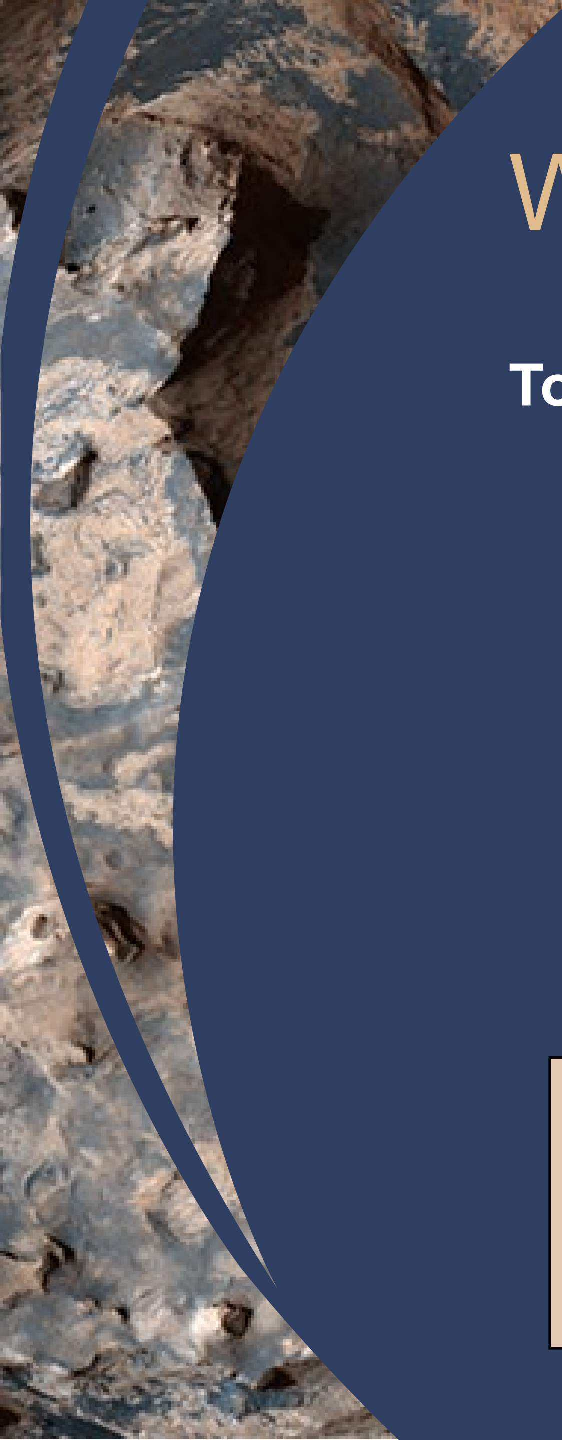
Science and Planetary Protection in Advance of Human Missions Seminar/Workshop - Outbrief and Next Steps

NASEM Committee on A Science Strategy for the Human Exploration of Mars Meeting

December 18, 2024

Science Organizing Committee:

Nick Benardini, NASA HQ, Office of Planetary Protection
Sarah Johnson, Georgetown University, MEPAG and NfoLD
Erin Lalime, NASA HQ, Office of Planetary Protection
*Becky McCauley Rench, NASA HQ, Mars Exploration /Astrobiology Program
Lane Painter, NASA HQ, Mars Exploration Program
David Smith, NASA HQ, Planetary Protection Research Program
*Andy Spry, BQMI
Mary Beth Wilhelm, NASA Ames Research Center
Kennda Lynch, NASA HQ, ESSIO

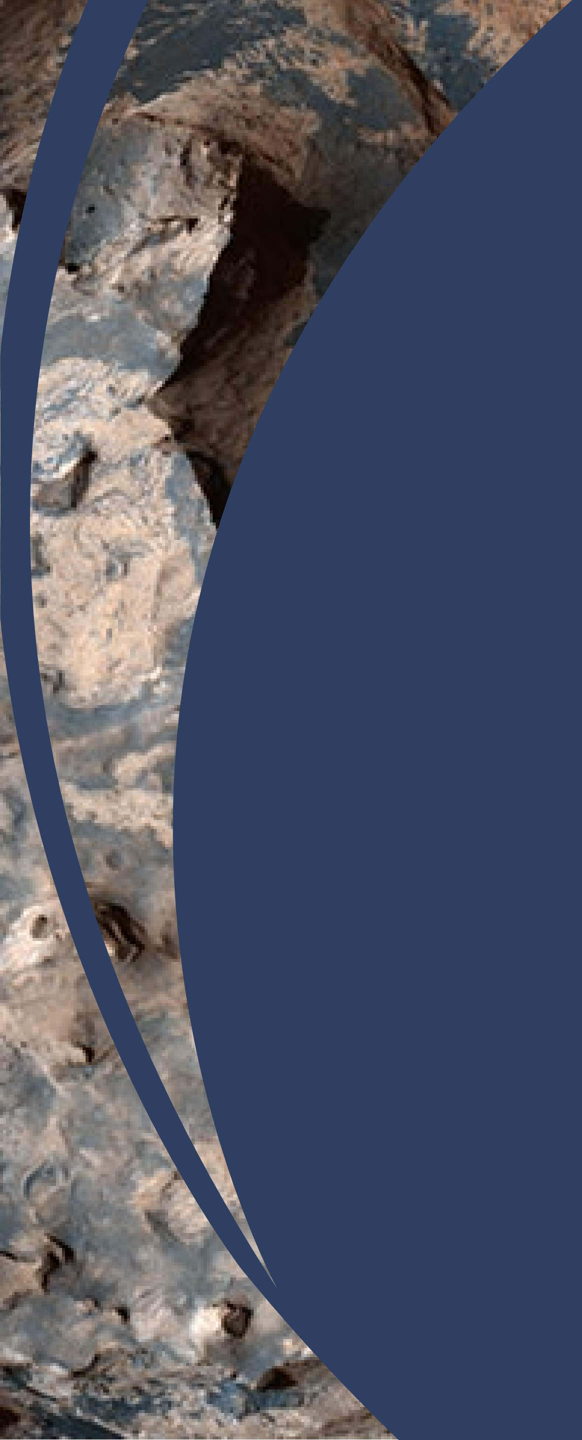


Workshop Goals

Topic: Science and Planetary Protection in Advance of Human Missions

1. Identify science priorities for robotic missions in advance of humans arriving on Mars
2. Inform development of planetary protection guidelines for crewed missions to Mars
3. Develop a framework for how forward and backward contamination control be incorporated into human elements for Mars research activities

Generate referenceable workshop report completed in time to be available to NASEM Committee on *A Science Strategy for the Human Exploration of Mars*



Interdisciplinary Approach

Science Organizing Committee

Nick Benardini, NASA HQ, Office of Planetary Protection
Sarah Johnson, Georgetown University, MEPAG and NfoLD
Erin Lalime, NASA HQ, Office of Planetary Protection
Becky McCauley Rench, NASA HQ, Mars Exploration Program/Astrobiology Program
Lane Painter, NASA HQ, Mars Exploration Program
David Smith, NASA HQ, Planetary Protection Research Program
Andy Spry, BQMI
Mary Beth Wilhelm, NASA Ames Research Center
Bob Collom, NASA HQ, SMD Policy
Kennda Lynch, NASA HQ, ESSIO

Sponsoring Organizations

Office of Planetary Protection,
Mars Exploration Program,
Mars Exploration Program Analysis Group (MEPAG),
Astrobiology Program, &
NfoLD (an Astrobiology Research Coordination Network)

SCIENCE MISSION DIRECTORATE

SCIENCE AND PLANETARY PROTECTION IN ADVANCE OF HUMAN MISSIONS

Seminar - Jul 31 and Aug. 1, 2024

- 4-hours / day across 2 days
  - 20 min “briefing” talks, followed by
  - ~1.5h breakout session; ~30min report outs from each breakout group
- Topics included
  - Overview of Planetary Protection, MEPAG Goals, NASEM Science Objectives for Human Surface Missions
  - Microbial survivability on Mars
  - Transport on Mars
  - Target locations for the search for life
  - Potential human impacts to Mars
  - Tools and Operations to Monitor Human Health and Impacts

Workshop - Oct 30 – Nov 1, 2024

- 4-hours / day across 3 days
  - 3 sessions; ~1hr long of 20 min talks based on abstracts submitted
  - 3 panels; ~1 hr long panel discussion, with Q&A from audience on a topic based on abstracts submitted
  - Scenario Exercise; ~1.5hr all participants discuss a crew mission scenario in breakouts, and ~2h of report outs from each breakout group with large group discussion
- Topics included
  - Life detection in the context of Planetary Protection
  - Analogue environments and future exploration
  - Mars environments and terrestrial biology
  - Risk mitigation for Planetary Protection
  - Instrument and technology development
  - Science investigations prior to crew
  - An astronaut reality check

Seminar

Jul 31 and Aug. 1, 2024

First seminar in MSSW series, “Science and Planetary Protection in Advance of Human Missions”

July 31 and Aug. 1, 2024

Brainstorming Session(s) and Key Questions

- What are the priority knowledge gaps in our understanding of survival of terrestrial microbes, building on the existing literature (Final Report of the COSPAR Planetary Protection Knowledge Gaps for Human Mars Missions Workshop Series and Paths to Knowledge Gap Closure).
- What measurements do we want to prioritize and what research can we conduct in advance of human arrival on Mars to ensure future science integrity?
- What tools (incl. crew-robot interface) could crew utilize on the surface to preserve scientific integrity of samples?
- What aspects of guidance for crewed science missions could use further discussion, are missing, and/or work well?
- What are the prioritized science tasks to achieve before humans arrive?
- What scientific research is desired to be conducted before humans arrive and will it inform the activities of the human explorers once they are on the surface?
- What research will the crew themselves be doing, and how will forward and backward contamination control be incorporated into those research (e.g. science and engineering) activities?

