



Spaceflight Analogs



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What is an analog?

- Analog:
 - an object, concept or situation which in some way resembles a different situation
- Spaceflight analogs as used for human research:
 - Create a situation that produces affects on the human body similar to those experienced in spaceflight
 - Physiological
 - Cognitive/behavioral

Why Use Ground-based Analogs for Human Spaceflight Research?

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- Allows for selection of best candidate countermeasures before using them in flight
- Saves time and money as studies can be completed more quickly and less expensively on the ground.

NASA Flight Analogs Project

- Coordinates science in ground-based analogs that support NASA investigations
 - NEEMO
 - Haughton-Mars
 - Antarctica
 - HERA
 - Summit Station, Greenland
 - Flight Analogs Research Unit (bed rest facility)

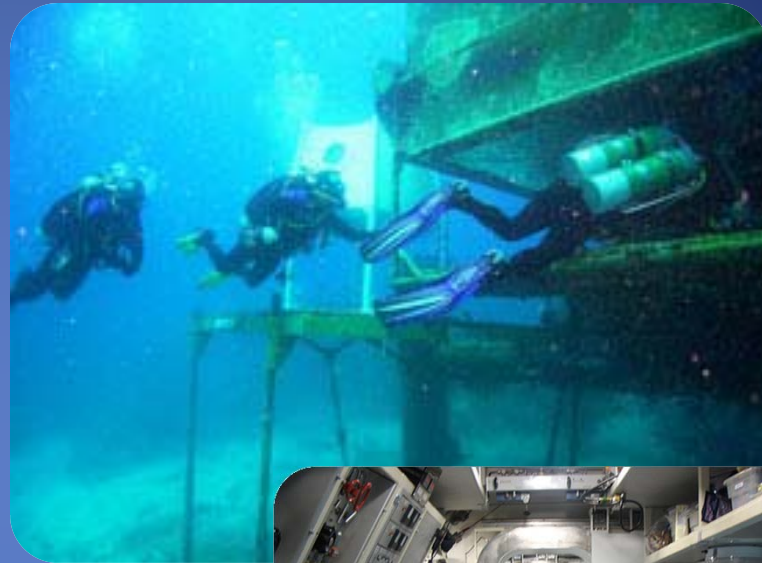
NEEMO

- NASA Extreme Environment Mission Operations
 - Located 3.5 miles off of Key Largo, FL
- Facility Operations:
 - National Oceanic & Atmospheric Administration (NOAA)
 - National Undersea Research Center at University of North Carolina, Wilmington (NURC)



NEEMO

- Aquarius
 - Underwater habitat - an environment similar to living in space
 - Operating depth 47 feet
 - 11 cubic meters living/lab space, similar to Destiny module of the ISS
- Application
 - Isolation/confinement
 - telemedicine
 - Extravehicular activities
 - simulations of partial gravity
- For more information
 - http://www.nasa.gov/mission_pages/NEEMO/index.html

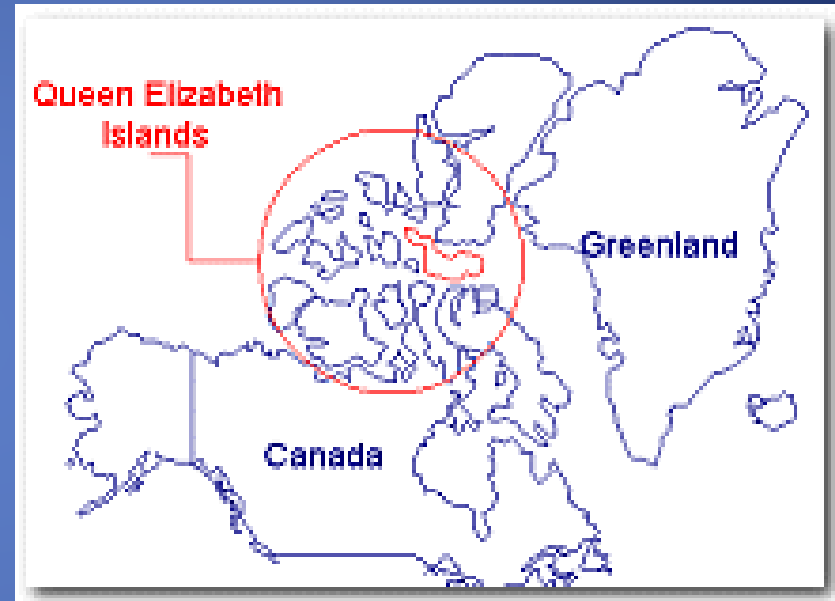


NEEMO Investigations

- Nutritional
 - Smith SM, Davis-Street JE, Fesperman JV, Smith MD, Rice BL, Zwart SR. Nutritional assessment during a 14-d saturation dive: the NASA Extreme Environment Mission Operations V project *J Nutr* 134:1765-1771, 2004.
 - Zwart SR, Kala G, Smith SM. Body iron stores and oxidative damage increased after a 10- to 12-day undersea dive in humans. *J Nutr* 139:90-95, 2009.
- Immune
 - Crucian B, Stowe R, Mehta S, Quiariarte H, Yetman D, Pierson D, Sams C. Immune Function Changes During a Spaceflight-analog 12-day Undersea Mission. HRP IWG, 2008.
- Behavioral
 - PI: D Dinges. Vigilance, Stress and Sleep/Wake Measurements - NEEMO 13
 - PI: N Kanas. Effects of High vs Low Autonomy on Space Crewmember Performance -NEEMO 13
- EVA
 - PI: M. Gernhardt. Advanced Extravehicular Activity (EVA) Exploration Activities Study to Assess Human Performance Responses in Partial Gravity Environments

Haughton-Mars

- Location
 - Site of the Haughton meteorite impact crater
 - Devon Island in the Canadian high arctic
- Facility Operations
 - Mars Institute
 - SETI Institute (Search for Extraterrestrial Intelligence)



Haughton-Mars

- Haughton-Mars Project
 - International, interdisciplinary field research project
 - Rocky, polar desert setting provides insights into the evolution of Mars
 - Terrestrial analog for Mars and lunar studies
- Application
 - Human performance
 - physical
 - behavioral
 - Extravehicular activity systems
 - Human factors
- For more information
 - <http://www.marsonearth.org>



Haughton-Mars Investigations

- Immune

- Crucian B, Lee P, Stowe R, Jones J, Effenhauser R, Widen R, Sams C. **Immune system changes during simulated planetary exploration on Devon Island, high arctic.** BMC Immunol 8:7, 2007.

