Space Psychology

Space Studies Program 2022

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Learning Outcomes

1. Describe risks related to individual psychological/behavioral health, team cohesion and performance, and human factors, for future spaceflight;

2. Describe relevant research currently underway to address these risks;

3. Highlight limitations of recent research and future work that may be needed to mitigate risk.

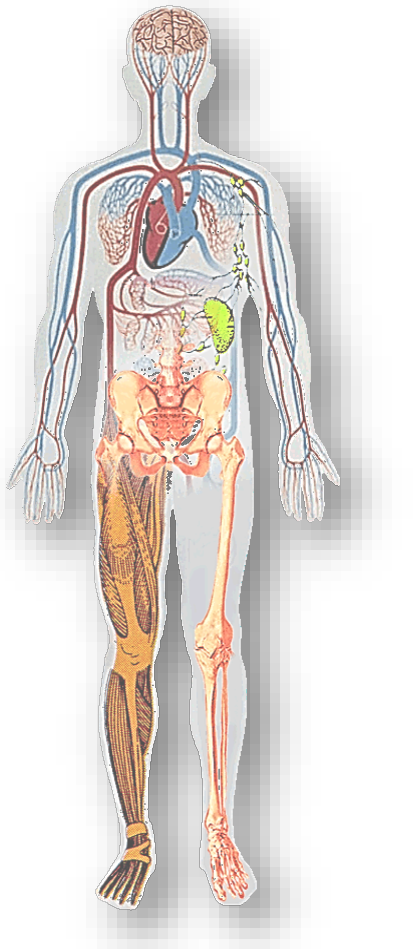
Outline

- Overview: Space Psychology for Future Spaceflight
  - Hazards of Spaceflight
  - Psychological Risks for Exploration Missions
- Psychological Support Services in Current Spaceflight
- Research to Address Risks
  - Spaceflight
  - Terrestrial Analogs
- Limitations and Future Challenges