Seminar Participant Poll

- Are there precursor planetary protection and/or science investigations necessary in advance of human exploration?
  - 86% answered “absolutely”
- Are the current planetary protection standards and guidelines sufficient for human exploration?
  - 79% answered between “getting there” and “need major revision”

SCIENCE MISSION DIRECTORATE

SCIENCE AND PLANETARY PROTECTION IN ADVANCE OF HUMAN MISSIONS

Seminar Key Questions

- What are the priority knowledge gaps in our understanding of survival of terrestrial microbes, building on the existing literature (Final Report of the COSPAR Planetary Protection Knowledge Gaps for Human Mars Missions Workshop Series and Paths to Knowledge Gap Closure)?
- What measurements do we want to prioritize and what research can we conduct in advance of human arrival on Mars to ensure future science integrity?
- What tools (incl. crew-robot interface) could crew utilize on the surface to preserve scientific integrity of samples?
- What aspects of guidance for crewed science missions could use further discussion, are missing, and/or work well?
- What are the prioritized science tasks to achieve before humans arrive?
- What scientific research is desired to be conducted before humans arrive and will it inform the activities of the human explorers once they are on the surface?
- What research will the crew themselves be doing, and how will forward and backward contamination control be incorporated into those research (e.g., science and engineering) activities?

Science Seminar Key Takeaways

- **Understanding the survival of terrestrial microbes under Martian conditions:** This includes studying a wider range of organisms, focusing on extremophiles, and understanding the effects of Martian environmental factors on microbial survival.
- **Developing robust sample collection and analysis methods**: This includes minimizing contamination from humans and spacecraft, using sterile tools, and developing efficient and effective decontamination procedures.
- **Prioritizing research before human arrival:** This includes conducting detailed surveys of potential landing sites, studying the survival of microbes in unique environments, and developing models to predict the spread of contamination.
- **Creating a framework for collaboration and interdisciplinary work:** This includes sharing knowledge across different fields, such as astrobiology, life support, and planetary protection, to develop more comprehensive solutions for future missions.

Workshop

Oct 30 – Nov 1, 2024

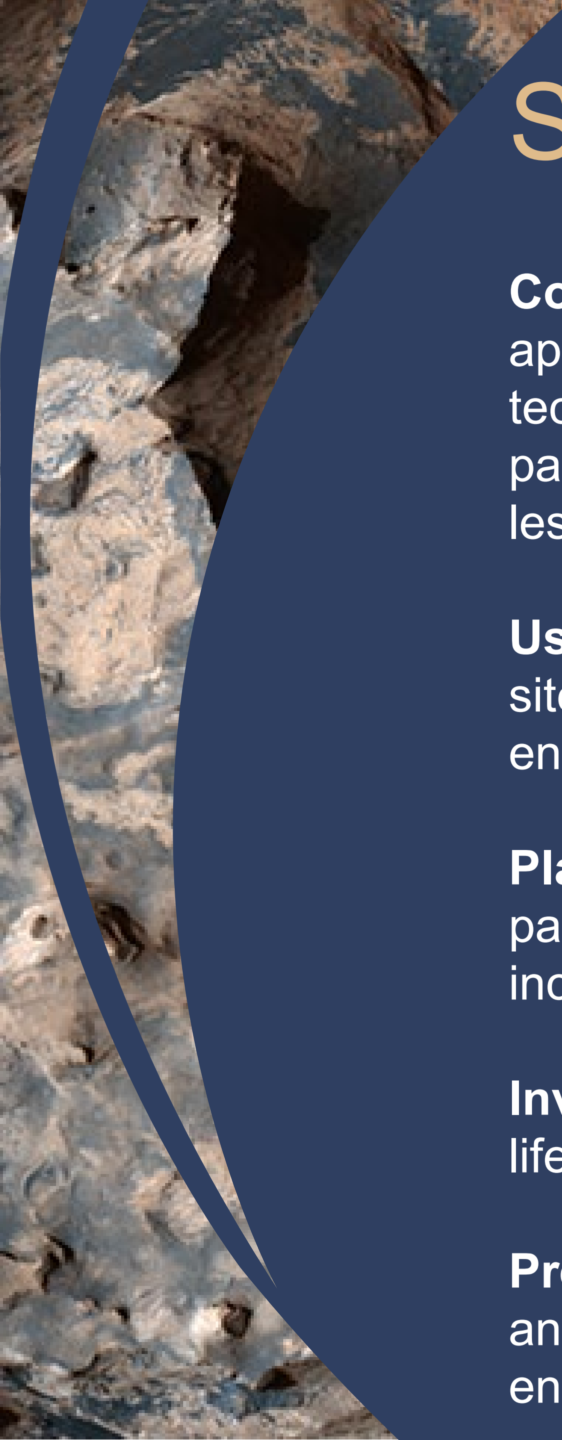
SCIENCE MISSION DIRECTORATE

SCIENCE AND PLANETARY PROTECTION IN ADVANCE OF HUMAN MISSIONS

Brainstorming Session(s) and Key Questions

- Are there key analogue environments that we should be focusing on to help drive decision making?
- What analogue extreme environmental variables would you consider and why? Is there a “must-have”?
- What are the key technology development needs that we need to enable key measurements before humans arrive? (Should be achievable and realistic in the next 5 years etc...)
- If you had to choose 1-3 technology developments in the near-term, what would they be? What about the longer-term?
- What’s your “non-starter”, we must understand “this” science before we send humans, and why?
- How would you delineate the line between robotic and crew activities? Are there specific activities that you would bin one way or another?
- With MEPAG Goals (from Goals Documents) in mind, what investigations/science campaigns would you conduct on a first crewed Mars mission? What does this campaign need to look like (recon., early experiments, EVAs, returned samples)?
- What does planning the crewed mission science reveal about what is needed from earlier robotic missions?

**Note: Key takeaways based on AI summary of breakout notes and human-created content



Science Workshop Key Takeaways

Collaboration and Communication Across Disciplines: Need for a multi-faceted approach to Mars exploration, integrating geology, biology, human factors, and technological advancements. Collaboration among scientists, engineers, and industry partners to address the complex challenges of human exploration, including building on lessons learned from past missions.

Use of Analog Sites: Need to better understand how the limitations of individual analog sites can be shored up by lab analogs, modeling, or by the broader selection of analog environments on Earth and beyond.

Planetary Protection as a Priority: Science-led planetary protection protocols are paramount to protect both the Martian environment (of which its biological potential is still inconclusively studied) and Earth from potential contamination.

Investing in Technology: Develop advanced technologies, particularly in the areas of life detection, sample return, and robotic capabilities.

Preparing for Human Presence: Understand human adaptation to Martian conditions and mitigating risks to human health and safety, as well as human impacts to the Mars environment.

