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). **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.

DRAFT PRESENTATION

(NOTE: "BLANK" SLIDES WILL BE REFORMATTED TO SHOW READABLE TEXT IN B&W AS WELL AS COLOR. BPC)

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

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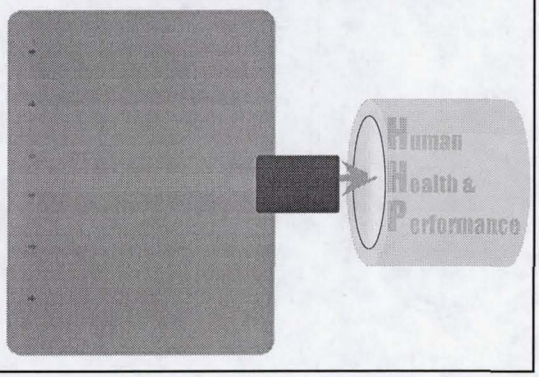
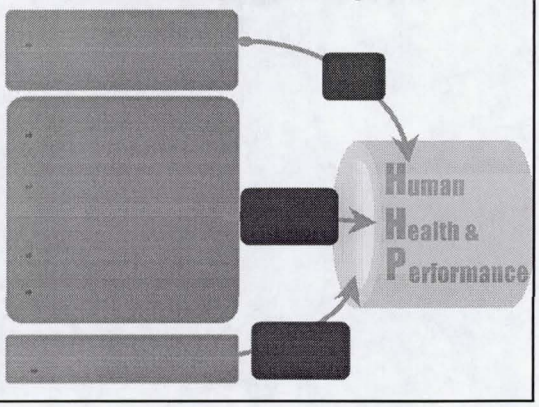
Gravity (m/s²):	9.81	3.73 (0.38 g)
Press$_{atm}$ (mbar):	1,000	6 (0.009 g)
Atm. Gases:	N2 78% O2 21% Ar 1%	CO2 95% N2 3% Ar 1.6%
Temp (mean) (C):	14	-55
Solar day (hr.):	24	24.36 (1.029 g)
Year (days):	365.26	687 (1.88 g) 669.6 Mars days

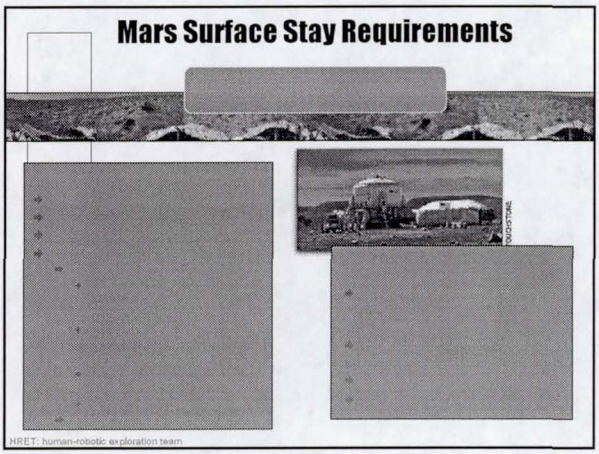
Risk Elements & Categories



Risk Elements & Categories



Mars Surface Stay Requirements



HRET- human-robotic exploration team

Assumed Surface Hazards and Risks

Bioastronautics Critical Path Roadmap (CPR)

BCPR: blueprint for focused evolving research and technology for "risk reduction" to prevent or reduce the risks to humans in space environment

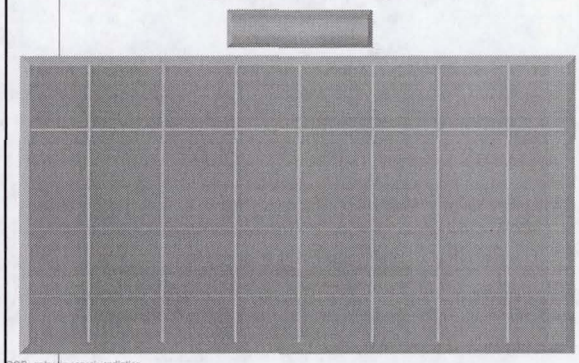
- Mars Design Reference Mission (1997) - "most challenging" scenario
- Identified: 55 risks, 343 critical questions in 12 risk areas