Hazards of Spaceflight

Altered Gravity

Space Radiation



Isolation & Confinement

Distance from Earth

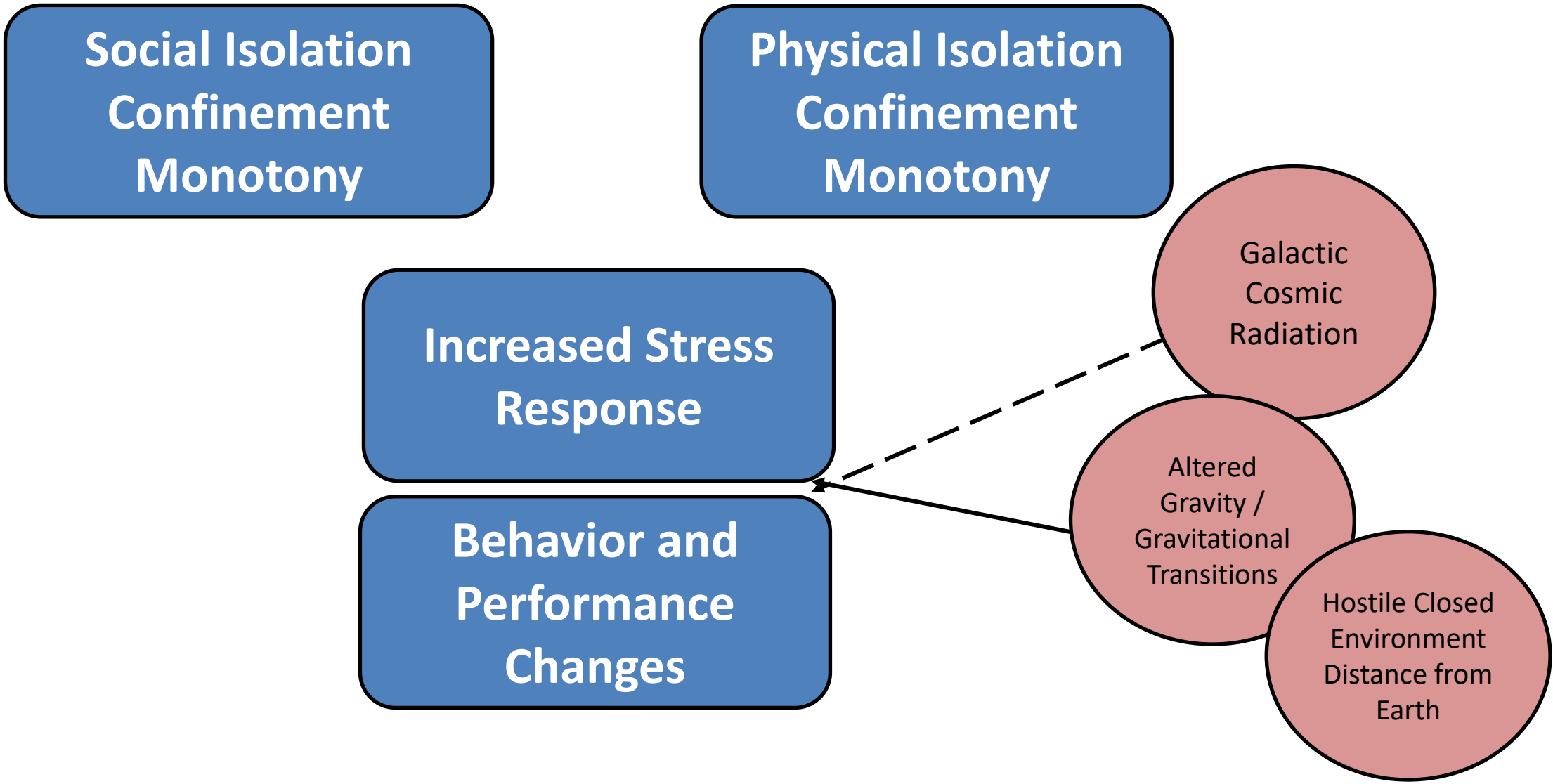
Hostile/ Closed Environment

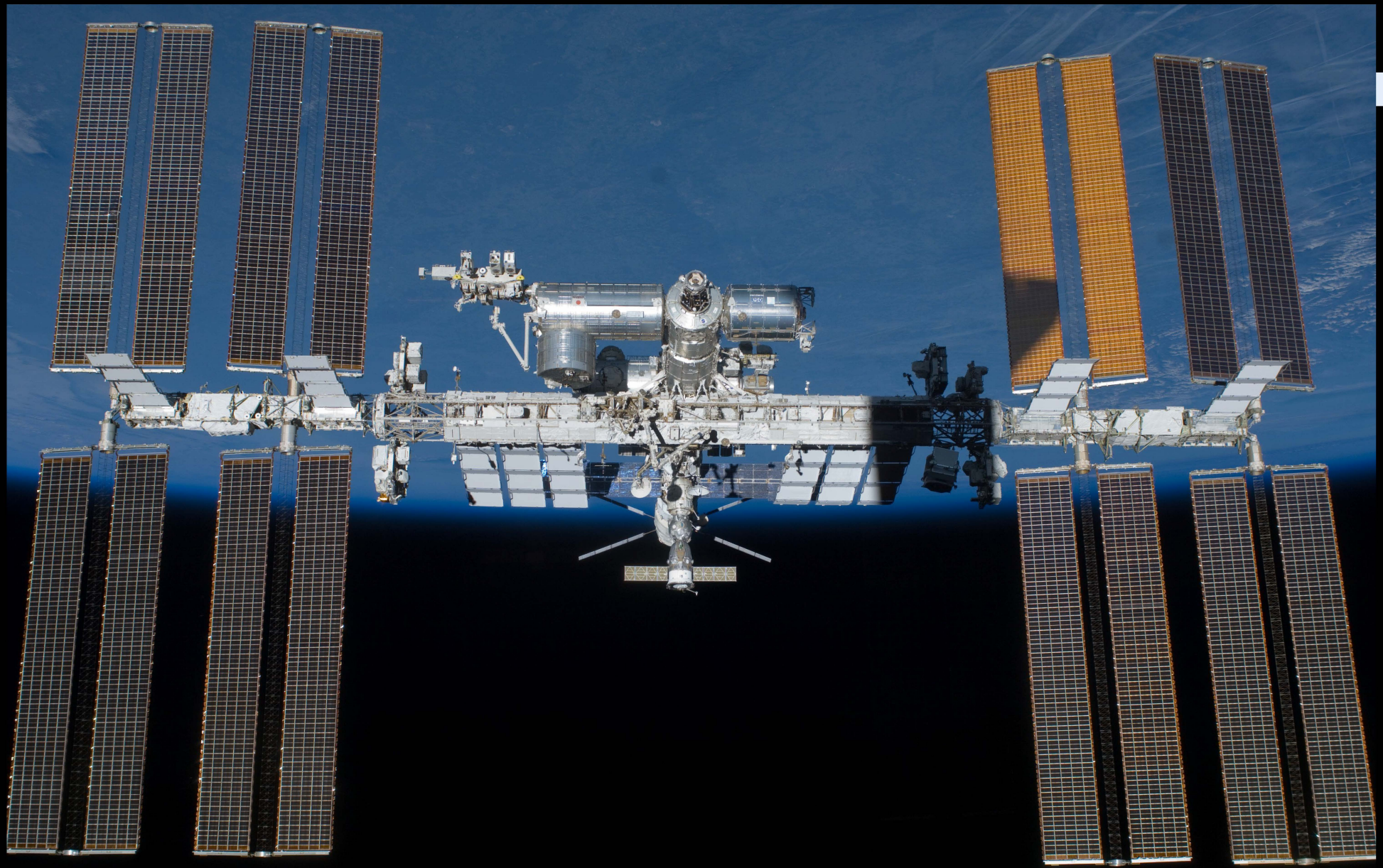
Individual Psychological Health and Cognitive Function

Team Cohesion and Performance

Sleep and Circadian Rhythms

Human Factors


Social Isolation
Confinement
Monotony
Physical Isolation
Confinement
Monotony
Increased Stress
Response
Behavior and
Performance
Changes
Galactic
Cosmic
Radiation
Altered
Gravity /
Gravitational
Transitions
Hostile Closed
Environment
Distance from
Earth

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Psychological Support - ISS

Psychological support services to crewmembers is decided upon by international agreement

The ISS Spaceflight Human Behavior and Performance Working Group (SHBPWG) meets annually to discuss and implement a common behavioral monitoring and countermeasures program for all ISS crewmembers

SHBPWG at JAXA, August 2014

SHBPWG in Houston, October 2015

Beven (2012)

Psychological Support - ISS

Operational Psychology Services
– Services provided to the crew include movies, music, family contacts, special events, crew care packages

Behavioral Medicine Services
– Information gathered from the crew through Private Psychological Conferences (PPCs)
– WinSCAT neurocognitive testing

All behavioral medicine components are private medical records

Beven (2012)

Psychological Support - ISS

Behavioral Medicine Services

ISS Preflight Assessments (L-12 months, L-6 months, L-30-60d)
Primary pre-flight evaluation topics:

- Training issues including perception of mission readiness
- Training workload and fatigue levels
- Family or personal relationship issues
- Crew-crew training interactions, familiarity and concerns
- Management issues or concerns
- Mood and anxiety
- Mission goals, desires, challenges and risks
- Post mission rehabilitation or family concerns
- Emergency notification method—bad news from whom?

Crew medical officer training (L-18 months)
highlights possible "worst case" scenarios —delirium, complicated bereavement, common symptoms of major mood and anxiety disorders, and familiarization with treatment options on the ISS

ISS Postflight Assessment (R+3, R+14 and R+30-60d)
ISS Behavioral Medicine Evaluation Topics:

- Mission in retrospect—level of personal satisfaction
- Greatest challenges, frustrations, joys
- Retrospect review of fatigue level prior to events
- Family reintegration issues
- Postflight mood, anxiety and cognition
- What are short and long-term career plans?
- What worked/didn't work from a BHP standpoint?
- What BHP services need improvement or change?