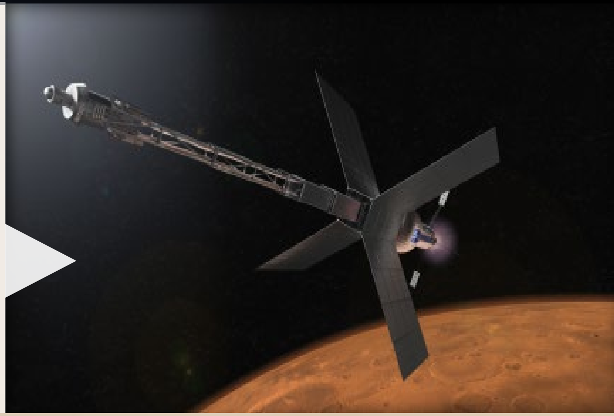
Scenario Exercise

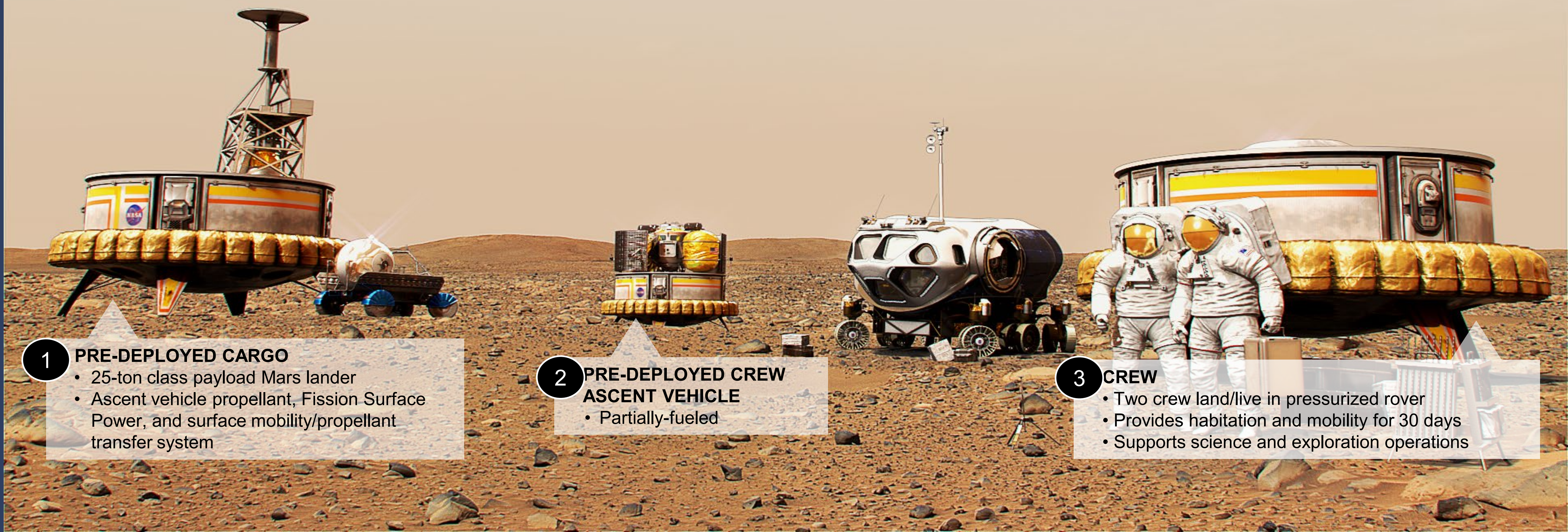
Scenario Exercise Guidelines

- Target landing site is at Jezero Crater; no ISRU requirements
- A Zone of Minimum Biological Risk (ZMBR) is established where crew have no PP-based operational constraints
- Three science sorties of 5 days each, are planned beyond the limit of the ZMBR.
- A notional 8hr science workday, which includes EVAs (max 16)
- COSPAR guidelines for crewed missions continue apply

TRANSIT HABITAT (TH) AND HYBRID NUCLEAR ELECTRIC PROPULSION (NEP) / CHEMICAL STAGE

- Supports four crew on the transit to Mars
- Two crew remain in orbit while two crew visit the Mars surface





1 **PRE-DEPLOYED CARGO**

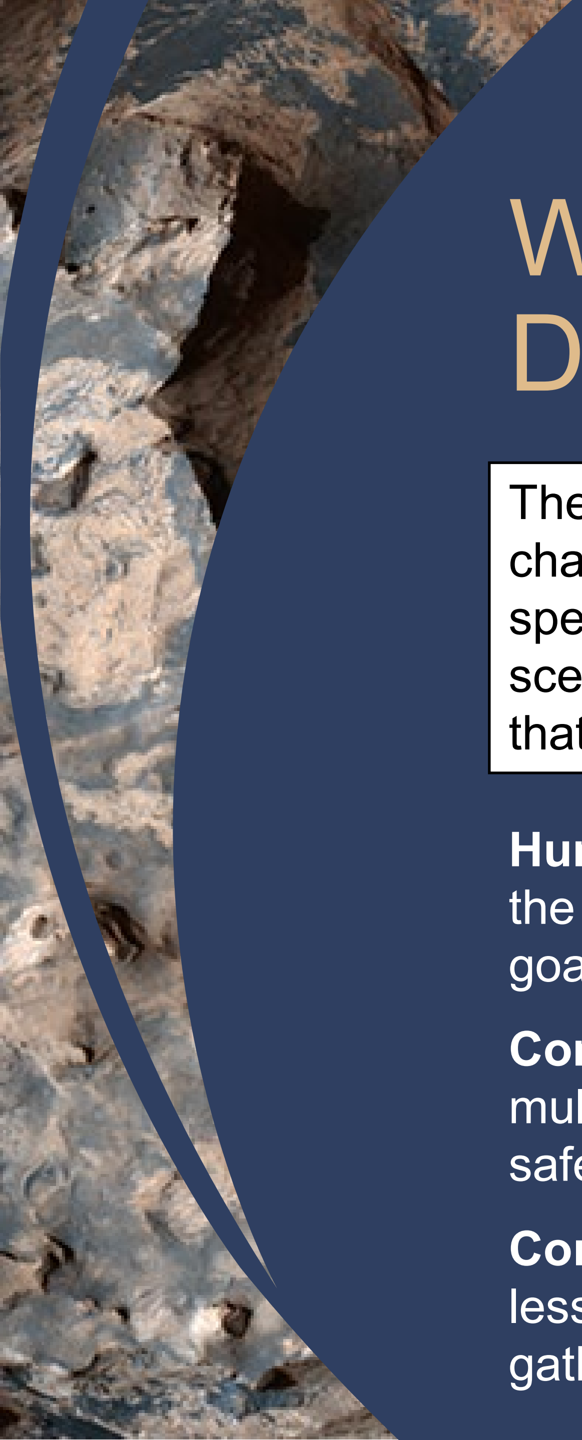
- 25-ton class payload Mars lander
- Ascent vehicle propellant, Fission Surface Power, and surface mobility/propellant transfer system

2 **PRE-DEPLOYED CREW ASCENT VEHICLE**

- Partially-fueled

3 **CREW**

- Two crew land/live in pressurized rover
- Provides habitation and mobility for 30 days
- Supports science and exploration operations



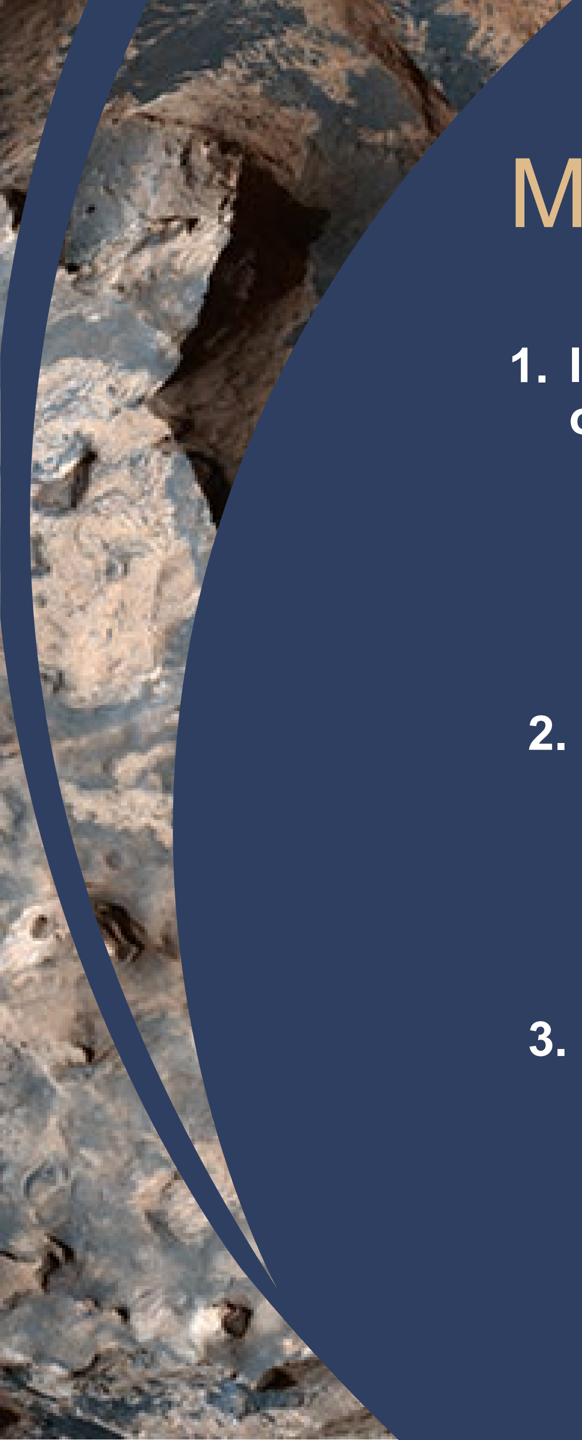
Workshop Key Scenario Exercise Discussion

The breakout rooms engaged in a lively discussion about the scientific goals, logistical challenges, and critical considerations for a first crewed mission to Mars, at the specified target, Jezero Crater. While each room explored different aspects of the scenario, a common thread emerged: the need for a balanced, multi-faceted approach that balances science, technology, and human factors.

