NASA's Human Research Program Use of Extreme Environments

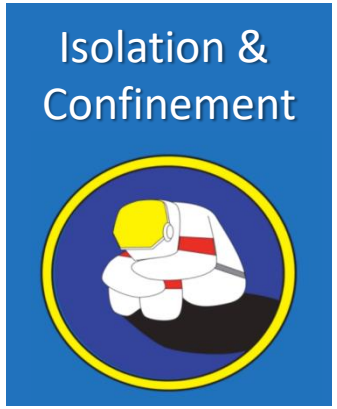
Human Research Program
Research Operations & Integration
Nichole Schwanbeck, Deputy Manager-Flight

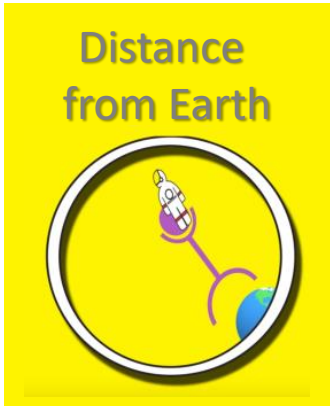
Presenter Introduction

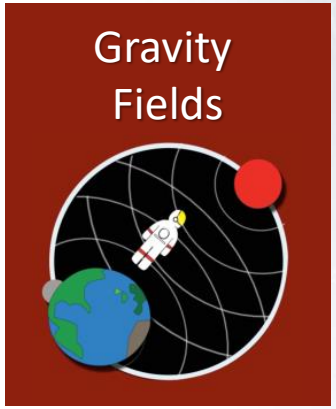
- Graduate of ERAU-Daytona Beach ‘97, BS Engineering Physics
  - ERAU Volleyball player
  - Limited internship opportunities
- Started career at NASA in the Mission Operations Directorate at JSC with United Space Alliance
  - ISS Electrical Power and Thermal Control Systems training division
  - ISS 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?

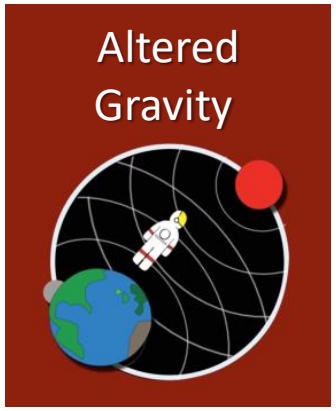
- HRP is NASA's Human Research Program, formally established in 2005.
- Investigates risks to human exploration beyond Earth's atmosphere to help inform understanding, management and mitigation of these risks to reduce threats posed to astronauts on exploration missions.
- HRP's current research portfolio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



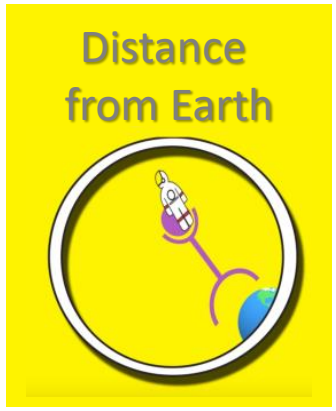




5 Hazards of Spaceflight - HRP Risk Investigation

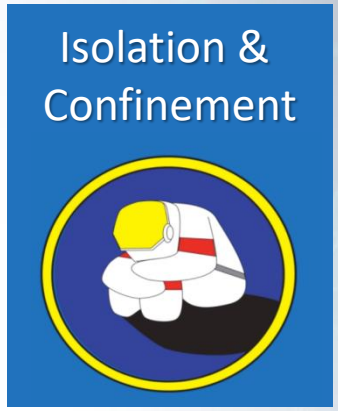


- SANS
- Sensorimotor
- Cardiac Rhythm
- Host-microorganism
- Bone Fracture
- Aerobic Capacity
- Muscle Mass/Strength
- Orthostatic Intolerance



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

- CO2 Exposure
- Dynamic Loads
- Hypoxia
- Sleep Loss
- Immune Response
- Decompression



- Cognitive/Behavioral
- Team Adaptation

- Cancer

HRP's Research Platforms - Flight & Ground based

ARTEMIS

ORION

Soon!