Beven (2012)

Psychological Support - ISS

Private Psychological Conferences, or PPCs

- every two weeks on orbit

- Sleep (duration and quality)
- Sleep shift issues
- Fatigue level
- Workload and pace of work
- Individual and crew morale
- Crew relationships
- Crew-ground relationships
- Mood
- Cognition
- Family and personal relationships
- Environment and habitability issues, including food
- Operational psychology issues or requests
- Preparation for important tasks, such as EVA's

Neurocognitive Assessment with WinSCAT

(Space Flight Cognitive Assessment Tool for Windows)

Preflight to establish a basline; in-flight every 30 days; and post-flight R+30

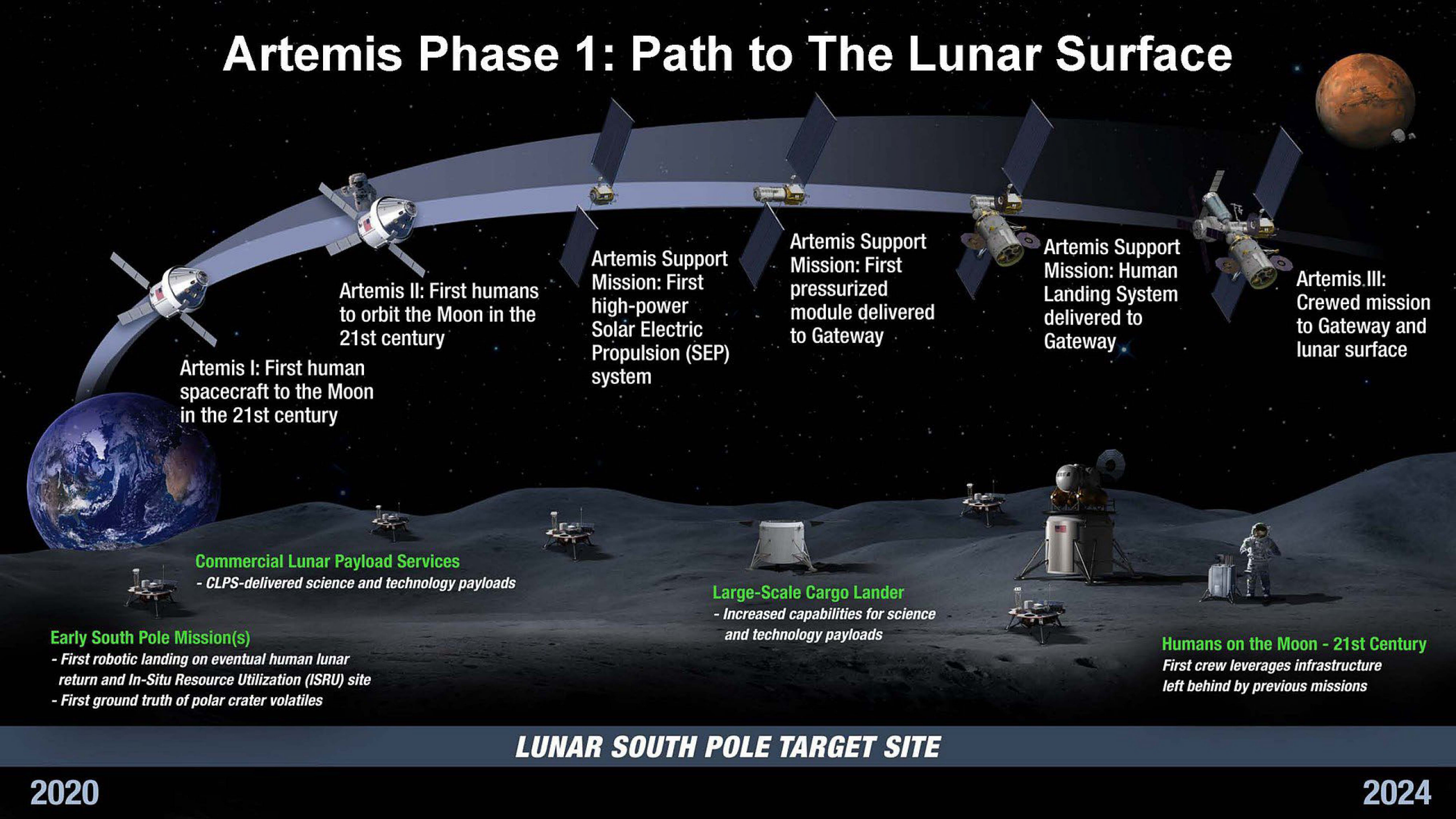
WinSCAT is brief (11-15 minutes) and assesses aspects such as:

– response time
– sustained attention/concentration
– visual working memory
– verbal working memory

Subtests are from the Automated Neurological Assessment Metrics (ANAM)

Beven (2012)

