NASA's Human Research Program

For ERAU's Molecular & Cellular Biology Class

Human Research Program
Research Operations & Integration
Nichole Schwanbeck, Deputy Manager-Flight

DAA 20230015300

Presenter Introduction

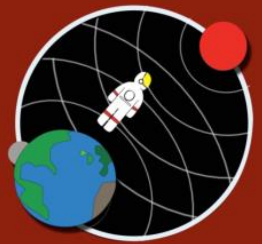
- Graduate of ERAU-Daytona Beach ‘97, BS Engineering Physics
  - ERAU Volleyball player
  - Limited internship opportunities
- Started career at NASA in the Mission Operations Directorate at JSC with United Space Alliance
  - ISS Electrical Power and Thermal Control Systems training division
  - ISS Increment Training Integrator (transitioned to Civil Servant)
  - Group Lead Management in the Training Division
  - Moved to Human Research Program’s Research Operations & Integration element
    - Increment Manager
    - Deputy Manager, Flight & CIPHER Project Manager
  - Rotational Opportunities
    - ISS Payloads Office
    - Human Health and Performance Deputy Chief Health & Performance Officer, ISS
    - Branch Chief Management - Biomedical Engineer Flight Controllers, Space Radiation Analysis, HRP’s Research Operations and Integration element, ISS and Exploration Medical Operations Integration office
- Member of ERAU’s College of Engineering Philanthropic Council and the Women’s Giving Circle

What is HRP?

- HRP is NASA's Human Research Program, formally established in 2005.
- Investigates risks to human exploration beyond Earth's atmosphere to help inform understanding, management and mitigation of these risks to reduce threats posed to astronauts on exploration missions.
- HRP's current research portfolio is addressing 23 of the 30 NASA Human System Risks that are organized into 5 Hazard categories:

5 Hazards of Spaceflight - HRP Risk Investigation

Altered Gravity



- SANS
- Sensorimotor
- Cardiac Rhythm
- Host-microorganism
- Bone Fracture
- Aerobic Capacity
- Muscle Mass/Strength
- Orthostatic Intolerance

Distance from Earth

- Medical Conditions
- HSI Architecture
- Renal Stone
- EVA Injury
- Food/Nutrition
- Ineffective/Toxic Meds

Hostile/Closed Environments

- CO_2 Exposure
- Dynamic Loads
- Hypoxia
- Sleep Loss
- Immune Response
- Decompression

Isolation & Confinement

- Cognitive/Behavioral
- Team Adaptation

Radiation

- Cancer

HRP's Research Platforms - Flight & Ground based

ARTEMIS

ORION

Soon!

GATEWAY

HUMAN LANDING SYSTEM PROGRAM

Future!

COMMERCIAL LEO DEVELOPMENT PROGRAM

Research on ISS

- Research on ISS covers all 5 Hazards of Spaceflight. These are just a few of our studies:
  - Salivary Markers (complete), Dr. Richard Simpson
    - The Effects of Long-Term Exposure to Microgravity on Salivary Markers of Innate Immunity
    - Investigating if spaceflight induced immune system dysregulation increased infection susceptibility or posed a significan health risk to crewmembers onboard the ISS. Involved the collection of blood, saliva, urine and a health assessment.
    - The investigation utilized a longitudinal, repeated measures design to determine the effects of long-term exposure to microgravity on a host of salivary antimicrobial proteins (AMPs), latent viral reactivation, antibacterial properties of saliva, and blood markers associated with innate host immune defense.
    - High Level findings:
      - Spaceflight-associated immune dysregulation may jeopardize future exploration-class missions. Salivary antimicrobial proteins act as a first line of innate immune defense. It was reported that several of these proteins are elevated in astronauts during an ISS, particularly in those embarking on their first space voyage.
      - Astronauts who shed a latent herpesvirus also had higher concentrations of salivary cortisol compared with those who did not shed.
      - Stress-relieving countermeasures are needed to preserve immunity and prevent viral reactivation during prolonged voyages into deep

