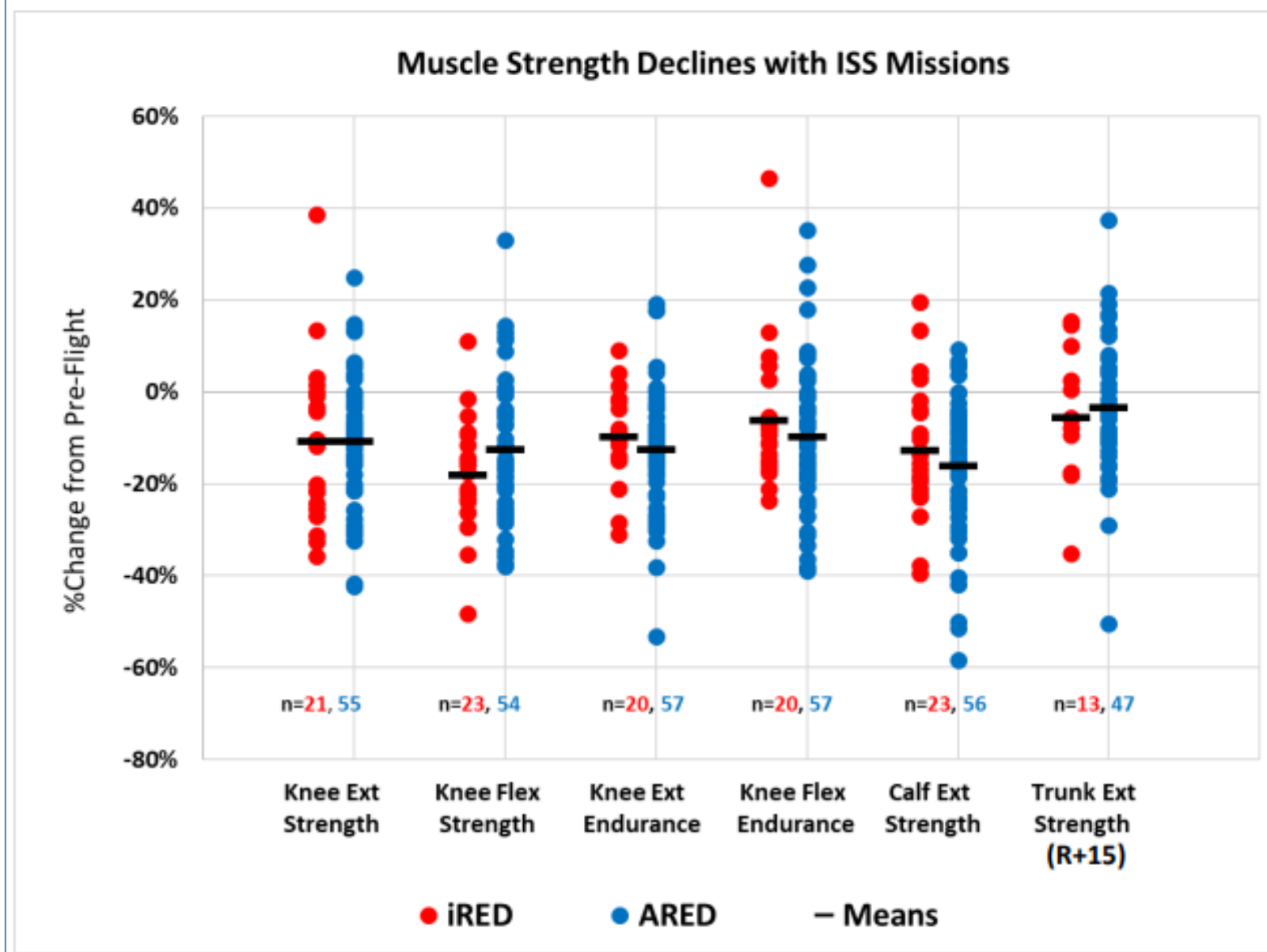


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