



Human Research Program Human Exploration Research Analog (HERA) Facility and Capabilities Information

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**ROI - Flight Analogs
Human Research Program**

**NASA FLIGHT ANALOGS PROJECT
HERA FACILITY AND CAPABILITIES INFORMATION**

This document provides an overview of the HERA facility, its operations, and capabilities for the purpose of preparing research protocols.

**NASA FLIGHT ANALOGS PROJECT
HERA FACILITY AND CAPABILITIES INFORMATION**

Table of Contents

INTRODUCTION 4

HERA FEATURES 4

HERA STANDARDIZED MISSION CONDITIONS 5

HERA FACILITY CAPABILITIES..... 6

CAMPAIGN CHARACTERISTICS AND STUDY REQUIREMENTS 7

HERA DIETARY CONDITIONS..... 8

SUBJECT DAILY AND WEEKLY WORK REQUIREMENTS..... 8

HERA SUBJECT RECRUITMENT AND SCREENING 8

SUBJECT REQUIREMENTS..... 9

 Pre-Mission..... 10

 Mission..... 10

 Post Mission..... 11

INVESTIGATOR RESPONSIBILITIES 11

INVESTIGATOR PREPARATIONS FOR HUMAN SUBJECTS BOARDS 12

INVESTIGATOR RESOURCE/FISCAL RESPONSIBILITIES 12

Appendix A HERA Facility Layout 1

Table of Figures

Figure 1 Schematic representation of HERA..... 5

Appendix

[Appendix A HERA Facility Layout A-1](#)

NASA FLIGHT ANALOGS PROJECT

HERA FACILITY AND CAPABILITIES INFORMATION

INTRODUCTION

The Flight Analogs (FA) team within the Research Operations and Integration (ROI) element conducts research utilizing ground-based facilities that provide scenarios and environments analogous to those anticipated for exploration missions. The FA team supports the accomplishment of Human Research Program (HRP) objectives by investigating, acquiring, utilizing or operating high fidelity ground analogs of the space exploration environment. The use of high fidelity ground analogs enables the conservation of spaceflight resources while expeditiously and efficiently addressing research questions for future human exploration missions.

The information within this document describes the standard conditions and capabilities provided for experiments performed in the Human Exploration Research Analog (HERA), as well as the services provided by FA.

The HERA campaigns began in 2014 with four 7-day missions, and have increased mission duration incrementally. A campaign is defined as one integrated science protocol with one primary mission scenario consisting of multiple missions in order to meet study subject requirements. Studies designed to utilize the capabilities of HERA described in this document are integrated with other investigations on a non-interference basis and run together as one integrated science complement.

Planned mission durations may range from 7 days up to 45 days. The HERA planning schedule currently anticipates 4 missions within a year (approximately one per quarter) of 45-day duration.

HERA FEATURES

The HERA is a two-story, four-port habitat unit residing in Building 220 at NASA Johnson Space Center (JSC). It is cylindrical with a vertical axis, and connects to a simulated airlock and hygiene module (Figure 1). The total space comprises 148.6 m³ or 636 sq. ft., distributed as follows: core (56.0 m³) or 187 sq. ft., loft (69.9 m³) or 349 sq. ft., airlock (8.6 m³) or 42 sq. ft., and hygiene module (14.1 m³) or 58 sq. ft. (see Appendix A).

HERA facility capabilities include a network that allows electronic research data collection, storage, and distribution, and voice communications between the crew and mission control personnel located in Building 220. The research data can be securely accessed remotely by investigators in real-time or near real-time through a JSC-based data storage capability. HERA has a surveillance video system for monitoring crew safety and compliance, flight-like voice communication system, flight-like timeline and procedure viewer to provide a space mission experience.

Currently, the HERA represents an analog for simulation of isolation, confinement and remote conditions of exploration mission scenarios. Studies suitable for this analog may include, but are not limited to behavioral health and performance assessments, communication and autonomy

NASA FLIGHT ANALOGS PROJECT

HERA FACILITY AND CAPABILITIES INFORMATION

studies, human factors evaluations, human health countermeasures, and exploration medical capabilities assessments and operations.