GATEWAY

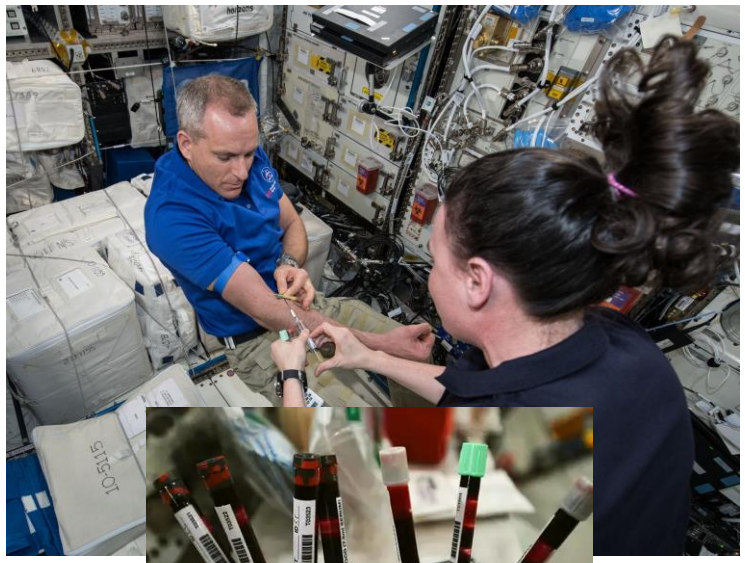
HUMAN LANDING SYSTEM PROGRAM

Future!

