

# Human Analogs



Ronita L. Cromwell, Ph.D.  
Universities Space Research Association  
Flight Analogs Project Scientist  
NASA Johnson Space Center

# Overview

- Analogs that support NASA investigations
  - NEEMO
  - Haughton-Mars
  - Antarctica
  - Flight Analogs Project Bed Rest Facility
    - Standard Conditions
    - Standard Measures
    - Study Selection Process

# 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



# NEEMO

## ■ Investigations

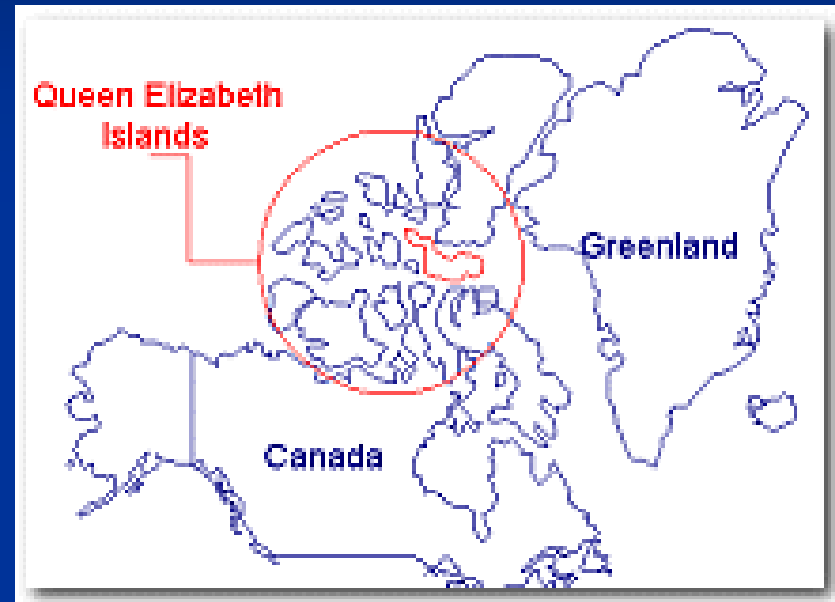
- Smith SM, Davis-Street JE, Fesperman JV, Smith MD, Rice BL, Zwart SR. Nutritional assessment during a 14-d saturation dive: the NASA Extreme Environment Mission Operations V project *J Nutr* 134:1765-1771, 2004.
- Zwart SR, Kala G, Smith SM. Body iron stores and oxidative damage increased after a 10- to 12-day undersea dive in humans. *J Nutr* 139:90-95, 2009.
- 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.
- 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
- PI: M. Gernhardt. Advanced Extravehicular Activity (EVA) Exploration Activities Study to Assess Human Performance Responses in Partial Gravity Environments

## ■ For more information

- [http://www.nasa.gov/mission\\_pages/NEEMO/index.html](http://www.nasa.gov/mission_pages/NEEMO/index.html)
- <http://www.uncw.edu/aquarius>

# 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



# Haughton-Mars

## ■ Investigations

- 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.
- 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
- 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.**

