



Human Health & Performance Directorate

BIOMEDICAL RESEARCH FOR HUMAN SPACEFLIGHT

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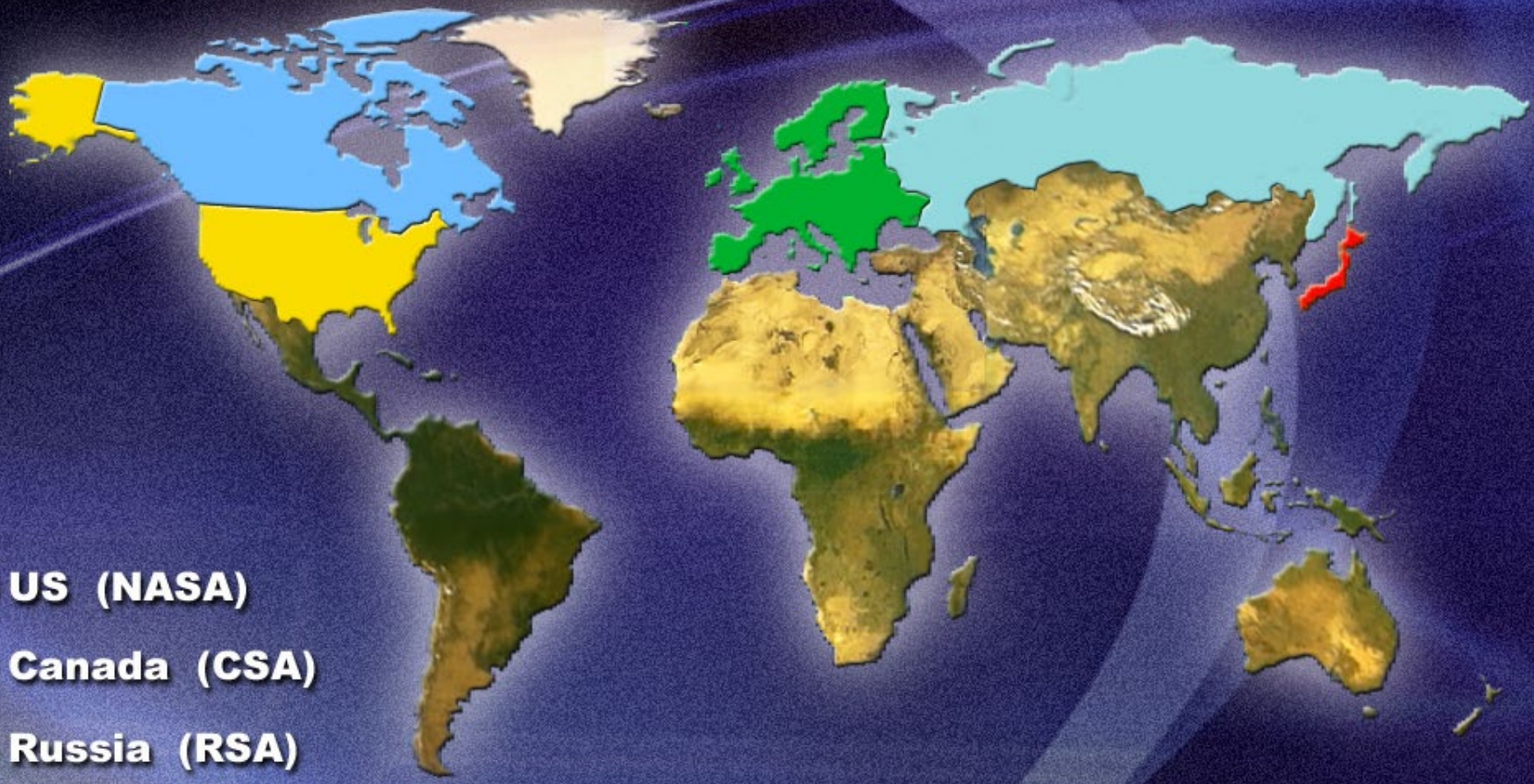


NASA Team





International Space Station Partners



- **US (NASA)**
- **Canada (CSA)**
- **Russia (RSA)**
- **Europe (ESA)**
- **Japan (JAXA)**

