AREA OF STUDY: Human Factors in Deep Space Analogs, including: adaptation, isolation and confinement, crew behavior, cognition, behavioral health and performance resilience, communication and autonomy studies, medical capability assessments, and analog simulations.

PROJECT SUMMARY: A simulated deep space mission at the NASA Johnson Space Center in Houston, TX, officially known as HERA (Human Exploration Research Analog), is a high fidelity analog of the International Space Station (ISS).

For 30 days, the crew was confined and isolated from the outside world, save for routine communication with the Mission Control ground crew. The crew performed various biological and geological science activities as well as flight operational tasks that closely parallel the workday tasks and housekeeping/maintenance of the ISS. Diet, exercise and schedule are nearly identical to the ISS in order to carefully evaluate crew interaction with flight-like hardware and conditions onboard.

Two weeks into the mission, the crew rendezvoused with the asteroid Geographos and experienced communications delays, sleep deprivation, emergency scenarios and challenging flight and sampling protocols during multi-member virtual reality EVA simulations.

The HERA is a three-story, habitat unit residing in Building 220 at NASA Johnson Space Center (JSC). The total space comprises 148.6 m³ or 636 sq. ft., distributed as follows: core (56.0
m$^3$) or 187 sq. ft., loft (69.9 m$^3$) or 349 sq. ft., airlock (8.6 m$^3$) or 42 sq. ft., and hygiene module (14.1 m$^3$) or 58 sq. ft.

**HERA XII Crew:**
Ulyana Horodyskyj (TM ‘12 (now, FN ‘17)), Todd Huhn, Mark E. Kerr (FN ‘15) and Jonna Ocampo

Dr. Ulyana Nadia Horodyskyj, PhD. (TM ‘12, now, FN ‘17), founder and owner of Science in the Wild, is principal investigator. Previous research has found her working in the Himalaya, Andes, and Antarctica. She is an awardee of The Exploration Fund for fieldwork in the Himalaya (2014) she has carried TEC flags on two previous expeditions: Nepal 2012 (TEC Flag #89) and Baffin Island 2016 (TEC Flag #61). Since finishing her PhD from the University of Colorado at Boulder, she has gone on to create a company called "Science in the Wild," a citizen-science educational initiative aimed at blending athletics and academics in remote places on the planet. For more information, please see: http://scienceinthewild.com and http://scienceinthewild.com/team/

Dr. Todd Huhn, D.O., M.P.H., is the Department of Defense Aerospace Medicine Liaison Officer to NASA Johnson Space Center, Houston, Texas where he conducts Mission Control Center Houston (MCCH) surgeon console operations, provides comprehensive health care for NASA astronauts and aviators, and deploys to provide Soyuz launch and landing support. He is board-certified in Family Medicine and Osteopathic Manipulative Treatment, as well as in both Aerospace Medicine and Occupational Medicine. He has a B.S. in Microbiology from University of Wisconsin-La Crosse (1995), a Doctorate of Osteopathic Medicine (1999) from Kirksville College of Osteopathic Medicine and Master of Public Health (2009), Harvard University. Born in Watertown, Wisconsin, he is married to Barbara Huhn from El Paso, Texas and has three daughters.

Mark E. Kerr (FN ‘15) – An architect, curious character, Naval Officer, reluctant enthusiast, explorer, amateur photographer, and construction engineer drawn toward design and construction of habitable environments in outer space and the many related analog environments. He is currently a Project Engineer with the Seattle District, U.S. Army Corps of Engineers, and a Lieutenant Commander in the reserve component of the Navy Civil Engineer Corps. He is a Registered Architect in the State of New Mexico. Mark has worked as an ECLSS Engineer at Bigelow Aerospace, North Las Vegas, Nevada; a Research Technician in Pulmonary Physiology (Swenson/Deem Pulmonary Lab) at the University of Washington, Seattle, WA; and as Hyperbaric Technician at Virginia Mason Medical Center in Seattle, WA. He spent two summers at the South Pole Station in Antarctica. An avid mountaineer, backpacker, and reader, he spends much of his free time, in a tent, with his family in the Pacific Northwest.

