National Aeronautics and Space Administration

The Beyond Low Earth Orbit (BLEO) Instrumentation and Science Series

Jessica Audrey Lee
Matthew Lera

NASA Ames Research Center

ASGSR annual meeting
November 18, 2023

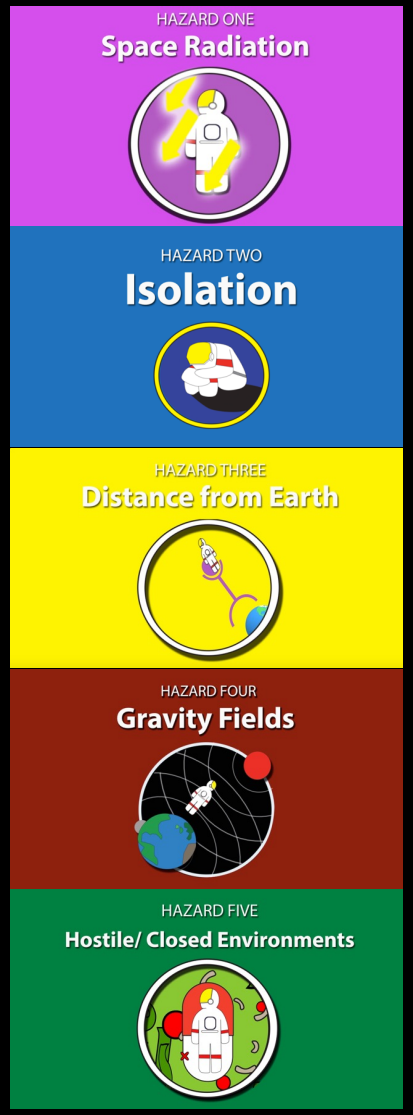
We are sending humans to the Moon...and beyond

But what do we know about how to help organisms thrive in deep space?

Most space biology research to date has been in **Low Earth Orbit** (Shuttle, ISS) or suborbital flight.

The space environment Beyond LEO is different

5 hazards of human spaceflight



Space radiation: different type and higher dose rates

Isolation and **distance from Earth** require developing greater self-sufficiency in food, life support, medicine

Gravity: not just microgravity, but also partial G on planetary surfaces

Planetary environments include challenges like dust / regolith

https://www.nasa.gov/hrp/5-hazards-of-human-spaceflight

Research Beyond LEO presents new challenges

Current BLEO platforms involve...

- **Longer payload integration / transit periods**
  → longer stasis periods for organisms
- **Lower mass/volume/data limits**
  → compact, efficient hardware
  → onboard data processing
- **Little / no crew time**
  → autonomous / passive hardware
- **Little / no sample return**
  → in situ measurement; assays that return only data

Luckily, ARC has strengths in all the right areas!
low-cost missions, biological cubesats, invertebrates and microbes, AI/ML

image credit: NASA

Thriving in Deep Space (TIDES)

Challenge:

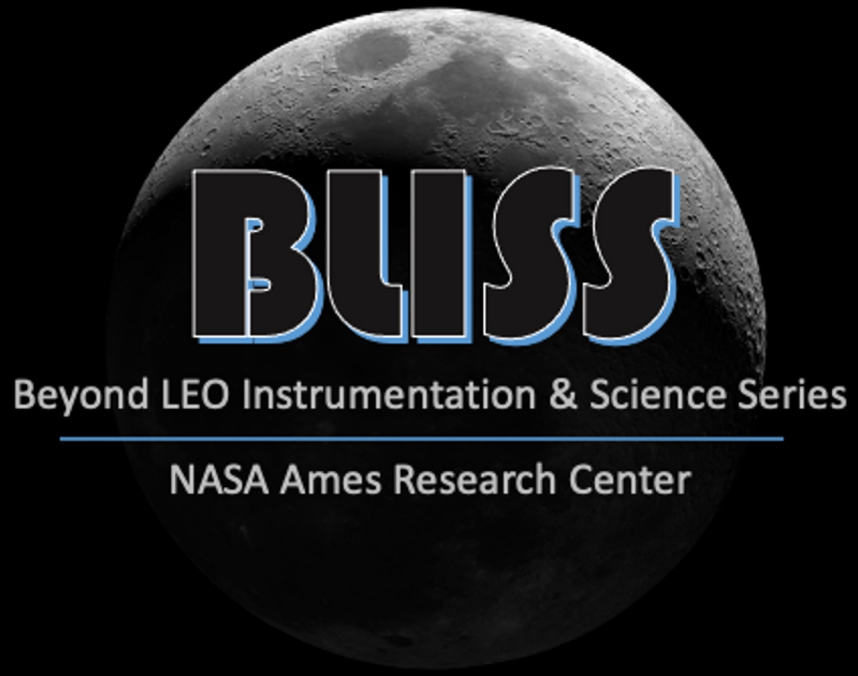
- Need robust prediction of biological responses to long-duration exposure to deep space to enable crew, plants, and microbiome to thrive in deep space exploration
- Combined effects of stressors (e.g., radiation, reduced gravity, elevated CO_2, circadian disruption) are unknown