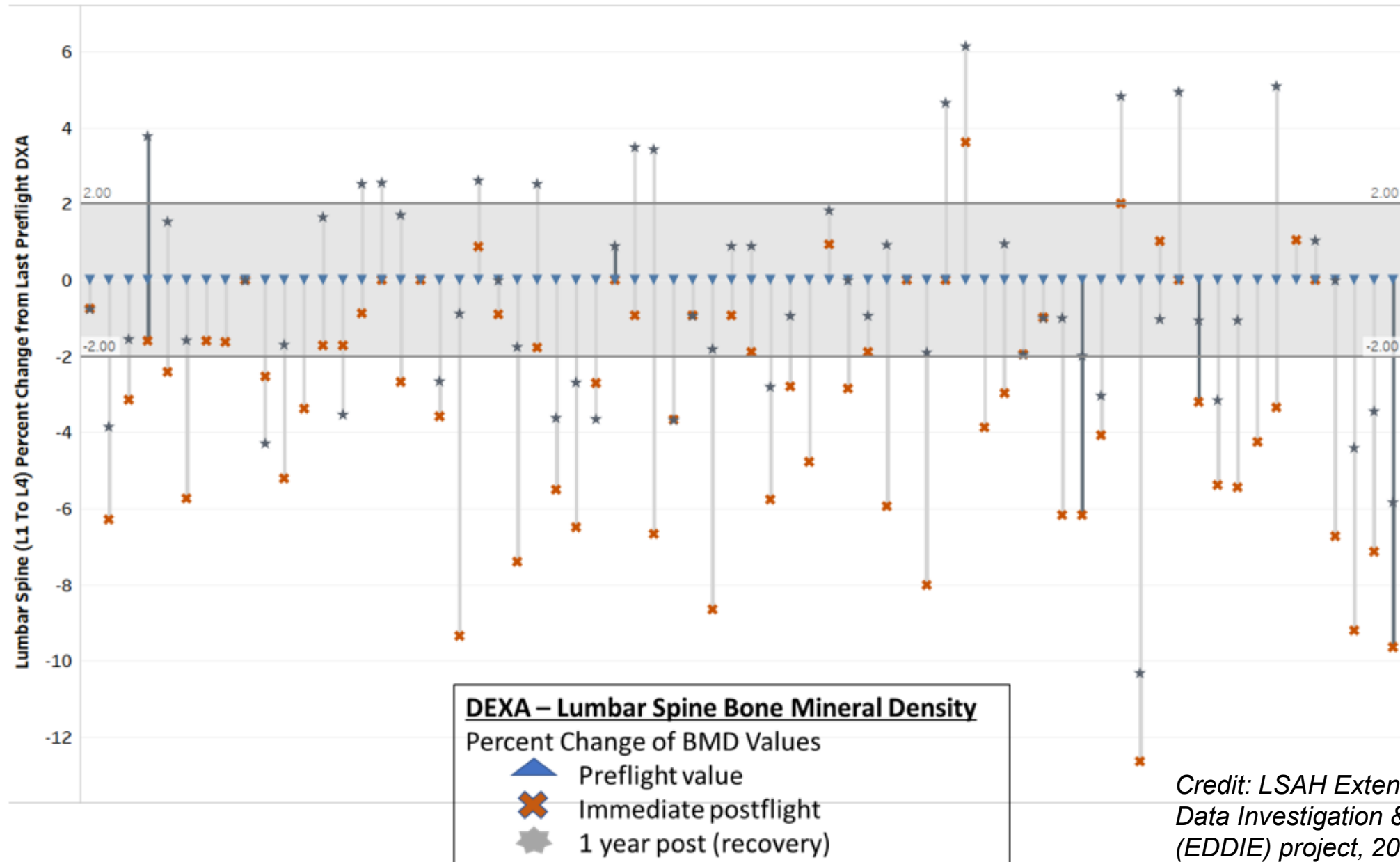
Sensorimotor Countermeasures