Jonna Ocampo is a Citizen Scientist-Astronaut Candidate with Project PoSSUM, a Biomedical Researcher, and Founder of CD-SEAS (Compound Derivative-Synthesis and Evaluation of Antimicrobials in Space) Mission Microgravity group. As a scientist, her biomedical research will soon fly to space, on board the “Citizens in Space” first suborbital flight research mission. Jonna has recently matriculated into the Molecular Medicine program at the University of South Florida in 2017. She is also a Team USA Athlete on the first ever U.S. Women's team to win the overall gold at the World Championships, and recently published her first children's picture book.
Introduction:

There are a growing number of human analog missions being undertaken on Earth in various environments in order to simulate long duration stresses associated with human missions to deep space. These tests are often performed in locations identified based on their physical similarities to extraterrestrial field sites or for their abilities to be able to control isolation to effectively study the participants. The ground analog HERA platform is uniquely focused on controlling a crew member’s experience in order to build confidence in the cognitive and group dynamic nature of long duration spaceflight. Researchers are able to establish controlled conditions in which to evaluate impacts due to isolation, remoteness, and confined habitation.

HERA facility capabilities include network connections which allow electronic research data and voice communications to be exchanged between the crew and ground controllers located adjacent to the HERA facility. Message traffic is augmented to simulate communications delays in keeping with the simulated distance from Earth. The research data is securely shared with remote investigators real-time or near real-time though the JSC Telescience Center (TSC).

There are many independent and overlapping studies that will dovetail with ISS studies in order to provide more data points for analysis. For HERA, principle investigators examine key psychological, physiological and human factor impacts which will aid in the development and verification of countermeasures to reduce or mitigate those impacts. Many of the PIs have been with the HERA program since its inception with Campaign 1 in 2014 and are doing multi-mission analyses over multiple campaigns which will result in multiple publications. A great deal of this data will be part of ongoing research to develop effective countermeasures for long duration space travel. The NASA mission promotes the full sharing of data with the research and applications communities, private industry, academia, and the general public.
The data is continually refined and carefully edited to protect private health information from disclosure.

The opportunity to contribute to the greater goal of long duration space travel speaks abundantly to the sense of human curiosity, of wonder and awe, and the desire to be a part of the scientific exploration of space, in support of the greatest human research program in history — our ability to project humanity into the stars.

**Project Objective:**

This study is uniquely focused on the participants. Using HERA, researchers are able to establish controlled conditions in which to better study and evaluate impacts due to isolation, remoteness and confined habitation. Investigators will be looking at psychological, human factor and physiological impacts and the development and verification of countermeasures to reduce or mitigate those impacts. This information will produce significant amounts of data that will be analyzed, shared, and archived as baseline for further studies.

**Methodology:**

The studies are integrated on a non-interference basis and run together as one study. A “mission” is defined as one run of experiments in HERA; a “campaign” is defined as the four nearly identical missions needed to complete a set of integrated studies.

Each mission will be a high fidelity simulation of a space exploration mission and will carefully represent each phase of the mission. Crewmembers will conduct activities and operational tasks which closely parallel workday tasks, general housekeeping, and maintenance. Diet, schedule and many other variables are nearly identical to the ISS in order to carefully evaluate crew interaction with flight-like hardware.
In HERA Campaign 3, there are over 20 independent and overlapping studies which will dovetail with ISS studies in order to provide more data points for analysis. The larger number of overlapping data draws make listing each one somewhat prohibitive for this application. There are multiple psychological, physiological, social and physical tests taking place using a variety of methods.

