Mars Habitats

May 18, 2022
Michael Elsperman
The Boeing Company

Not subject to US Export Administration Regulations (15 C.F.R. Parts 730-774) or US International Traffic in Arms Regulations (22 C.F.R. Parts 120-130)
Agenda

- Habitation Overview
- Extensibility of Common Subsystems
- Lunar Surface and Gateway as Proving Grounds
Habitation is a Critical Capability for Exploration

- Habitats provide long term living and working space for crewed missions
  - Provides shelter and life support for crews
  - Enables long duration science and exploration
    - >60 day lunar surface missions
    - ~600 - 1200 day Mars transit missions
    - Multi year Mars surface applications

- Habitats must ensure 24/365 availability of critical crew functions over the course of the mission
  - High reliability (vs mass of spares)
  - Advanced health monitoring and predictive maintenance

- Extensibility is a key consideration for deep space habitation architecture design and development
  - Envelope worst case design environments
  - Leverage “run time” on preceding applications to improve designs across the product line

- Early development and life testing reduce risk
  - Early ground based mockups, tech maturation, and demonstrations
# Habitation Subsystems

<table>
<thead>
<tr>
<th>LEO or Gateway Habitat</th>
<th>Lunar Surface Habitat</th>
<th>Mars Transit Habitat</th>
<th>Mars Surface Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gateway Interoperable Avionics</td>
<td>Gateway Interoperable Avionics</td>
<td>Gateway Interoperable Avionics</td>
<td>Gateway Interoperable Avionics</td>
</tr>
<tr>
<td>Open Loop ECLSS</td>
<td>Partial Regen ECLSS</td>
<td>Full Regen ECLSS</td>
<td>Full Regen ECLSS</td>
</tr>
<tr>
<td>Body Mounted Radiators (BMR)</td>
<td>BMR &amp; Deployable</td>
<td>Body Mounted Radiators</td>
<td>BMR &amp; Deployable</td>
</tr>
<tr>
<td>Common Power</td>
<td>Common Power</td>
<td>Common Power</td>
<td>Common Power</td>
</tr>
<tr>
<td>0 G Crew Quarters &amp; Hygiene</td>
<td>.18 G Crew Quarters &amp; Hygiene</td>
<td>0 G Crew Quarters &amp; Hygiene</td>
<td>.30 G Crew Quarters &amp; Hygiene</td>
</tr>
<tr>
<td>0 G Exercise</td>
<td>.18 G Exercise</td>
<td>0 G Exercise</td>
<td>.30 G exercise</td>
</tr>
<tr>
<td>Common Windows</td>
<td>Common Windows</td>
<td>Common Windows</td>
<td>Common Windows</td>
</tr>
<tr>
<td>EVA Accommodations and Airlock</td>
<td>EVA Accommodations and Airlock</td>
<td>EVA Accommodations and Airlock</td>
<td>EVA Accommodations and Airlock</td>
</tr>
</tbody>
</table>

**High degree of common subsystems and component usage supports extensibility**

Not subject to US Export Administration Regulations (15 C.F.R. Parts 730-774) or US International Traffic in Arms Regulations (22 C.F.R. Parts 120-130).
Artemis Provides Mars Habitation Proving Ground Opportunity

- LEO, Cislunar Space, and the Lunar Surface are well suited to conduct relevant technology maturation and system level testing to verify safe and reliable operations for Mars Surface Habitation
  - Mars gravity is close to moon (~1/3 vs 1/6 G)
  - Martian dust is assumed similarly as bad as Lunar Regolith but for different reasons
    - Extremely small particles
    - Perchlorates
  - Mars surface temperatures enveloped by lunar surface
  - Radiation comparable to deep space/lunar surface
    - Mars Odyssey probe detected ongoing radiation levels which are 2.5 times higher than what astronauts experience on the International Space Station
  - Martian atmospheric effects are unknown
    - Composition effect on hab materials and crews (toxic gas metals, hydrogen peroxide, ozone)
    - Erosion due to wind blown dust

Surface data from Mars Rovers is critical to a comprehensive Mars Surface Habitat Qual program