Impact:

- Use of well-characterized biological models, from the simplest to more complex organisms, has been utilized to understand Earth-based biological processes and has led to several Nobel prizes. BPS needs to use a similar approach to understand the effects of the novel environment of deep space on crew, plants, and microbiome.
- Will provide mitigation methods for risks to crew health and performance; design guidance for plants and microbiome; biomarkers to monitor the health of crew, plants, and microbiome
- Will provide insight into development, aging, and disease mechanisms of interest to NIH, NSF, and biotechnology industry

- **Approach:**
  - Conduct a series of Earth-based, Low Earth orbit (LEO), and BLEO investigations
  - Omics and physiological data from cells, organs/tissues, and whole organisms will be compared within populations and across organisms to develop models that predict biological responses to long-duration exposure to deep space
  - Technology development for dosimetry, in flight radiation source and artificial gravity
- **Partners:**
  - NASA's HRP, STMD, and AES will benefit from mitigation methods, identification of biomarkers, and design guidance
  - Other govt agencies (NIH, NSF, DOD, DOE, etc.) are interested in how space explores the limits of biological systems
  - International partners share interest in the science and the potential to improve human health in space

BLISS Organization



ARC Space Biology Portfolio
Amy Gresser – Manager
Matthew Lera – Deputy Manager

BLISS
Jessica Lee – Manager
Scientist / Technologist TBD

Science Working Group
Jessica Lee/Matthew Lera

Mini-ECLSS
(Environmental Control & Life Support System)
Joint project with MSFC

Future BLEO Payload:
BLISS - 2

LEIA
Mark Settles/
Sergio Santa Maria – PIs
Dave Pletcher - PM

Research Pathfinder
Janani Iyer - PI
Kevin Martin - PM

BLISS Science Working Group

The voice of the scientific community for deep-space biology

SWG membership

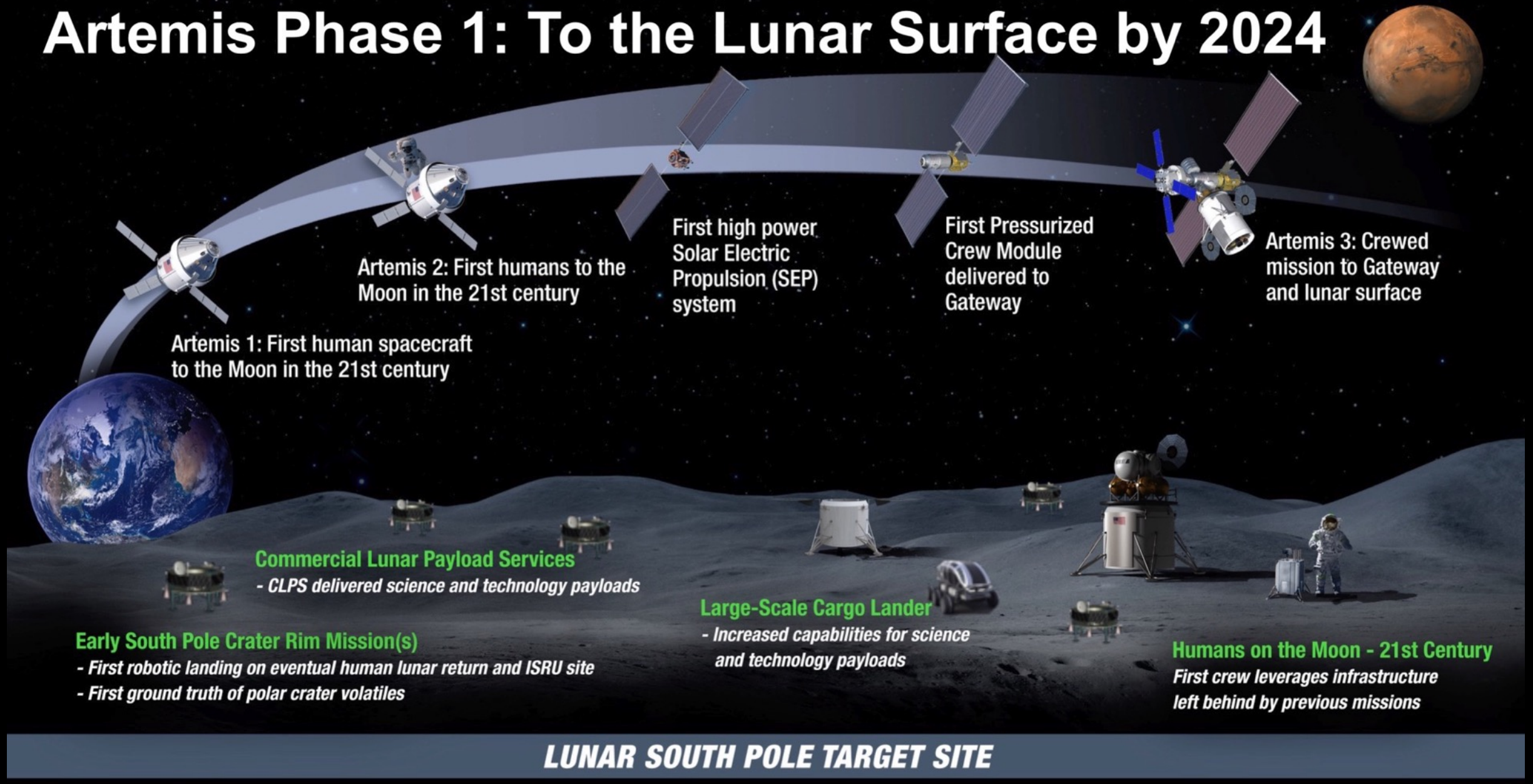
- Diverse members of the research community (19)
- Some NASA, mostly external
- Expertise in variety of model organisms, experimentation and instrumentation, research approaches, institution types, career stages
- Meet monthly: guest speakers, discussion, report writing

Annual Reports - *available online!*

- 2021: research & tech development areas for next 5 years
- 2022: 5-15 year timeframe; applications of AI/ML
- 2023 (in development): Enhancing the Payload Development Process for Lunar Gateway and Lunar Surface

https://ntrs.nasa.gov/citations/20210023324, https://ntrs.nasa.gov/citations/20230008417

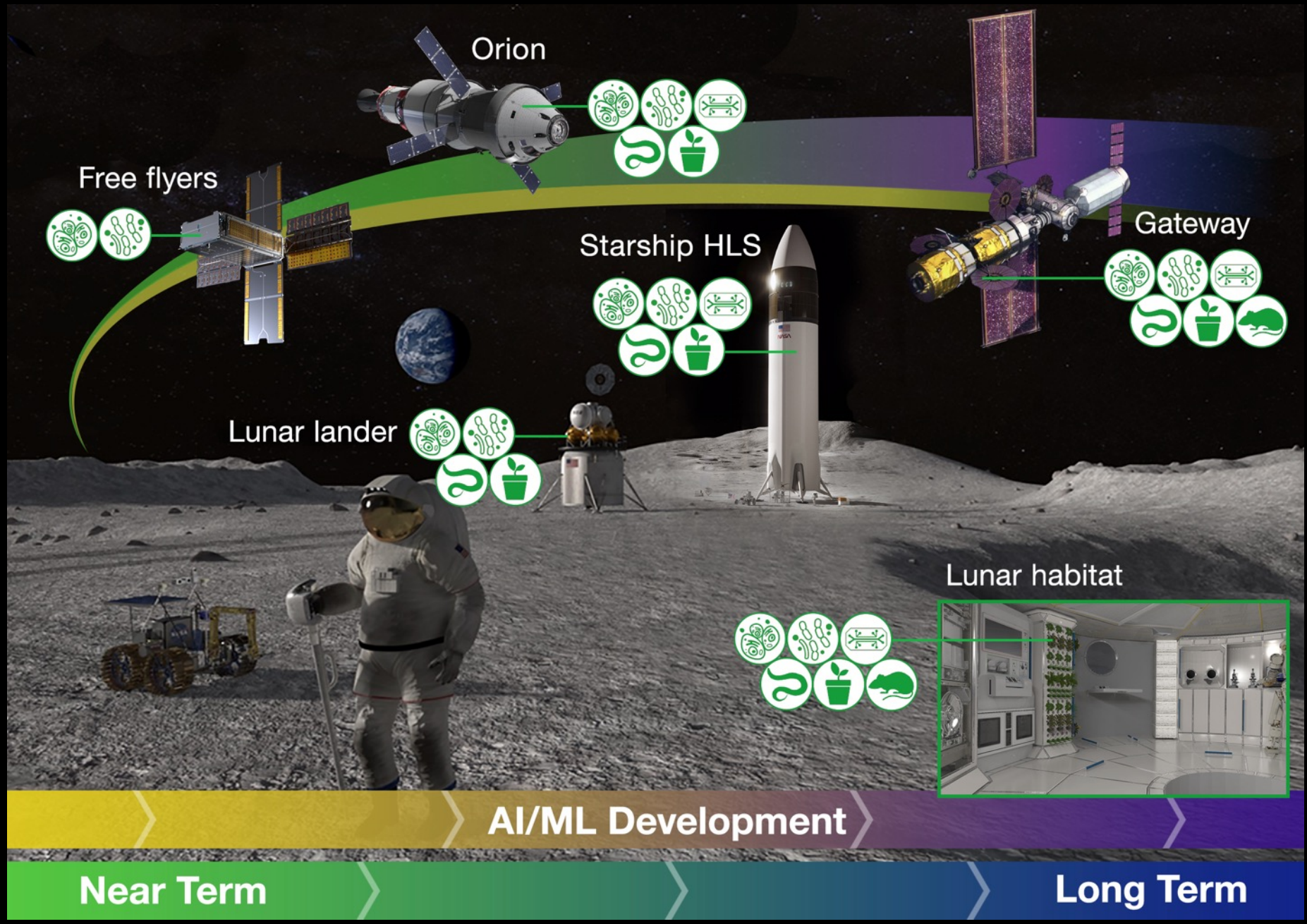
Artemis Phase 1: To the Lunar Surface by 2024