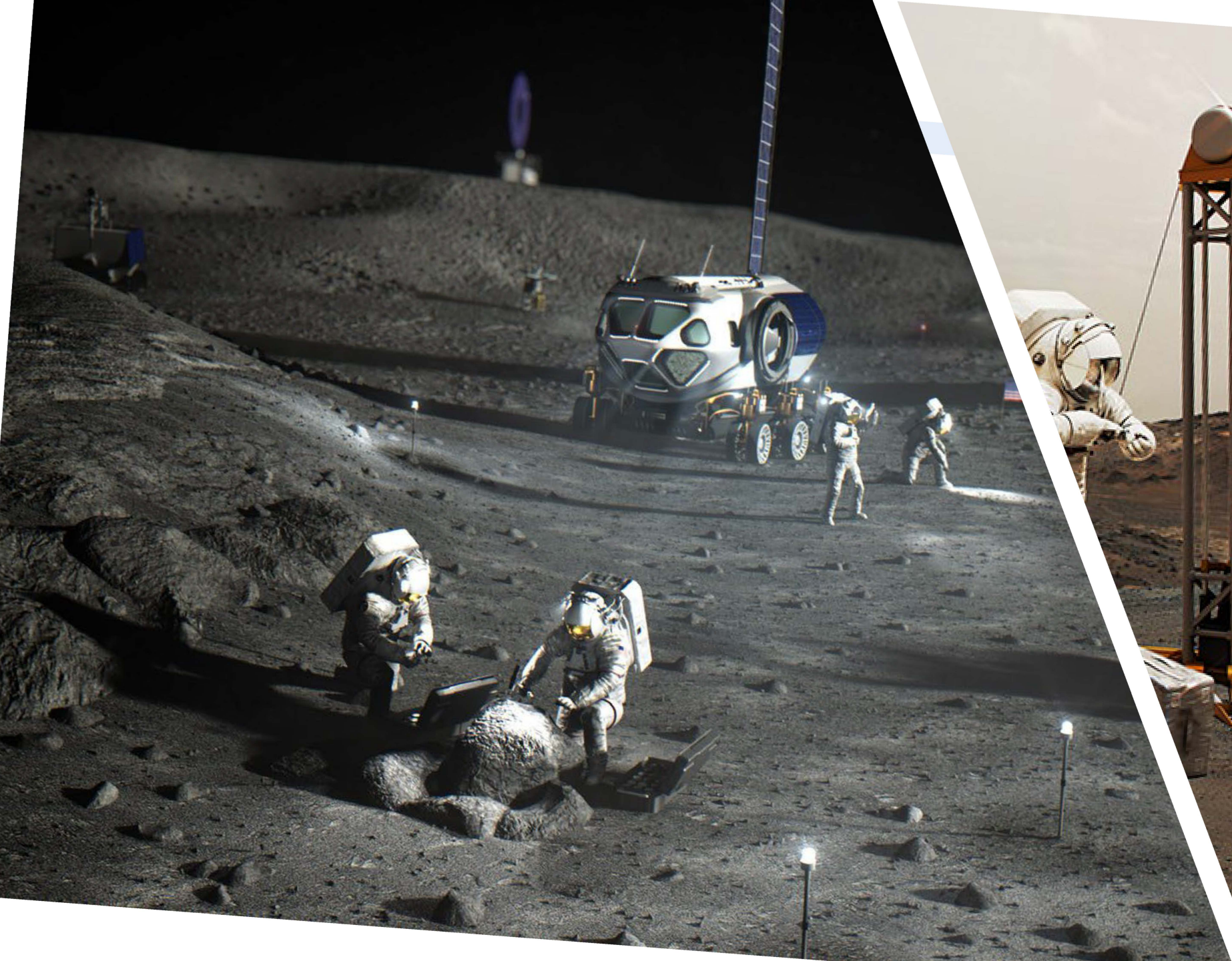
Artemis Phase 1: Path to The Lunar Surface



Activity

Reflect on the early months of the covid-19 pandemic, or another time of your life when you may have been physically isolated

- How was your experience of physical isolation?
- What helped you get through this time?
- What did you learn about yourself as a result of the isolation?



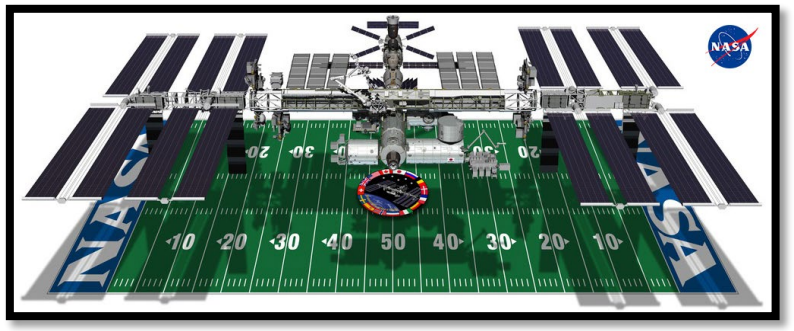
Current Operations v Exploration

Current Operations

Low Earth Orbit

- Real-time communications (ground operations, family, friends)
- Provision of crew care packages
- Evacuation options
- Cupola and photography
- Exercise 2 hours
- Large volume and private quarters
- Mostly six-month duration
- Long training & preparation period

Astronauts thrive on the ISS
(Habitable Volume: 15,000 Ft^3)



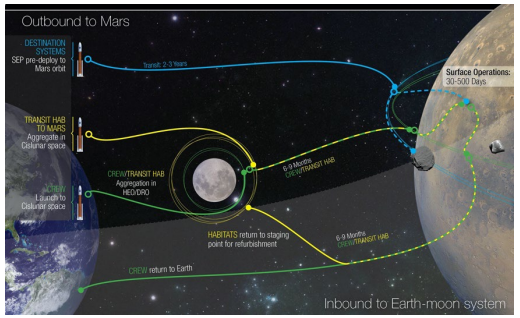
Exploration Class Missions

Deep Space

- Unprecedented duration and distance
- Loss and delay of communications with ground
- Limited or no re-supply
- Limited or no option for evacuation
- Limited exercise options
- Limited volume in confinement and isolation
- More autonomous operations, including during emergency
- Earth out-of-view

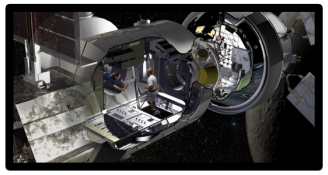
Major Challenges

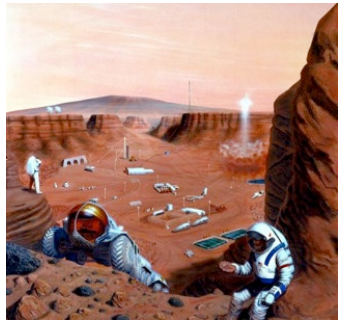
- **Workload, sleep, circadian & fatigue**
- **Stress; interactions, mood & morale**
- **Selection and crew composition**
- **Psychosocial adaptation & training**
- **Growth and resiliency**
- **Meaningful work, motivation**
- **Family connectedness and communication**