- Med Ops

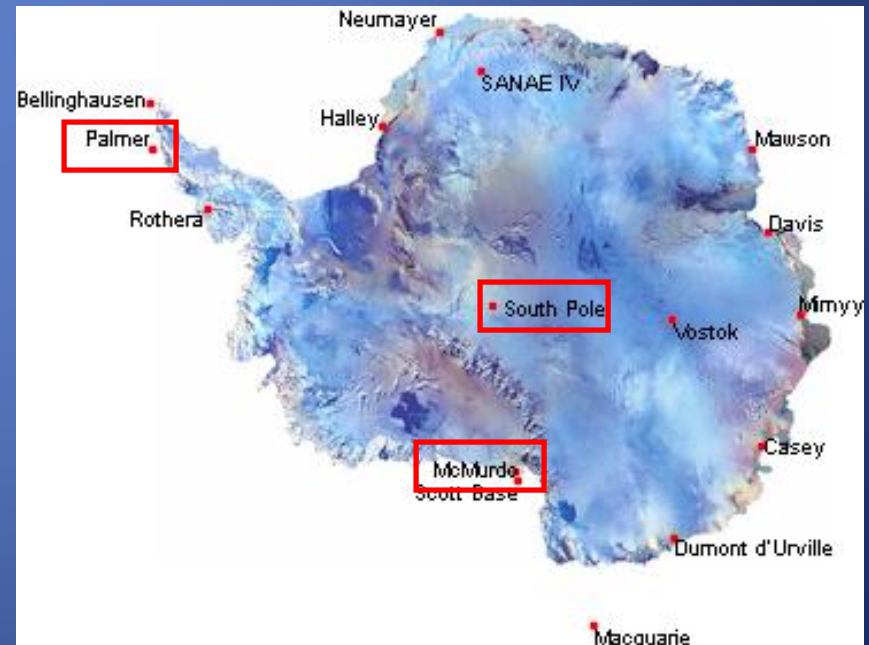
- Scheuring RA, Jones JA, Lee P, Comtois JM, Chappell S, Rafiq A, Braham S, Hodgson E, Sullivan P, Wilkinson N, Bach D, Torney S. **An Evidence-based approach to Developing a Management Strategy for Medical Contingencies on the Lunar Surface.** 16th Annual Humans In Space 2007, Beijing, China
- Chappell SP, Scheuring RA, Jones J A, Lee P, Comtois J M, Chase T, Gernhardt M, Wilkinson N. **Equipment and Methods for Medical Evacuation of an Injured Crewmember.** AsMA Annual Conference, 2007, New Orleans, LA

- Behavioral

- PI: D F Dinges. **Vigilance, Stress and Sleep/Wake Measures in HMP – 2008 – A Simulated Lunar Environment.**
- PI: N Kanas. **Effects of High vs. Low Autonomy on Space Crewmember Performance.**
- PI: L Schmidt. **Measures of Team Cohesion, Team Dynamics, and Leadership in a Simulated Lunar Environment.**

Antarctica

- 64 stations operated by 20 countries
- United States Antarctic Program
 - National Science Foundation, Office of Polar Programs
- 3 year-round research stations
 - Palmer Station
 - Amundsen-Scott South Pole Station
 - McMurdo station
 - Main US station
 - Located on Ross Island



Antarctica

- Antarctic environment
 - Climate, terrain, temperature, isolation and stress parallels that of long-duration space missions
- For more information
 - http://www.nsf.gov/od/opp/antarct/treaty/opp08001/bigprint0708/bigprint0708_toc.jsp
 - <http://www.antarcticconnection.com/antarctic/stations/index.shtml>
- Application
 - Isolation/confinement
 - physiological stress
 - disrupted circadian rhythms
 - telemedicine



Antarctica Investigations

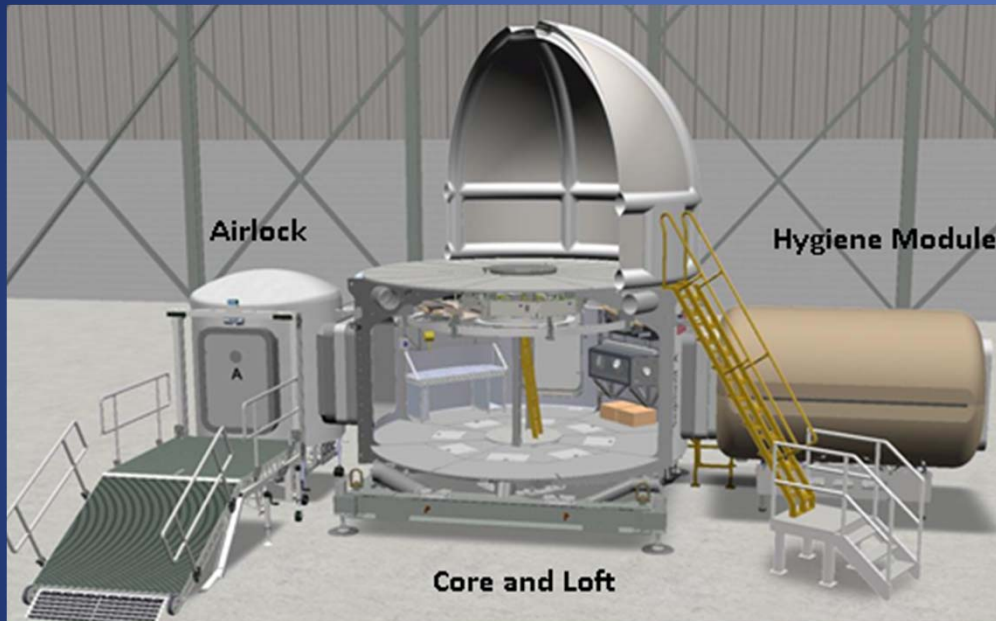
- Nutritional Studies

- Smith SM, Gardner KK, Locke J, Zwart SR. **Vitamin D supplementation during Antarctic winter**. *Am J Clin Nutr.* 89 (4): 1092-1098, 2009.

- Immune

- Choukèr A, Baatout S, Campolongo P, Crucian B, Duchamp C, Gunga H, Kaufmann I, Kreth S, Pierson D, Praun S, Raccurt M, Sams C, Schachtner T, Schelling G, Thiel M. **Consequences of longterm-Confinement and Hypobaric HypOxia on Immunity in the Antarctic Concordia Environment (CHOICE – Study)**