Urine sample syringes

Research on ISS

- Research on ISS covers all 5 Hazards of Spaceflight. These are just a few of our studies:
  - Microbiome (complete), Dr. Hernan Lorenzi
    - Study of the impact of long-duration space missions at the International Space Station on the astronaut microbiome
    - Investigating if the number of stressors crew are exposed to on ISS missions can alter the composition of their microbiome and have an negative impact on astronauts' health. Involved collection of blood, saliva, skin, nasal and fecal samples.
    - <u>High Level Findings:</u>
      - The results from this study demonstrate that the composition of the astronauts' microbiome is altered during space travel. There was evidence showing that the microbial communities of the gastrointestinal tract, skin, nose and tongue change during the space mission.
      - The composition of the intestinal microbiota became more similar across astronauts in space, mostly due to a drop in the abundance of a few bacterial taxa, some of which were also correlated with changes in the cytokine profile of crewmembers.
      - Alterations in the skin microbiome that might contribute to the high frequency of skin rashes/hypersensitivity episodes experienced by astronauts in space were also observed.


Swab Kit

Research on ISS

- Research on ISS covers all 5 Hazards of Spaceflight. These are just a few of our studies:
  - B-Complex, current
    - Tests whether a daily B vitamin supplement can prevent or mitigate Spaceflight-Associated Neuro-ocular Syndrome (SANS) and also assesses how an individual’s genetics may influence the response.
    - Blood collection, daily Vitamin B supplement, Optical coherence tomography (OCT) testing, Vascular function testing
  - Host Pathogen, current
    - Analyzes the relationship between the increased microbial virulence and reduced human immune function commonly observed during orbital spaceflight.
    - Blood/Saliva collection - ambient only, poses logistical challenges

Research on ISS - CIPHER Highlight

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.**

Mars-forward use of ISS to measure the time course of **physiological and psychological adaptations** to spaceflight to reduce crew health & performance risks during multi-year deep space exploration missions.

Designed to be conducted on 30 crew members of varying mission durations, but categorized into three subject pools:

- Short: 30 to 105 days
- Standard: 106 to 239 days
- Extended: 240+ days

Why are we doing CIPHER?

- There is limited data that has been collected on missions greater than six months which has highlighted some uncertainty in human system responses to longer-duration missions.
- Data generated by CIPHER will help researchers gain deeper knowledge about how the body would change during a three-year, round-trip mission to Mars.

Pre/In/Post-flight
Pre/Post only

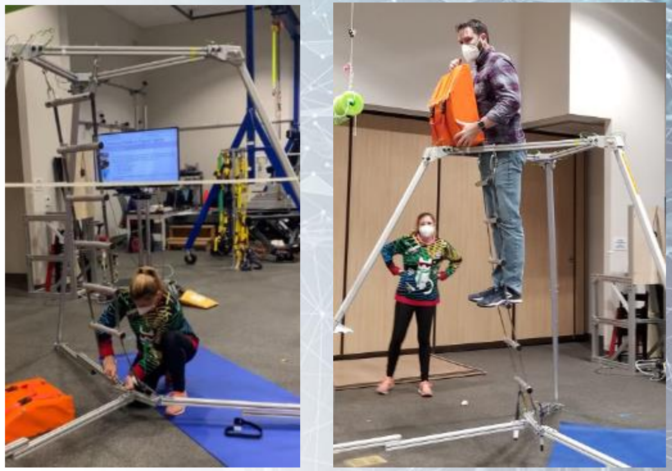
CIPHER Measures
Expanded Biochemical Measures and Cellular Profile - Blood, Saliva & Urine samples
Brain and Behavior – Actigraphy; Cognition testing; Sleep & Personality Surveys; MRIs with Cognition testing; Robotic arm trainer testing
Microbiome - Body swab, Fecal sample, Saliva swabs
Cardiovascular - Carotid Intima-Media Thickness (cIMT); ultrasound; Biomonitor physical activity monitoring; blood pressure; Coronary computed tomography angiography (cCTA); cMRI; myocardial contrast echocardiography
Sensorimotor - Sit-to-stand; Tandem Walk; Recovery from Fall/Stand; neurovestibular evaluation; vestibular exam
SANS/Vision – Ocular MRI; eye exam; Vision and Vascular Tests (Optical coherence tomography (OCT); Electroretinography (ERG); Pneumatonometry; Blood Pressure and heart rate)
Bone and Joint Health – High-resolution peripheral quantitative computed tomography (HR-pQCT); Quantitative Computed Tomography (QCT); dual-energy x-ray absorptiometry (DXA); Electrical Impedance myography (EIM); Questionnaire
Egress Fitness – Planetary EVA circuit (suited); mock-up capsule egress
Exercise and Muscle – Isometric Mid-Thigh Pull (IMTP); VO2 Max testing; strength test, nutrition and exercise data
Data Integration - integrated data analysis using both CIPHER and Medical Operations data