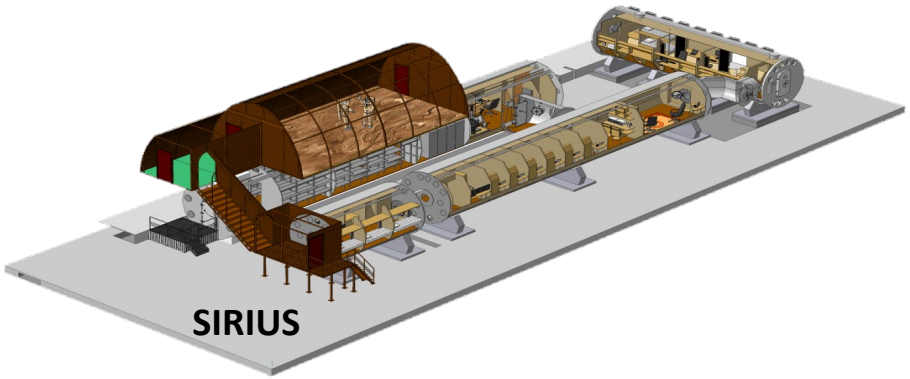
Orion Capsule 316 Ft^3

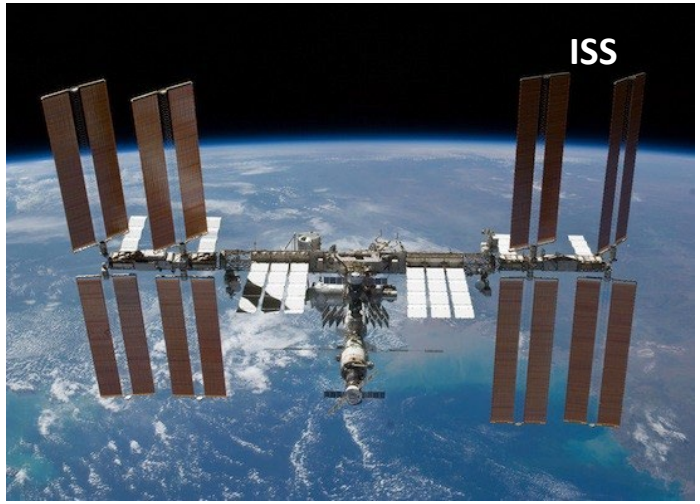
Gateway Habitat 4415 Ft^3





Research to Address Risks





HERA

Four 45-Day Missions / Year Simulating Exploration Mission

High Fidelity Environment
- Limited volume and privacy
- Workstations, exercise capability, spaceflight-like food

High Fidelity Mission
- High workload tempo w/ spaceflight-like tasks
- Scenarios include journey to Phobos
- Varying levels of autonomy

High Fidelity Crew Composition
- Four subjects per mission
- Single or mixed gender, goal is 50/50 male:female ratio
- Age 30 to 55 years
- Technical skills proven through professional experience
- Advanced degree or equivalent experience (military)
- Motivation & work ethic that is “astronaut-like”
- Medical and psychological assessments

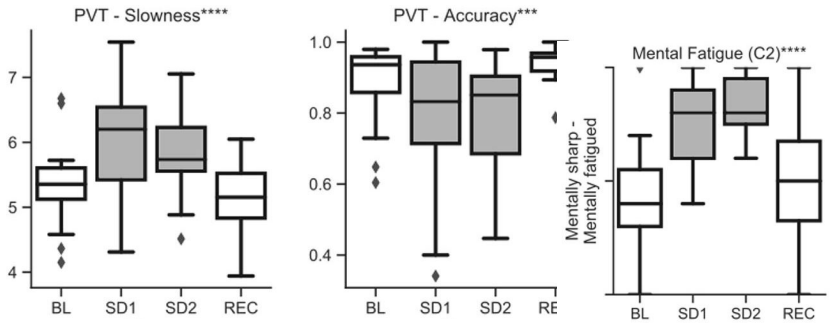
https://analogstudies.jsc.nasa.gov/hera

HERA

Cognitive Performance During Confinement and Sleep Restriction in NASA's Human Exploration Research Analog (HERA) (PI: Basner)

Data collected in HERA C1 (7 days) and C2 (15 days)

- Sleep deprivation (~27h awake) and one day partial sleep restriction (~4h sleep) (Campaign 1)
- Total sleep deprivation (Campaign 2) (SD1 = ~22h awake; SD2 = ~ 38h awake)



Significant decrements:

- Vigilant attention (PVT) speed and accuracy
- Sensorimotor reaction speed & visual scanning processing speed
- Reduced accuracy on facial emotion recognition test

(Nasrini et al., 2020)

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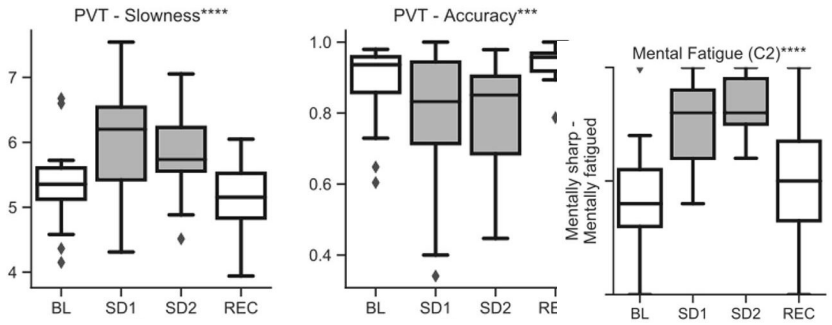

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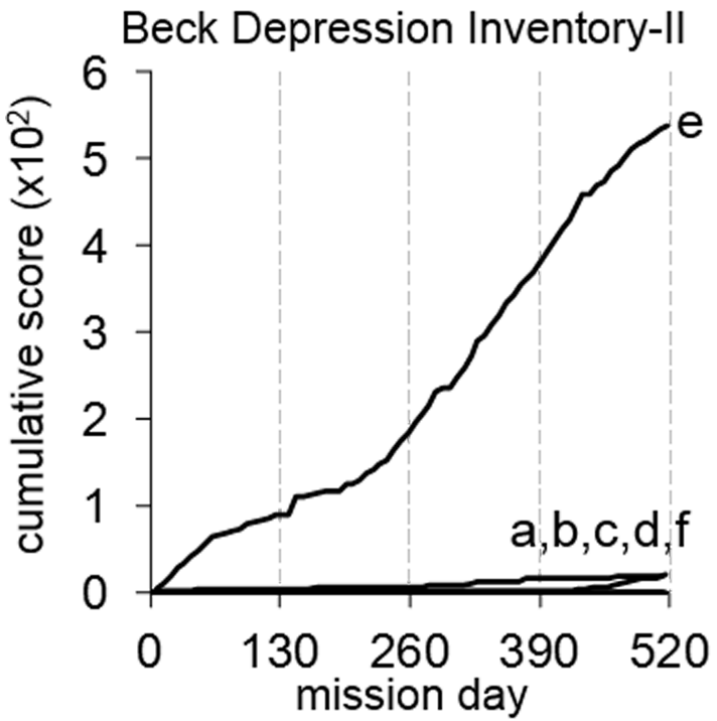
Long Duration: Mars – 520 Day