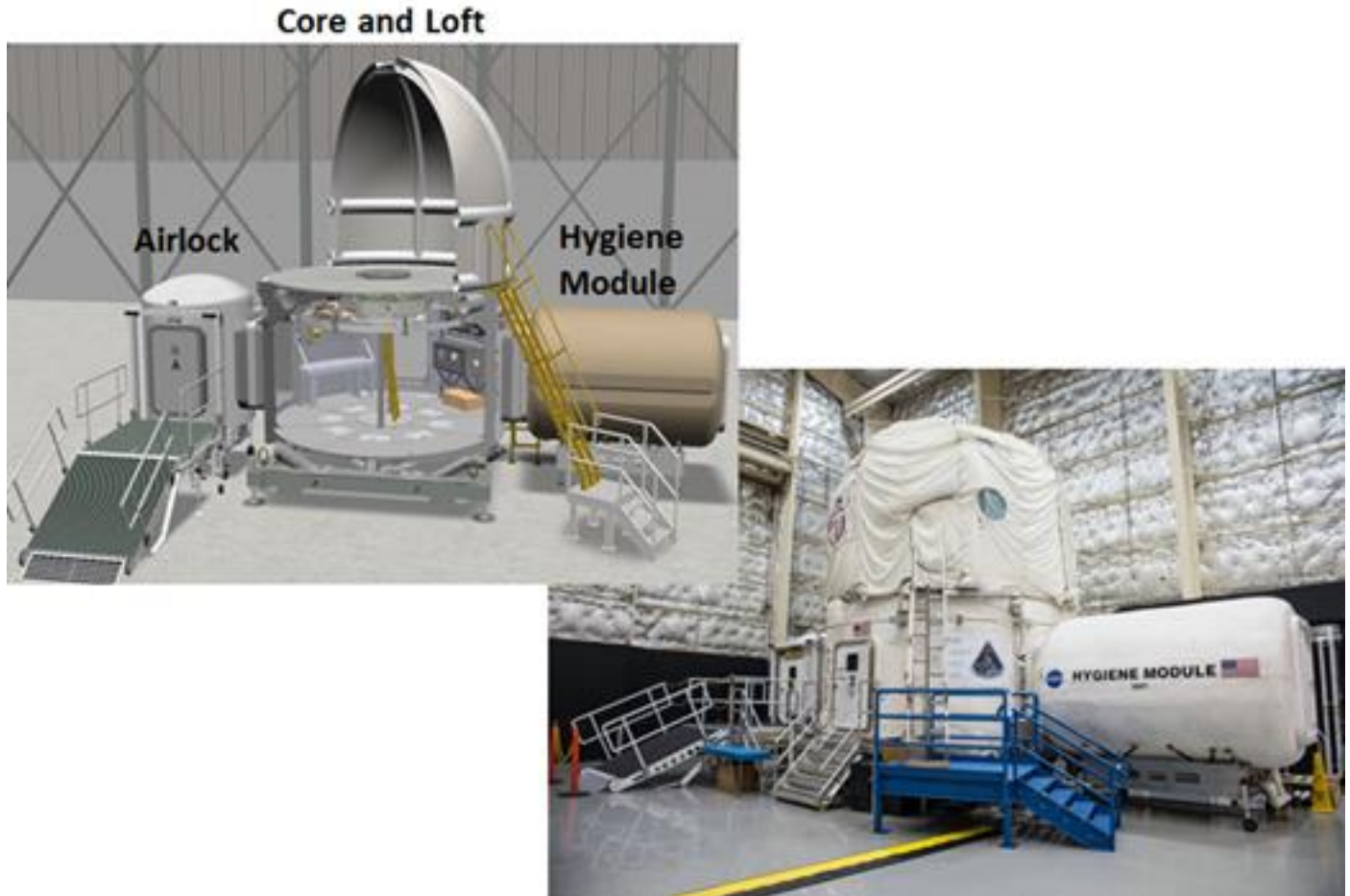


Figure 1 Schematic representation and exterior photo of HERA

The following sections describe the conditions and capabilities that are considered the baseline for operations with HERA. Researchers may propose modifications to any of these parameters; such proposed modifications will be evaluated for feasibility by the Flight Analogs team. They will also be considered during the study integration phase, taking into account the impact of such modifications on all other studies proposed for the research campaign. If modifications cannot be accommodated, FA may recommend a study be moved either to a later HERA campaign, or to a different analog environment. The sponsoring HRP element (if applicable) will make the final decision to either modify, defer, or move a study to a different analog.

