



Review of Isolated, Confined Extreme Environment (ICE) Studies

Behavioral Health & Performance Element
NASA Human Research Program

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Environments

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Outline

- Defining Isolation Studies
- Why isolation studies are needed?
- What are the most important BHP-related research questions?
- What are the best analogs?
- Examples of BHP ICE studies
- Summary of BHP Concept for Example ICE Analogs



Isolation Studies Defined

- **Isolation studies** are focused investigations of individuals and teams living and working in facilities (i.e., analogs) of varying fidelity (i.e., mission-like) with regard to characteristics associated with future spaceflight missions
- **ICE – Isolated, Confined, Extreme** environments may provide higher fidelity with regard to danger, isolation; but less for selection, training, operational activities

Characteristics include: duration, selection criteria, crew size and composition, team training, operational activities, schedule, roles, danger, stressors, communication delays



Research Lab
Lower

FIDELITY



Antarctic Station
Higher

Why are Isolation Studies Needed?



The Trip

Earth to Mars - 6 months
On Mars Surface - 18 months
Mars to Earth - 6 months

} Unprecedented
duration and distance!

The Vehicle

Confined within a small and limited volume

- Current evidence recommends total net habitable acceptable volume = 150 cubic meters; 25 cubic meters/person

The Crew

Living and working with same small group: 1 among 4 to 6 individuals

- Homogeneous or heterogeneous (e.g., nationality, sex, married, single, children, age)
- Skill set and behavioral competencies
- Training: 2 years for 6 months; ? years for 36 months; team training with mission crew?

The Environment: extreme and dangerous; threat of radiation exposure; no escape or rescue; altered day/night cycles; separation from family, friends, removed from normal biophilia – no view of Earth! Reduced sensory stimulation, monotonous combined with overload; chronic or cumulative psychological stress exposure and potential sleep problems



Spaceflight Challenges

Current ISS Operations

Low Earth Orbit

- Real-time communication with ground operations
- Real-time comm. with family and friends
- Provision of crew care packages
- Discretionary events
- Evacuation options
- Cupola and Photography
- Exercise 2 hours/day
- High tempo workload

Astronauts thrive on the ISS

Large Volume

Private Crew Quarters

Six Month Duration (to date)



Future Exploration Class Missions

Deep Space

- Unprecedented duration and distance
- Loss and delay of communications with ground
- More autonomous operations
- No re-supply, no option for evacuation
- Limited volume in confinement
- Radiation exposure threats
- Earth out of view!

Major Challenges

- Providing Acceptable Net Habitable Volume and Adequate Sensory Stimulation
- Selecting & Composing Crew
- Managing Levels of: Sleep, Fatigue, Workload & Circadian; Stress, Mood, Morale & Conflict
- Ensuring: Meaningful Work, Motivation, Family Connectedness & Communications
- Enhancing Growth & Resiliency





Isolation Studies: Key Research Questions and Gaps

Predict and Prevent:

- What are the key indicators related to behavioral outcomes?
- What are the characteristics, competencies, predictive biomarkers needed for selection?
- What is the right crew mix and composition?

Monitor and Detect Early

- What are the best measures to monitor and detect changes?
- What is the best way to provide feedback to the crewmember and the flight surgeon?
- What are the temporal variations in key indicators of behaviors (individual and team)?

Counteract and Treat

- What are the best countermeasures and protocols to mitigate BHP risks?
- How can training be provided to inoculate and prepare crews for exploration missions?
- What tools can be developed to maintain communications with families?
- How can we best modify the environment to counteract stressors?