Human-Robot Collaboration: The discussion demonstrated a strong appreciation for the unique combination of human ingenuity and robotic capabilities for achieving scientific goals on Mars.

Comprehensive Planning: Successful mission planning requires a multidisciplinary approach, integrating scientific objectives, technology development, crew safety, and planetary protection protocols.

Continuous Learning and Adaptation: Future missions to Mars will benefit from the lessons learned from the first crewed mission, requiring a constant cycle of data gathering, analysis, and adaptation.

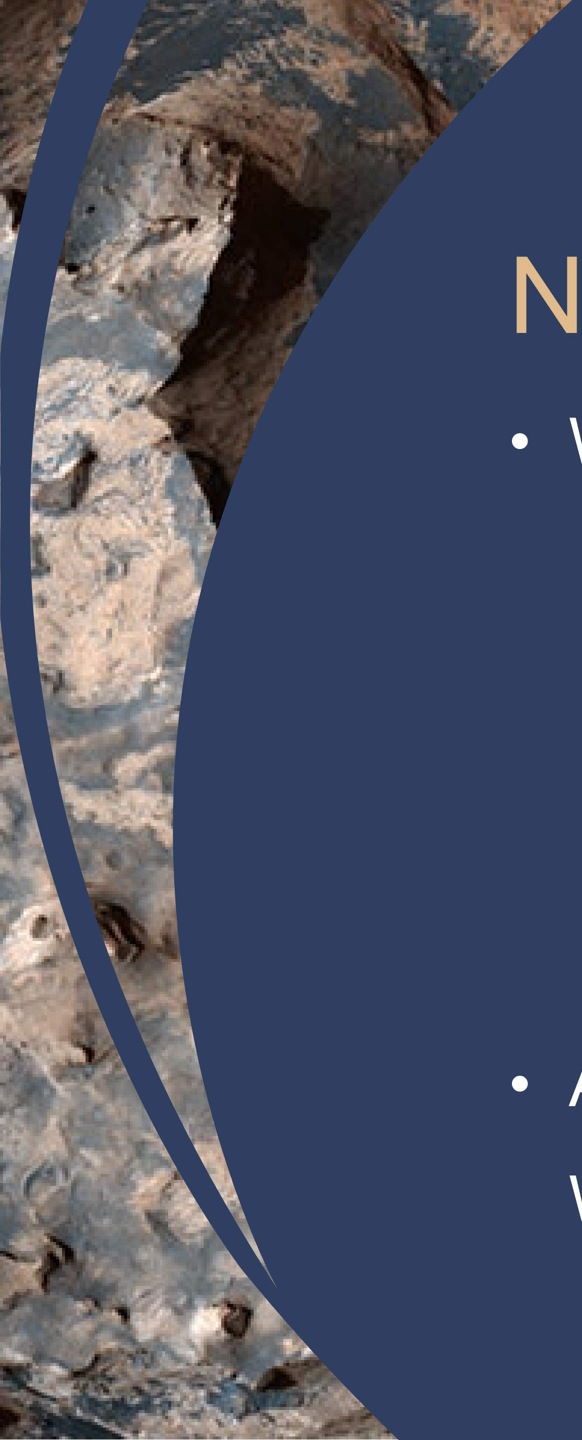


Meeting the Initial Goals of the Workshop

1. **Identify science priorities for robotic missions in advance of humans arriving on Mars**
   - understanding life at Mars through Mars missions and research on Earth
   - monitoring surface weather at Mars to better understand dust movement and weather patterns to inform transport models for Forward PP/Contamination

2. **Inform development of planetary protection guidelines for crewed missions to Mars**
   - leverage past missions to understand future PP requirements
   - monitor and study of human microbiome

3. **Develop a framework for how forward and backward contamination control can be incorporated into human elements for Mars research activities**
   - approach to developing PP must be science-led (and not just planetary science led, but all science including virology and evolutionary expertise that can weigh in on the actual risks of Mars-sourced biology on Earth-biology and ecological impact)

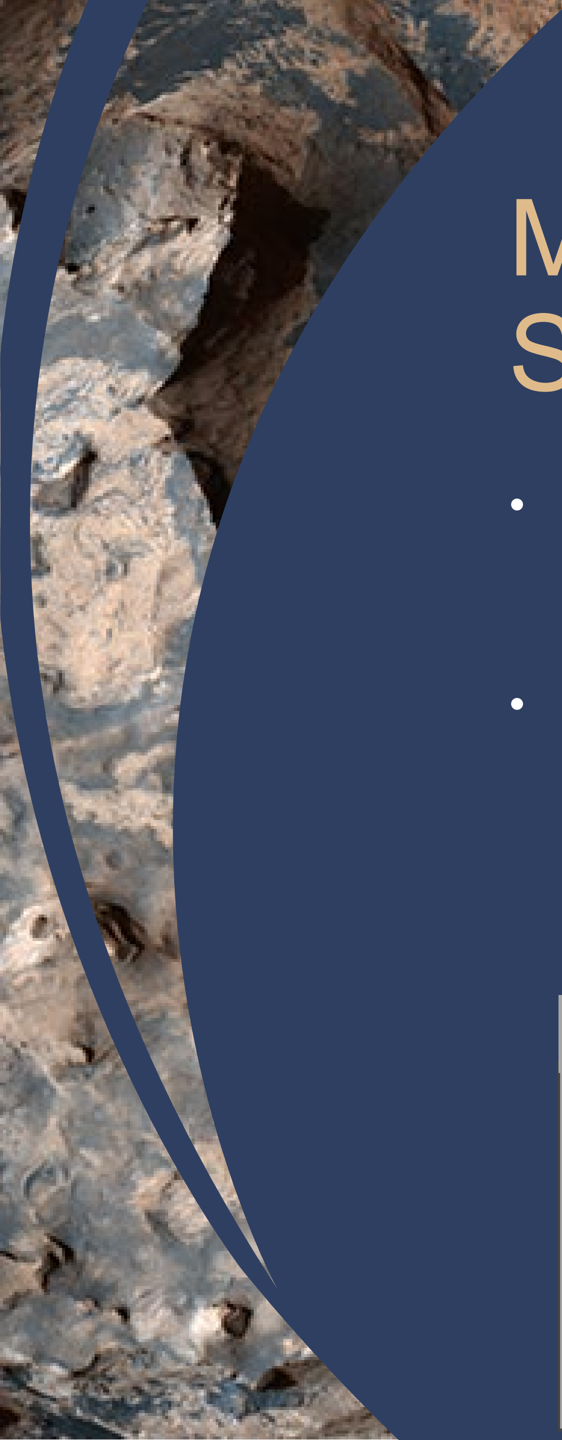


Next Steps

- Workshop Series Report
  - Winter 2025 - NASA Technical Reports Server
    - Delivery and coordination with NASEM Science Objectives for Human Surface Missions Study Committee
  - Summer 2025 - Peer-reviewed Journal Workshop Report
- Additional future workshops in the Mars Surface Science Workshop Series
  - https://science.nasa.gov/planetary-science/resources/documents/mars-surface-science-workshops/

Questions?