HERA STANDARDIZED MISSION CONDITIONS

- Simulated space mission using the HERA to emulate a non-specific spacecraft
- 4 crew members

NASA FLIGHT ANALOGS PROJECT HERA FACILITY AND CAPABILITIES INFORMATION

- Duration: Up to 45 days confined habitation specific to science requirements; approximately 68 total study days inclusive of 16 days pre- and 7 days post-confinement
- Light/Dark Cycle: Lights on 0700, lights out 2300, 7 days per week
- Typical crew day schedule requires 16 hours awake, 8 hours of sleep scheduled, no napping is permitted
- Crew mission schedule modeled after ISS crew schedule, modified to reflect exploration mission activities and events
- Mission scenario constructed to simulate varying degrees of workload and includes specific stressful conditions commonly encountered in space flight
- Crew remains isolated for the duration of the mission
 - No access to internet content, social media, television/radio, and telephone. However, the crew will receive uplinks of Houston Chronicle and USA Today newspapers Monday – Friday.
 - Crew members are allowed private family conference, private medical conference, and private psychological conference once per week.
 - Crew members have access to a limited selection of movies and music through a controlled account
- Continuous monitoring of crew members during isolation, excluding sleep quarters, hygiene module, and during private family/medical/psychological conferences

HERA FACILITY CAPABILITIES

- Mission Control Center (MCC) for real-time interaction with HERA crew members
 - 24/7 mission video surveillance with audio, recorded during mission
 - Voice communication recordings between HERA and MCC during the mission
 - Communication delay, voice and/or text, up to 20 minutes each way
 - Simulation of Acquisition of Signal/Loss of Signal (AOS/LOS) of varying duration
- HERA-provided Windows-based laptops and iPADS for each crew member for investigator data collection.
 - Laptops and iPADS configured with operating systems within a single major release of most current operating system.
 - Configuration is maintained for duration of campaign
- Flight Simulators to support an exploration mission scenario (Multi Mission Space Exploration Vehicle (MMSEV))
- Virtual reality simulation for simulated EVA tasks
- Ability for investigator data collection to occur via the internet through pre-approved websites and forms
- Heart Rate Monitor to support exercise or research
- Actigraphy
- Charging station for devices with 120V Alternating Current (AC) and USB ports.
- Study and mission data product distribution through the JSC-based data storage capability
 - Mission data includes temperature, relative humidity, eLog, and Mission Log

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- Surveillance video from up to 9 cameras, with limited real time access for study teams during mission
- Biological sample collection pre, during and post mission
 - Venous blood/saliva/urine/fecal collection using investigator provided supplies. Crewmembers are not trained for sample processing of any kind.
 - **NOTE:** There is no refrigeration capability internal to the HERA. Samples are removed from the habitat according to negotiated schedules, and investigators must make their own arrangements for pickup, storage, processing, and shipment of samples.
- Medical Workstation
 - Remote medical procedures and examinations
- Adjustable LED lighting on L2
- Simulated stowage module (pass through for hardware, biological samples, and trash)
- Modifiable virtual window views
- Ability to control temperature for subject comfort.
- Exercise equipment (aerobic and resistive) to simulate daily operational activities.
- Simulated Environmental Control and Life Support System (ECLSS) to support complex operational activities
- 3D printer to support vehicle maintenance and operational tasks
- Simulated alarm system to support emergency rescue drills
- Flight-similar galley capabilities for preparing meals
- Plumbed water for crew consumption and food rehydration
- Shower/sink with hot and cold running water for crew hygiene

CAMPAIGN CHARACTERISTICS AND STUDY REQUIREMENTS

A HERA Campaign is defined as one integrated protocol with one primary mission scenario. An integrated protocol consists of a number of individual investigator studies that can be combined on a non-interference basis. Each campaign is expected to consist of 4 missions, providing a total of 16 subjects for each study. Power analyses for each study will determine the number of missions needed to achieve the required study sample size.

- Each HERA mission will consist of 4 subjects participating in mission activities:
 - Up to 16 days of pre-confinement activities (i.e. baseline data collection (BDC), training, informed consent); final duration will be dependent on research requirements
 - 45 days in-mission confinement activities (i.e. operational activities expected for an exploration mission along with research activities) depending on campaign requirements.
 - Up to 7 days of post-confinement activities (i.e. post-mission data collection, debriefing); final duration will be dependent on research requirements
- To support the isolation requirement, test subjects will be informed of restrictions to their activities and access to communications channels (i.e. no access to email, personal work, phone calls, or the internet will be allowed; family conferences are scheduled weekly). FA

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personnel will provide news items via periodic uplinks (exception for family emergencies which require intervention) consistent with simulating the space flight condition.