COMMERCIAL LEO DEVELOPMENT PROGRAM

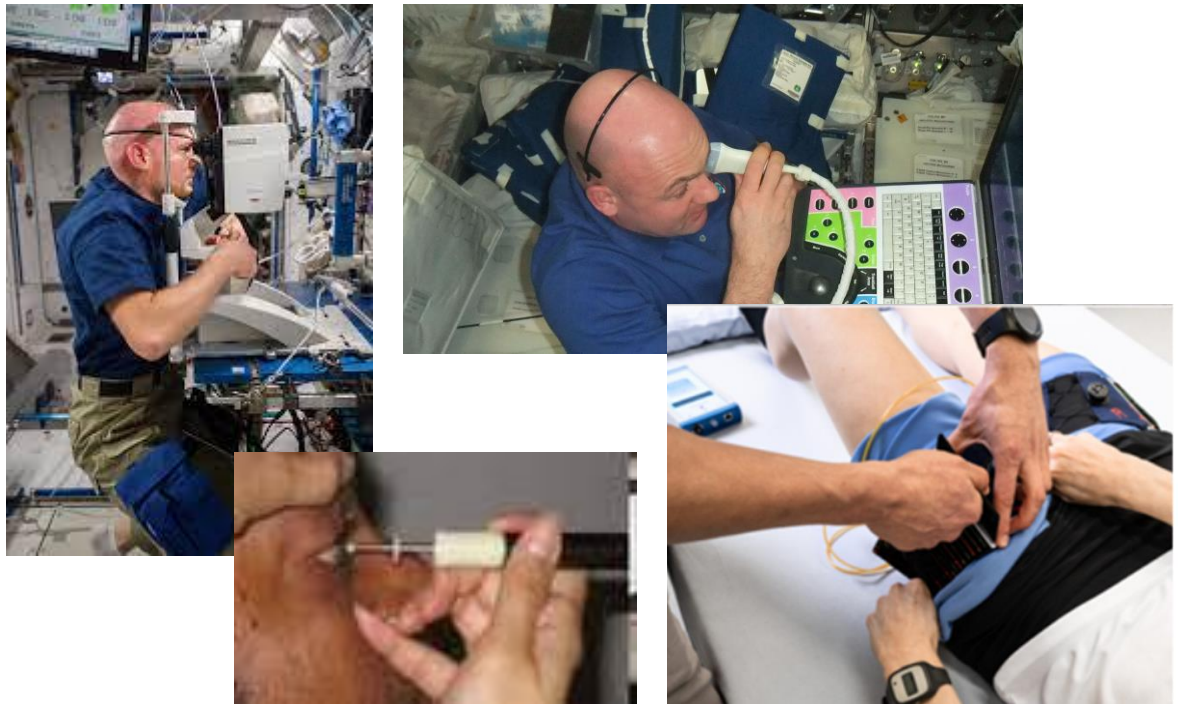
Research on ISS

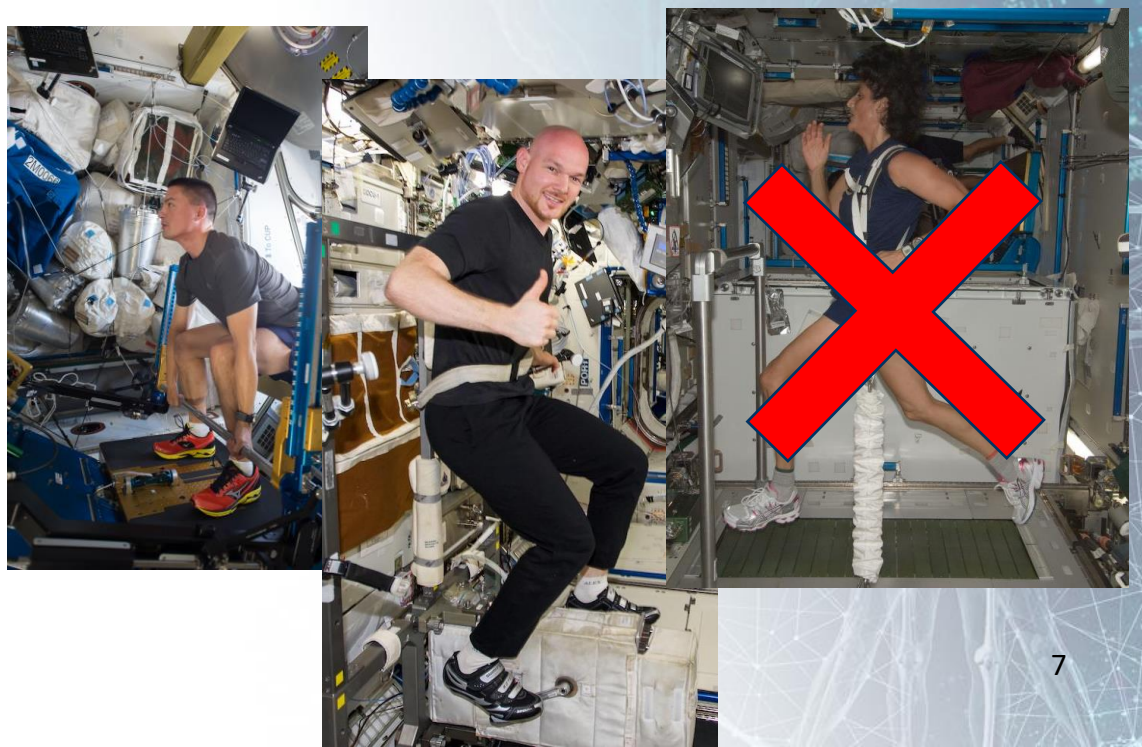
- Research on ISS covers all 5 Hazards of Spaceflight. These are just a few of our studies:
  - B-Complex
    - Tests whether a daily B vitamin supplement can prevent or mitigate Spaceflight-Associated Neuro-ocular Syndrome (SANS) and also assesses how an individual's genetics may influence the response.
    - Blood collection, daily Vitamin B supplement, Optical coherence tomography (OCT) testing, Vascular function testing
  - Host Pathogen
    - 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

- Research on ISS covers all 5 Hazards of Spaceflight. These are just a few of our studies:
  - Thigh Cuff
    - Looking at using cuffs tightened on the legs to change the way fluid moves around inside the body and, hopefully, help prevent health problems in astronauts.
    - Wearing Thigh Cuff through the day, measures of eye with OCT, Ultrasound, Pneumotonometer
  - Zero T2
    - Examines the effects on bone, muscle, aerobic, and sensorimotor health and performance when crew members do not use a treadmill during a mission. Results could help determine whether exercise regimens for future exploration missions are adequate to maintain physical health.
    - Sensorimotor testing pre/post flight, blood/urine data sharing, Muscle performance and IMTP test, VO2 Max test, DXA scans