Human Exploration Research Analog (HERA): General Description



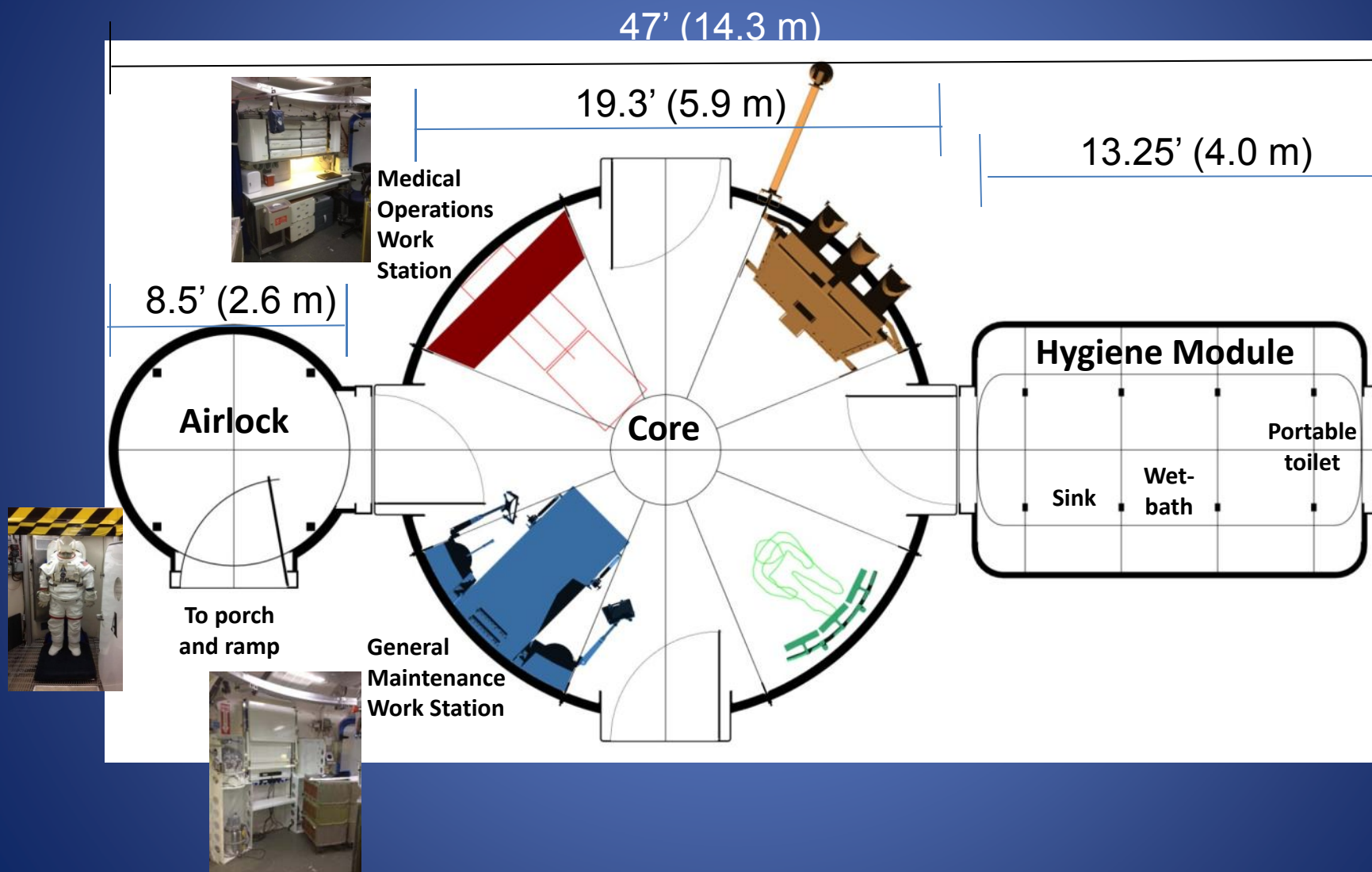
The Human Exploration Research Analog is a two-story, four-port habitat unit residing in Building 220 at NASA JSC. It is cylindrical with a vertical axis, and connects to a simulated airlock and hygiene module

Total space: 148.1 m³

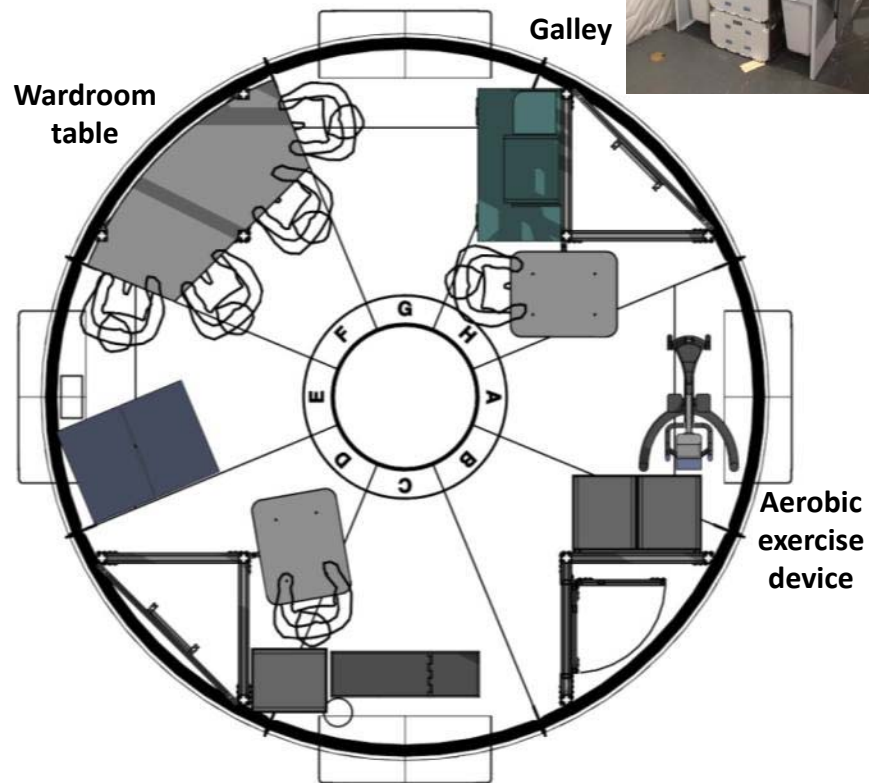
- core (56.0 m³)
- loft (69.9 m³)
- airlock (8.6 m³)
- hygiene module (14.1 m³)



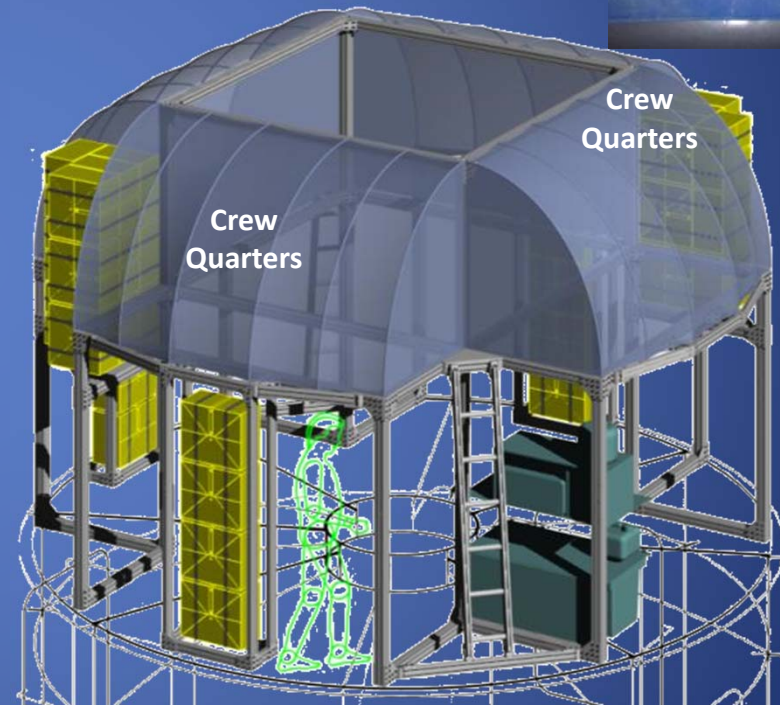
HERA interior (1st floor)