- A mission control center (MCC) is located within Building 220 to support HERA operations including surveillance, communications, computers and phones.
 - Staffing provided 24/7 for duration of mission isolation phase

HERA DIETARY CONDITIONS

Participating subjects will be provided a minimum of 3 meals each day. Diet and core menu is based on NASA spaceflight nutritional requirements. Once a crew is selected, specific crew caloric requirements are determined by using the Mayo Clinic calculator. A core menu of food items is provided with a flight like combination of thermo-stabilized, rehydratable, and natural food items. Fresh foods are not available, as there is no refrigeration inside the HERA. Food items are primarily sourced as off the shelf food items; menus are constructed to meet caloric and standard nutritional requirements. Feasibility of studies with specific dietary needs will be assessed on a per study basis.

SUBJECT DAILY AND WEEKLY WORK REQUIREMENTS

The operational plan uses the ISS Program nominal 24-hour work day structure as a guideline. Below is the HERA mission plan:

- All time spent in the habitat will be working on tasks related to the study.
- Subjects awake at 0700 and are off duty at 2300 with one shift operation for all subjects.
 - Sleep period (8.0 hours).
- Post-sleep period, includes morning meal (1.5 hours).
- Daily planning conferences, medical conferences, work preparation, and plan familiarization (2.0 hours).
- Work consists of scheduled research tasks and HERA operations tasks, i.e. HERA maintenance, flight simulator for a spacecraft and/or terrestrial rendezvous mission, public affairs activities, education outreach, etc. (6.5-8.0 hours).
- Midday meal (1 hour).
- Exercise period (1.25-2.5 hours, includes time for setup, cardiovascular/resistive exercise, stowage, hygiene (cool down and cleanup)).
- Pre-sleep period, includes evening meal (2.0 hours).
- A nominal 7-day work/rest cycle will consist of 5.5 days available for conducting planned mission tasks and research activities and 1.5 consecutive off-duty days. Housekeeping and 1.0 hour of scheduled work on the weekends is included in the 5.5 working days.

HERA SUBJECT RECRUITMENT AND SCREENING

The NASA JSC Test Subject Screening (TSS) provides advertising, recruiting and health screening for subject candidates. Once subjects pass the health requirements of the TSS, they will be provided to FA to coordinate any additional screening required by investigator studies. Only subjects who pass all screening (psychological and physiological) criteria will be considered for enrollment in the campaign.

NASA FLIGHT ANALOGS PROJECT HERA FACILITY AND CAPABILITIES INFORMATION

SUBJECT REQUIREMENTS

- Four subjects per mission
- Must be US citizens, or hold a US Permanent Resident Card (Green Card)
- Goal of 50/50 male:female ratio for each mission and campaign but the actual crew mix is contingent on subject pool availability
- The preferred age range of subjects is from 30 – 55; subjects outside the stated age range may be considered but will require additional approvals
- Height limited to 6’2” maximum
- Pass a modified Class III flight physical
- Technical Skills demonstrated through professional experience and education.
- Must have demonstrated motivation and work ethic similar to the current astronaut population.
- Psychological assessment by a clinical psychologist to qualify for participation
- Astronaut-like characteristics that are considered during HERA test subject selection include the following criteria used in astronaut selection:
 - The requirements for Astronaut Candidates are a bachelor’s degree from an accredited institution in engineering, biological science, physical science, or mathematics. Quality of academic preparation is important.
 - An advanced degree (e.g. M.S.) in STEM field is preferred and may be substituted for experience as follows: master’s degree = 1 year of experience,
 - Doctoral degree = 3 years of experience.
 - Military experience may be considered equivalent years of experience.