BLEO platforms will offer opportunities for biological payloads with increasing complexity

BLISS-SWG 2022 annual report

https://ntrs.nasa.gov/citations/20230008417



Lunar Explorer Instrument for space biology Applications

a South Pole Lunar surface investigation on Commercial Lunar Payload Services

Motivation.

- What are the radiation health risks for crewed exploration of the lunar surface?
- Will proposed mitigations for crew health using in-space biomanufacturing be effective beyond low Earth orbit?

Approach.

- Engineer yeast strains to test growth and metabolism for sensitivity to radiation.
- Measure biologically relevant radiation in transit and on the lunar surface.

Expected Outcomes and Impact.

- Determine cellular sensitivity to the lunar environment.
- Evaluate feasibility of bioproduction on the Moon.
- Test genetic strategies to enhance cellular tolerance to the lunar environment.
- Determine ground truth radiation risks for crew.

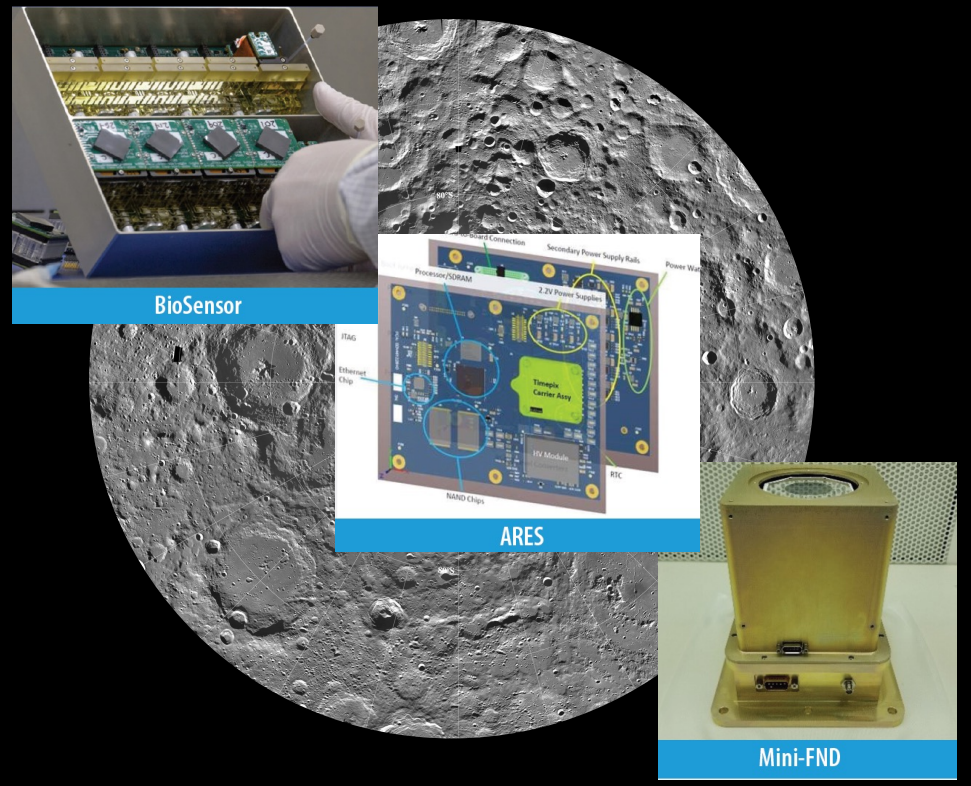


Image credits: NASA

Team: Dr. A. Mark Settles (PI), Dr. Sergio Santa Maria (Deputy PI), Dr. Donald M. Hassler (Co-I, SwRI), David Pletcher (PM), Leandro James (SE)

For more information: https://www.nasa.gov/ames/leia

Research Pathfinder for BLEO Space Biology Investigations

Two experiments with multicellular organisms
3-year grants from Space Biology - announced September 2023

1. Neurological, cardiac, and muscular consequences of the deep space environment in *Drosophila melanogaster*

