Abstract: Mars surface environmental issues (Jones AsMA 2002 panel, scheduled for Wednesday, May 8 2002 2:12PM.)

**Introduction:** Planetary exploration by astronauts will require extended periods of habitation on a planet’s surface, under the influence of environmental factors that are different from those of Earth and the spacecraft that delivered the crew to the planet. Human exploration of Mars, a possible near-term planetary objective, can be considered a challenging scenario. Mission scenarios currently under consideration call for surface habitation periods of from 1 to 18 months on even the earliest expeditions. **Methods:** Environmental issues associated with Mars exploration have been investigated by NASA and the National Space Biomedical Research Institute (NSBRI) as part of the Bioastronautics Critical Path Roadmap Project (see [http://criticalpath.jsc.nasa.gov](http://criticalpath.jsc.nasa.gov)). **Results:** Arrival on Mars will immediately expose the crew to gravity only 38% of that at Earth’s surface in possibly the first prolonged exposure to gravity other than the 1G of Earth’s surface and the zero G of weightless space flight, with yet unknown effects on crew physiology. The radiation at Mars’ surface is not well documented, although the planet’s bulk and even its thin atmosphere may moderate the influx of galactic cosmic radiation and energetic protons from solar flares. Secondary radiation from activated components of the soil must also be considered. Ultrafine and larger respirable and non-respirable particles in Martian dust introduced into the habitat after surface excursions may induce pulmonary inflammation exacerbated by the additive reactive and oxidizing nature of the dust. Stringent decontamination cannot eliminate mechanical and corrosive effects of the dust on pressure suits and exposed machinery. The biohazard potential of putative indigenous Martian microorganisms may be assessed by comparison with analog environments on Earth. Even in their absence, human microorganisms, if not properly controlled, can be a threat to the crew’s health. **Conclusions:** Mars’ surface offers a substantial challenge to the health and safety of future human explorers.
Biomedically Relevant Features Of Mars' Surface Environment

Introduction

- Planetary exploration by astronauts will require extended habitation on planet's surface
- Example: human exploration of Mars
  - Possible near-term planetary objective
  - A challenging scenario
- Surface habitation of 1 to 18 months
- Different environmental factors from either Earth or spacecraft

Methods

Mars surface exploration environmental issues have been investigated by NASA and National Space Biomedical Research Institute (NSBRI) as part of the Bioastronautics Critical Path Roadmap Project (BCPR)

ref: http://criticalpath.jsc.nasa.gov

Comparing Mars

- Gravity [g]
  - Earth: 1.000
  - Mars: 0.381
- Press [Pa]
  - Earth: 1,013
  - Mars: 610
- Alt. (m)
  - Earth: 0
  - Mars: 0
- Temp [°C]
  - Earth: 20
  - Mars: 20
- Solar day (hr)
  - Earth: 24
  - Mars: 24
- Year (days)
  - Earth: 365.25
  - Mars: 687.2
Risk Elements & Categories

Mars Surface Stay Requirements

Assumed Surface Hazards and Risks
**Physical Challenges**

**Bioastronautics**

**Critical Path Roadmap (CPR)**

- BCPR: Blueprint for focused evolving research and technology for "safe return" to prevent or reduce the risks to humans in space environment
- NASA Design Reference Mission (1997) - "most challenging"
- Identified: 55 risks, 343 critical questions in 12 risk areas

<table>
<thead>
<tr>
<th>Habitat systems</th>
<th>Mediciation system</th>
<th>Medical care systems</th>
<th>Clinical on-sight</th>
<th>Microgravity and micro-atmosphere</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Advanced life support</td>
<td>- Cardiac and lower extremity</td>
<td>- Mental status</td>
<td>- Musculoskeletal</td>
<td>- Mobility and balance</td>
</tr>
<tr>
<td>- Environmental health</td>
<td>- Cardiovascular alterations</td>
<td>- Human behavior and performance</td>
<td>- Musculoskeletal disorders</td>
<td>- Sensory and Motor performance</td>
</tr>
<tr>
<td>- Microgravity</td>
<td>- Human behavior and performance</td>
<td>- Neurocognitive disfunction</td>
<td>- Sensory and Motor performance</td>
<td>- Motor function</td>
</tr>
</tbody>
</table>

**Radiation**

- Not well documented
- Planet's bulk and thin atmosphere may moderate the influx of galactic cosmic radiation and energetic protons from solar flares
- Secondary radiation from activated components of the soil must also be considered

**CPR Issues: Radiation**
Radiation Research

- Continuous monitoring of the radiation environment with dedicated equipment
  - The Phantom Torso (TORSO): monitors radiation absorption at brain, heart, stomach, thyroid, colon (2 month study)
  - Dosimetric mapping (DOSMAP): documents nature and distribution of radiation inside ISS and around crew members' bodies - German investigator, periodic data download (4 month study)
  - Bonner Ball Neutron Detector (BBND): monitors neutron radiation that may affect blood-forming bone marrow
    - NODA provided hardware
    - Increment 2 and 3 (ongoing 5 months)

- Medical research and care
  - Data base of personal annual and lifetime exposure limits for crew members with regular medical examinations (ongoing)

Gravity

- 0.38 g
- Possibly the first prolonged exposure to hypogravity between 1 g and 0 g
- Unknown effects on crew physiology

Bone Integrity in Weightlessness

Plot showing change from pre-flight bone integrity over time in space flight compared to on Earth.
Physical Challenges

CPR Issues: Hypogravity

Strategy for Mars Surface Operations

Artificial Gravity (AG) Considerations

Conservative assumption: only 3 out of 9 crew members will be available immediately after landing.

Strategy: start with passive tasks inside vehicle (day 1-3) and progress to active tasks on surface (day 4-9).
CPR Issues: Hypogravity

Artificial Gravity Concepts
Continuous / Long Radius / Low \( \omega \)

"Gravity Augmentation" During Exercise On Mars

Biomedically Relevant Features Of Mars' Surface Environment

Dust
- Ultrafine and larger respirable and non-respirable particles in Martian dust introduced into the habitat after surface excursions may induce pulmonary inflammation exacerbated by the additive reactive and oxidizing nature of the dust. Stringent decontamination cannot eliminate mechanical and corrosive effects of the dust on pressure suits and exposed machinery.
Biomedically Relevant Features Of Mars' Surface Environment

**Biohazard**
- Potential of putative indigenous Martian microorganisms may be assessed by comparison with analog environments on Earth.
- Even in their absence, human microorganisms, if not properly controlled, can be a threat to the crew's health.

**Circadian factors**

CPR Issues: Environmental

CPR Issues: Human Behavior and Performance
CPR Issues: Human Behavior and Performance

Issues:
- Small group size
- Multi-cultural composition
- Extended duration
- Remote location
- High autonomy
- High risk (both expensive and life-threatening)
- High visibility (e.g., high pressure to succeed)

Acute Medical Issues

Clinical Problems

- Expanded clinical capabilities
- Orthopaedic and musculoskeletal problems (e.g., Ili hip surgery)
- Infections, hemorhoidal, and thoracic-related diseases
- Dermatological, ophthalmological, and ENT problems
- Acute medical emergencies
  - Vascular, intestinal, and burns
  - Toxic exposure and acute anaphylaxis
  - Acute medical illnesses
  - Development and treatment of communicable diseases
  - Dental, ophthalmologic, and psycho-logic issues
- Chronic illnesses
  - Radiation-induced problems
  - Responses to drug exposure
  - Prevention of adverse medication and disease processes

Autonomous Clinical Care
Conclusions: Mars' surface offers a substantial challenge to the health and safety of future human explorers.