ROI FLIGHT ANALOGS TEAM RESPONSIBILITIES

The ROI Flight Analogs team is responsible for all HERA facility preparations, maintenance, upgrades, and integration activities prior to the start of a research campaign, as well as any required maintenance between missions within the campaign. The FA team performs a feasibility assessment of each research proposal to determine the degree of adherence to the standard conditions described in this document, and makes recommendations for admission of the study to the HERA complement, assignment to a future complement, or assignment to a different analog. The FA Team assigns individuals to work directly with each researcher to ensure that individual research protocols are integrated into the complement with the goal of maximizing science return while mitigating confounds between studies. The FA team members also ensure researchers maintain cognizance of schedule deadlines, and recommend removal of a study from the complement if they cannot meet established deadlines. The FA team strives to:

- Provide a mission scenario and operational conditions which create an immersive environment for the crew members

NASA FLIGHT ANALOGS PROJECT HERA FACILITY AND CAPABILITIES INFORMATION

- Maximize resources by combining individual investigations into integrated studies within a campaign.
- Develop a customized mission scenario, supporting activities, and stressor plan as needed to meet investigator requirements
- Ensure consistency for studies in the campaign by maintaining identical HERA study conditions and mission scenario across all missions in the campaign

Pre-Mission

- Develop and manage schedules associated with the implementation of integrating studies
- Coordinate investigator meetings
- Identify opportunities for data sharing among researchers using common measures and/or hardware
- Prepare complement protocol submission for the JSC Institutional Review Board (IRB) for the campaign
- Develop and baseline, in conjunction with each PI, a Science Requirements Document detailing the individual study's requirements
- Develop and baseline the complement Integrated Requirements Document which contains agreed upon protocols, data collection, and data sharing
- Assist the investigator in acquiring an account to the JSC-based data storage capability account to enable the transfer electronic data from HERA to remote investigators via this capability
- Facilitate access to JSC-based data storage capability for approved PI data sharing agreements
- Recruit and perform standard subject screening through the JSC TSS facility
 - Provide subject reimbursement and travel for study purposes
- Coordinate receipt of investigator hardware shipment and coordinate with the investigator for integration, setup and checkout of their hardware
- Design and execute an integrated test to ensure all PI hardware and software are compatible with HERA facility systems; resolve any interference issues between PI systems
- Develop detailed timelines for pre-, in-, and post-mission crew activities
- Provide facility and mission training
 - Coordinate PI specific training for all primary and secondary crew members
 - Provide facility orientations and training for crew members
- Coordinate on-site PI baseline data collections
- Conduct integrated Test Readiness Reviews, safety walk-throughs and operations check-outs prior to starting the study

Mission

- Provide 24/7 real-time on-site mission support for all mission operations

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- Provide medical monitor and psychological support as required throughout mission operations
- Provide a daily operational status report during mission
- Document and report all off-nominal or adverse events to the JSC IRB
- Contact individual researchers as needed to resolve in-mission hardware, software or operational issues

Post Mission

- Coordinate post mission subject follow up testing and debriefings as required.
- Conduct any necessary repairs, modifications, or maintenance to the HERA facility
- Coordinate with PI's for any needed repairs or modifications to PI hardware, software, procedures, etc.
- Following the final mission in the campaign, coordinate de-integration and return of PI hardware
 - **NOTE:** PI hardware is not returned to the investigator between missions due to the short turn-around time

INVESTIGATOR RESPONSIBILITIES

- Participate in meetings with Flight Analogs team and investigators of other studies to develop integrated protocols to support a campaign (i.e. Science Requirements Document and Integrated Requirements Document)
- Work closely with the assigned FA team member to identify incompatibilities with the HERA standard conditions and/or with other investigations, and propose solutions to enable maximum scientific results
- Adhere to the campaign schedule deliverables for investigators. **NOTE:** Failure to meet target deadlines for the campaign schedule can result in removal of an investigation from the complement, and assignment to either a later complement or to a different analog environment.
 - Obtain institutional IRB approvals at home institution, if required
 - Submit Stand-alone Protocol to JSC IRB
 - Provide all hardware, consumables, and software required for implementation of the study pre-, in- and post-mission
 - Provide all training materials and procedures required for crew and mission operations
- Ensure the investigator study requirements are compatible with the standard conditions of HERA to the degree possible without compromising scientific results
- Provide for on-site or remote study support at the HERA facility at Johnson Space Center, Houston TX including investigator resources and scientific expertise as needed.