Backup

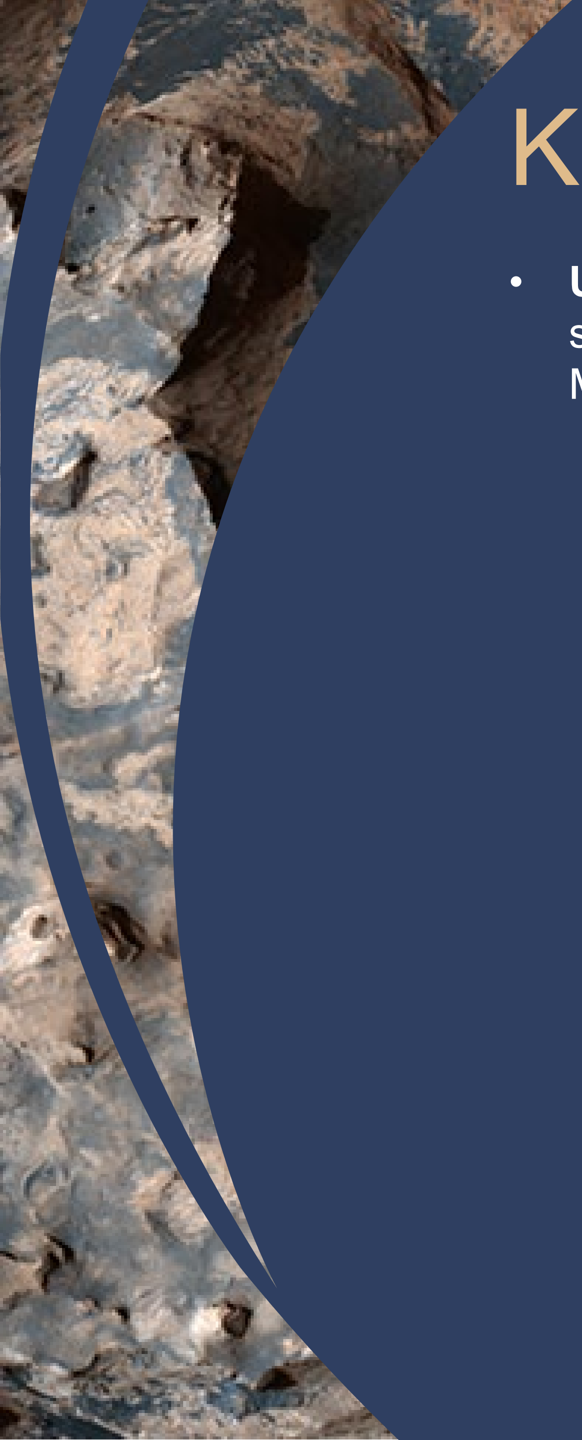


Mars Surface Science Workshop Series

- Modeled similar to the Lunar Surface Science Workshops (LSSW), these workshops are an opportunity for community engagement and knowledge gathering in preparation for crew surface science activities at Mars.
- Conveners for the workshop series include
  - NASA's Mars Exploration Program (MEP),
  - NASA's Exploration Exploration Science Strategy and Integration Office (ESSIO), and
  - the community-led Mars Exploration Program Analysis Group (MEPAG)

Potential Future topics could include:

Subsurface Access & Caves
Science Enabled by the Mars Base Camp
Orbital Observation Science
Geologic Maps for Strategic Decisions
Defining a Coordinated Martian Resource Evaluation Campaign
Assessing the Value of Modern Field Geology Tools
Heliophysics Applications Enabling and Enabled by Human Exploration of the Mars System
Inclusive Martian Exploration
Landing Sites and Capabilities for Future Small Mars Missions
Fundamental and Applied Martian Surface Research in Physical Sciences
Structuring Real-Time Science
Foundational Data Products
Mars Surface Mobility
Samples
Volatiles
Tools and Instruments



Key Takeaways - Seminar

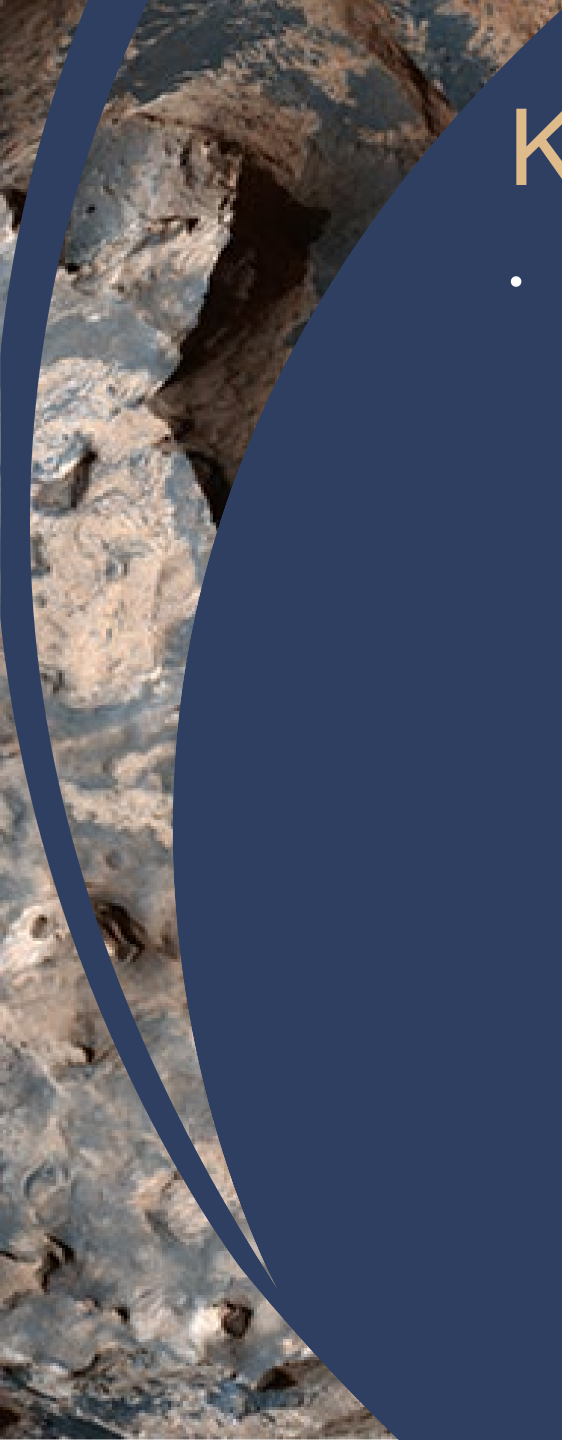
- **Understanding the survival of terrestrial microbes under Martian conditions:** This includes studying a wider range of organisms, focusing on extremophiles, and understanding the effects of Martian environmental factors on microbial survival. Proposals included:
  - Database of terrestrial biosignatures
  - Search for extant life before humans arrive
  - Investigations into survivability across a variety of environments (near habitable volumes, on the surface, in the subsurface)
  - Establish a clear timeline for the search for life on Mars, with a defined "period of biological exploration" before human arrival
  - Conduct a thorough search for extant life, including using penetrators and advanced imaging techniques
  - Develop a "life heat map" to identify areas with a high likelihood of harboring life that should be kept pristine from human contamination
  - Potential for microbial evolution and adaptation to the Martian environment

**Note: Key takeaways based on AI summary of breakout notes and human-created content

Key Takeaways - Seminar

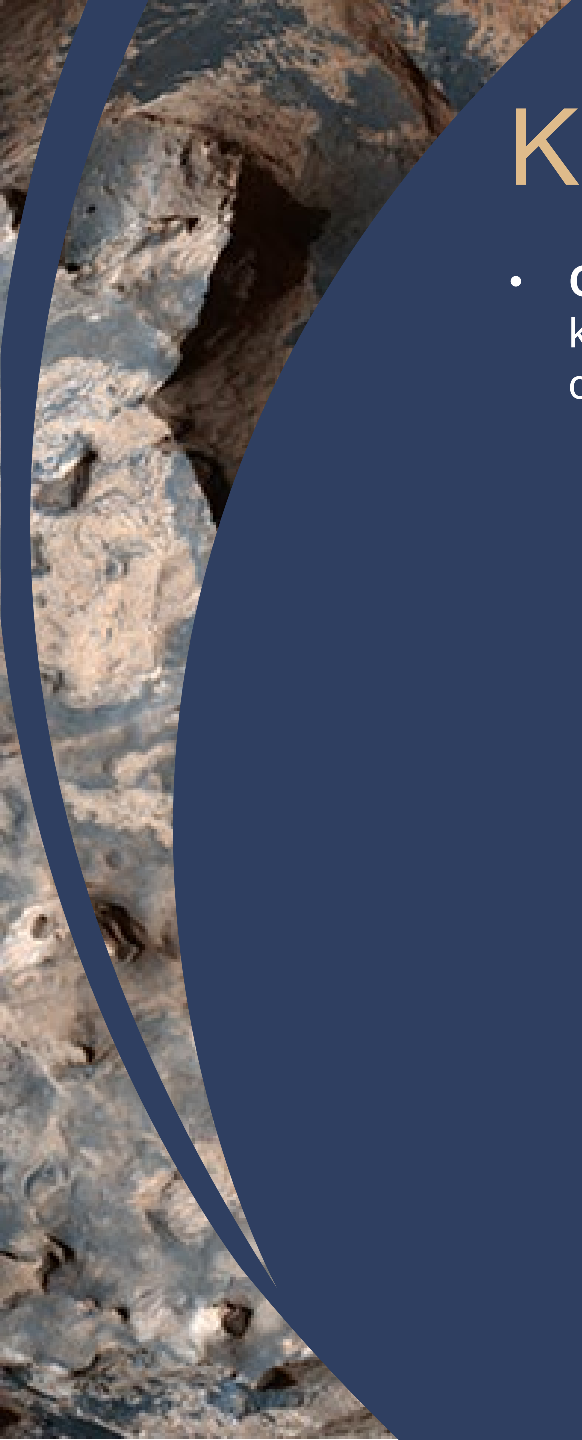
- **Developing robust sample collection and analysis methods**: This includes minimizing contamination from humans and spacecraft, using sterile tools, and developing efficient and effective decontamination procedures.
  - Volatile oxidants may play a role in lethality to terrestrial organisms (as well as solar uv, etc.)
  - More to understand about human commensals and survival
  - Reusable sterilization tools are critical for proper sample collection and handling
  - Sustainability in the tools and consumables is key to make sure the crew can repeat their strategies
  - MinIon is an important tool/capability for in-situ organism identification
  - Maybe we should divide samples into 1) samples exposed to and assessed (upgraded/selected) by humans and 2) samples collected under pristine conditions
  - Acceptable contamination and science goals are going to change over time as mission objectives and capabilities change
  - Measurements for planetary protection (safety) and science are synergistic
  - The Moon can be used as a testbed for some aspects of human exploration and contamination control
  - Development of hand-held instruments that humans can use for in-situ analyses is essential