- Six crew members completed a 520-day mission at the Sirius facility at IBMP
- No major deleterious outcomes reported
- Results from Basner et al. (2014) demonstrates most one of six participants reporting increase in depressive symptomology over time
- Other issues included one participant severely misaligned; reduced movement over time (Dinges et al., 2014)

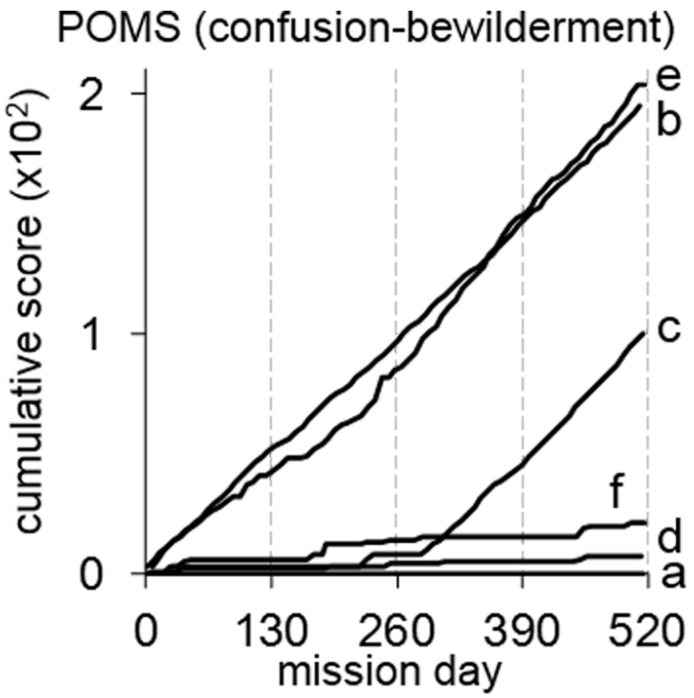
1 of 6 (20%)

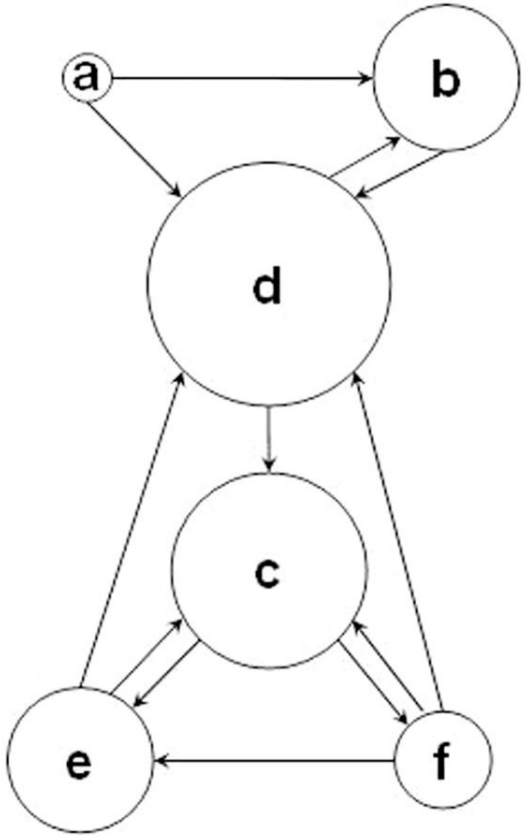
Adverse Behavioral Condition



3 of 6 (50%)

Adverse Mood

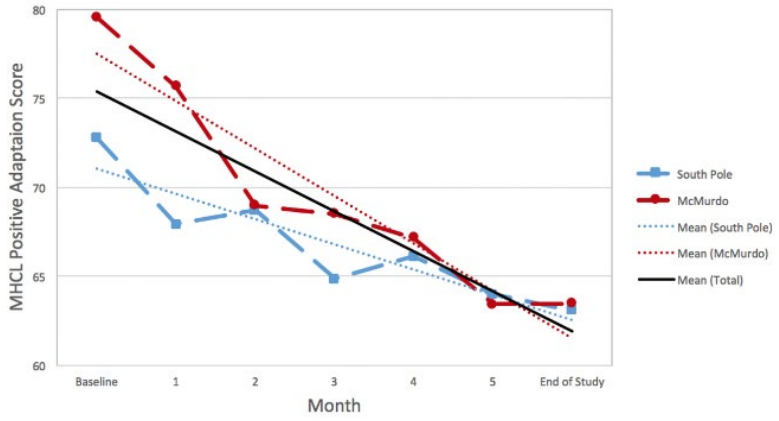




Long Duration: Antarctica

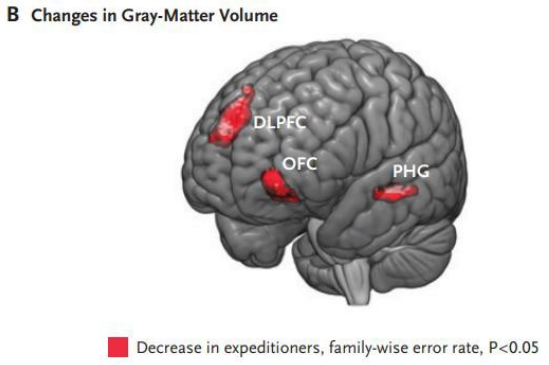
Alfano et al. (2020)
Tracked monthly assessments of mental health and McMurdo and South Pole Station (n=110) for a nine month period.