NASA FLIGHT ANALOGS PROJECT HERA FACILITY AND CAPABILITIES INFORMATION

- Make arrangements for the retrieval, storage, management and shipping of any biological samples collected during the mission
 - Flight Analogs does not provide sample management or processing. PI's are encouraged to develop separate agreements for sample retrieval, management, analysis, processing, etc. with one of the JSC labs. Agreements can include a JSC co-I as part of the study team, or a separate contractual arrangement with the labs
 - **NOTE:** The HERA does not have a refrigeration capability internal to the module. Crew members are not permitted to aliquot samples; the samples are removed from the habitat on a scheduled basis.
- Carry out investigator science protocols with integrity and professionalism
- Provide in-mission support as required for anomaly resolution
- Participate in periodic data debriefs
- Conduct negotiations required for data sharing (e.g. publication rights, etc.)
- Provide complete experimental data sets to the NASA Life Sciences Data Archive per the terms and conditions of their grant

INVESTIGATOR PREPARATIONS FOR HUMAN SUBJECTS BOARDS

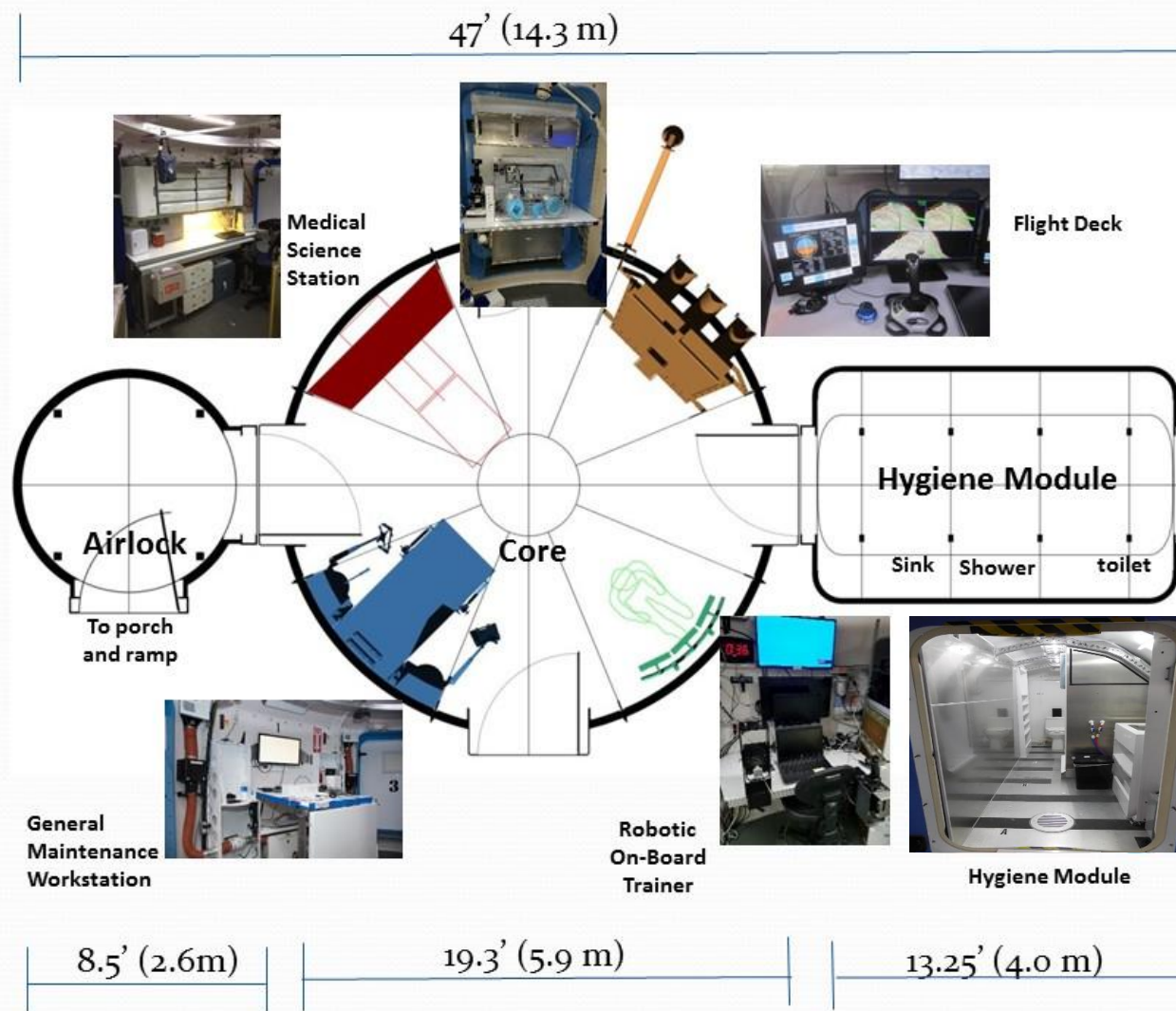
- Work with the Flight Analogs team members to determine needed approvals from the investigator's home institution.
- Prepare individual protocol submissions to the JSC IRB with the assistance of FA Project team member