**Note: Key takeaways based on AI summary of breakout notes and human-created content



Key Takeaways - Seminar

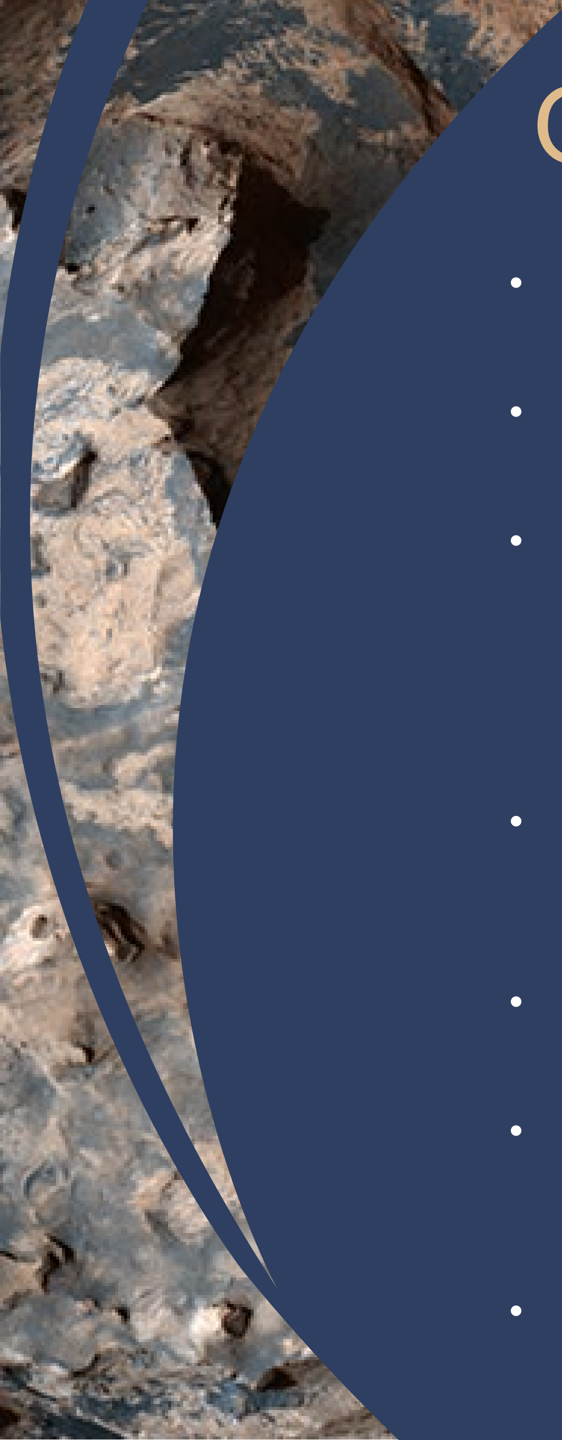
- **Prioritizing research before human arrival:** This includes conducting detailed surveys of potential landing sites, studying the survival of microbes in unique environments, and developing models to predict the spread of contamination.
  - Protection standards may depend on the location
  - Ice sites or lava tubes may have greater potential for life, which makes them both more enticing and more risky from a contamination perspective
  - How do we decide what to assess in-situ and what to bring back (surface instrument capabilities)?
  - We need to characterize the Martian atmosphere and weather (surface measurements needed) to understand contamination transport
  - We need to map Martian ice deposits to understand habitability and ISRU potential
  - The bioburden of a human mission needs to be characterized, including the microbes present in the habitat, suits, and other equipment
  - Not everything needs to be primarily a science payload/mission to inform science objectives (e.g. landed assets needed to supply human explorers also provide data)
  - More detailed procedures are needed for exploring “Special Regions" on Mars, including protocols for contamination prevention
  - Clear guidance on energy needs and mass limitations is needed for science on crewed missions
  - There is potentially a role for “Exploration Zones” in mitigating contamination risks
  - Research on human health and performance in the Martian environment, particularly regarding isolation and microbiome changes



**Note: Key takeaways based on AI summary of breakout notes and human-created content

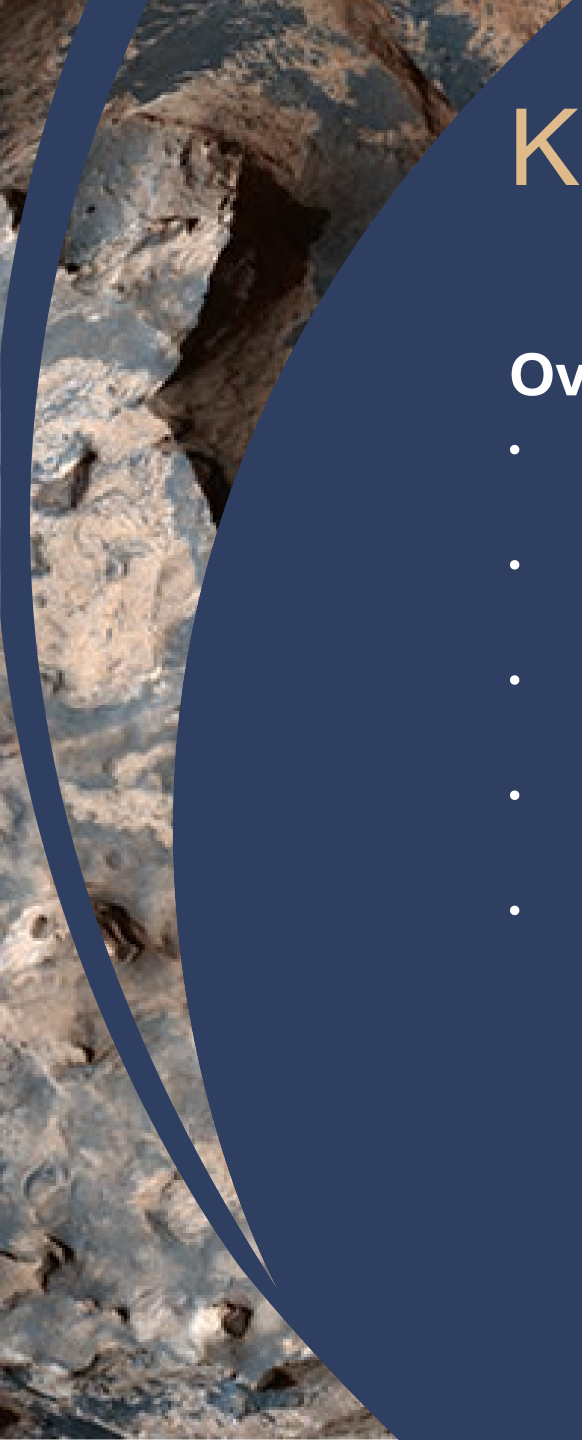
Key Takeaways - Seminar

- **Creating a framework for collaboration and interdisciplinary work:** This includes sharing knowledge across different fields, such as astrobiology, life support, and planetary protection, to develop more comprehensive solutions for future missions.
  - Strategies for reducing bioburden - either further than existing methods or with less resource intensive methods - will be key
  - Human (deep) drilling has the potential to introduce contamination into a habitable environment
  - Astronauts will be involved in collecting samples, conducting in-situ analyses, and maintaining records of sample integrity
  - Focus needs to be maintained on managing forward and backward contamination control during pristine sample collection, handling, and analysis
  - Protocols for crew health monitoring, including microbiome analysis, are needed
  - Astronauts will need to be trained in the proper use of instruments, tools, and sample manipulation procedures
  - Robust archiving system to preserve a sample subset until advanced detection methods are developed (cf Apollo)
  - The community is not just interested in the science objectives themselves, but also the operations (e.g. how to interact with Special Regions) and technologies (e.g. consumables for sample collection) that will be used to achieve them
  - The international effort for Mars exploration should consider the phasing of precursor missions and the need for international collaboration