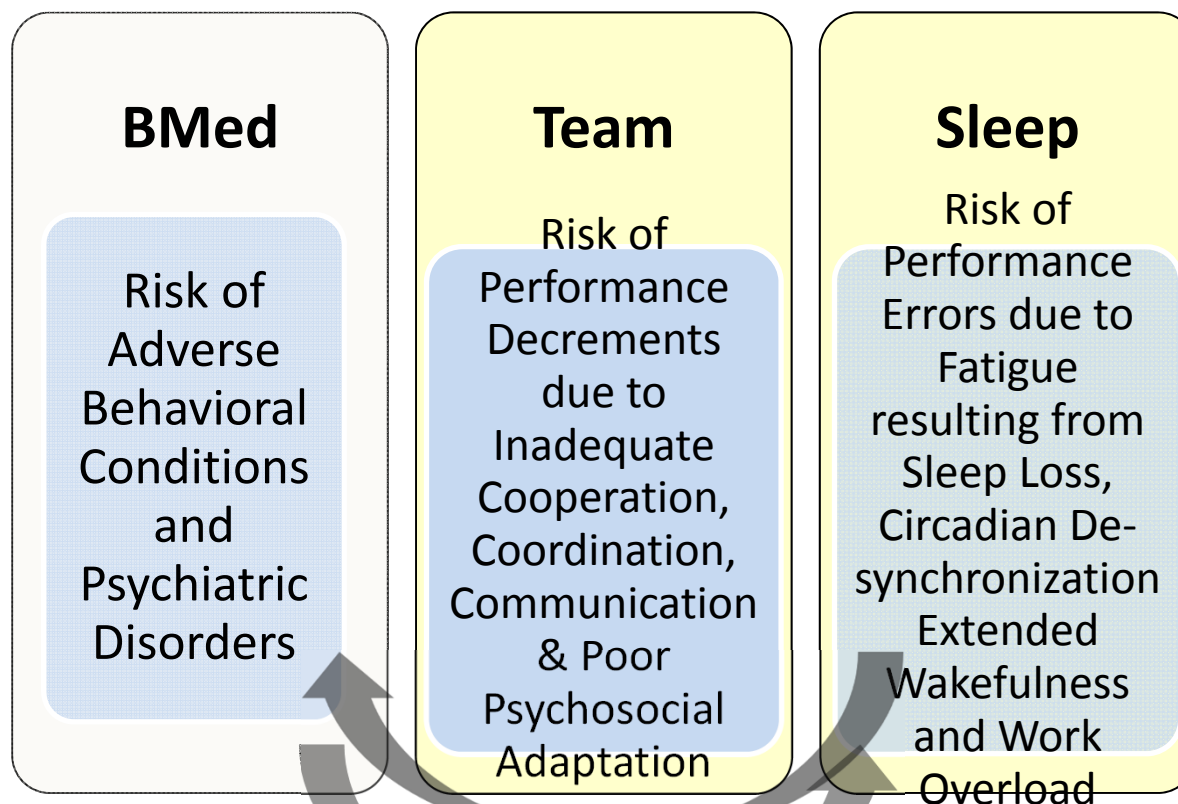
Thresholds and Standards

- What are the thresholds for setting individual and team function standards?
- What are the standards for reintegrating crews?



Why are Isolation Studies Needed?

Behavioral Health and Performance Risks



Isolation Studies →

*Evidence to quantify & characterize risk due to prolonged isolation;
Tools for early detection;
Test Individualized CMs*

Longitudinal data and tools for team function

*Understand why sleep is reduced in microgravity;
Individualized CMs*



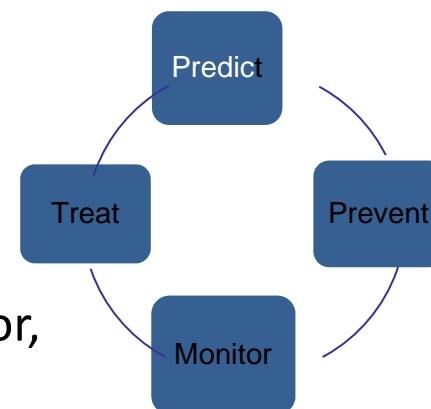
BHP Element Background

BHP Element Goal

- Identify, characterize, and prevent and mitigate behavioral health and performance risks associated with space travel, exploration and return to terrestrial life

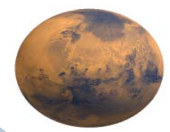
BHP Requirements

- Characterize and assess risks (quantify likelihood and consequences on performance and health)
- Develop tools and technologies to prevent, monitor, and treat adverse outcomes
 - ✓ Reduce human systems resource requirements (e.g., crew time, mass, volume, power)
- Inform human health and performance standards



