

THE NITTY GRITTY: HOW WE MAKE ANALOGS WORK

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NASA's Human Research Program (HRP) is becoming increasingly reliant on Isolated, Confined and Controlled (ICC) analogs to accomplish many of its research objectives. Compared to other research platforms, ICC analogs present a unique set of operational challenges that must be addressed in order to ensure a high fidelity research environment. In particular, the Human Exploration Research Analog (HERA) habitat, which is classified as an ICC environment, has been developed over the past three years to accommodate the operational needs of research investigations from each of the HRP Elements. During the development period, various types of requirements have contributed to the current operational model, which strives to achieve the highest possible level of mission fidelity with limited resources. This presentation will focus on the operational aspects of the HERA habitat, with emphasis on how we develop the analog research environment to meet researchers' needs. Specific discussion topics include mission scenario development, operational tasks, mission timeline integration, stressor implementation, console support, and improvements based on lessons learned. The information is intended to help investigators better understand the details behind HERA operations and the benefits to their research goals.



The Nitty-Gritty: How We Make Analogs Work

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Mission Scenario



- Mission scenario defines the Human Exploration Research Analog (HERA) simulation environment
 - Determines the types of activities the crew will participate in when they are not performing investigator science testing
 - Mission objectives
 - Tasks related to crew health and safety
 - Allows crew to engage in the simulation, forget about real world
 - Provides sense of purpose, goals, teamwork environment
 - Provides a unique research environment not available at most academic institutions
 - Developed by personnel with experience and expertise in spaceflight operations





Mission Scenario Development



- Planning starts up to 2 years before campaign execution
- Scenario requirements are consolidated at the Human Research Program (HRP) Element level, and then discussed with International Space Station Medical Projects (ISSMP) Flight Analogs
 - Best compromise is reached based on available resources and schedule
- Current HERA configuration can support transit scenarios
 - Isolation and confinement within the habitat
 - Use of virtual reality (VR) technology to simulate asteroid extravehicular activities (EVAs)
- Future configurations may support exploration scenarios
 - Crew leaves the habitat for simulated planetary EVAs (NEK)

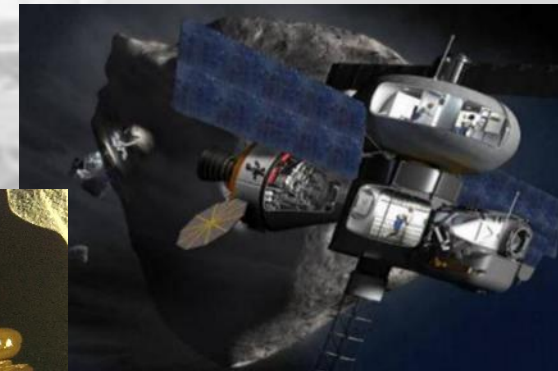




Campaign 4 Mission Scenario



- **Destination:** Near-Earth asteroid 1620 - Geographos
- **Mission Duration:** 715 days
- **Crew Size:** Four (CDR, FE, MS1 & MS2)
- **Objectives:**
 - Crew health and safety
 - Conduct geological survey of Geographos
 - During transit, crew will use on-board training system to prepare for excursions to asteroid surface
 - Conduct scientific research in the areas of spaceflight psychology, physiology and human factors/habitability
 - Vehicle systems maintenance
 - Education and outreach payloads





Simulated Mission Phases



Mission Phase	Scenario Duration	Simulated Duration/MD
Orion launch, dock with Habitat vehicle, transit burn	2 days	1 day: MD1
Transit to Geographos (comm delay phase in)	370 days	18 days: MD2 – MD19
Proximity Ops & Rendezvous with Geographos (comm delay)	21 days	5 days: MD20 – MD24
Transit to Earth (comm delay phase out)	320 days	20 days: MD25 – MD44
Rendezvous with Earth, Orion undocks and lands	2 days	1 day: MD45



Mission Operations Task Development



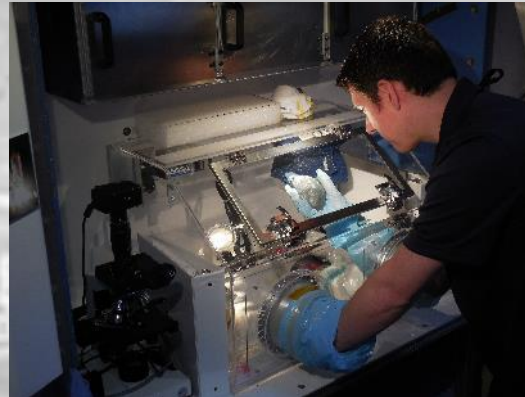
- **Mission Objectives**

- Multi-mission Space Exploration Vehicle (MMSEV) Flight Simulator & Virtual Reality EVA