Example of Individual Variability in Spaceflight Physiology: Muscle



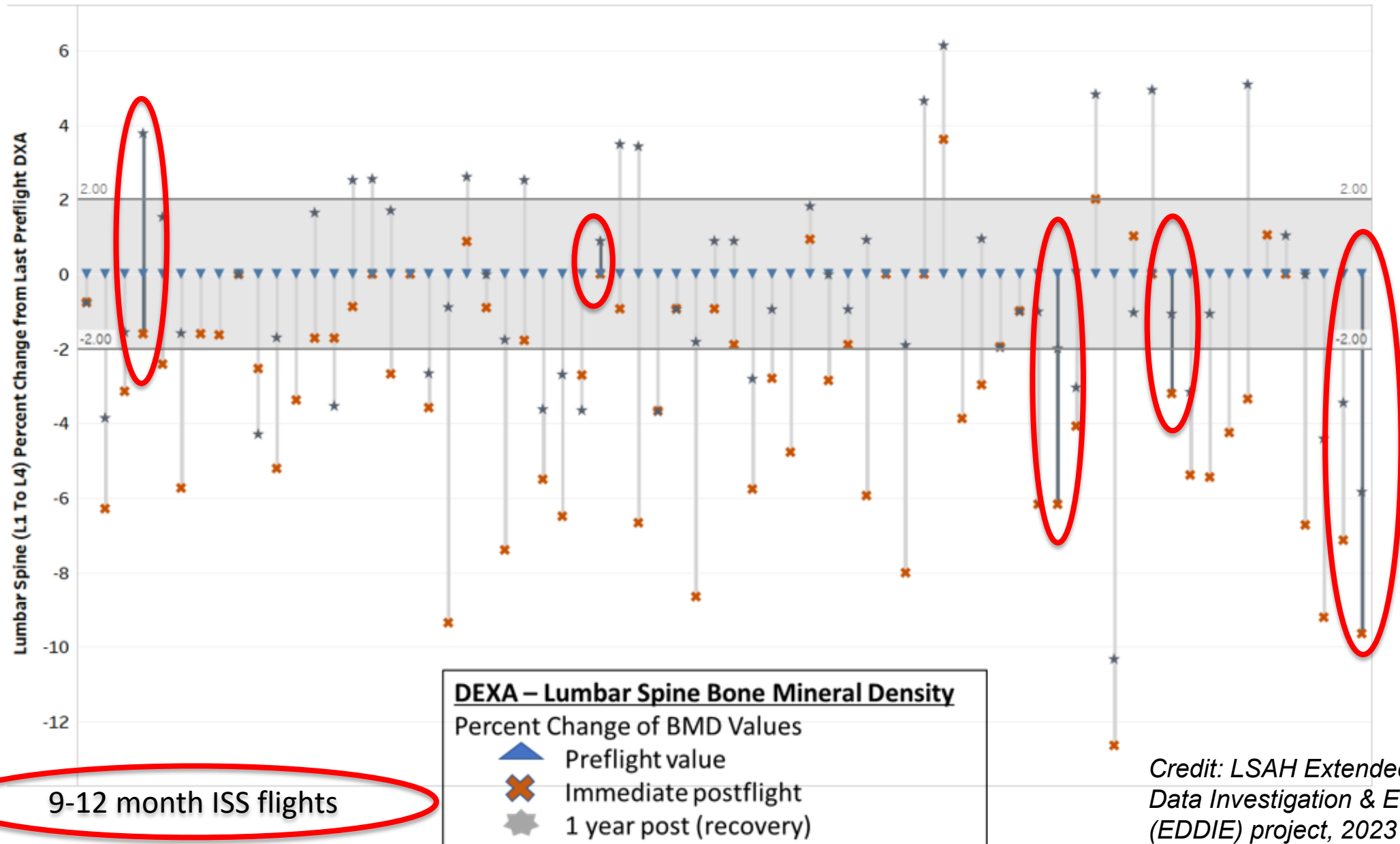
Credit: NASA Johnson Space Center Exercise Laboratory

Duration vs. Individual Variability: Pre/Post Bone DXA measurements

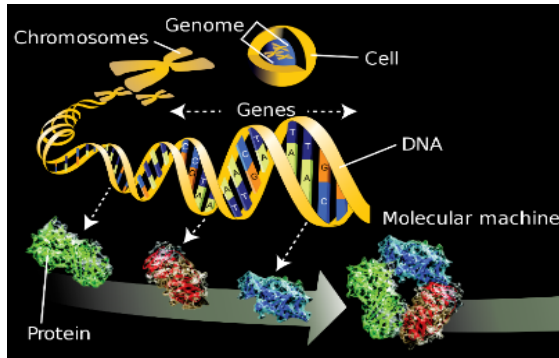


Credit: LSAH Extended Duration Data Investigation & Evaluation (EDDIE) project, 2023

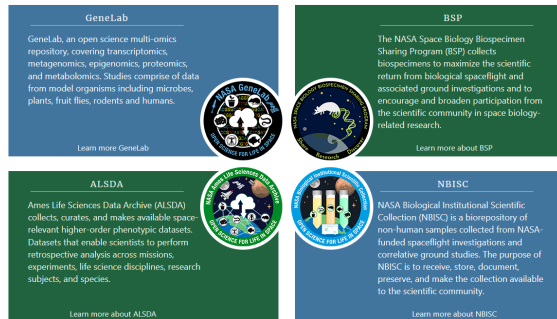
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Tasks: Gathering and Making Datasets More Accessible for Analysis