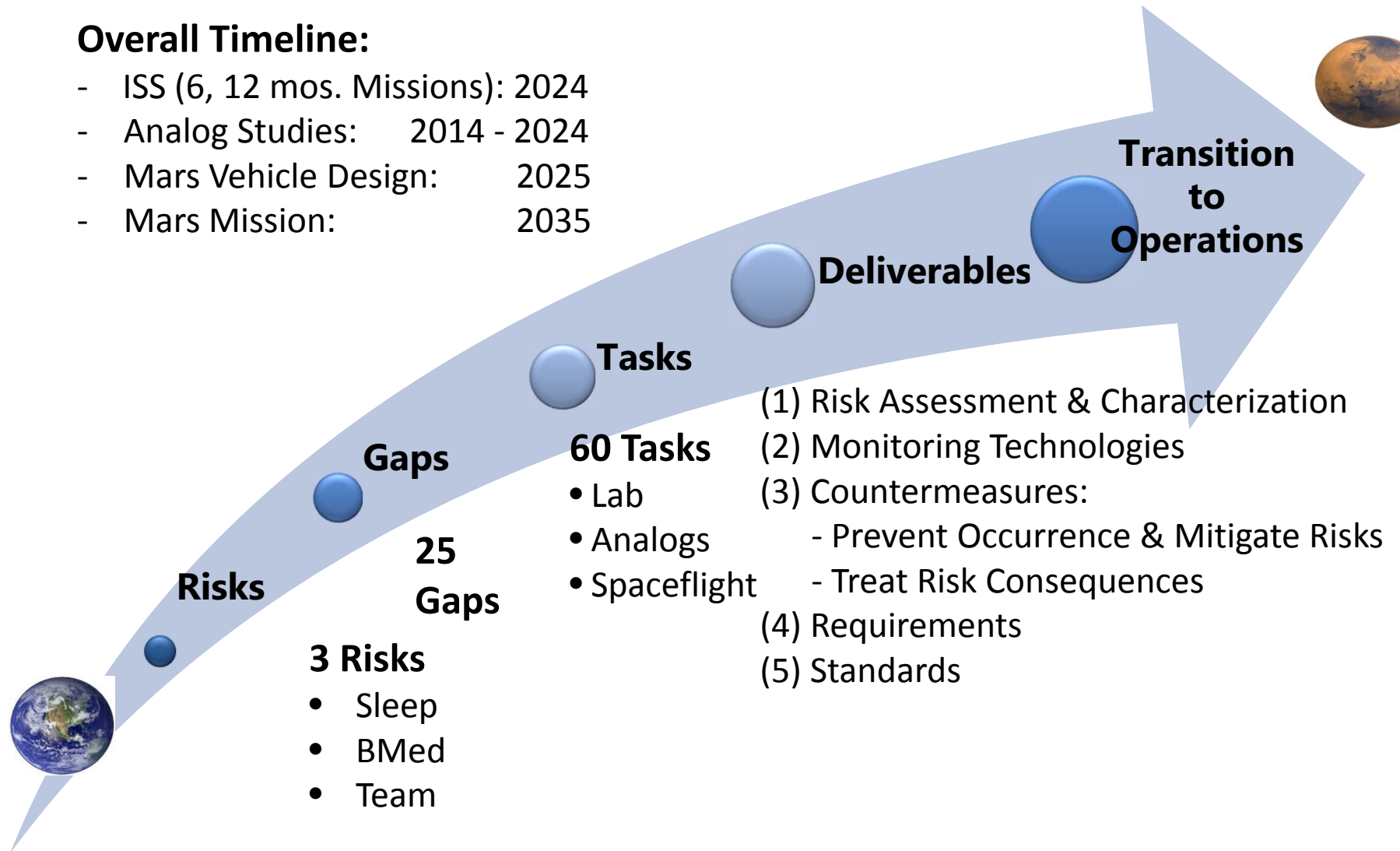
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Path to Risk Reduction



Overall Timeline:

- ISS (6, 12 mos. Missions): 2024
- Analog Studies: 2014 - 2024
- Mars Vehicle Design: 2025
- Mars Mission: 2035





What are the Best Analogs?