HERA interior (2nd & 3rd floors)



2nd floor



3rd floor

HERA Applications

- **Capability and potential for long duration (30+ days) human research.** Currently planned 7-30 days mission scenarios
- **Currently identified for research in HERA**
 - **Behavioral Health and Performance**
 - Test crew hierarchy, team cohesion and stress in confined, isolated crewmembers
 - Remote communications with a delay
 - Simulate autonomous operations
 - **Space Human Factors and Habitability**
 - Controlled environmental conditions
 - Temperature
 - Humidity
 - Lighting
 - **Exploration Medical Capability**
 - Telemedicine operations

Summit Station

- Summit Station is an NSF research station located at the highest point on the Greenland Ice Sheet
- The station is operated year-round
- Originally established in April 1989 in support of the Greenland Ice Sheet Project Two (GISP2) deep ice coring effort
- A variety of astronomy, atmospheric/climate, and glaciological projects are supported

Summit Station

- A staff of 5 – 6 people are assigned year-round
 - Station manager
 - One or two mechanics
 - Three technicians (typically science technicians)
- Staff is typically mixed gender; mixed nationality is possible
- Staff are rotated approximately every three months
- The station population can grow to 20 – 40 people during the summer
 - Scientific research teams
 - Construction / maintenance personnel
 - Other support staff added (e.g., dedicated cook, EMT)

Greenland Stations

Thule Air Base

- Port for surface vessel
- Cargo storage
- Maintenance
- Staging for GrIT (surface traverse)

Summit Station

- Highest point on Greenland
- Permanently staffed research station
- Maintenance/repair available