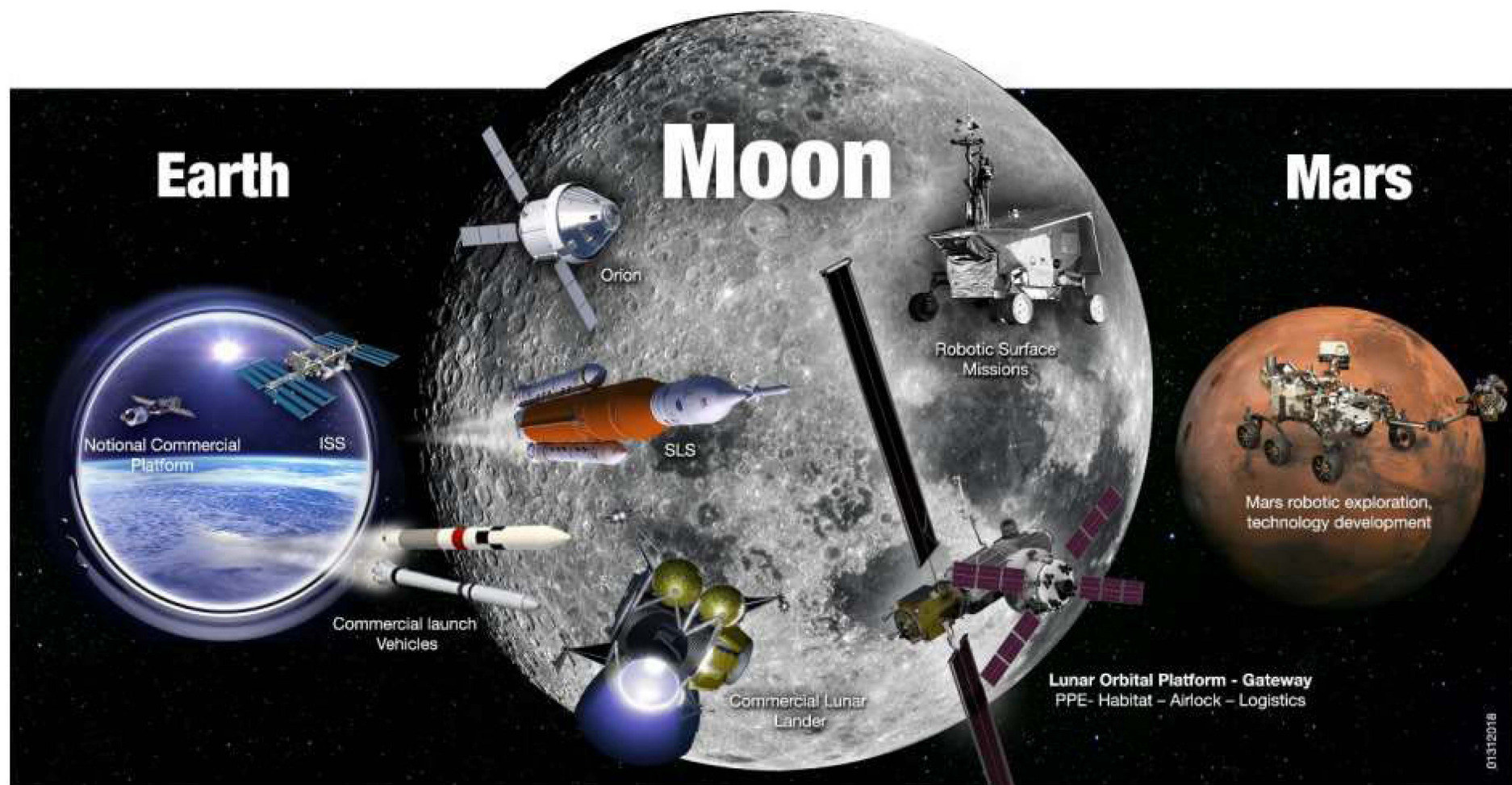


Earth

FROM MARS CURIOSITY ROVER

Exploring Space | Enhancing Life

EXPLORATION CAMPAIGN



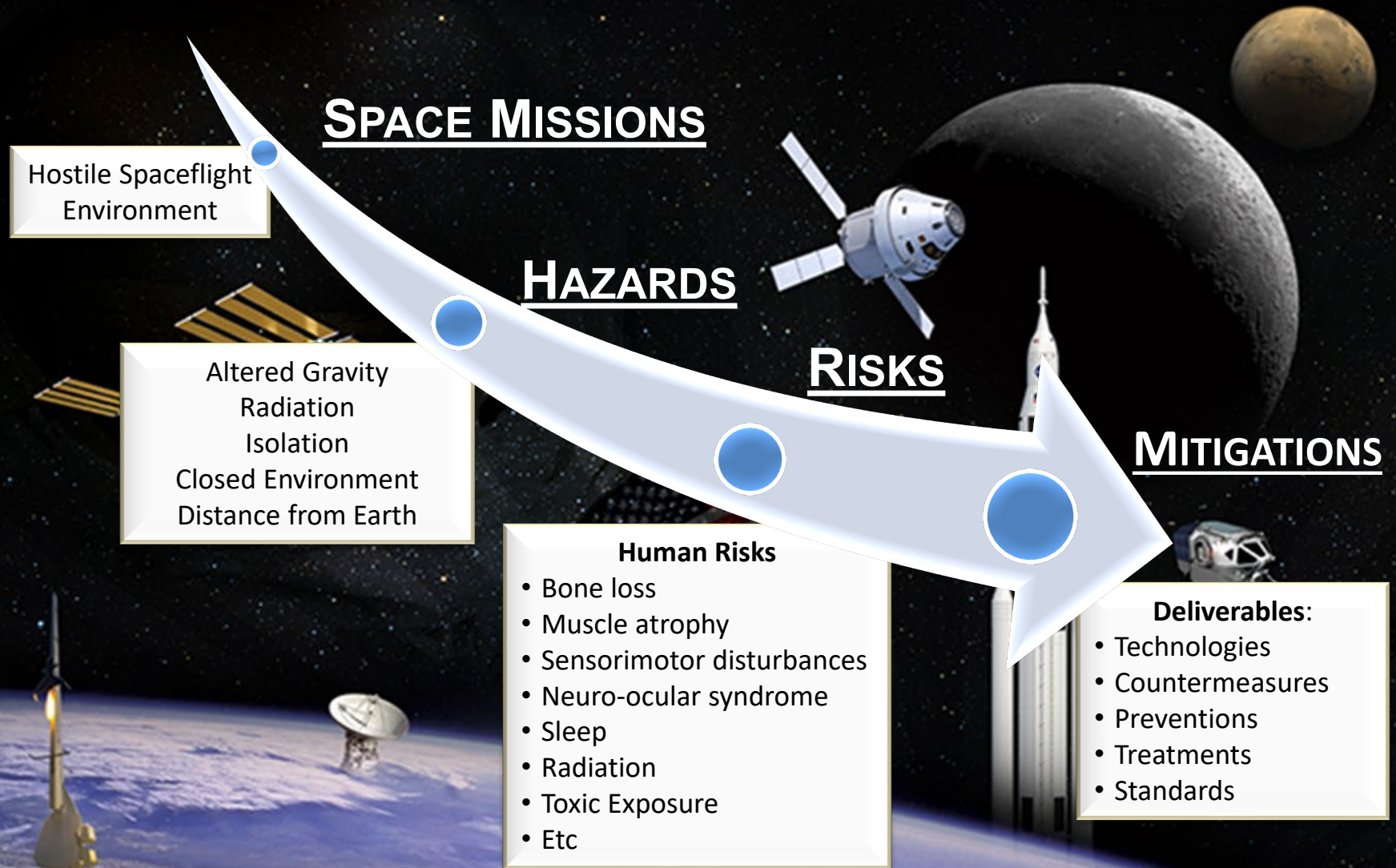
In LEO
Commercial & International partnerships

In Cislunar Space
A return to the moon for long-term exploration

On Mars
Research to inform future crewed missions

NASA HUMAN HEALTH & PERFORMANCE

To enable successful exploration by minimizing the *Human System Risks* of spaceflight hazards



HUMAN SYSTEM RISKS OF SPACEFLIGHT

GROUPED BY HAZARDS – 30 HUMAN RISKS



Altered Gravity Field

1. Spaceflight-Induced Intracranial Hypertension/Vision Alterations
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
10. Cardiac Rhythm Problems
11. Space Adaptation Back Pain

Concerns

1. Clinically Relevant Unpredicted Effects of Meds
2. Intervertebral Disc Damage upon & immediately after re-exposure to Gravity
3. Subcortical White Matter Hyperintensities