CIPHER Collections

Fiber electrode on cornea

Light stimulus

Planetary EVA Circuit



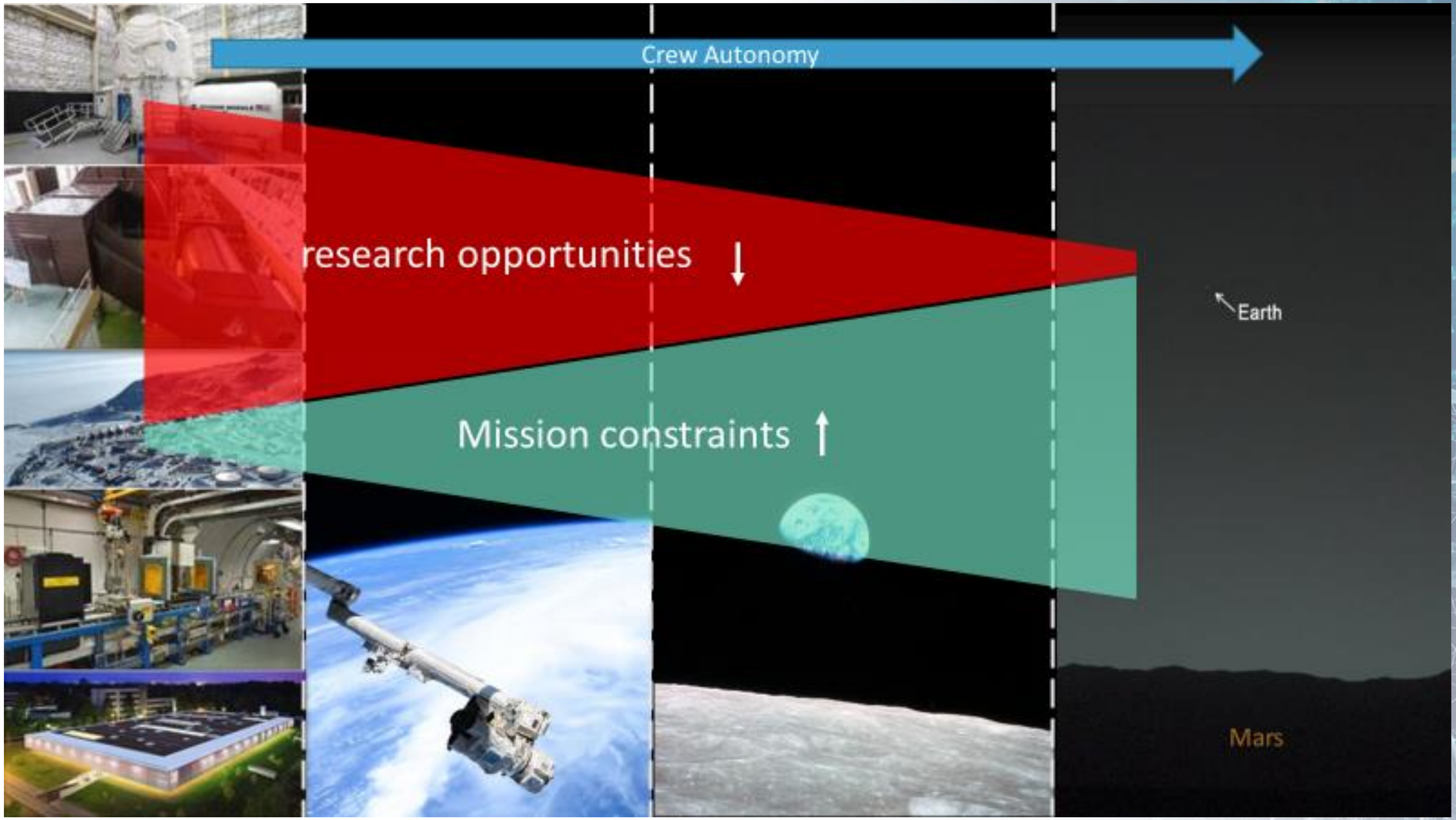
Mock-up Capsule Egress

CIPHER Collections

Research on Artemis Missions

Constraints
- Limited Up mass
- Limited sample return
- Limited space
- Limited Crew time