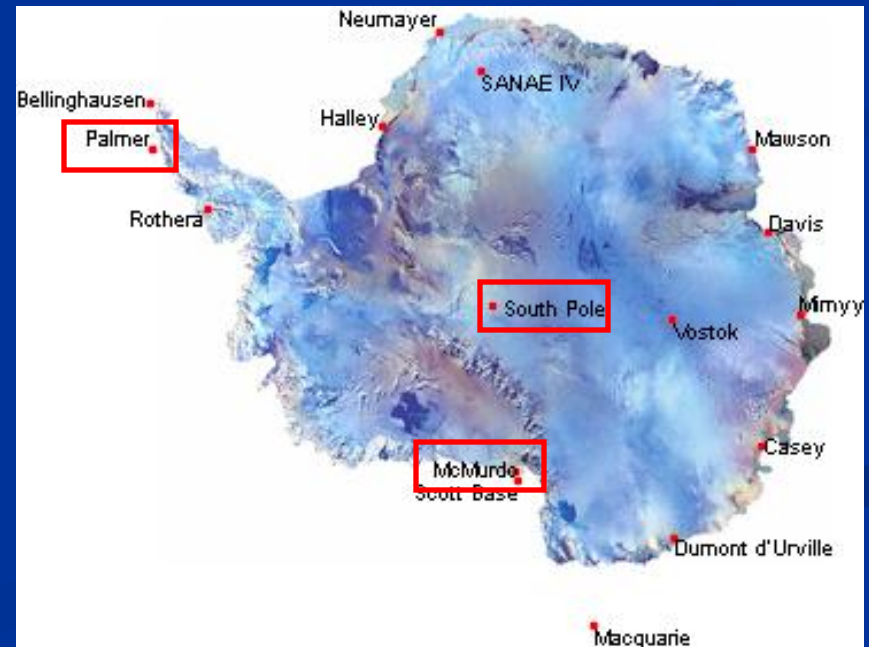
## ■ For more information

- <http://www.marsonearth.org>



# 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

- Application

- Isolation/confinement
- physiological stress
- disrupted circadian rhythms
- telemedicine



# Antarctica

## ■ Investigations

- Smith SM, Gardner KK, Locke J, Zwart SR. **Vitamin D supplementation during Antarctic winter**. *Am J Clin Nutr* (in press).
- 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)**

## ■ For more information

- [http://www.nsf.gov/od/opp/antarct/treaty/opp08001/bigprint0708/bigprint0708\\_toc.jsp](http://www.nsf.gov/od/opp/antarct/treaty/opp08001/bigprint0708/bigprint0708_toc.jsp)
- <http://www.antarcticconnection.com/antarctic/stations/index.shtml>

# Involvement in Analogs

- NASA Research Announcement
  - Scientific Review Panels – Scientific Merit
- Directed Studies in collaboration with NASA labs
  - Non-advocate review process – Scientific Merit
- Human Research Program (HRP)
  - prioritizes proposals based upon relevance to the HRP Integrated Research Plan
  - approves and funds relevant protocols
- Proposals integrated as appropriate into analog missions

# Involvement in Analogs

- Developing website

- Detailed analog information
- Schedules and timelines
- <http://humanresearch-dev.jsc.nasa.gov/analogs/analogs.asp>

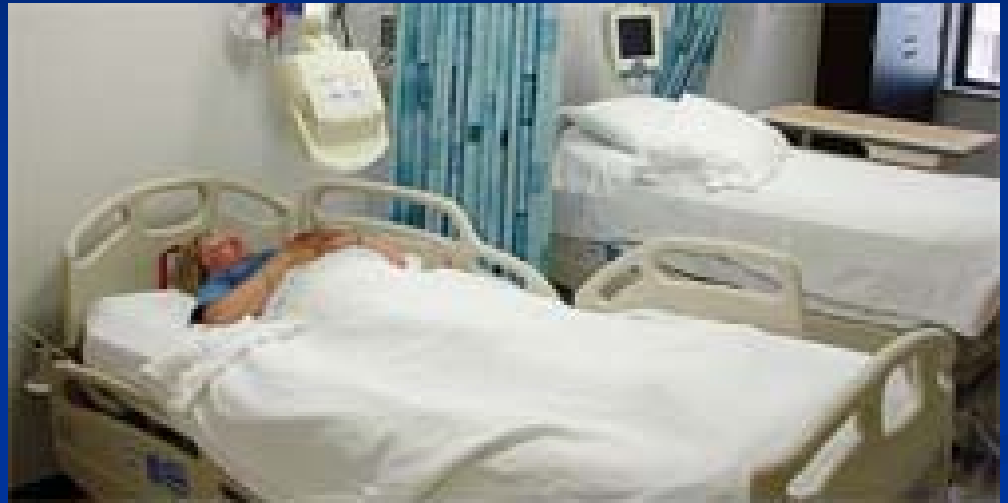


- Contact information

- **Joe Neigut**, Flight Analogs Project Manager
  - [Joseph.S.Neigut@nasa.gov](mailto:Joseph.S.Neigut@nasa.gov) 281-483-2204
- **Jon McFather**, Flight Analogs Deputy Project Manager
  - [Jon.C.McFather@nasa.gov](mailto:Jon.C.McFather@nasa.gov) 281-483-7784
- **Pamela Baskin**, Mission Coordinator
  - [pamela.baskins-1@nasa.gov](mailto:pamela.baskins-1@nasa.gov) 281-212-1360