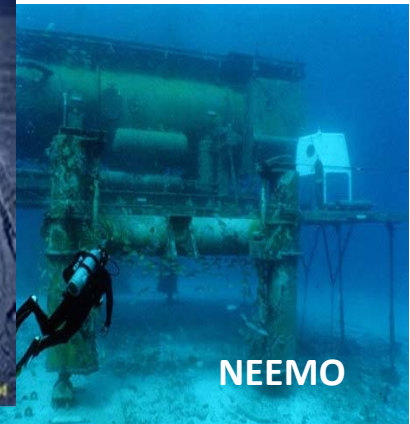
- Human Exploration Research Analog (HERA)
- NEEMO
- Mars 500
- Antarctic Stations (e.g., Concordia)
- Arctic Stations (Nord)
- Hawaii Space Exploration Analog and Simulation (HiSEAS) (non NASA facility)
- :envihab
- CAVES



Nord Station



Concordia



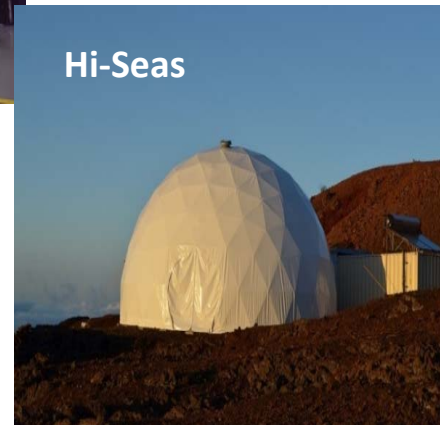
NEEMO



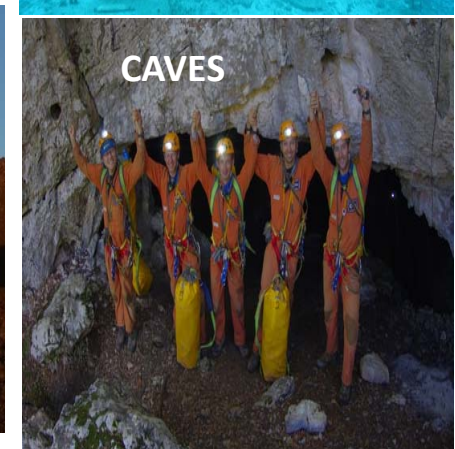
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MARS 500



Hi-Seas



CAVES

BHP Isolation Studies: Key Indicators & Measures



Key Indicators	Measures	PI	Description	Analogs
Cognitive Function	Psychomotor Vigilance Test	Dinges	Brief 3 minute version of the 10-minute gold standard; measures reaction time, a leading indicator of cognitive decline	Lab, NEEMO (multiple), ISS (6 and 12 mos.), Mars 500, HERA
	Cognition	Basner	Neurological battery of 10 brief measures associated with brain regions representing working memory, executive function and risk taking	Lab, HERA, Antarctic Stations, ISS (6 and 12 mos.), MOD
	Neurostructural Changes	Siedler	fMRI pre and post ISS studies and cognitive testing in-flight	ISS and bed-rest
		Basner	fMRI studies pre and post Antarctic winter overs	Concordia Nayermayer, HERA Hi-Seas
Sleep Levels	Actiwatch	Barger/Czeisler	Wrist-worn actigraph tracking sleep/wake and light exposure	ISS (6 and 12 mos.)
	Advanced Actiwatch	TBD	Next generation automated to permit automatic download and feedback to user	HERA
	Sleep Stages	TBD	Use of portable ECG to measure sleep stages, CO2 levels	:envihab, ISS

BHP Isolation Studies: Key Indicators & Measures



Key Indicators	Measures	PI	Description	Analogs
Stress Levels	Optical Computer Recognition (OCR)	Dinges, Maxis	High resolution camera records facial movements (eye, eye brows, forehead, mouth) and advanced algorithms used to detect fatigue, affect and stress	Lab, HERA
	Lexical Indicators	Salas, Driskell	5-factor model using words to detect stress levels	Lab, HERA
	Visual Analog Scales	Dinges Barger	Automated scales used to rate levels of stress, workload, exhaustion (and conflict)	NEEMO, ISS, HERA, Mars 500
Conflict	Personal Diaries	Stuster	Content analysis of diaries over entire mission (mission quarters)	Antarctica, ISS (6, 12 mos.)
Cohesion	Sociometric Badge	Kozlowski	Sensor-based system monitors proximity, contact initiation and termination; includes physiological measures (e.g, heart rate, swallowing, skin conductance), and feedback interface	Lab, ANSMET, Antarctic Stations, HERA, NEEMO
Cooperation	Team Performance Test	Roma	Behavioral assay measuring propensity to cooperate over time; predictive measures	Lab, Concordia, HERA, NEEMO, Hi-Seas