- Habitation systems
  - Advanced life support
  - Environmental health monitoring
  - Food and nutrition
- Medical care systems
  - Clinical capabilities
  - Multi-system (cross-risk) alterations
- Adaptation and countermeasure systems
  - Bone loss
  - Cardiovascular alterations
  - Human behavior and performance
  - Immunology, infection and hematology
  - Muscle alterations
  - Neurovestibular adaptation
  - Radiation effects

Radiation

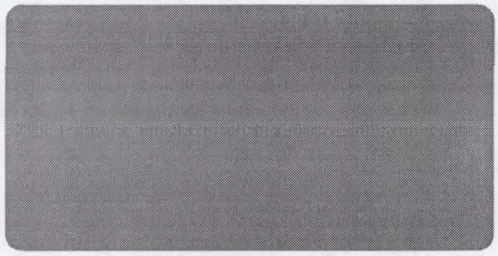
- Not well documented
- Planet's bulk and thin atmosphere may moderate the influx of galactic cosmic radiation and energetic protons from solar flares
- Secondary radiation from activated components of the soil must also be considered

Physical Challenges



GCR: galactic cosmic radiation
SPE: solar particle events
SEP: solar electric propulsion

CPR Issues: Radiation

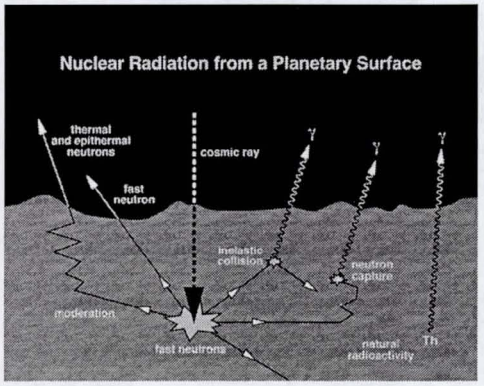


Radiation Research

- 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): document 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
    - NASDA provided hardware
    - Increments 2 and 3 (ongoing 8 months)
- Medical research and care
  - Data base of personal annual and lifetime exposure limits for crew members with regular medical examinations (ongoing)

Phantom Torso

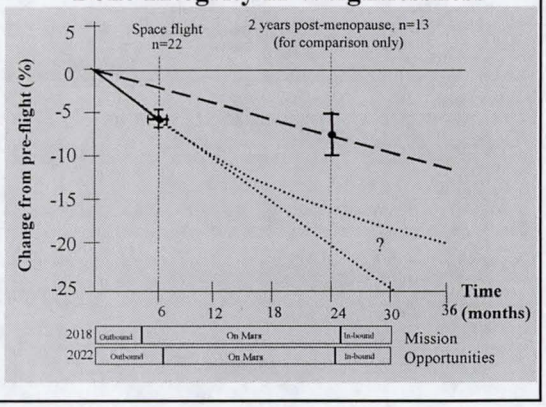
Bonner Ball



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



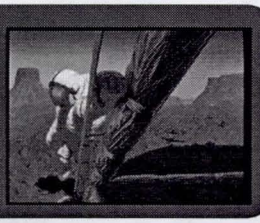
Physical Challenges

TMI: trans-Mars injection
TEI: trans-Earth injection

CPR Issues: Hypogravity

Strategy for Mars Surface Operations

Anecdotal evidence: ~50% of Russian *Mir* crewmembers are ambulatory *with* assistance immediately after landing, increasing to 100% within hours, then decreasing due to fatigue for several days

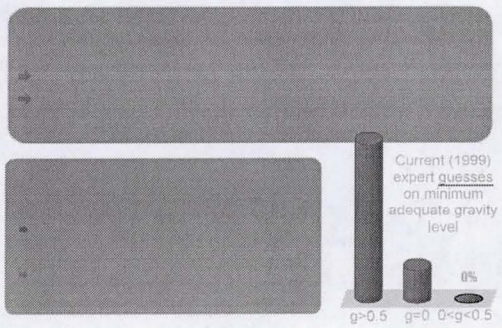


Conservative assumption: only 3 out of 5 crewmembers will be ambulatory immediately after landing