Radiation

1. Adverse Health Outcomes and Performance Decrements resulting from Space Radiation Exposure(cancer, cardio & CNS)

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

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-Spacecraft Design

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

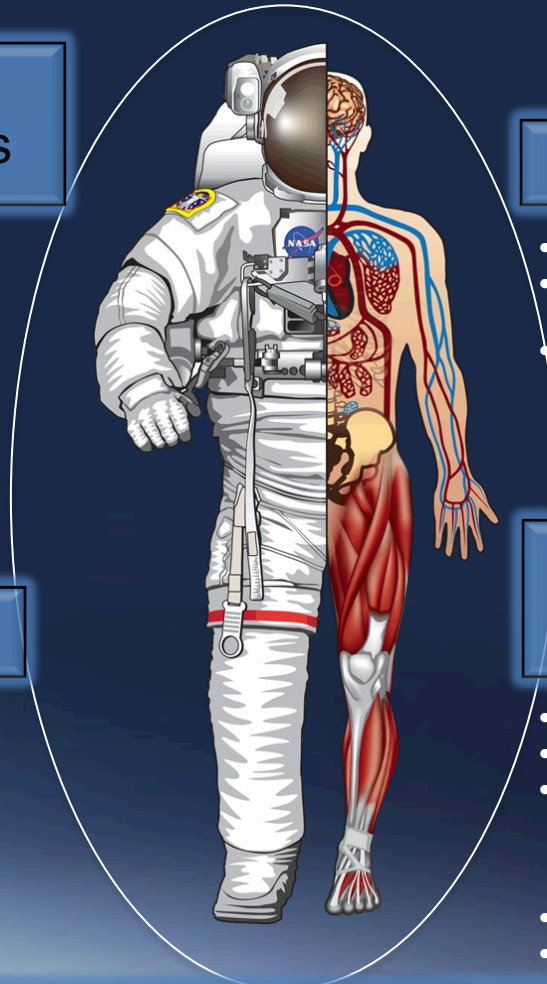
HUMAN SYSTEM RISKS FOR HUMAN SPACE EXPLORATION

Altered Gravity - Physiological Changes

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

Space Radiation

- Acute In-flight Effects
- Long-term Cancer Risk



Distance from Earth

- Food & Drug Stability
- Adverse Medical Outcomes
 - ✓ Need for “autonomous” operations
- Psychosocial Adaptations

Hostile/ Closed Environment

- Space Suit Design
- Advanced Technology & Habitability
- Environmental Health
 - ✓ CO₂ Levels
 - ✓ Toxic Exposures
 - ✓ Water Quality
- Decreased Immune Function
- Microbiome Changes

Isolation & Confinement

- Psychosocial Adaptations
- Sleep Disorders

HUMAN HEALTH AND PERFORMANCE



We are the JSC Technical Directorate responsible for

- Spaceflight Healthcare and Medical Systems
- Flight Medicine and Occupational Clinical Operations
- Biomedical Research and Environmental Sciences
 - Physiological, Environmental and Behavioral Effects of Spaceflight
- Human Systems Engineering and Integration
 - Integration of Hardware and Software Systems in Support of Current and Future Spaceflight Programs
- Health and Medical Technical Authority for NASA Human Spaceflight Programs

We provide

- Multidisciplinary expertise in executing health and performance services
- Research and development related to human system risks and their mitigations
 - Managing a balanced risk portfolio to address the highest risks to human health and performance in space flight
- Multidisciplinary expertise in developing standards and requirements for all human health and performance systems
- Integration of the human as a system to all phases of mission planning and execution