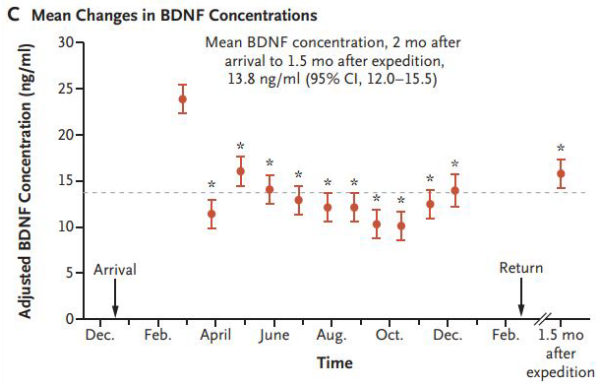
Participants showed a decrease in positive adaptation and an increase in negative self-regulation over the course of the mission



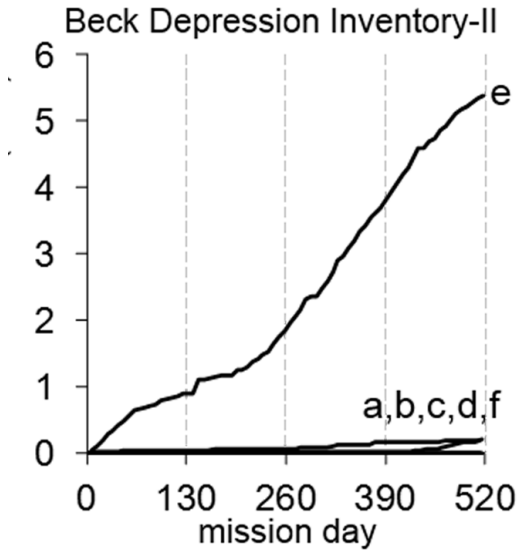
Stahn et al (2019): 14 months Neumayer III Station
- Pre and post MRI
- In-mission cognitive testing and biomarker assessment

Results:
- Environmental monotony and prolonged physical and social isolation impede neurogenesis
  - Dentate gyrus volume and grey matter volume reductions





Summary: Analog Research



Successful missions with healthy crew ~ signs of increased risk

- Declines in emotion recognition and emotion regulation
  - Dampening of positive affect and decline in self- regulation (Antarctic Stations) *Alfano et al. (2021)*
  - Inaccuracies in emotion recognition in HERA under acute sleep deprivation *Nasrini et al. (2020)*
  - Slowing in emotion recognition and with bias towards more negative emotion over time (60 days HDBR) *Basner et al. (2021)*
- One crew member - depression symptoms increase over time; social isolation *Basner et al. (2014)*
- Evidence of neurostructural changes from isolation and confinement *Stahn et al (2019)*

Limitations of Analog Research

- Small n
- Generalizable to exploration? To astronauts?
- Testing Countermeasures – need to isolate variables

Activity

Consider the results we discussed from psychological research in analogs.

- What do you think are methods through which we could offset these results?
- Describe an experiment to test your idea.

Countermeasures for Exploration

Evaluating behavioral health and performance effects of:

- Stress-management training
- Exploration-like food system
- Optimize habitat design with reduced volume and privacy
- Virtual reality as a sensory monotony countermeasure
- Plant systems
- Exercise with guided imagery
- Communication protocols

Countermeasures for Exploration

Plant systems

Evaluation of behavioral responses to VEGGIE on ISS, and plant systems in pro-longed isolated, confined and extreme environments

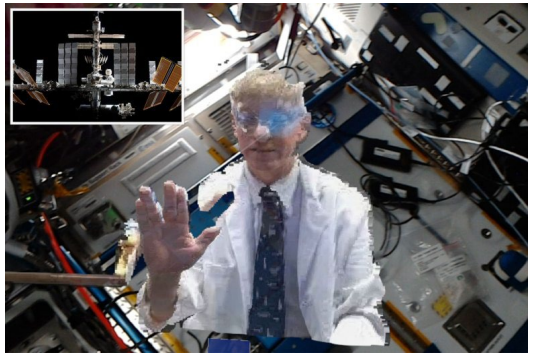
Assessment of greenhouse use in Antarctica (Neumayr Station)

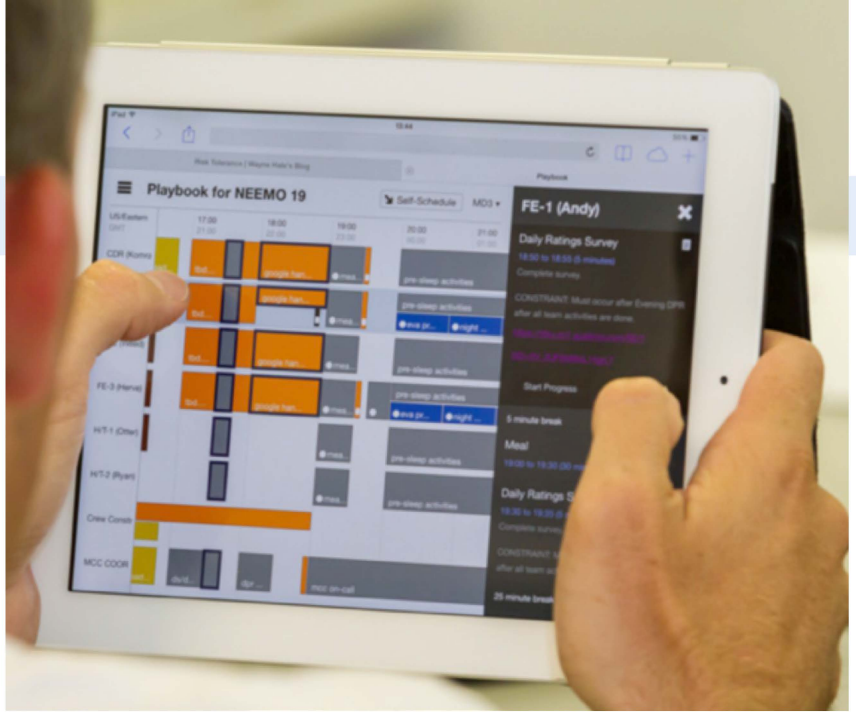
Massa et al. (in work)