Specific study procedures and tests include:

1) Vitamin D Supplementation for Extended Duration in Confined Habitation
2) Virtual Reality EVA Simulation
3) Lexical Indicators (emotional state questionnaires and audio recordings)
4) Cognition (test batteries to measure mental changes)
5) Optical Computer Recognition (various psychological and social evaluations)
6) Team Cohesion (ANSMET) Survey
7) ISS Fit (food intake analysis)
8) Leadership Fellowship (teamwork surveys)
9) Dynamic Team Role (teamwork surveys)
10) Biomarkers as Predictors of Resiliency and Susceptibility to Stress in Space Flight
   a. Low Latency Teleoperation (LLT).
   b. STARwatch to Deliver Objective Sleep Measures
   c. Understanding and Preventing Crew Member Entrainment
13) Standardized Behavioral Core Measures
   a. Cognition Test Battery
   b. Visual Analog Scales (VAS)
   c. Actigraphy (sleep/wake activity)
   d. Journaling
   e. Robotic On-Board Trainer (ROBoT) (operational performance measurement tool)
   f. Team Measure questionnaires
14) Meal Replacement Mass Reduction and Integration Acceptability
15) Sleep Electroencephalography and Near-infrared Spectroscopy Measurements
16) Team Research in 2016 HERA Challenge (workload data tool)
17) Performance Degradation Precursors in Operational Teams (data collection tool)
18) Effect of Isolation and Confinement on Hippocampal Volume and Visual Spatial
   a. MRI
   b. Cognition
   c. Visio-spatial Ability
   d. Visual analog scales and Questionnaires
   e. Biomarkers
   f. Actimetry
19) Effects on Circadian Rhythms in Humans During Long-Term Isolation and Confinement
20) Physical Activity for Better Sleep and Psychophysiological State
**Preliminary Results:**

Since this is a continuing study, the researchers have not completed collecting the full datasets at the time of this Flag report. In order to protect the scientific integrity of the study, specific details have been purposely withheld.

A great deal of this data will be part of the ongoing research on effective countermeasures for long duration space travel. NASA promotes sharing of all data with the research and applications communities, private industry, academia, and the general public. The greater the availability of the data, the more quickly and effectively the user communities can utilize the information to address basic scientific questions and provide the basis for developing innovative practical applications to benefit the general public.

The study is sponsored by the NASA Human Research Program and is conducted at Johnson Space Center in Houston, TX. All data will be disseminated, archived and analyzed by NASA-funded study investigators, except for specific medical information that is covered by The Standards for Privacy of Individually Identifiable Health Information ("Privacy Rule") based upon the Health Insurance Portability and Accountability Act of 1996 ("HIPAA"). All research is federally funded and therefore federal regulations concerning the privacy and confidentiality of these data will be followed.

**Additional Photos:**

Experiencing the universe inside the mundane; HERA sits in this nondescript building at JSC, Houston, TX.
Inside HERA: First Deck.

Inside HERA: Second Deck.

Inside HERA: Sleeping Quarters (Entrance on the Left, Bunk area on the Right)
Mission Control provided 24 hour communications and support for the duration of the 30 day mission. (There is no mission control for the pre-mission/post-mission phase of the study.)

Evening meal preparation in the galley.
Crewmember Jonna Ocampo placing leads for an onboard HERA study.

The crew taking physiological measurements using a portable ultrasound.
Crewmember Mark Kerr taking air samples.

Crewmember Todd Huhn taking air flow measurements.
Crewmember Ulyana Horodyskyj performing her daily Physical Training (PT) on the exercise bicycle (above), Crewmember Jonna Ocampo stretches (below).
Crewmember Mark Kerr (above) begins plant growth studies, Crewmember Ulyana Horodyskyj (below) confirming growth.
Crewmember Ulyana Horodyskyj (Left) and Mark Kerr (Right) practice on the EVA simulator.

Crewmember Todd Huhn practices on the Robotic On-Board Trainer (ROBoT).
Many of the studies performed baseline measurements prior to ingress, here Crewmember Ulyana Horodyskyj (above) develops a baseline profile. Crewmember Jonna Ocampo (below) performs measurements *in situ.*