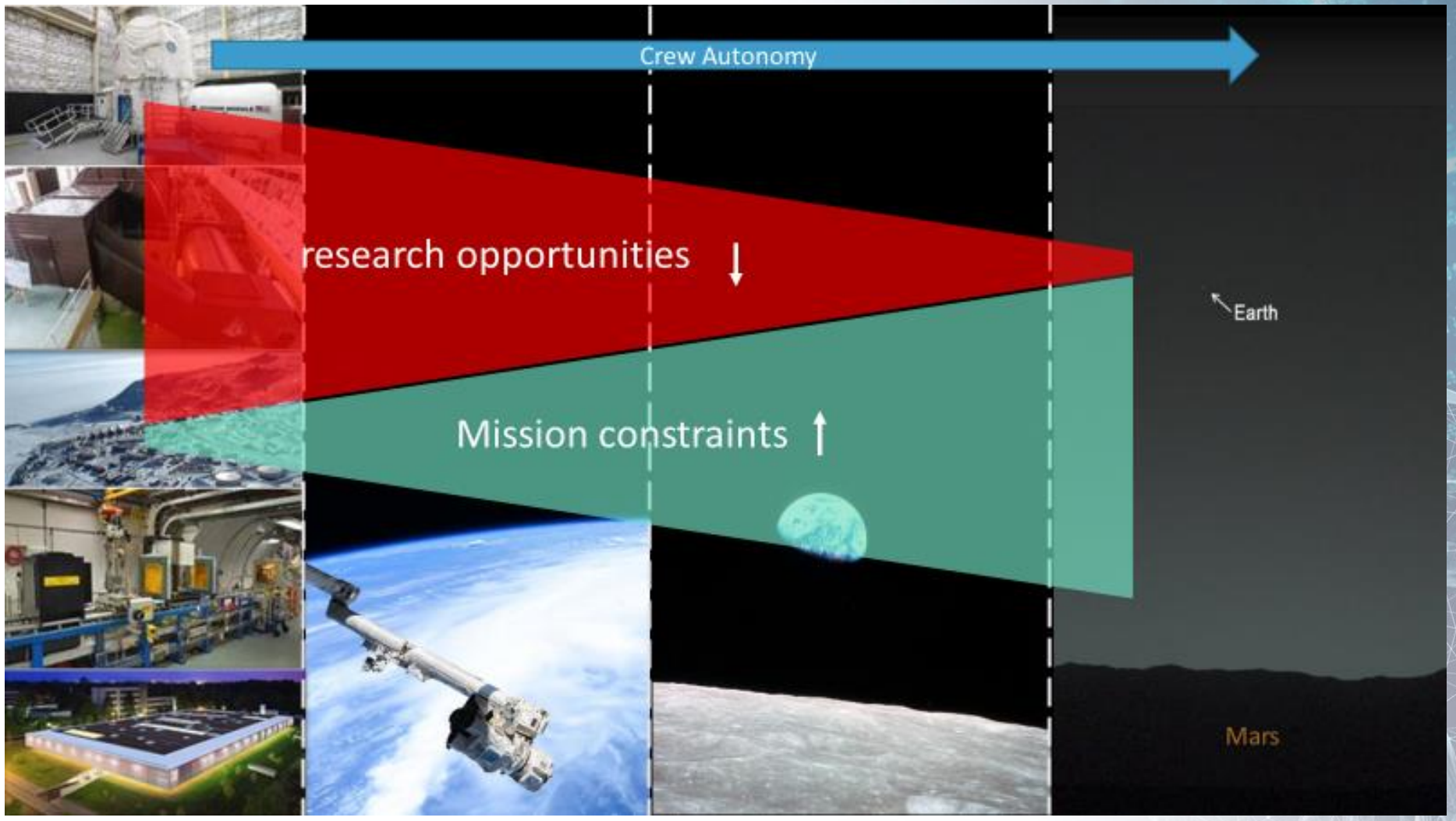




Research on Artemis Missions

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)