HRP Focus
- Pre/Post measures
- Minimal mass/volume sample return
- Passive inflight measures
  - Dosimetry
  - Video recording
  - Actigraphy
- Computer based testing
- Surveys



Research in Spaceflight Analogs

- An ANALOG attempts to create an environment to replicate an aspect of spaceflight for the purposes of research.
- Human Research Program uses many different analogs for research and ROI manages HRP research in 3 main types of analogs.
  - ISOLATION AND CONFINEMENT
  - BED REST
  - PARABOLIC FLIGHT

Human Exploration Research Analog (HERA)

RESEARCH PARTICIPATION

6 Campaigns * 4 missions * 4 crew members = 96

1 mission * 4 crew members = 4

 # OF STUDIES PER CAMPAIGN

C1 = 9	7 days
C2 = 14	14 days
C3 = 18	30 days
C4 = 15	45 days (C4–C7)
C5 = 13	
C6 = 15	
C7 = 18	

40.6% FEMALE

59.4% MALE

NUMBER OF MISSIONS

COMPLETED 24

INCOMPLETE 1

Human Exploration Research Analog (HERA)

CAMPAIGN 7 - JAN 2024 - MISSION I

- Transmit mission to/from Mars
- 45 days
- 5 minutes max com delay

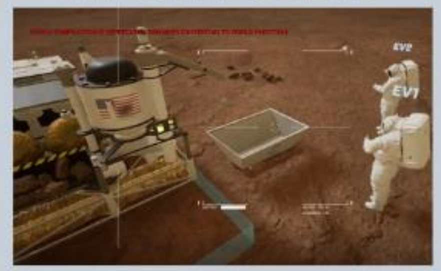
PLANNED STRESSORS

VARYING LEVELS OF AUTONOMY

INTERNATIONAL CREWS

At least 1 of the 4 crew members will be culturally different from typical NASA astronauts.

VR SURFACE EVAS



18 STUDIES

11 HRP
6 UAE
1 ESA

CREW AUTONOMY

BEHAVIORAL HEALTH COUNTERMEASURES

PHYSIOLOGICAL EFFECTS OF ISOLATION AND CONFINEMENT

TEAMWORK AND MULTICULTURAL FACTORS

CAMPAIGN 8 - JAN 2026 - MISSION I

ARTEMIS

TEAMWORK AND TRAINING COUNTERMEASURES

BEHAVIORAL HEALTH COUNTERMEASURES

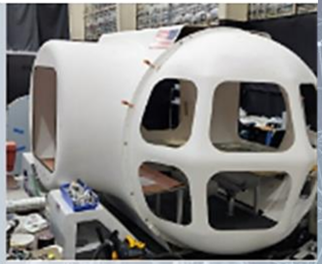
IN MISSION PROBLEM SOLVING

Distributed team systems with Lunar communication delay.

45-days

8-30 sec com delay

Surface EVA's (VR)
Planned off-nominal stressors
Varying level of autonomy
High mission tempo
Split crew crew operations with simulated rover



Antarctica

Isolation & Confinement and Extreme Environment

WINTER-OVER 2023		
PALMER	AMUNDSON-SCOTT SOUTH POLE	POSSIBLE FUTURE STUDIES
PI: Crucian Year 2: Immune Countermeasures	PI: Stankovik Year 2: VR Sensory Stimulation Countermeasure Modeling Individual and Mult-Agent Team Problem Solving	In discussion with Australian Antarctic Division about potentially conducting HRP studies at Australian stations Possibly in 2025 Smaller winter-over populations with greater autonomy Some more remote Some with tighter constrained water/power usage

Amundsen-Scott South Pole Station

High altitude, small population

McMurdo Station

Larger population, more services

Palmer Station

Coastal, small population

:envihab @ DLR (German Space Agency)