HUMAN HEALTH AND PERFORMANCE

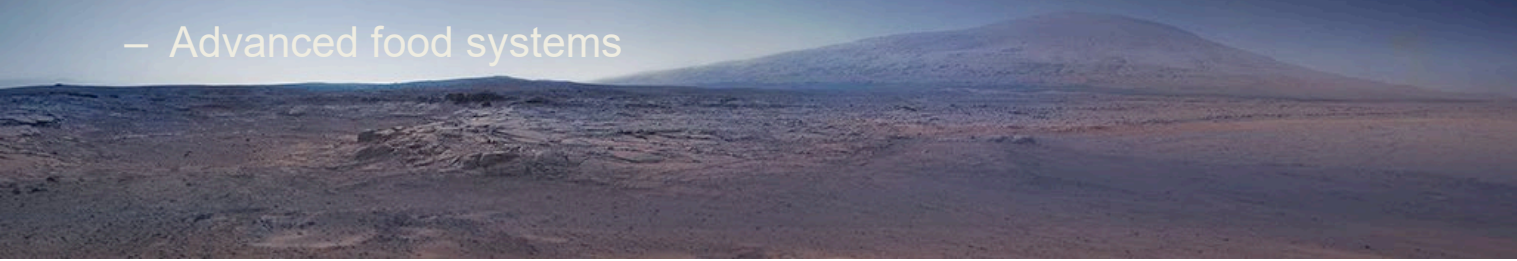
Space Medicine Operations Division

- Prevent health problems, developing medical systems to treat illness and injury in space flight, and by providing crewmember support through training and telemedicine
- Maintains behavioral health and performance in remote environments
- Space Weather forecasting and threat assessments for flight crews
- Integrates of complex human operations into the flight plan



Human Systems Engineering and Integration Division

- Human Systems Integration expertise to integrate human health and performance requirements with other space flight systems
- Hardware solutions and system managers for human system risks
- Flight hardware: development to testing and verification to flight
- Habitability and human factors in space craft and habitat design
- Advanced food systems



BIOMEDICAL RESEARCH & ENVIRONMENTAL SCIENCES DIVISION



Mission: To maintain astronaut health & performance during & after space exploration.

- **Assess human adaptation** to spaceflight and planetary environments
 - ✓ Peer-reviewed research
 - ✓ Assess Human System Risks
 - ✓ Provide validated treatments and countermeasures
 - ✓ Develop applied scientific / medical evidence in the context of the human exploration environment

- Engaged in **operational support** for all human spaceflight programs
 - ✓ Conduct medical assessment tests to assess crew health and performance
 - ✓ Astronaut Training (AsCan, Generic Rodent, Biomedical Basics, Payload)
 - ✓ Set standards & requirements
 - Human health & performance
 - Spacecraft environment
 - ✓ Develop, test, and deliver
 - Biomedical **countermeasures and prescriptions**
 - **Environmental monitoring** strategies to minimize impact on the crew for all mission types and durations in air, water, surface or food
 - **Confirm flight readiness** (e.g., toxicology, microbiology)
 - Assess design and human performance for **advanced space suits**

- **Future growth areas for Exploration**
 - ✓ Autonomous technologies
 - ✓ Genomics and Precision Medicine



BUILDING 21

HUMAN HEALTH & PERFORMANCE LABORATORY



Human Performance Laboratories (North Wing)

- Flexible, reconfigurable, multipurpose open **high bay**

Bioanalytical Laboratories (South Wing)

- Reconfigurable, open lab bay concept
- Secure National Archive Sample Repository Freezer Storage

Shared resources

- Microscopy, tissue culture, force plates, motion capture & strength measures
- Advanced Conference Rooms & Huddle Rooms
- Visiting Scientist/Student Flex space



Biomedical & Environmental Analytical (10)

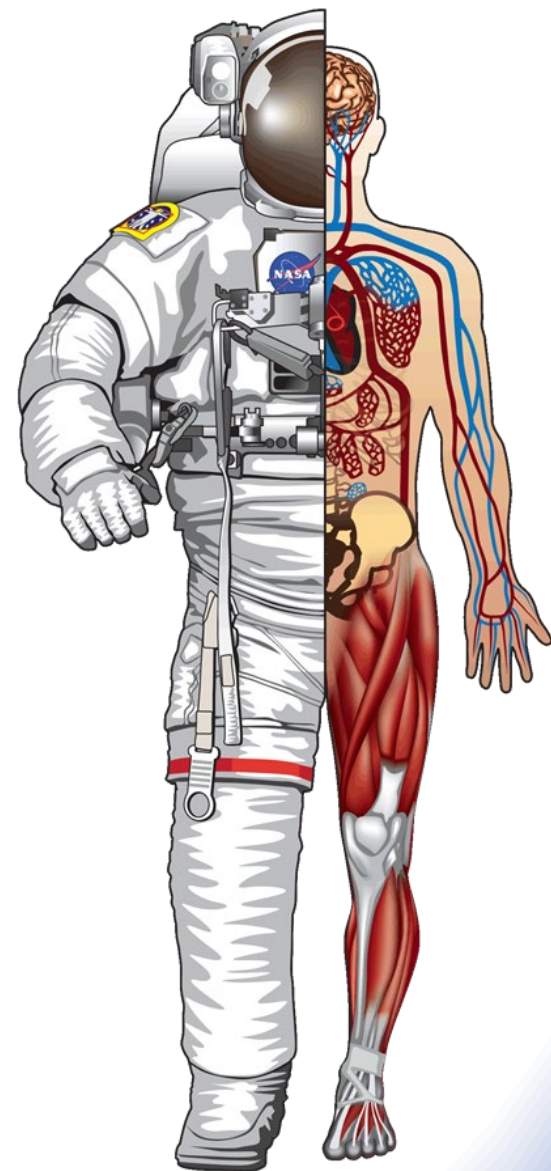
- Clinical Laboratory (SD)
- Bioanalytical Core Laboratory
- Immunology
- Nutritional Biochemistry
- Toxicology & Environmental Chemistry
- Pharmacotherapeutics
- Radiation Biology
- Space Cell Biology
- Microbiology
- Animal Care Facility