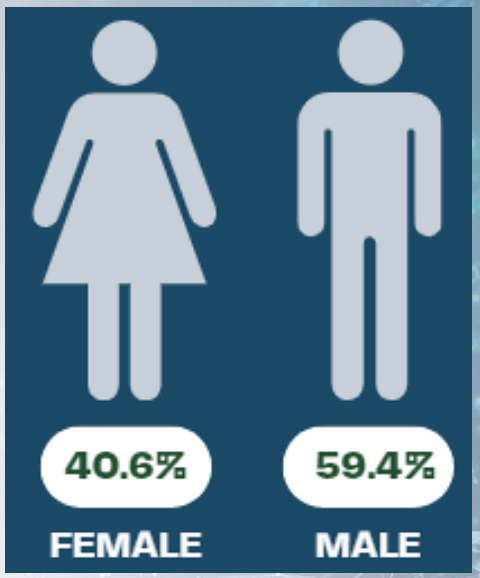
RESEARCH PARTICIPATION

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
C5 = 13	
C6 = 15	
C7 = 18	



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

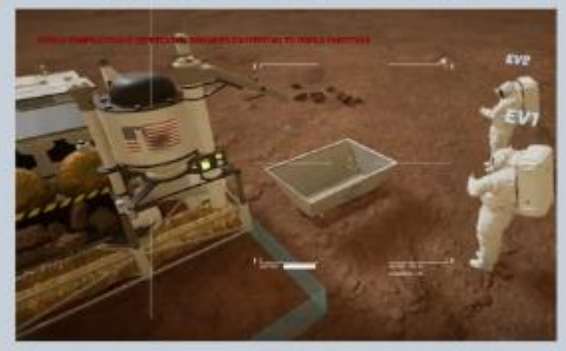
PLANNED STRESSORS

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

Human Exploration Research Analog (HERA)

CAMPAIGN 8 - JAN 2026 - MISSION I

ARTEMIS

TEAMWORK AND TRAINING COUNTERMEASURES

BEHAVIORAL HEALTH COUNTERMEASURES

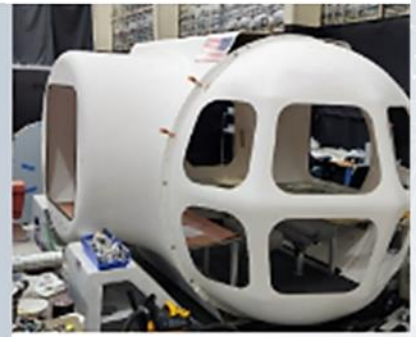
IN MISSION PROBLEM SOLVING

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

Palmer Station

Coastal, small population

McMurdo Station

Larger population, more services

: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 miRNAs

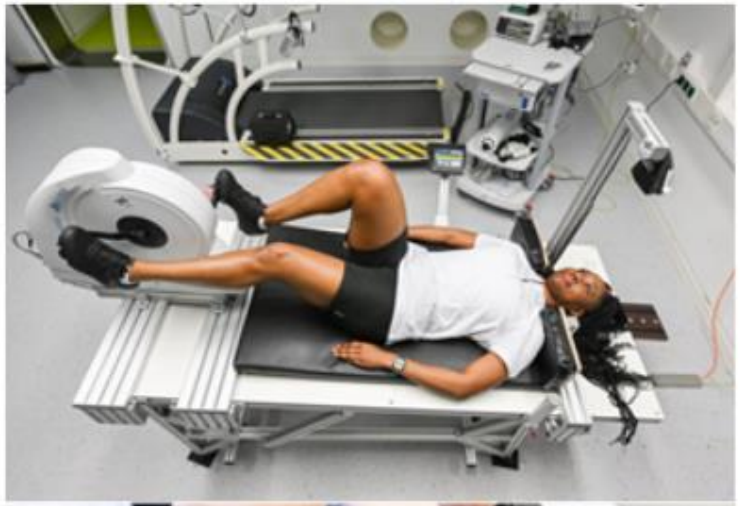
COMPLETED SANS COUNTERMEASURES STUDY JULY 2023