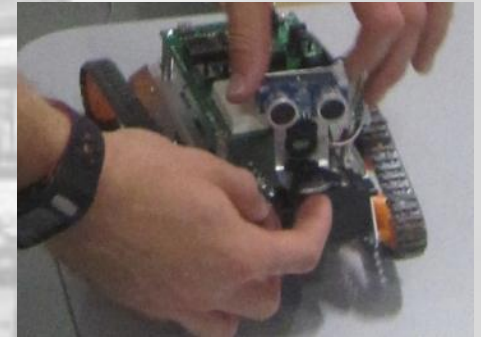
- **Planetary Geology**

- Asteroid Sample Identification



- **Educational Payload Operations**

- Robotic Vehicle Concept
- Animal Biology
- Plant Biology



- **Human Research**

- Microbiome
- Mini PCR
- Body Measures



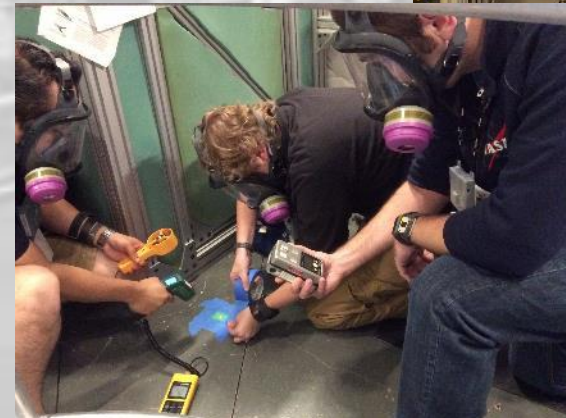


Mission Operations Task Development



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- **PAO (x3)**
- **Vehicle Operations**
 - Crew Health – Medical Drill (x2)
 - Vehicle Safety – Emergency Drills (x3)
 - Systems Status (x3)
 - Housekeeping
- All tasks developed to support scenario
- Can be modified to meet science requirements and include stressors
 - 2-person or 4-person team tasks
- Entire suite provides mix of individual and team activities

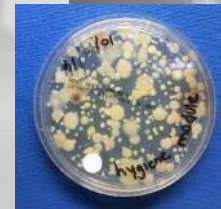




Mission Fidelity



- Objective: Develop the mission scenario using realistic spaceflight activities and create an operational environment that allows the crew to fully engage in the simulation
- Habitat and related systems
 - Realistic communication system and voice protocol
 - Simulated Environmental Control and Life Support System (ECLSS)
 - Food rehydration system; meals from JSC Space Food Systems Lab
 - Includes coffee, tea and other drinks
 - View ports (virtual windows)
 - Sound system; acoustic insulation
 - 3D printer
- Operations
 - Timeline viewer application, realistic science and operational activities
 - Daily summary report & crew daily schedule that mirrors spaceflight
 - Habitat housekeeping and maintenance
 - Mission Control Center (MCC) support
 - Stressors