NASA Omics Data Archive - <https://www.nasa.gov/mission/station/research-explorer/investigation/?#id=8275>
ISS flight study



NASA's Open Science Data Repository (OSDR) - <https://osdr.nasa.gov/bio/>

- Genelab
- Biospecimen Sharing Program (BSP)
- Ames Life Sciences Data Archive (ALSDA)
- NASA Biological Institutional Scientific Collection (NBISC)



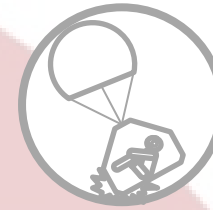
NASA's Life Science Portal (NLSP) - <https://nlsp.nasa.gov/explore/lisahome>

- Life Science Data Archive
- Lifetime Surveillance of Astronaut Health

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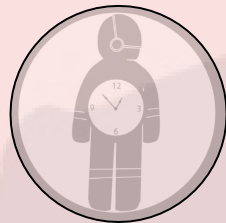
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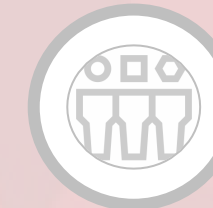
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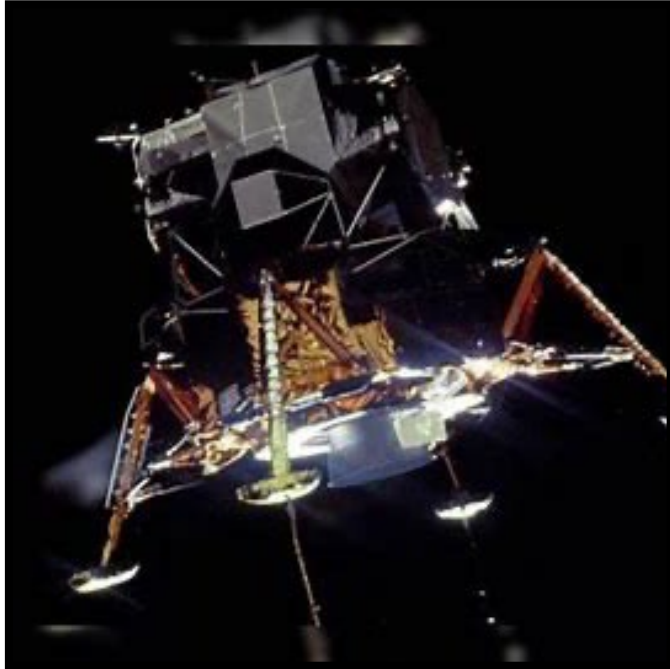
State-of-the-Art Landings on Earth After Six Months in Low Earth Orbit