INVESTIGATOR RESOURCE/FISCAL RESPONSIBILITIES

- The investigator will provide resources for their experiment unique requirements
- The investigator will have responsibility for the costs of any investigator protocol specific test subject screening requirements, equipment, and other investigation specific requirements.
- The investigator is responsible for costs associated with their specific protocol operations, consumables, sample collection, and on-site support, etc.
- The investigator is responsible for costs associated with shipment to/from the Johnson Space Center for all hardware, supplies, consumables, etc. associated with their protocol
- The investigator is responsible for test subject travel costs for follow up testing required beyond the standard schedule
- The investigator is responsible for data sharing arrangements with other investigators.

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Appendix A HERA Facility Layout



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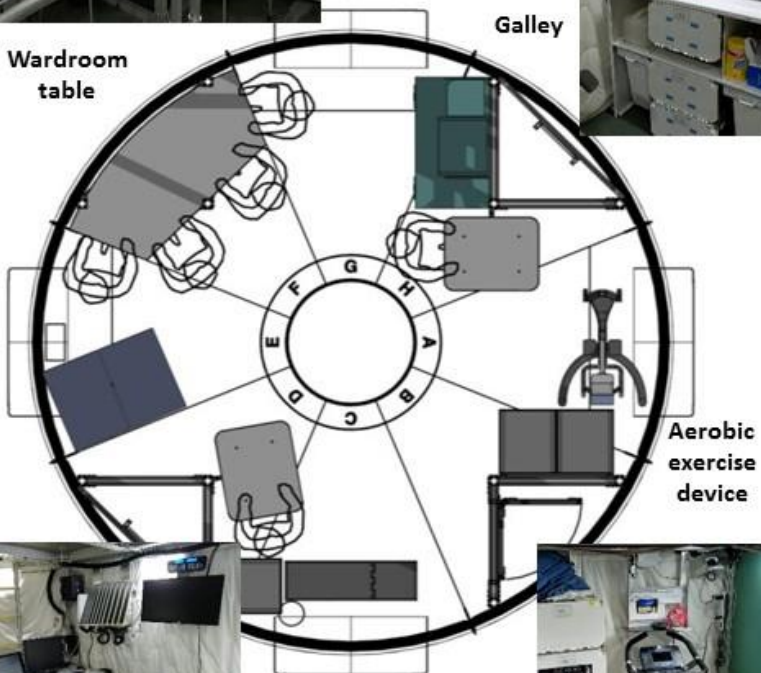
Wardroom table



Galley



Crew Quarters

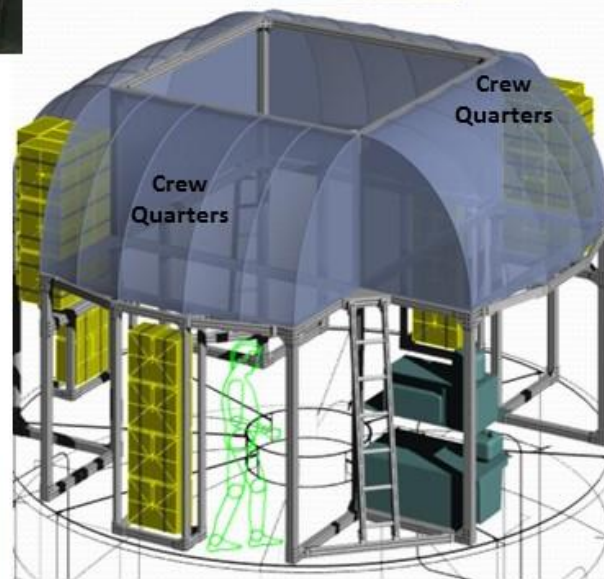


Aerobic exercise device

2nd floor



Communication Station



3rd floor