Open Questions - Seminar

- Who has the authority to oversee the activities of non-governmental actors at Mars? What guidelines are they operating under?
- What is the relationship between protection, preservation, and ethical concerns for Mars? What opportunities will the community have to weigh in on each?
- What brine environments are likely to be found on Mars? How habitable are these environments for either terrestrial or martian life?
  - Potential Forward work: Characterize the potential brine environments in order to expand understanding of potential habitable environments (for forward-contaminating and potential backward-contaminating organisms).
- To what extent can the survival and growth of uncultivable terrestrial microbes on Mars be estimated? To what extent do these parameters (survival and growth) differ when we talk about individual microbes versus complex microbial communities?
- Is it possible for Mars surface crew to operate without compromising science integrity or contamination? What human/robotic interfaces could enable pristine science operations?
- How habitable is the environment on and near human surface assets (suits, rovers, habitats)? How does that habitability persist and change over time and through different environmental conditions?
- What happens if we find extant life on Mars? How does the discovery impact our broad strategy and equipment?



**Note: Key takeaways based on AI summary of breakout notes and human-created content

Key Takeaways - Workshop

Overall

- **Multi-faceted Approach:** Need for a multi-faceted approach to Mars exploration, integrating geology, biology, human factors, and technological advancements.
- **Collaboration and Communication:** Collaboration among scientists, engineers, and industry partners to address the complex challenges of human exploration.
- **Planetary Protection as a Priority:** Planetary protection protocols are paramount to protect both the Martian environment and Earth from potential contamination.
- **Investing in Technology:** Develop advanced technologies, particularly in the areas of life detection, sample return, and robotic capabilities.
- **Preparing for Human Presence:** Understand human adaptation to Martian conditions and mitigating risks to human health and safety.

**Note: Key discussion based on AI summary of notes and human-created content

Key Discussion - Workshop

Life Detection and Planetary Protection (presentations):

- Challenge of finding signs of life on Mars while ensuring forward and backward contamination control.
- Experts discussed the need to move beyond binary "life/no life" thinking and adopt a spectrum approach to better understand potential Martian biospheres.
- The importance of understanding the biocidal effects of the Martian environment and the potential for human-introduced microbes to survive and evolve.

Analog Sites and Future Exploration (panel):

- Explored the value of analog sites for informing future exploration, emphasizing the need for cross-correlation studies and a more standardized approach to data collection.
- Studying microbial adaptation to multiple stressors and the need for better integration of modeling and lab experiments.
- The creation of an astrobiology sample repository was proposed to enhance accessibility and collaboration.

**Note: Key discussion based on AI summary of notes and human-created content

Key Discussion - Workshop

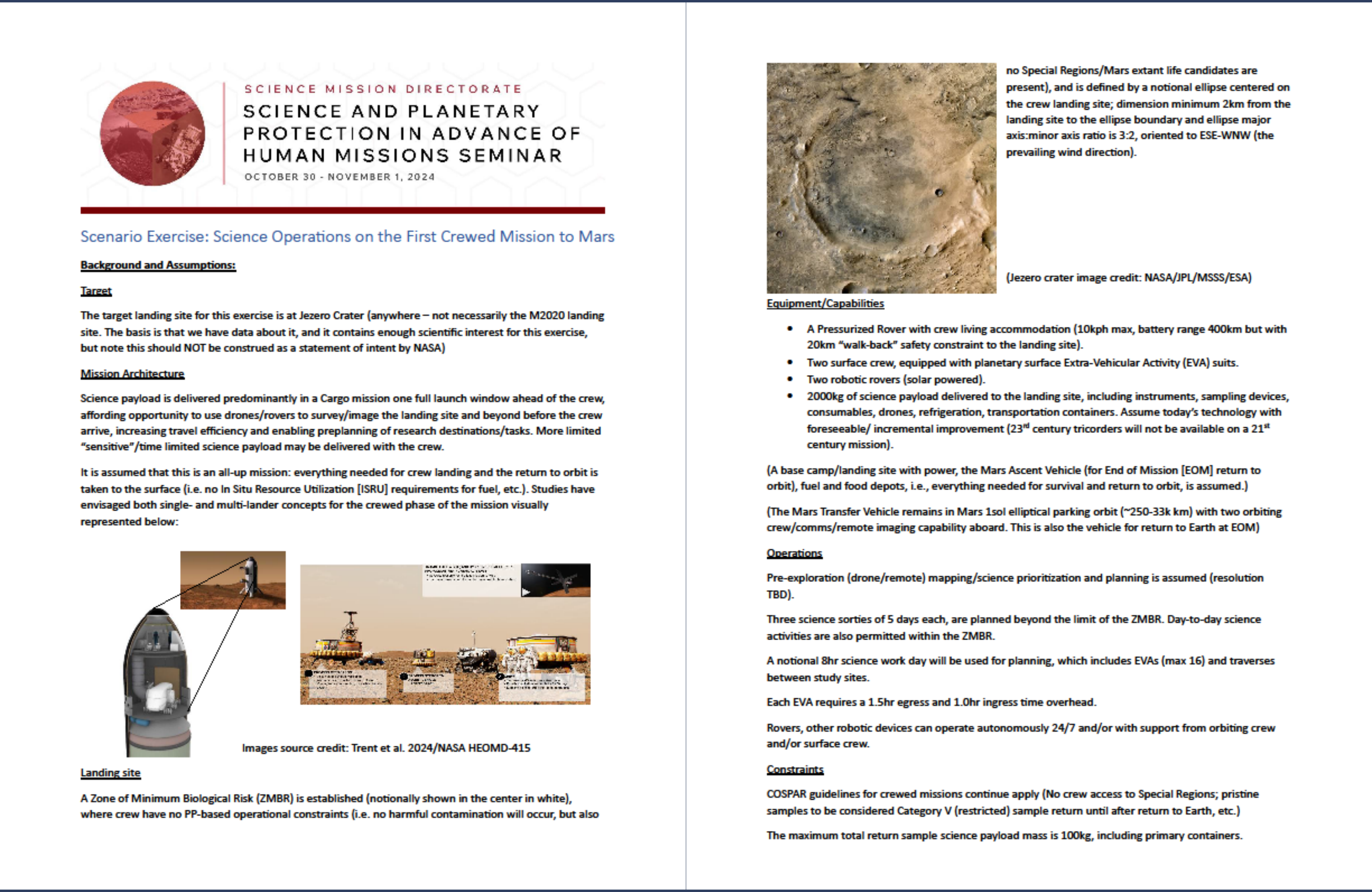
Mars Environmental and Terrestrial Biology/Mitigating Risk for PP (presentations):

- Precursor robotic missions for data gathering, technology validation, and environmental characterization.
- Detailed pre-mission surveys to identify potential refugia and mitigate contamination.
- Advancements in robotic capabilities, particularly in mobility, manipulation, and drilling, were discussed.
- The limitations of current spacesuits in terms of dexterity and contamination control.
- The potential for human-introduced microbes to impact the Martian environment and the need for robust mitigation strategies.
- Understanding the interplay between human health, engineering, and planetary protection.
- Value of conducting human factor experiments, including monitoring of human physiology and psychology.

Instruments and Technology Development (panel):

- More sensitive instruments and multiple orthogonal detection methods for life detection.
- A call for greater collaboration and standard interfaces for instruments was made to improve efficiency and adaptability.
- Concerns were raised about the limitations of current technology, particularly the sensitivity of existing instruments for detecting microbial life.
- The importance of understanding the geochemical context of samples alongside biosignature detection was stressed.
- The need to simulate Martian environmental conditions in laboratory settings was highlighted.

Scenario Exercise



SCIENCE MISSION DIRECTORATE

SCIENCE AND PLANETARY PROTECTION IN ADVANCE OF HUMAN MISSIONS SEMINAR

OCTOBER 30 - NOVEMBER 1, 2024

Scenario Exercise: Science Operations on the First Crewed Mission to Mars

Background and Assumptions:

Target

The target landing site for this exercise is at Jezero Crater (anywhere – not necessarily the M2020 landing site. The basis is that we have data about it, and it contains enough scientific interest for this exercise, but note this should NOT be construed as a statement of intent by NASA)

Mission Architecture

Science payload is delivered predominantly in a Cargo mission one full launch window ahead of the crew, affording opportunity to use drones/rovers to survey/image the landing site and beyond before the crew arrive, increasing travel efficiency and enabling preplanning of research destinations/tasks. More limited "sensitive"/time limited science payload may be delivered with the crew.