PI: Janani Iyer

- Flown on ISS; internal to crewed habitat
- Utilizing hardware flown on multiple ISS missions
- Adapting experiment design to incorporate deep-space stressors (e.g. radiation)

2. Protection from Cosmic Radiation

PI: Timothy Hammond

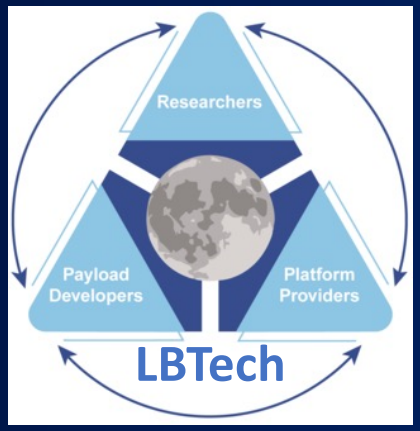
Ground study to develop automated instrumentation for nematode experiments

image credits: NASA

Other BLISS activities

Building research community

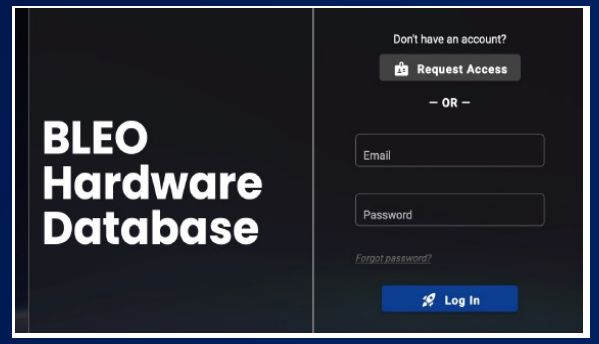
- 2022 Lunar Biology Technology (LBTech) virtual conference
- This session at ASGSR!



https://cms.nasa.gov/ames/research/space-biosciences/BLISS/LBTech

Generating resources for future missions

- Mini-ECLSS habitat study (with MSFC)
  Concept for a multi-organism (tissue chips & plants) habitat
- BLEO open hardware database



Are you interested in contributing? Get in touch after this session!

Thank you!

BLISS-SWG members past and present
Lynn Harrison (chair, 2020-2022)
Luis Zea (deputy chair, 2020-2021)
Chris Carr (chair, 2023-present)
Candice Tahimic (deputy chair, 2023-present)
Liz Blaber
Thomas Boothby
Melanie Correll
Craig Everroad
Jamie Foster
Jon Galazka
Simon Gilroy
Janet Jansson
Cheryl Nickerson
C. Mark Ott
Imara Perera
Tony Ricco
Lauren Sanders
Stephanie Smith
Nate Szewczyk
Paul Todd
Siva Vanapalli
Ye Zhang
Marinka Zitnik

The BioSentinel team

The NASA Exploration Science Strategy Integration Office (ESSIO)

The NASA Division of Biological and Physical Sciences (BPS)

image credit: NASA