BHP Isolation Studies: Countermeasures



Key Indicators	Tools	PI	Description	Analogs
Stress Management	SMART-OP	Rose	An interactive media software program providing scenarios and training	Lab, Validated with Law School Students, MOD, HERA
Depression Management		Buckey	An interactive media software program providing scenarios and training	Lab, Clinical Population (Cartreine), Antarctica (new)
Conflict Management		Buckey	An interactive media software program providing scenarios and training	Lab, Clinical Population (Cartreine), Antarctica (new)
Communications	Comm Delay Study	Palinkas	Understanding of impact of comm delay on individual and team performance	NEEMO, ISS
	Comm Modes	Fischer, Mosier	Determination of different types of modes of communication effectiveness and delay intervals	HERA, NEEMO
	Virtual Environment	SBIR	ANSIBLE: an immersive environment providing communications for asynchronous communications between crew and family	Lab, TBD – HERA, NEEMO, Antarctic, IBMP Chamber

BHP Isolation Studies: Countermeasures



Factor	Tools	PI	Description	Analogs
Team Training	Debrief Protocols	Juentsh	Structured debrief protocol for after-action use	Lab, Navy Submariners, MOD Integrated Sims, HERA, NEEMO, NOLS
		Tannenbaum	A brief customizable structured debrief protocol for use by crews to bolster team functioning and cohesion	Lab, NASA Project teams, HERA, NEEMO, Hi-Seas, NOLS, CAVES (TBD)
	Virtual environment	SBIR	Provides team training for individual or team via game strategies	Lab, HERA (TBD)
Lighting Protocols	LED technology	TBD		Lab, HERA, ISS
Sleep problems	Software scheduling for sleep-wake countermeasures	TBD		Lab, HERA, ISS



Summary Concept of BHP for Example ICE Analogs

Are 500 day simulation studies required?

- Based on results from the MARS 500 study, anticipate issues will start to manifest before 120 days with most severe issues shown by the 3rd quarter (1 year)
- At least some six-month durations for transit phases simulation
- Shorter durations of 4 months facilitate higher N's for team studies
- **Recommend mix of:** 14 day, 3 mos., 4-6 mos., and 8 mos., -1 year

<u>Analogs</u>	<u>Benefit</u>	<u>FY17</u>	<u>FY18</u>	<u>FY19</u>
HERA	<ul style="list-style-type: none"> • Increase of N for validation of measures/countermeasures • Increase of N for Team Research (each crew is N=1 for Team) 	4 missions 2 mo. each	4 missions 2 mo. each	4 missions 2 mo. each
IBMP Chamber	<ul style="list-style-type: none"> • Increased durations for 6 key BHP areas: Training and Culture; Team Composition; Workload, Lighting Scheduling and CO2; BHP Performance Measures; Standardized BHP Measures; Sensory Stimulation Tools 	1 mission 4 mo.	1 mission at 6 mo.	1 mission at 12 mo.
Antarctica	<ul style="list-style-type: none"> • High fidelity operational and psychological environment (isolation, confinement, duration, threat to life, altered photoperiod, team dynamics) 	8 mo. - 1 yr.		



BHP Summary Concept for Example ICE Analogs

<u>Example Analogs</u>	Training & Culture	CO2	Standardized BHP Measures: Risk Characterization	NHV: Sensory Stimulation Tools, Behavioral Assessments	Selection & Team Composition	Autonomous Ops	Workload, Lighting Scheduling Tools	Stress from danger and remoteness
HERA	✓		✓	✓	✓	✓	✓	
IBMP Chamber	✓	✓	✓	✓	✓	✓	✓	
Antarctica	✓		✓	Limited	Limited	Limited	✓	✓

International test subject crews facilitates:

- Cultural studies
- Stress studies