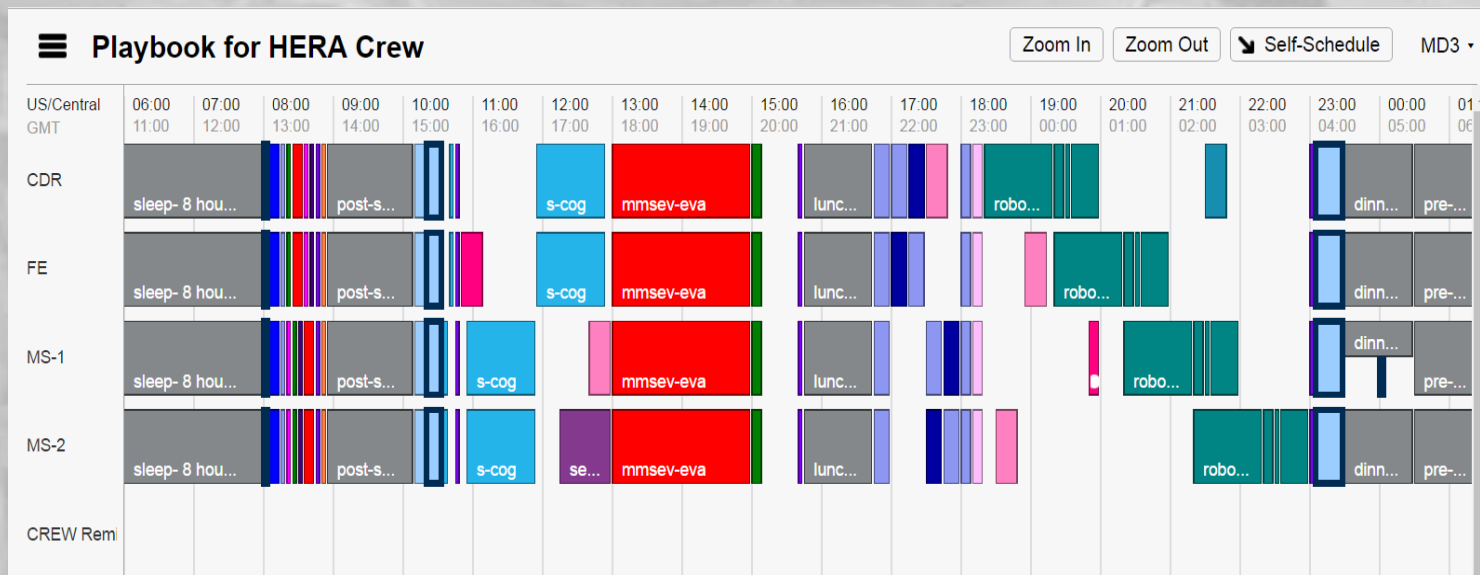




Timeline Integration



- Typical science complement contains 15-20 investigations
 - Require about 3.5 hours/crewmember/day (on average)
 - Test sessions scheduled according to requirements and constraints



- Remainder of timeline filled with mission-related operational/science activities
 - Use mission scenario as guidance when scheduling activities
 - Use activities and associated procedures to introduce stressors as required



Crew Daily Schedule



- Daily activity schedule similar to ISS flight plans
- Subjects awake at 0700, off duty at 2300 (CST)*
- ½ day of work on Saturday, full day off on Sunday

Timeline Activity	Duration (hrs)
Post-sleep, morning meal	1.5
Morning DPC, daily prep	1.0
Private conferences	0.5
<i>Work - science & ops</i>	<i>~ 6.5</i>
Midday meal	1.0
Exercise	1.25
Evening DPC	0.5
Pre-sleep, evening meal	2.0

* Modified schedule for Campaign 4:

– M-F: 0700-0200; S-S: 0700-2300



Stressor Implementation



- Stressor requirements are part of Principal Investigator (PI) science requirements
 - Operational: increase fidelity
 - Full day (e.g., comm delay, sleep deprivation)
 - Within task (e.g., time pressure, unexpected failure, task or role ambiguity)
- Assessment is performed to determine most effective implementation method
 - One or more operational tasks may be used
- Integrated stressor plan is developed
 - Schedule is developed and conflicts are resolved
 - Detailed plan is implemented by MCC team





Crew Training – Simulation Engagement



- HERA mindset training – how to approach/think about the mission
 - Crew is briefed on mission scenario and operational processes
 - Treat all work during the mission as real work performed during a real mission
 - Example mindset: *If this was real, and I was really in space on this mission, what would I do?*
 - Example mindset: *How would I behave if I was in this simulation with a group of real astronauts?*



Crew Training – Simulation Engagement



- Commander (CDR): responsible for the mission and the team’s success on each task. The CDR is the leader for the crew and sets the tone for how things function in terms of both social and task work.
- Other three positions are assigned, but not given specific duties tied to each position
 - Flight Engineer, Mission Specialist 1 and 2
- Bottom line:
 - Treat everything as real because the researchers are assuming this during data analysis



MCC Console Support



- Two positions staffed during crew wake period, 7d/week
 - HABCOM
 - Primary communicator, key part of research environment due to daily interactions with subjects
 - Trained to set tone for the simulation & keep crew engaged
 - SCI OPS
- Other positions as needed
 - FLT SIM
 - HAB Systems, Data Systems
 - PI support area
- Crew sleep period
 - Subject monitors on duty overnight





MCC Console Support



- Real-time support from PI team
 - Support in HERA MCC is optional; based on specific test requirements
 - The assigned Experiment Support Scientist (ESS) provides primary interface to MCC to resolve issues
 - ESS may contact PI team for answers to certain issues
 - PI teams are expected to be available to help resolve problems
 - PI teams should verify real-time data as it becomes available



Lessons Learned



- The operations team conducts a post-mission debrief with each crew
 - Debrief topics focus on habitat, simulation environment, operational processes, major anomalies
 - Crew comments evaluated, specific items are deemed actionable
 - The operations team then conducts an internal debrief to discuss specific crew comments and operational issues
 - Decisions are made regarding changes to be implemented between missions and campaigns
 - Safety-related changes and small improvements are implemented between missions
 - Significant changes are delayed until next campaign
- Lessons learned are documented after each mission and campaign



Lessons Learned



- Examples of lessons learned
 - Too many wearable devices
 - Too many surveys
 - Too much repetition, data session frequency too high
 - Mental tug-o-war ongoing during mission
- Examples of what not to do
 - Schedule survey 6x per day, 7 days/week
- Challenges for future protocol planning
 - Think about subject's perspective, spend a day in their shoes
 - Try to design measures to be as flight-like as possible
 - Daily and weekly frequency
 - Would an astronaut sign up to do this?