# Flight Analog

- 6° Head-down Tilt
  - serves as a model for studying the physiological changes that occur during spaceflight under controlled conditions;
  - provides a ground-based platform for comparison to spaceflight;
  - provides a mechanism for testing countermeasures prior to being used in flight.



# NASA Flight Analogs Research Unit



**University of Texas  
Medical Branch**



**Children's  
Hospital**



**Flight Analogs  
Research Unit**

# 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 1<sup>st</sup> 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 maintain weight within 5%



# Purpose of Standard Measures

- Characterize human physiological responses to head down tilt bed rest.
- Provide a basis for comparison between bed rest and spaceflight.
  - Many standard measures are medical requirements for long-duration 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
- **Immune Status**
  - General immune status
  - Viral specific immunity
  - Latent Viral Reactivation
  - Physiological stress
- **Nutrition**
  - Nutritional analysis
  - Markers of bone resorption and bone formation
  - Circulating bone and calcium regulatory factors
  - Antioxidants and oxidative damage

# Standard Measures

- **Bone Assessment**
  - Dual Energy X-Ray Absorptiometry (DXA) – Bone Density



# Standard Measures

- **Physical Fitness**
  - Isokinetic Testing – muscle strength/endurance
  - Cycle Ergometry – maximum aerobic capacity
  - Functional Fitness – strength, endurance, flexibility



# Standard Measures

- Functional Neurological Assessment
  - **Posturography** testing – standing posture
  - Stretch Reflex – monosynaptic





# Standard Measures

- Cardiovascular
  - Operational Tilt Test – orthostatic tolerance
  - Blood volume – carbon monoxide rebreathing
  - Echocardiography – hemodynamic assessment



# ASEM Special Supplement

- Spector, E.R., Smith, S.M., & Sibonga, J.D. (In press). The flight analogs project as a test platform for the skeletal effects of spaceflight. *Aviation, Space, and Environmental Medicine*.
- Reschke, M.F., Bloomberg, J.J., Paloski, W.H., Mulavara, A.P., Krnavek, J.M., Feiveson, A.H., Taylor, L.C., Brady, R.A., Fisher, E.A., Harm, D.L., Somers, J.T., Blauw, D.L., & Ford, G.A. (In press). Effect of 6% head-down tilt bed rest on postural reflexes, balance control, and functional mobility. *Aviation, Space, and Environmental Medicine*.
- Platts, S.H., Martin, D.S., Perez, S.A., Ribeiro, L.C., Summers, R., & Meck, J.V. (In press). Cardiovascular adaptations to long duration head-down tilt bed rest. *Aviation, Space, and Environmental Medicine*.
- Inniss, A.M., Rice, B.L., Smith, S.M. (In press). Dietary support of long duration bed rest. *Aviation, Space, and Environmental Medicine*.
- Crucian, B.E., Stowe, R.P., Mehta, S.K., Yetman, D.L., Leal, M.J., Pierson, D.L., & Sams, C.F. (In press). Immune status, latent viral reactivation and stress during bed rest as a spaceflight analog. *Aviation, Space, and Environmental Medicine*.
- Zwart, S.R., Mathews Oliver, S.A., Fesperman, J.V., Kraughs, J., & Smith, S.M. (In press). Nutritional status assessment before, during, and after 60 to 90 days of bed rest. *Aviation, Space, and Environmental Medicine*.
- Meck, J.V., Dreyer, S.A., Warren, L.E. (In press). Multisystem responses to long duration bed rest: overview. *Aviation, Space, and Environmental Medicine*.
- Seaton, K.A., Bowie, K., & Sipes, W.A. (In press). Behavioral and psychological issues in long duration head-down bed rest. *Aviation, Space, and Environmental Medicine*.
- Seaton, K.A., Slack, K.J., Sipes, W.A., & Bowie, K. (In press). Cognitive functioning in long duration head-down bed rest. *Aviation, Space, and Environmental Medicine*.