Notional Mars Landing



Sensorimotor Capabilities Needed for Critical Activities



Manual Control

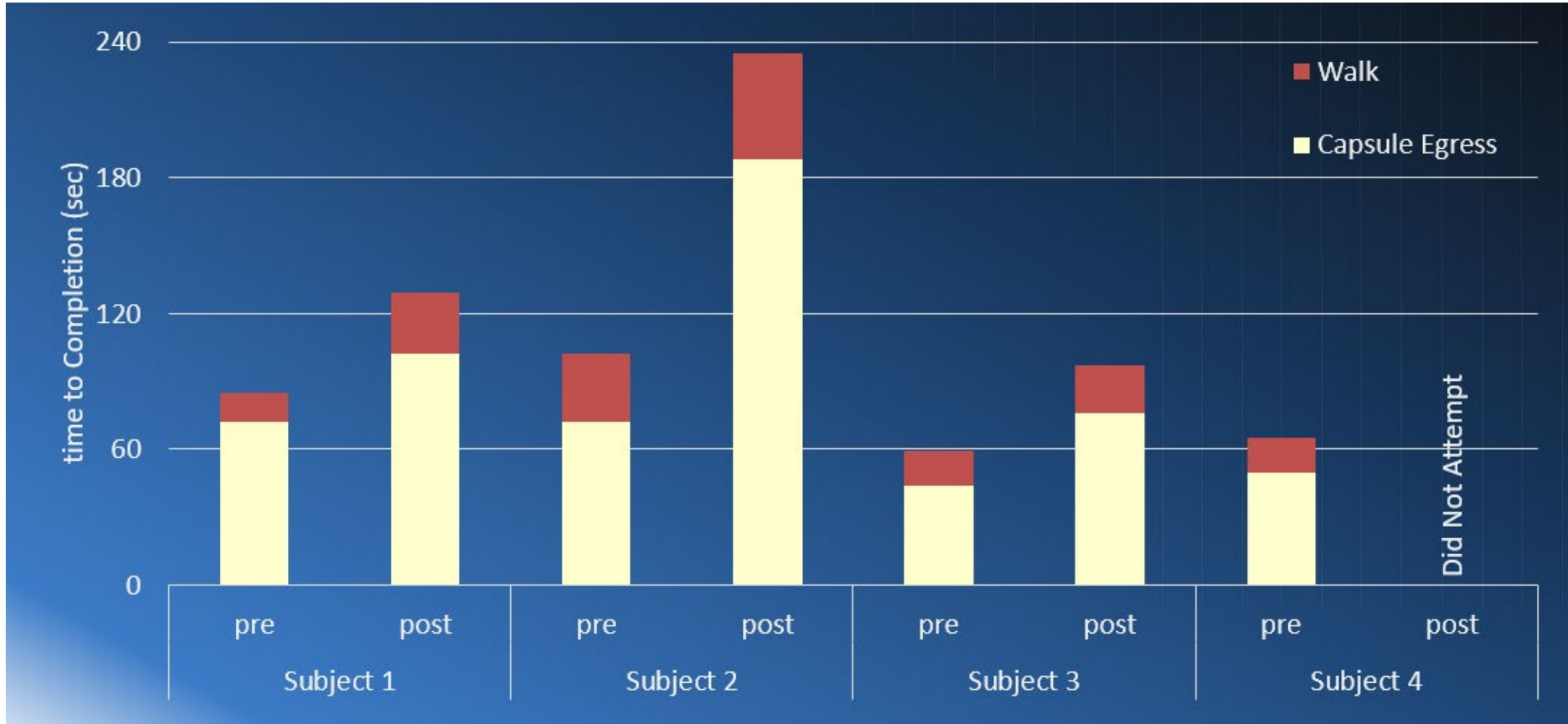


Early EVA



Crew Egress

Mock-up Capsule Egress Results

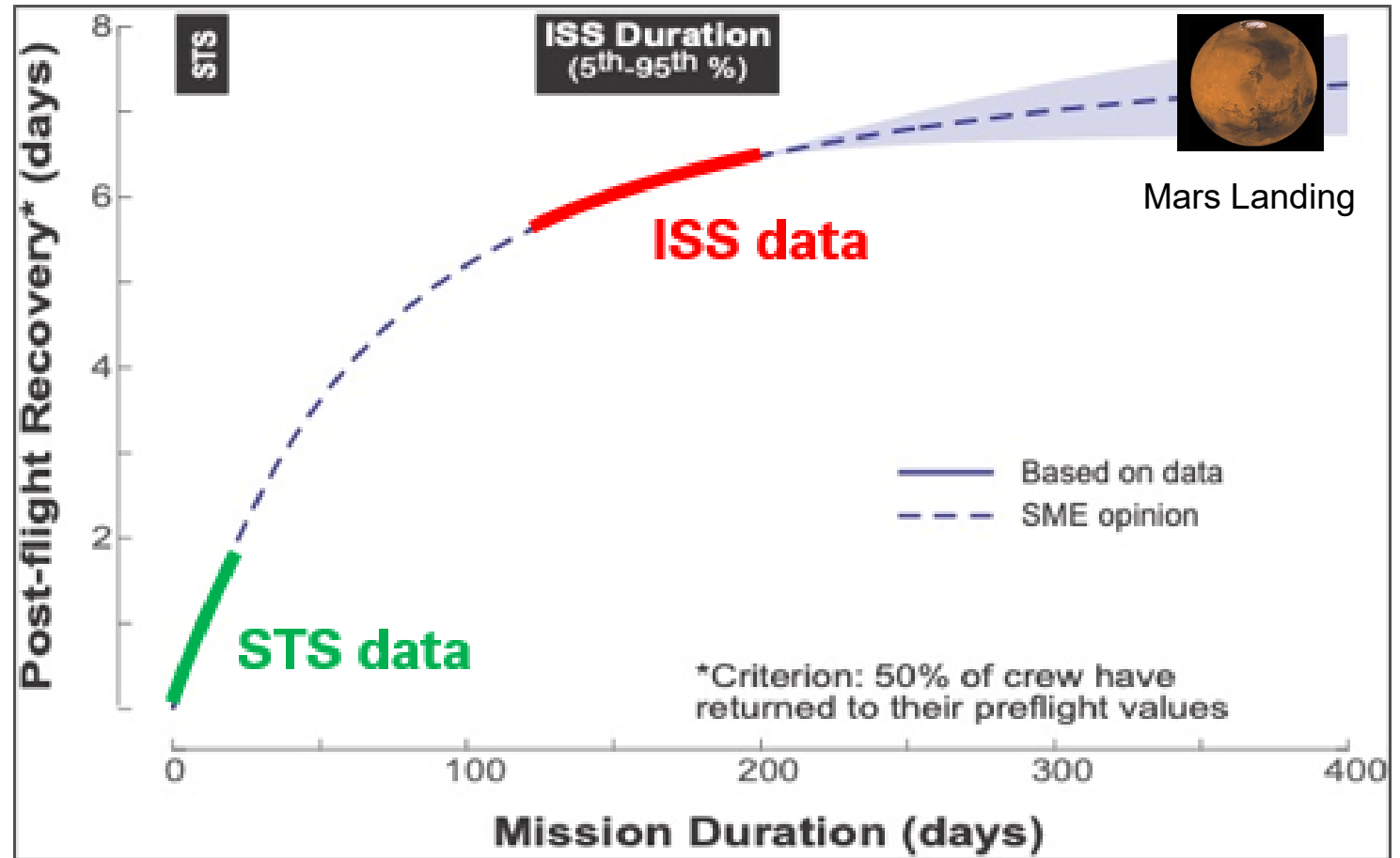


Credit: Pilot Egress Study, PI: Norcross, presentation at the 2024 HRP Investigators' Workshop

Postflight Recovery Curves for Sensorimotor Adaptation

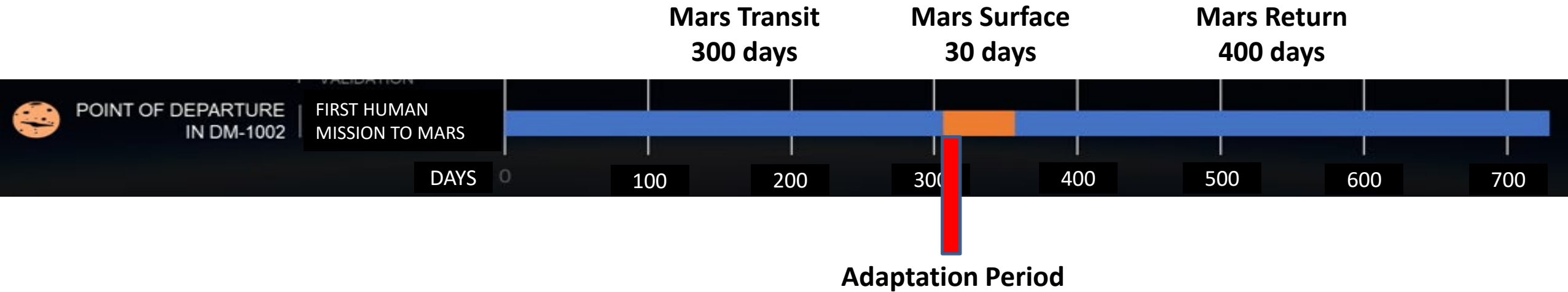


Field Test was performed in the medical tents or rally airports as soon as possible after landings.



Credit: Analysis by Scott Wood, Johnson Space Center

Example of a Mars Architecture Team timeline



Mars Architecture Team (MAT) is protecting **3-7 days** for Sensorimotor adaptation after landing on Mars for nominal EVAs

Depending on the Mars surface stay duration, that could represent a significant percentage of the planetary science timeline.

Task: Sensorimotor Countermeasure Development and Testing



KRAKEN Disorientation Device at NAMRU-D

Kraken is a state-of-the-art Navy motion simulator that can be utilized to mitigate emerging Lunar landing HLS risks and test sensorimotor countermeasures for landing, egress and early EVA's.





Looking to the future....





Commercial Space Opportunities





AXIOM
STATION

ORBITAL REEF

STARLAB

Funded Commercial Partnerships

PRIVATE ASTRONAUT MISSIONS







NASA IWS 2025

The Human Research Program Investigators' Workshop (IWS) is the primary venue for reporting progress and results of research on safe, productive, and efficient human spaceflight. Join us!



January 28-31, 2025
Galveston, Texas

REGISTRATION OPEN
<https://www.nasa.gov/hrp-iws-2025/>