Strategy: start with passive tasks inside vehicle (day 1-3) and progress to strenuous tasks on surface (second week)

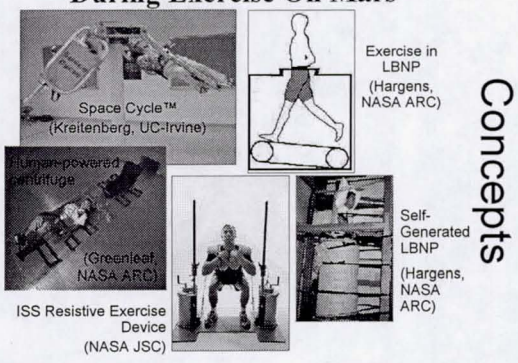
Artificial Gravity (AG) Considerations

CPR Issues: Hypogravity



Artificial Gravity Concepts
Continuous / Long Radius / Low ω

"Gravity Augmentation" During Exercise On Mars



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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.

CPR Issues: Environmental

Biomedically Relevant Features Of Mars' Surface Environment

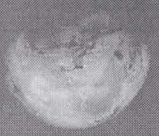
Circadian factors

CPR Issues: Human Behavior and Performance

CPR Issues: Human Behavior and Performance

Issues:

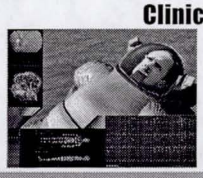
- Small group size
- Multi-cultural composition
- Extended duration
- Remote location
- High autonomy
- High risk (both expensive and life-threatening)
- High visibility (e.g., high pressure to succeed)



Acute Medical Issues

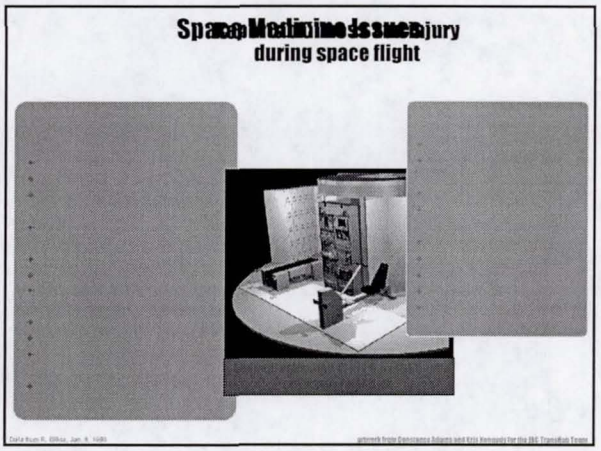
Clinical Problems

Require appropriate medical capability



- Expected illnesses and problems
  - Orthopedic and musculoskeletal problems (esp. in hypogravity)
  - Infectious, hematological, and immune-related diseases
  - Dermatological, ophthalmologic, and ENT problems
- Acute medical emergencies
  - Wounds, lacerations, and burns
  - Toxic exposure and acute anaphylaxis
  - Acute radiation illness
  - Development and treatment of decompression sickness
  - Dental, ophthalmologic, and psychiatric
- Chronic diseases
  - Radiation-induced problems
  - Responses to dust exposure
  - Presentation or acute manifestation of descent illness

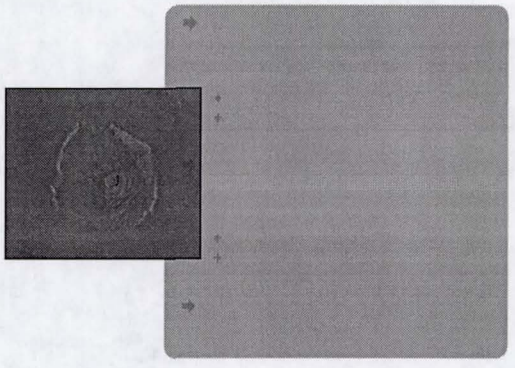
Autonomous Clinical Care



Biomedically Relevant Features Of Mars' Surface Environment

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

Conclusions



Conclusions