# Selection of Studies for Bed Rest

## ■ Review Process

- NASA/NSBRI Research Announcement
  - Scientific Review Panels – Scientific Merit
- Directed Studies in collaboration with NASA labs
  - Non-advocate review process – Scientific Merit
- Human Research Program (HRP)
  - prioritizes proposals based upon relevance to the HRP Integrated Research Plan;
  - approves relevant protocols;
  - provides protocols to the Flight Analogs Project for implementation.
- Flight Analogs Project operates and maintains the bed rest facility as a service to our PIs and does not directly fund studies.

# Protocol Implementation

- Compatible projects are integrated into a campaign.
- Human Use Boards
  - PI provides approved protocol from home institution.
  - FAP coordinates submission of integrated campaign to JSC & UTMB.
- Stand alone studies
- PI works directly with human use boards at JSC & UTMB after obtaining approvals at home institution.

# Protocol Implementation

- Subjects recruited/screened through FAP
- FAP monitors day-to-day operations at the Flight Analogs Research Unit
  - Attending physician and nursing staff
  - Medical monitors
  - Coordinators
  - Subject Monitors
- FAP provides the bed rest facility as a service and does not administer PI studies
  - PI supports
    - costs of equipment and testing requirements
    - personnel to run testing, collect/handle samples and data

# Protocol Implementation

- FAP develop data management and sharing plans
  - Assist with access to Life Sciences Data Warehouse for data transfer
  - Provide access to standard measures data for use by PIs

# Flight Analogs

- Tour of the Flight Analogs Research Unit
  - 1:00, Wednesday, February 4<sup>th</sup>
  - Sign-up following Plenary Session
- Lunar Analog Session
  - 3:30-5:30, Salons C&F

# Contact Information

## ■ Flight Analogs Project

- **Ronita L. Cromwell**, Flight Analogs Project Scientist
  - [Ronita.L.Cromwell@nasa.gov](mailto:Ronita.L.Cromwell@nasa.gov) 281-483-7261
- **Joe Neigut**, Flight Analogs Project Manager
  - [Joseph.S.Neigut@nasa.gov](mailto:Joseph.S.Neigut@nasa.gov) 281-483-2204

## ■ JSC labs that provide standard measures

- **Jean Sibonga**, Bone and Mineral
  - [Jean.Sibonga-1@nasa.gov](mailto:Jean.Sibonga-1@nasa.gov) 281-483-4556
- **Steven Platts**, Cardiovascular
  - [Steven.Platts-1@nasa.gov](mailto:Steven.Platts-1@nasa.gov) 281-483-8177
- **Lori Ploutz-Snyder**, Exercise Physiology
  - [Lori.Ploutz-Snyder-1@nasa.gov](mailto:Lori.Ploutz-Snyder-1@nasa.gov) 281-244-1122
- **Clarence Sams**, Immunology
  - [Clarence.Sams-1@nasa.gov](mailto:Clarence.Sams-1@nasa.gov) 281-483-7160
- **Scott Wood**, Neurosciences (Posture)
  - [Scott.J.Wood@nasa.gov](mailto:Scott.J.Wood@nasa.gov) 281-483-7294
- **Millard Reschke**, Neurosciences (T-Reflex)
  - [Millard.F.Reschke@nasa.gov](mailto:Millard.F.Reschke@nasa.gov) 281-483-7210
- **Scott M. Smith**, Nutritional Biochemistry
  - [Scott.M.Smith@nasa.gov](mailto:Scott.M.Smith@nasa.gov) 281-483-7204