Kangerlussuaq

- Primary staging location for LC-130
- Cargo storage
- Maintenance

Raven Training Facility

- Training skiway for Air National Guard crews

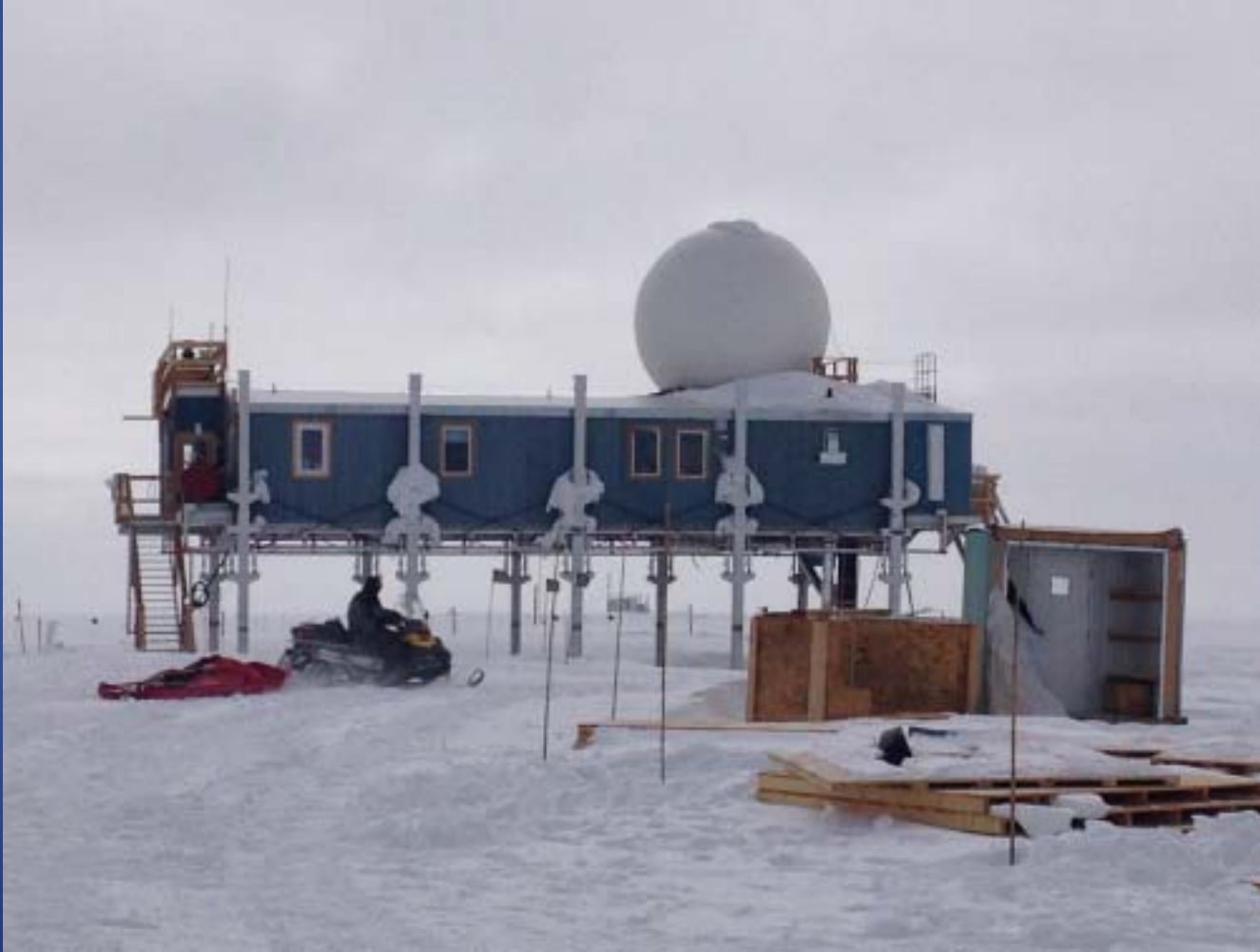


Current Station Layout

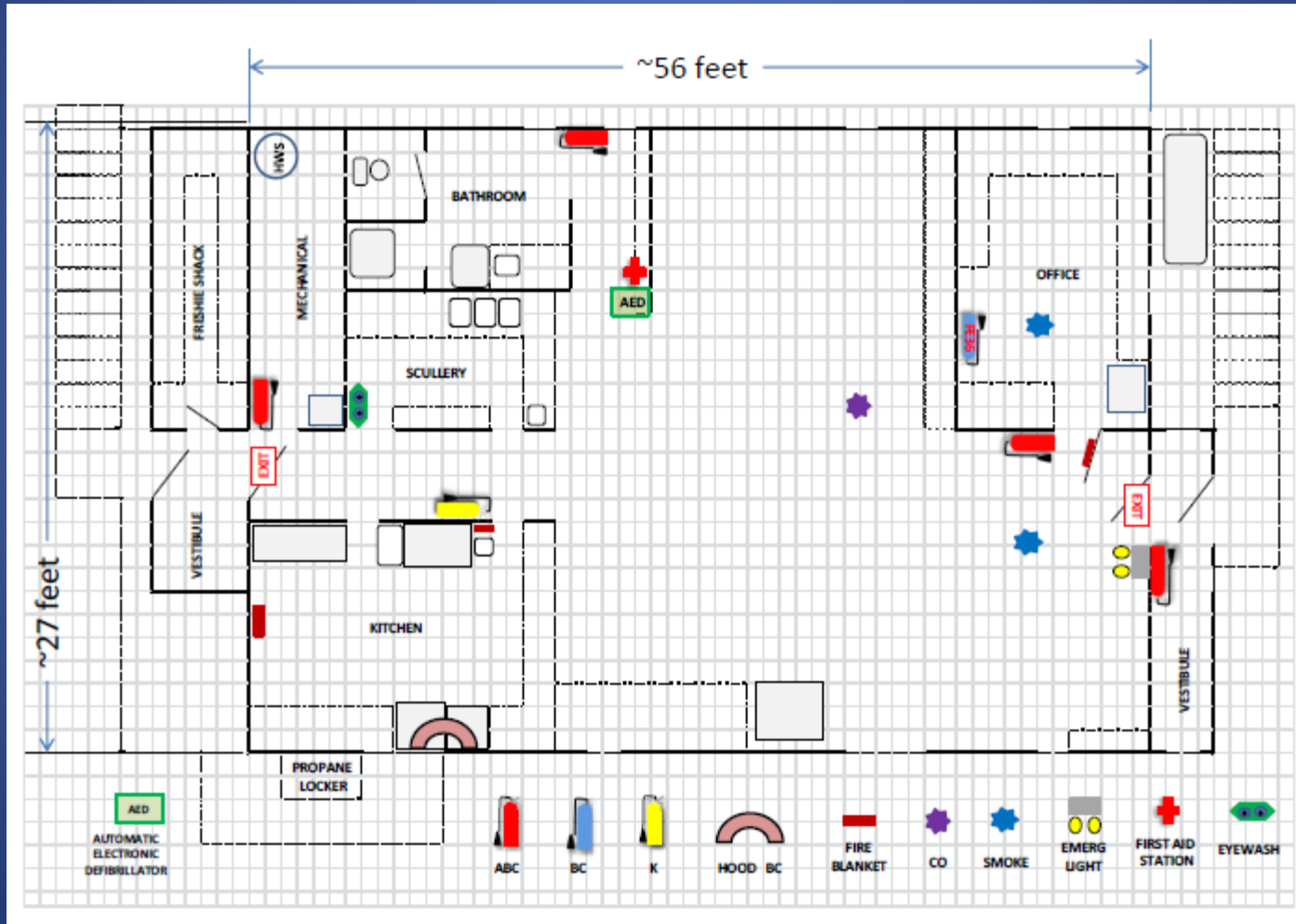


- Heated buildings and spaces
 - Big House
 - Green House/Clinic/Berthing Module
 - Science & Operations Barn
 - Sauna and seasonal office/work space
 - Temporary Atmospheric Watch Observatory (TAWO)
 - Mobile Science Facility (MSF)

Summit Station “Big House”



Summit Station “Big House”



Summit Station Visitors' Quarters



Selection for Analogs

- PI study
 - NASA Research Announcement
 - NASA Peer Review
 - Funding of project
- Analog Requirements Worksheet
 - Identify analog characteristics
 - Science
 - Operational
- Analog Assessment Tool
 - Identifies best analogs to complete the study

ANALOG CHARACTERISTICS	FARU - UTMB	NEEMO	Devon Island / HMP	Antarctica	Desert RATS	Human Related Chamber Complex
Environment/Terrain External to Habitat						
Desert (may include Arctic desert)			●	●	●	
Island			●			
Ice sheet				●		
Sub-ocean		●				
Other	●					●
Extreme Environment Features						
Hypoxia						●
Hyperbaric						●
Atypical day length			●	●		
High Humidity		●				
High temperature					●	
Low temperature			●	●	●	●
Characteristics						
Confinement within habitat	●			●		●
Crew Hierarchy (Commander, etc.)		●				
Microgravity simulation (0g)	●	●				
Lunar gravity simulation (1/6g)	●	●				
Mars gravity simulation (3/8g)		●				
Difficult or limited logistics		●	●	●		
Isolation from outside world		●	●	●		●
Limited local infrastructure		●	●		●	
Remote communications			●	●		●
Autonomous operations		●	●	●		●
Autonomous medical care or "telemedicine"		●	●	●		
Moon/Mars-relevant field/EVA activities		●	●		●	
Lunar surface simulation			●		●	
Martian surface simulation			●		●	

- Analog Assessment Tool
 - Science and operation requirements are matched against analog characteristics
 - Appropriate analogs are selected
- Benefits of identifying multiple analogs
 - More missions available
 - Achieve necessary sample size for study sooner

Analog Missions

- NASA HRP studies are typically “piggy backed” on to existing analog missions
 - e.g. geological study at HMP
 - Provides a true mission scenario for effective study. Mission crew is an analog for a flight crew.
- For more information on NASA analogs:
 - <http://www.nasa.gov/exploration/analog/>

Flight Analogs Research Unit (FARU)

- Flight Analogs Research Unit
 - Located at University of Texas Medical Branch in Galveston, TX
- Facility Operations:
 - NASA funded through the NIH to the Institute for Translational Sciences - Clinical Research Center at UTMB



History of Bed Rest as a Flight Analog

- 1961: human spaceflight begins and bed rest is used as a ground-based analog of inactivity.
- Early 1970s: cosmonauts return from longer duration missions
 - difficulty sleeping due to sensation of slipping off the end of the bed
 - Foot of the bed was raised to compensate, then gradually lowered to horizontal

History of Bed Rest as a Flight Analog

- Soviets tested a variety of tilt angles
 - 6° of head down tilt (HDT) optimized comfort and provided sufficient magnitude of changes to physiological responses.
- HDT position provides the added benefit of studying fluid shifts that produce cardiovascular changes.
- 6° HDT bed rest is an accepted model for studying physiological affects of spaceflight on bone, muscle and cardiovascular systems.

Head Down Tilt Bed Rest

- Serves as a model for studying the physiological changes that occur during spaceflight under controlled conditions
 - Deconditioning - confinement to bed
 - Bone loss - long duration of inactivity
 - Fluid shifts - 6° head-down tilt
- Provides a platform for comparison between bed rest and space flight
- Provides a mechanism for testing countermeasures prior to being used in flight

Structure of Bed Rest Studies

- ◎ Studies that utilize the NASA Flight Analogs Research Unit are integrated into study complements on a non-interference basis.
 - Improves efficiency of research
 - Places least amount of subjects at risk
- ◎ Standardized conditions provide a controlled set of variables that are kept consistent across all complements.
- ◎ Standard measures are a battery of tests integrated with all complements.