Campaign 1 & 2

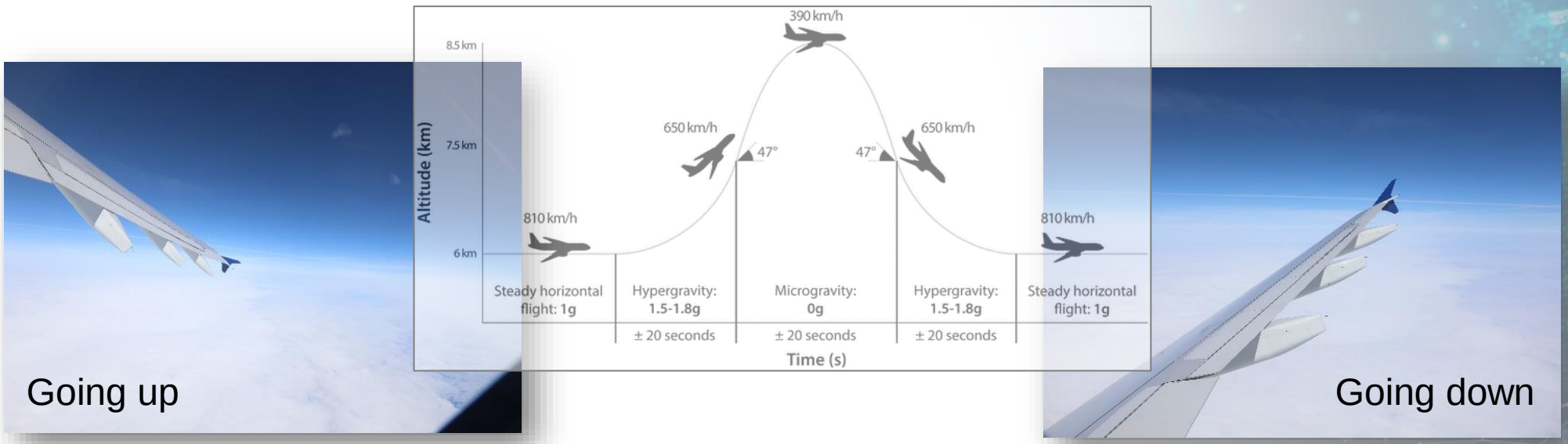
- Subjects divided into two groups of six subjects
  - Strict HDT +LBNP (6 hours per day)
  - Strict HDT + 6 hours seated CM (6 hours per day)

Campaign 3 & 4

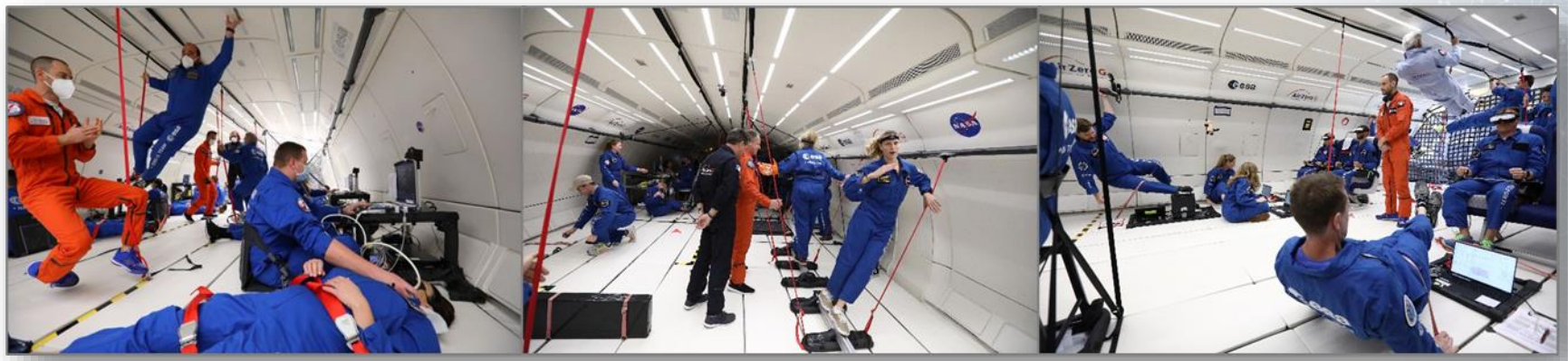
- Subjects divided into two groups of six subjects
  - Strict HDT Control
  - Strict HDT + Exercise (1 hour/6 days per week) + Thigh Cuff CM (6 hours/6 days per week)



Parabolic Flight through CNES (French Space Agency)



GRAVITY different from Earth

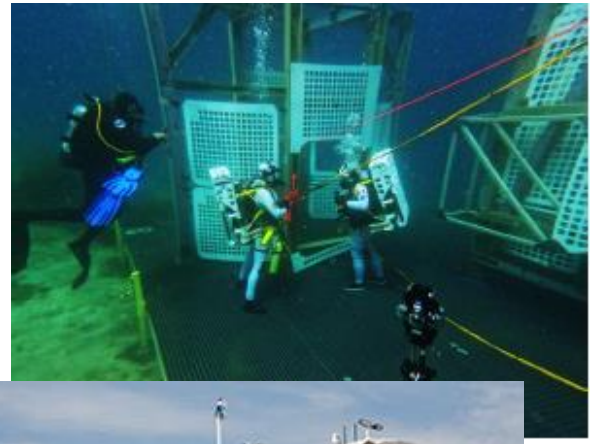


Parabolic Flight through CNES (French Space Agency)

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/