It is assumed that this is an all-up mission: everything needed for crew landing and the return to orbit is taken to the surface (i.e. no In Situ Resource Utilization [ISRU] requirements for fuel, etc.). Studies have envisaged both single- and multi-lander concepts for the crewed phase of the mission visually represented below:

Images source credit: Trent et al. 2024/NASA HEOMD-415

Landing site

A Zone of Minimum Biological Risk (ZMBR) is established (notionally shown in the center in white), where crew have no PP-based operational constraints (i.e. no harmful contamination will occur, but also no Special Regions/Mars extant life candidates are present), and is defined by a notional ellipse centered on the crew landing site; dimension minimum 2km from the landing site to the ellipse boundary and ellipse major axis:minor axis ratio is 3:2, oriented to ESE-WNW (the prevailing wind direction).

(Jezero crater image credit: NASA/JPL/MSSS/ESA)

Equipment/Capabilities

- A Pressurized Rover with crew living accommodation (10kph max, battery range 400km but with 20km "walk-back" safety constraint to the landing site).
- Two surface crew, equipped with planetary surface Extra-Vehicular Activity (EVA) suits.
- Two robotic rovers (solar powered).
- 2000kg of science payload delivered to the landing site, including instruments, sampling devices, consumables, drones, refrigeration, transportation containers. Assume today's technology with foreseeable/ incremental improvement (23rd century tricorders will not be available on a 21st century mission).

(A base camp/landing site with power, the Mars Ascent Vehicle (for End of Mission [EOM] return to orbit), fuel and food depots, i.e., everything needed for survival and return to orbit, is assumed.)

(The Mars Transfer Vehicle remains in Mars 1sol elliptical parking orbit (~250-33k km) with two orbiting crew/comms/remote imaging capability aboard. This is also the vehicle for return to Earth at EOM)

Operations

Pre-exploration (drone/remote) mapping/science prioritization and planning is assumed (resolution TBD).

Three science sorties of 5 days each, are planned beyond the limit of the ZMBR. Day-to-day science activities are also permitted within the ZMBR.

A notional 8hr science work day will be used for planning, which includes EVAs (max 16) and traverses between study sites.

Each EVA requires a 1.5hr egress and 1.0hr ingress time overhead.

Rovers, other robotic devices can operate autonomously 24/7 and/or with support from orbiting crew and/or surface crew.

Constraints

COSPAR guidelines for crewed missions continue apply (No crew access to Special Regions; pristine samples to be considered Category V (restricted) sample return until after return to Earth, etc.)

The maximum total return sample science payload mass is 100kg, including primary containers.

Scenario Exercise Questions

Attendees were requested to address the following questions in the Breakout session

1. With MEPAG Goals (from Goals Documents) in mind, what investigations/science campaigns would you conduct on a first crewed Mars mission? (*What does this campaign need to look like (recon., early experiments, EVAs, returned samples)?)*

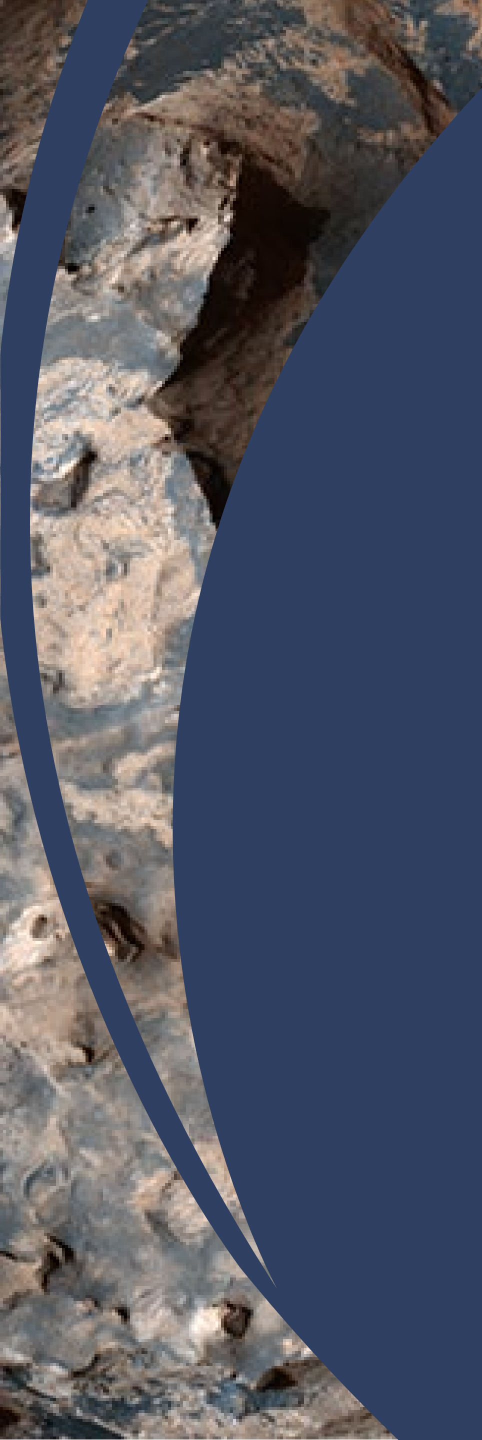
2. Suppose planetary protection constraints meant that EVAs could not be permitted, and all the operations had to be conducted from within the Pressurized Rover. How would that change the mission?

3. What if return sample payload mass constraints were relaxed to allow 400kg. How would that change the mission?

4. What if science payload was reduced from 2000kg to 500kg – how would that change the mission?

5. What does planning the crewed mission science reveal about what is needed from earlier robotic missions?

Guidance was to spend 80% effort on Q1, 20% effort on Q2-5, requesting any assumptions to be recorded



**Note: Key takeaways based on AI summary of breakout notes and human-created content

The breakout rooms engaged in a lively discussion about the scientific goals, logistical challenges, and critical considerations for a first crewed mission to Mars, at the specified target, Jezero Crater. While each room explored different aspects of the scenario, a common thread emerged: the need for a balanced, multi-faceted approach that balances science, technology, and human factors.

Key Takeaways – Scenario Exercise

- **Human-Robot Collaboration:** The discussion demonstrated a strong appreciation for the unique combination of human ingenuity and robotic capabilities for achieving scientific goals on Mars.
- **Comprehensive Planning:** Successful mission planning requires a multi-faceted approach, integrating scientific objectives, technology development, crew safety, and planetary protection protocols.
- **Continuous Learning and Adaptation:** Future missions to Mars will benefit from the lessons learned from the first crewed mission, requiring a constant cycle of data gathering, analysis, and adaptation.

Key Themes – Scenario Exercise

- **Science Focus:** All groups recognized the importance of aligning scientific goals with MEPAG objectives, particularly focusing on understanding Martian habitability, past life, and the potential for extant life.
- **Sample Collection and Return:** Sample return was a central theme, with groups advocating for diverse sample types, including subsurface cores, regolith, as well as microbial swabs.
- **Precursor Missions:** The value of robotic missions was consistently emphasized, particularly for pre-mission reconnaissance, data gathering, technology testing, and identifying potential sample locations.
- **Technology Development:** There was a strong call for investing in advanced technologies, including:
  - Miniaturized instruments and lab-on-a-chip systems.
  - Robust sample encapsulation methods.
  - Helicopters for environmental sampling and scouting.
  - Advanced robotic systems for sample collection and instrument deployment.
- **Human Factors:** The importance of understanding human adaptation to Martian conditions (physiological and psychological) and the impact of a confined environment on the crew was repeatedly highlighted.
- **Planetary Protection:** The discussion emphasized the need for robust protocols to minimize forward (Mars contamination) and backward (Earth contamination) risks, requiring advanced containment systems and careful sample handling procedures.
- **Flexibility and Adaptation:** The teams acknowledged that flexibility and adaptability would be critical for a successful mission, requiring the ability to respond to unforeseen challenges and constraints.

Key Areas of Non-Consensus – Scenario Exercise

Key Areas of Non-Consensus:

- **EVA Limitations:** Addressing Q2, while some groups accepted the possibility of restricted EVAs, others questioned the value of sending humans if their ability to directly interact with the Martian surface was significantly limited.
- **Sample Triage:** Addressing Q3 & 4, the need for sample triage due to limited return mass generated discussion about prioritization strategies and the potential trade-off between quantity and quality of samples.
- **In-situ Experiments vs. Sample Return:** Addressing Q3 & 4, there was some debate about the relative emphasis on conducting experiments on Mars versus collecting and returning samples for more detailed analysis on Earth.