NASA Flight Analogs Research Unit



UTMB



Research Building 6

WFAA - Dallas



<http://www.wfaa.com/news/texas-news/Subjects--121753299.html>

Bed Rest Platforms

- Standard platform
 - 60 days of bed rest
 - -6° head-down tilt
- Other platforms used
 - 90 days @ -6°
 - 30 days @ -6°
 - 14 days @ 0°
 - 14 days @ -6°
- Current platform
 - 70 days @ -6°



Subject Screening

- ▶ Phone screening to determine general health status and basic criteria (e.g. age 24-55 years)
- ▶ NASA-modified Air Force Class III physical examination.
- ▶ Exclusion criteria:
 - Hypertension
 - ECG abnormalities
 - Blood or urine chemistries abnormal
 - Medications
 - Recent sub-standard nutritional status
 - Metal implants
 - smoked within past six months
 - BMI outside of 21-30 Kg/m²
 - history of thyroid dysfunction, renal stones, mental illness, gastroesophageal reflux, cardiovascular disease, thrombosis, musculoskeletal or sensorimotor dysfunction
- ▶ For females: regular menses, a negative pregnancy test, and no current use of hormonal contraceptives

Subject Screening

- Illicit and comprehensive urine drug screen
- Tuberculosis screen
- HIV, Hepatitis A, B and C screen
- Dual-energy x-ray absorptiometry (DXA)
- Psychological Screening
 - Beck Anxiety Inventory
 - Beck Depression Inventory II
 - Substance Abuse Subtle Screening Inventory
 - Revised NEO Personality Inventory
 - Minnesota Multiphasic Personality Inventory – 2 Restructured Form
 - Forer Sentence Completion Test
 - 90-minute clinical interview

Standard Conditions

- 6° HDT bed rest
- Room Temperature: 70-74°
- Study duration ~87 days
 - 13-15 days pre-bed rest
 - 60 days in bed
 - 14 days recovery
- Sleep/Wake cycle
 - Wake at 0600 hrs
 - Lights out at 2200 hrs



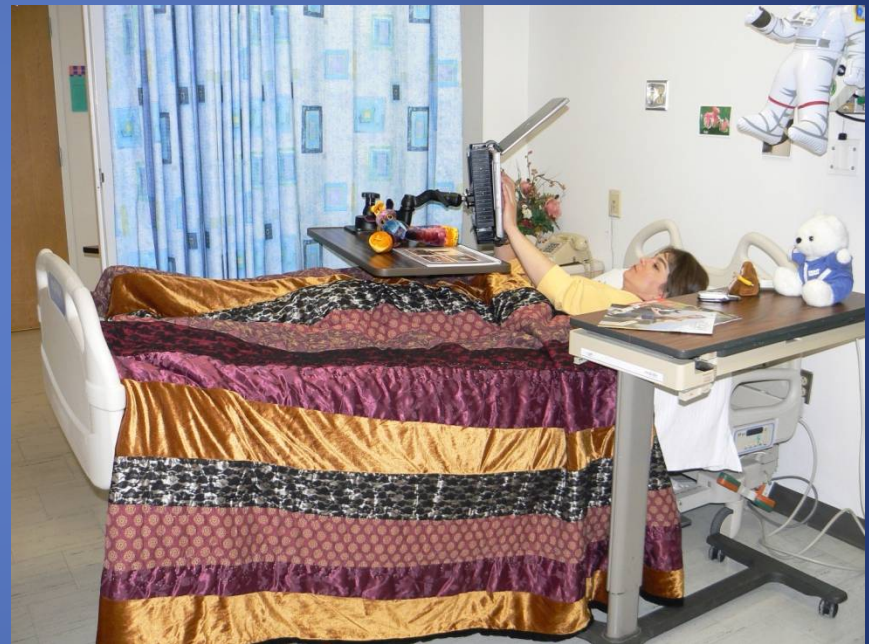
Standard Conditions

- Monitored 24 hrs/day
 - Subject monitors
 - cameras
- Daily Vital signs
 - Blood pressure
 - Heart rate
 - Body temperature
 - Respiratory rate
 - Body weight (bed scale)
- Fluid intake and output is measured
- Psychological support provided



Standard Conditions

- Stretching twice each day
- Physiotherapy (massage therapy)
 - every other day during bed rest
 - daily for 1st week post bed rest
- No exercise permitted



Standard Diet

- Isocaloric diet based on NASA spaceflight nutritional requirements
- Caloric intake 35.7 kcal/kg body weight (2500 calories/70 kg subject)
- Fluid intake 28.5 ml/kg body weight (2000 ml/70 kg subject)
- Carbohydrate:Fat:Protein ratio 55:30:15
- No caffeine, cocoa, chocolate, tea or herbal beverages
- All food must be consumed
- Caloric intake adjusted to weight within 5%



Standard Measures

- Purpose
 - Characterize human responses to head down tilt bed rest.
 - Provide a basis for comparison between bed rest and spaceflight
 - Provide a mechanism to assess candidate countermeasures in a multidisciplinary manner to determine outcomes on non-targeted systems.

Standard Measures

- Clinical Laboratory Assessment

- Blood and urine studies to monitor subject health
- BR-10, BR 28, BR+0, +5

- Immune Status

- General immune status
- Viral specific immunity
- Latent Viral Reactivation
- Physiological stress
- BR-10, BR28, BR+0, +5

- ▶ Nutrition

- Nutritional analysis
- Markers of bone resorption and formation
- Circulating bone and calcium regulatory factors
- Antioxidants and oxidative damage
- BR-10, -3, BR28, BR+0, +5

Standard Measures

- Bone Assessment
 - Dual Energy X-Ray Absorptiometry (DXA) – Bone Density
 - BR-13, BR+2, +180, +365
 - Quantitative Computerized Tomography (QCT) – hip and lumbar spine bone mass and structure
 - BR-4, BR+4, +180, +365



Standard Measures

- Physical Fitness
 - Isokinetic Testing – muscle strength/endurance
 - BR-11, -6, BR+2, +12
 - Cycle Ergometry – maximum aerobic capacity
 - BR-12, -7, BR+0, +11



Standard Measures

- Functional Neurological Assessment
 - Posturography testing – standing posture
 - BR-10, -5, BR+0, +1, +2, +4
 - T-Reflex – spinal monosynaptic stretch reflex
 - BR-10, -4, -1, BR 5, 20, 60, BR+0, +3, +5



Standard Measures

- Cardiovascular
 - Operational Tilt Test – orthostatic tolerance
 - BR-5, BR+0, +3
 - Carbon monoxide rebreathing - Plasma volume
 - BR-5, BR 3, 21, 31, BR+0, +3
 - Echocardiography – cardiac function assessment
 - BR-5, BR 7, 21, 31, BR+0, +3, +13



Integrated Complements

- Studies selected for the bed rest analog are integrated into complements on a non-interference basis.
 - Uses same subjects for all studies - placing the minimum number of subjects at risk
 - Studies are completed faster and more efficiently
 - Efficient way to answer research questions for NASA HRP in preparation for space missions
 - With ISS access available only until 2020, access to ground based analogs becomes more important

Current 70-day Bed Rest Studies

- Physiological Factors Contributing to Post Flight Changes in Functional Performance
 - **J. Bloomberg, NASA**
 - Identification of the key underlying physiological factors that contribute to performance of functional tests that are representative of critical mission tasks
- Integrated Resistance and Aerobic Training Study (iRATS)
 - **L. Ploutz-Snyder, USRA**
 - Evaluation of the efficacy of a new integrated resistance and aerobic training (iRAT) program designed to minimize loss of muscle, bone and cardiovascular function



Current 70-day Bed Rest Studies

- ▶ Testosterone supplementation as a countermeasure against musculoskeletal losses during space exploration
 - **R. Urban, University of Texas Medical Branch**
 - Examination of testosterone supplementation in conjunction with exercise (iRATS) to protect against functional loss of muscle and bone.
- ▶ Effects of retronasal smelling, variety and choice on appetite & satiety
 - **J. Hunter, Cornell University**
 - Examination of fluid shift effects on taste, olfaction and trigeminal response; and compare odorant acceptability ratings for pure, food-related odorants to subjects' appetite, or desire to eat a meal.