Human Performance (7)

- Bone & Mineral
- Cardiovascular Physiology
- Anthropometry & Biomechanics
- Behavior Health and Performance
- EVA Physiology
- Exercise Physiology
- Neurosciences

Services

- Biostatistics
- Medical Library
- Medical Editors
- Project Management
- Laboratory Support Services (LSS)

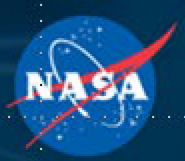


- **Biomedical Research and Environmental Sciences Division**

- Provides expertise and advanced technologies for microbiology, toxicology and radiation monitoring, and standards for air and water in closed environment
- understand physiological changes from extended exposure to the microgravity environment
- understand physiological effects related to ionizing and non-ionizing radiation exposure
- Informing standards and risk mitigation techniques through human research
- Provides expertise and advanced technologies for microbiology, toxicology and radiation monitoring, and standards for air and water in closed environment

- **Human Research Program**

- Funds research and technology development to support next-generation systems that enable humans to live and work safely and effectively in space
- Emphasis is placed on mitigation of critical risks to human health and performance.



- **Proposes and conducts peer-reviewed biomedical research in-flight and in ground-based spaceflight analogs to characterize the effects of spaceflight on human physiology and evaluate the candidate countermeasures**

- **Provides specific clinical/operational expertise in support of astronaut selection and training, and to the flight surgeons responsible for the health and safety of astronauts.**

- Provides solutions to issues humans encounter while living, working, and exploring in space
- Provides anthropometry and biomechanical analysis and evaluation expertise
- Evaluates crew work procedures and equipment, spacesuit design, extravehicular and intravehicular activities, tool designs, and crew-induced loads
- Improves crew living and working conditions to enhance productivity and operational efficiency



- **Promotes psychological readiness and performance in spaceflight by:**
 - **Conducting research that characterizes the risks of spaceflight to behavioral health, and individual and team performance**
 - **Developing and testing technologies and tools that optimize the adaptation of the individual and team to the space environment**



Astronaut Scott Kelly looking out the copula window on the International Space Station



Human Exploration Research Analog at Johnson Space Center

- **Collects research data:**
 - **In the lab, space (e.g., International Space Station), and space analog environments (e.g., Antarctica, Human Exploration Research Analog [HERA])**
 - **On astronauts and other high performance, astronaut-like individuals**
 - **Using specialized measurement techniques and innovative research design**



- **Provides statistical consulting and data analytics to BR&ES and the Space Medicine Health Care Systems Office**
- **Provides opportunities for students to be directly involved in the analysis and interpretation of biomedical research at NASA**
- **Conducts independent research to address the special challenges raised by the idiosyncrasies of data often gathered on small numbers of human subjects under nonstandard environments and test regimens**

- Exposure to spaceflight causes loss of bone density and changes in bone composition
- Without effective countermeasures, crewmembers could lose up to 1% to 2% of their overall bone density per month
- Besides bone loss, space travel can contribute to other bone-related health issues, such as increased risk of kidney stones, hip and spine problems, fractures and other injuries, and impaired healing capability
- Research characterizes changes in bone and determines the best countermeasure strategy