- SANS = Spaceflight Associated Neuro-ocular Syndrome
  - Physiological changes to eye in astronauts and bedrest subjects
- -6 deg head down tilt, 30-days
- Countermeasures:
  - Lower Body Negative Pressure
  - Upright Seated Posture
  - Thigh Cuff + Exercise
- Physiological Measures to Evaluate Countermeasure Effects:
  - Assessments of sensorimotor function
  - Somatosensory feedback
  - Musculoskeletal function
  - Muscle structure via MRI, ultrasound guided muscle thickness and echo intensity (EI)
  - Electrical impedance myography (EIM)
  - DXA bone scans
  - Serological measurements, neuromuscular biomarker, and circulating iRNAs

COMPLETED SANS COUNTERMEASURES STUDY JULY 2023

Campaign 1 & 2

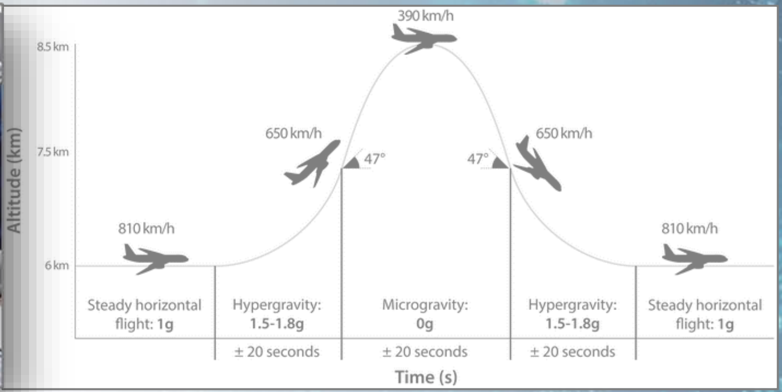
- Subjects divided into two groups of six subjects
  - Strict HDT +LBNP (6 hours per day)
  - Strict HDT + 6 hours seated CM (6 hours per day)

Campaign 3 & 4

- Subjects divided into two groups of six subjects
  - Strict HDT Control
  - Strict HDT + Exercise (1 hour/6 days per week) + Thigh Cuff CM (6 hours/6 days per week)

Parabolic Flight through CNES (French Space Agency)

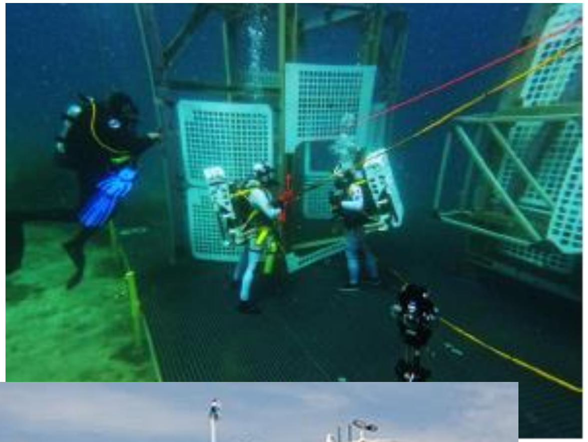
GRAVITY different from Earth



Flight Day 1	Flight Day 2	Flight Day 3	Flight Day 4
0g 2 flights, 16 parabolas each	0.25g, 0.5g, 0.75g Across 31 parabolas	0.25g, 0.5g, 0.75g Across 31 parabolas	0.25g, 0.5g, 0.75g Across 31 parabolas

- Collected data to model responses across gravity levels
  - Functional task testing
  - Fluid shift measurements
  - Ocular Alignment
  - Operational Performance Effects and Neurophysiology
- Enabled interpolation (to lunar and Martian gravity levels)
- Extrapolation (to hyper-gravity environments during dynamic spaceflight phases, landing and launch)

Other Extreme Environment Analogs



NASA uses other analogs to study various aspects of extreme environments

- Underwater analogs to simulate different levels of gravity + constraints of spacesuit on physical operations (moving cargo, construction and maintenance tasks)
- Desert analogs to test hardware and operations in harsh environments (extreme heat, dust, remote surface operations)
- Polar (arctic and antarctica) analogs to test hardware and operations in extreme cold and remote surface operations
- Pressure chambers to test humans and hardware in different atmospheric conditions (atmosphere composition, pressure)

Informative Links

- https://www.nasa.gov/hhp/human-system-risks/
- https://humanresearchroadmap.nasa.gov/
- https://www.nasa.gov/mission/cipher/
- https://www.nasa.gov/mission/station/research-explorer/
- https://www.nasa.gov/humans-in-space/the-human-body-in-space/
- https://www.nasa.gov/hrp/