Current 70-day Bed Rest Studies

- AD ASTRA: Automated Detection of Attitudes and States through Transaction Recordings Analysis
 - **C. Miller, Smart Information Flow Technologies, LLC**
 - Validation of automated linguistic analyses to assess written journals and derive psycho-social state assessments of subjects' emotional well being.
- Bed Rest as a Spaceflight Analog to Study Neuro-cognitive Changes: Extent, Longevity, and Neural Bases
 - **R. Seidler, University of Michigan**
 - Identification of the relationship between changes in participants' neurocognitive function and neural structural alterations following head-down tilt bed rest using structural and functional MR brain imaging.



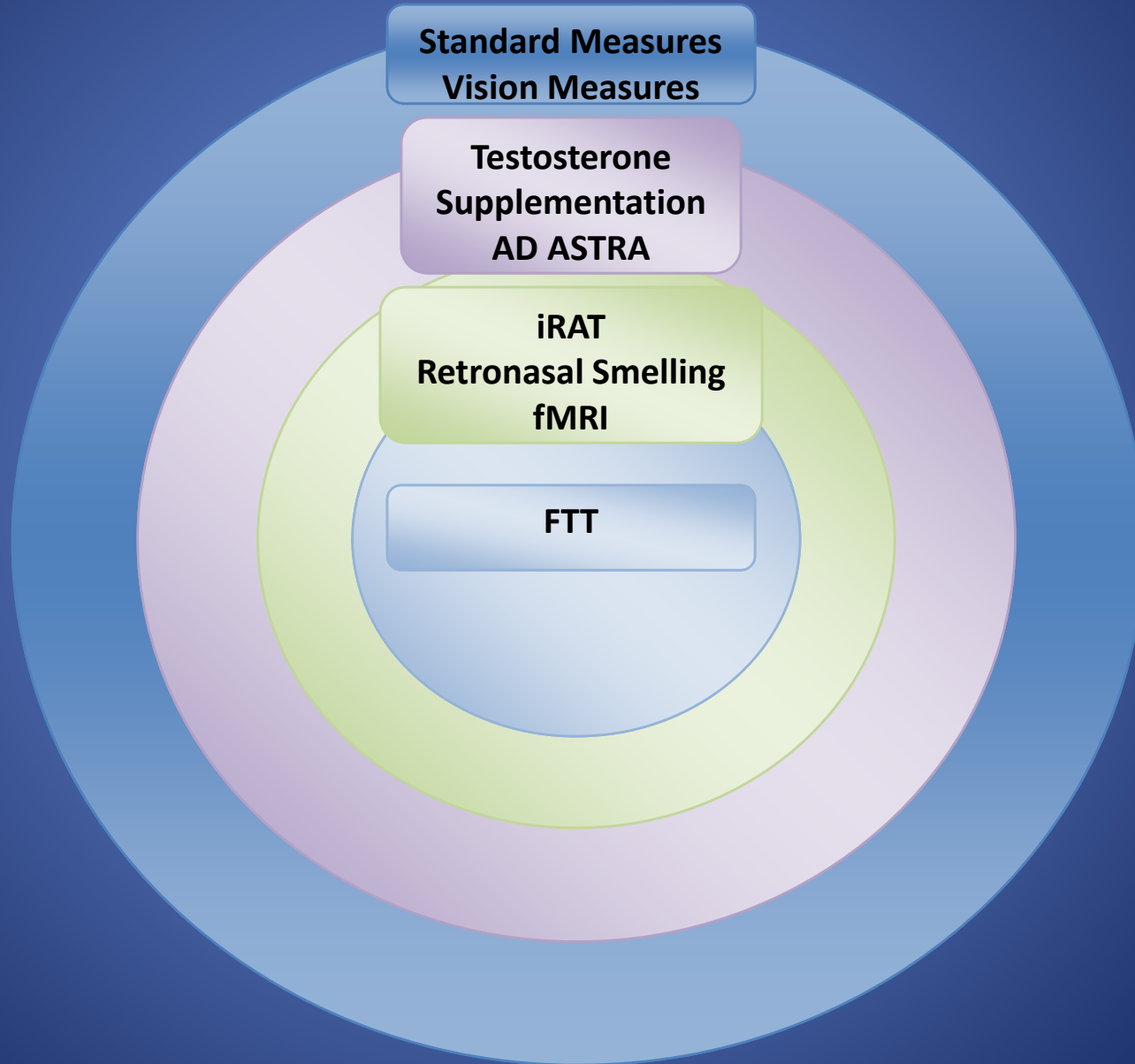
Study Planning

- ▶ Integrate and implement study complements
 - ▶ Host integrated working groups
 - ▶ Provide complement planning support
- ▶ IRB Approvals
 - ▶ PI obtains approval at home institution
 - ▶ FAP assists PI with NASA IRB submission of individual study
 - ▶ FAP obtains NASA IRB, UTMB ITS-CRC and UTMB IRB approvals for the complement
- ▶ NASA documentation and approvals obtained by FAP
 - ▶ Integrated Protocol Document
 - ▶ Integrated Requirements Document
 - ▶ Test Readiness Review

Study Implementation

- ▶ FAP Services
 - ▶ Recruit and screen subjects
 - ▶ Operations oversight and coordination
 - ▶ Provide subject support
 - ▶ Medical
 - ▶ Nursing
 - ▶ dietary
 - ▶ Psychological
 - ▶ Subject reimbursement
- ▶ PI budgets for:
 - ▶ data collection personnel
 - ▶ Use of hospital facilities such as:
 - ▶ Imaging services
 - ▶ Research pharmacy

C11 Integration



Upcoming Bed Rest Studies

- Integrated Resistance and Aerobic Exercise Training With Small Compact Exercise Equipment (Flywheel)
 - **L. Ploutz-Snyder, USRA**
 - Validation in an analog setting, of a small compact exercise device for the protection of cardiovascular, muscle, and bone health.