- **Conducts ground-based and in-flight research to describe cardiovascular and vision changes due to spaceflight**
- **Cardiovascular changes in spaceflight include:**
 - **Potential disturbances in cardiac rhythm**
 - **Postflight faintness upon standing, because of drop in blood pressure**
 - **Reduced exercise tolerance**
 - **Reduced circulating blood volume**
 - **Changes in vascular function**
 - **Visual Impairment**



Human Physiology, Performance, Protection & Operations (H3PO) Laboratory

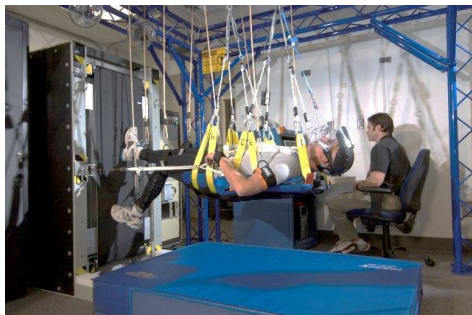


- **Development and testing of EVA prebreathe protocols for ISS and exploration missions**
- **Training crewmembers on prebreathe procedures**
- **Measurement and prediction of EVA metabolic rates during training and spaceflight**
- **Perform analyses of decompression scenarios for ISS and Commercial Crew Programs**
- **Perform testing of EVA exploration systems and concepts of operations in analog environments**

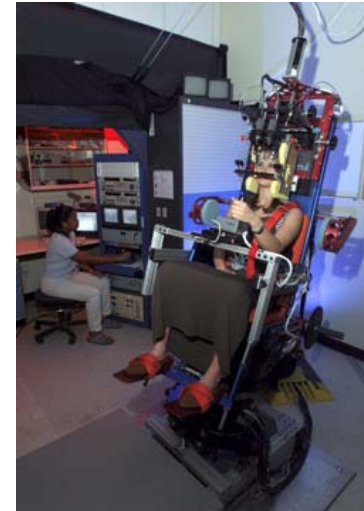
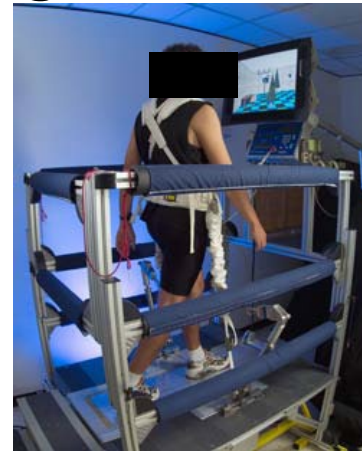




- **Exposure to long-term spaceflight causes reduction in muscle mass and strength, especially in the lower extremities**
- **Evaluates and validates exercise countermeasures hardware, exercise protocols, and conditioning programs for the maintenance of crew health and performance during spaceflight**
- **Understands the effects of spaceflight on human physiology and performance**
- **Develops advanced exercise concepts**

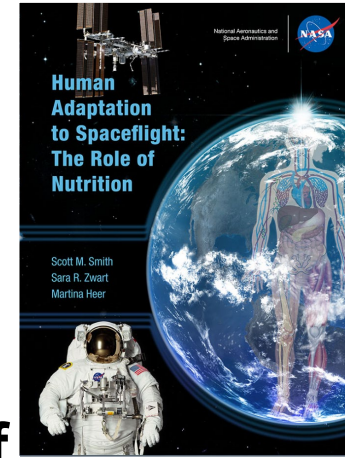


- **Absence of gravity during spaceflight leads to adaptive changes in central nervous system function**
- **Investigates the effects of spaceflight on**
- **Posture and gait function**
- **Eye-head coordination**
- **Perception**
- **Space motion sickness**
- **Vestibular-autonomic function**
- **Focuses on the development of countermeasures to mitigate the spaceflight related changes**
- **Supports ground-based and in-flight investigations, crew health monitoring, risk mitigation operational activities and countermeasures evaluation and validation research**





- Determine nutritional requirements for long-duration space missions
- Monitors crew nutritional status, including inflight dietary intake and body mass
- Research on effects of spaceflight on human adaptation to space flight, including the role of nutrition in other systems (vision, cardio, bone, muscle, radiation, and more).
- Develop, evaluate, and validate countermeasures
- Nutrition can serve as countermeasure to negative effects of spaceflight. Space benefits of food/nutrition countermeasures: low risks for side effects, low costs, and minimal additional crew time required.





QUESTIONS?

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GIANT LEAPS START HERE!