Augmented and Virtual Reality

Testing as aid for operational tasks

VR as countermeasure for behavioral health




Playbook for NEEMO 19
FE-1 (Andy)
Daily Ratings Survey

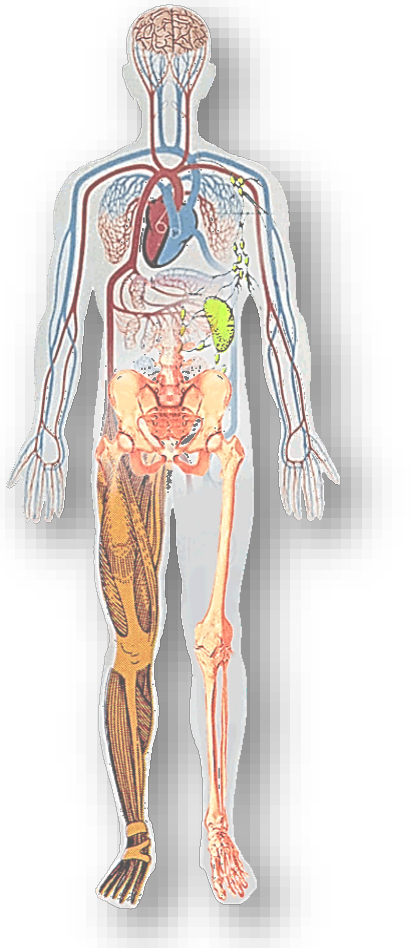

MADE IN SPACE
Cold Atom Lab


esa

Challenges: Hazards - Simultaneous

Altered Gravity

Distance from Earth



Space Radiation

Hostile/ Closed Environment

Isolation & Confinement

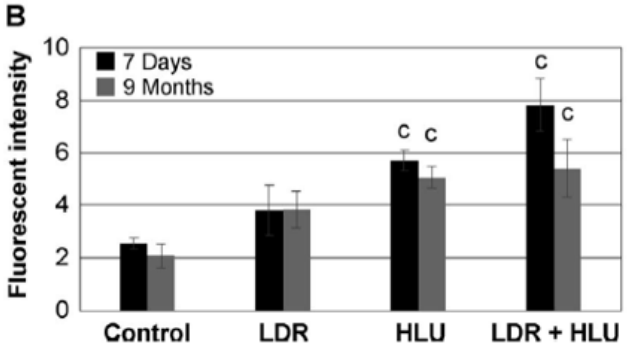
Challenges: Synergistic Effects

Stressors:

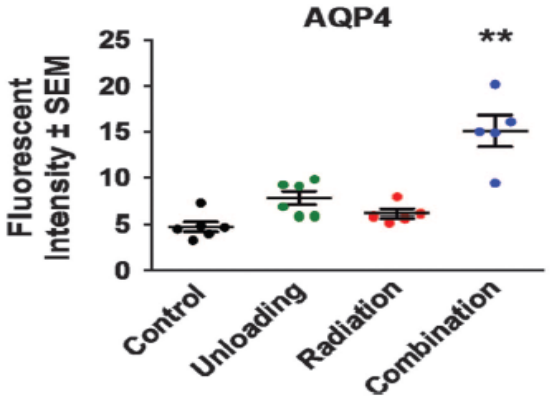
- Low dose gamma radiation (LDR) using a ^{57}Co source (0.01 cGy/h for a total dose of 0.04 Gy)
- Hindlimb unloading (HLU)
- Combination of both for 3 weeks

Measurements of LDR+ HLU Effects on:

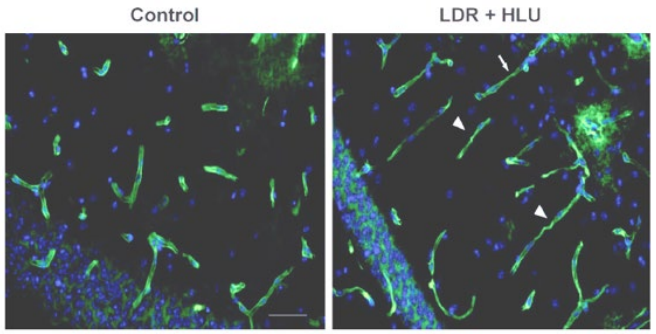
- Mouse Brain Oxidative Stress increases (4-HNE)
- Blood Brain Barrier modified (AQP4)
- Microvessel changes



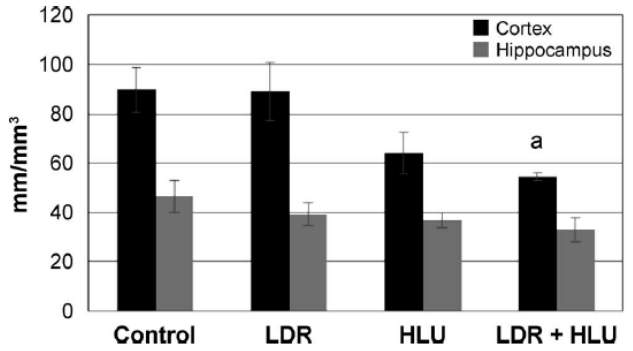
4-hydroxynonenal (4-HNE) staining in the hippocampus (panel B) at 7 days or 9 months.



Water transporter aquaporin 4, astrocyte foot / endothelium interface marker at 9 months.



Microvessel morphological changes in cortex at 9 months after combination treatment with LDR + HLU and in control.



Microvessel length density (mm/mm^3) in the cortex and hippocampus at 9 months.

Mao et al. (2016), Bellone et al. (2016)

Summary of Key Points

- There is a robust and effective psychological support system on the ISS
- Future exploration missions however will expose the crew to unprecedent hazards, included extended durations of isolation and confinement, distance from earth, galactic cosmic radiation
- Research in spaceflight and terrestrial analogs demonstrate that while most participants remain psychologically healthy and high performing, some risks do emerge, including declines in positive adaptation and emotion recognition
- We must understand and implement the right countermeasures to support the psychological health and performance in future exploration missions
- Future challenges include high fidelity research platforms and characterizing effects of multiple hazards