Upcoming Bed Rest Studies

- Mapping by VESGEN of blood vessels in the human retina undergoing bed rest for improved understanding of visual impairments and increased intracranial pressure (VIIP)
 - **Patricia Parsons-Wingerter, NASA**
 - Examination of retinal blood vessels in response to fluid shifting induced by head-down tilt bed rest using VESsel GENERation Analysis (VESGEN) technology.
- Effects of long duration spaceflight on venous and arterial compliance in Astronauts
 - **Steven Platts, NASA**
 - Examination of the VIIP syndrome as related to vascular compliance in the head and neck in current astronauts participating in long-duration spaceflight, different age groups of bed rest subjects, and subpopulations of the astronaut corps who might be more susceptible or resistant to changes in venous compliance.

Bed Rest Platform Improvements

- Carbon Dioxide Exposure Capability for the NASA Flight Analogs Research Unit
 - **S. Zanello, USRA**
- Evaluation of a system to enable CO₂ exposure in bed rest studies. Development of this capability will support studies of the VIIP syndrome and other central nervous system effects (e.g. cognitive). Successful use of this system will also allow for simulation hypoxia studies at normal atmospheric (sea level) pressure.



VIIP Study at :envihab

- Collaboration with Joern Rittweger and Karina Marshall-Bowman
- Planning 2 studies to examine the bed rest analog for studying the VIIP syndrome
 - Examine visual and cardiovascular responses to 4 hours of tilt at 0°, -6°, -12° and -18°
 - Using the pre-determined angle (above) examine visual and cardiovascular responses to 12 hours of tilt under conditions of:
 - High CO₂ levels
 - High sodium diet



International Standardization of Bed Rest

- A study group of the International Academy of Astronautics (IAA) was formed in 2009 to standardize the 60-day, 6° head-down tilt bed rest platform
 - establish consistency across bed rest studies world wide
 - allow for increased data sharing and collaboration internationally
 - Standard conditions and standard measures were addressed
- Standard Conditions
 - Subject selection
 - Study integration
 - Clinical support
 - Dietary standards
 - Biological sample handling
 - Study management
 - Data management



International Standardization of Bed Rest

- Standard Measures Purpose
 - Characterize analog platform
 - Monitor physiological systems not targeted by the study (effective for countermeasure assessment)
 - Compare to spaceflight studies to assess analog fidelity
 - Compare across studies within the platform, as well as compare multiple platforms (multi site studies)
- Standard Measures Disciplines
 - Sensorimotor
 - Cardiovascular
 - Exercise/Muscle
 - Bone
 - Nutrition
 - Hematology
 - Immunology
 - Psychology

International Standardization of Bed Rest

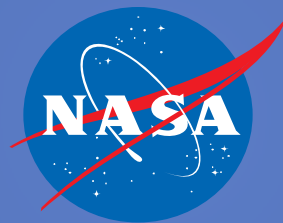
- When complete, the final document will be presented to the IAA
- Results will be published as guidelines for conducting bed rest studies





Questions?





Back Up slides

HERA: Identification of Science Requirements

- Task Description
- Hardware, software and facility requirements
- Test procedure requirements
- Data management requirements

HERA Requirements by Elements

- SHFH: Evaluator station/control room access
 - document environmental conditions
 - usability walkthrough (HERA hardware, software & equipment for SHFE studies)
 - data collection tools such as eye tracker
- BHP
 - Adjustable lighting (circadian entrainment studies)
 - Computer software lighting filters (adjusts color temperature and intensity and light emitted from screen)
 - Video & comm loops and recording (both internal in capsule and to mission control)
 - Realistic mission and realistic mission activities (e.g., maintenance, planetary exploration)
- HHC:
 - Sample & process urine (collection kits, centrifugation, cooling & freezer storage at -20 or -80°C)
 - Cardiovascular measurement
 - Exercise equipment
- ExMC
 - laptops/tablets
 - Medical scenarios with interruption due to other mission tasks

HERA Complements

- Studies designed to utilize the capabilities of HERA are integrated with other investigations on a non-interference basis and run together as one integrated campaign.
- Nomenclature:
 - A “mission” is defined as one run of integrated experiments in HERA, during a predefined set of days
 - A “campaign” is the series of missions needed to complete a set of integrated studies
 - A campaign may be constituted by one or more than one mission
 - Example: the first HERA run will be named: HERA-C01-M01

PROPOSED COMPLEMENT STUDIES FOR HERA

Co1

- **Protocols for Asynchronous Communication in Space Operations:** Communication Analyses and Experimental Studies; **PI: Ute Fischer**, GA Institute of Technology
- **Developing, Maintaining, and Restoring Team Cohesion (ANSMET);** **PI: Steve Kozlowski**, MI State University
- **AD ASTRA** (Automated Detection of Attitudes and States through Transaction Recordings Analysis) Bed Rest Analog (to be amended for HERA); **PI: Christopher Miller**, Smart Information Flow Technologies
- **Assessing Team Collaboration During Exploration** (Composing and Developing Resilient, Adaptive, and Self-Sustaining Teams for Long Duration Space Exploration); **PI: Scott Tannenbaum**, University of Central Florida
- **Development of an Objective Behavioral Assay of Cohesion** to Enhance Composition, Task Performance, and Psychosocial Adaptation in Long-Term Work Groups; **PI: Pete Roma**, Institute for Behavior Resources, Johns Hopkins Univ School of Medicine

PROPOSED COMPLEMENT STUDIES FOR HERA

Co1

- **Using Real-Time Lexical Indicators to Detect Performance Decrements in Spaceflight Teams: A Methodology to Dynamically Monitor Cognitive, Emotional, and Social Mechanisms that Influence Performance; PI: Eduardo Salas, University of Central Florida**
- **Neurocognitive Assessment Toolkit for Space Flight Fatigue ; PI: Mathias Basner, University of Pennsylvania**
- **Optical Computer Recognition of Stress, Affect and Fatigue During Performance for Spaceflight ; PI: David Dinges, University of Pennsylvania**

HERA C01 JSC IRB Approvals

- Standalone studies proposed are approved for HERA (and other analogs is applicable)

SUBJECTS

- **SUBJECT REQUIREMENTS**
- Four subjects per mission
- Single or mixed gender, aiming at 50/50 male:female ratio for each test unless science requirements are different.
- Age 26 to 55. Other age groups can be accommodated if required by the study.
- Height limited to 6'0" maximum (Maximum distance from floor to ceiling 74")
- Technical Skills demonstrated through professional experience. Advanced degree (M.S.) or equivalent years of experience.
- Must have demonstrated motivation and work ethic similar to the "Astronaut stereotype".
- Expected population originated within JSC community

STANDARD CONDITIONS

- **HERA STANDARDIZED CONDITIONS**

- Duration: 4-30 days
- Room Temperature: 72° F. (+/- 5 degrees)
- Humidity: 70% (+/- 10%)
- Light/Dark Cycle: Lights on 0600, lights out 2130, 7 days per week, no napping is permitted
- Monitoring of study operations 24 hours a day

- **HERA DIETARY CONDITIONS**

- Participating subjects will be provided 3 meals each day. Feasibility of studies with specific dietary needs will be assessed on a per study basis.

TESTING AND SCHEDULE

- TBD pending confirmation of study participation
- Schedules are built by integration of the individual testing requirements and presented in the complement for IRB approval

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