Challenges of Roundtrip Transit to Mars

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Mars Missions Are Different

Mars is much farther than the Moon

<table>
<thead>
<tr>
<th></th>
<th>Closest Approach to Earth</th>
<th>Farthest Distance from Earth</th>
<th>Typical Round-Trip “Odometer” Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moon</td>
<td>360,000 km</td>
<td>405,000 km</td>
<td>2,000,000 km</td>
</tr>
<tr>
<td>Mars</td>
<td>54,600,000 km</td>
<td>400,000,000 km</td>
<td>2,000,000,000 km</td>
</tr>
</tbody>
</table>

Mars gravity well is "deeper" than that of the Moon

- Gravity wells help visualize gravitational pull
- Mars’s gravitational pull is stronger than that of the Moon, requiring more energy to escape

Mars mission is unlike anything we’ve ever done for human spaceflight

Typical Roundtrip Transit Time

- ISS: Hours-Days
- Moon: Days-Weeks
- Mars: Years
Challenges of Mars Transit

Communication Delays & Disruptions

Example 850-day Roundtrip Mission

- Solar Conjunction Causing Communications Disruption
- Distance from Earth to Mars (Mil) - 450
- Mars Conen Delay - ~35-40 Minutes Roundtrip Delay when Crew is at Mars

Getting to the Surface of Mars

- Diameter (m)
  - Viking 1 & 2: 3,605
  - Pathfinder: 2,65
  - Spirit & Opportunity: 2,65
  - Phoenix: 4.5
  - Curiosity: 2.65
  - InSight: 4.5
  - Perseverance: 16-19
- Entry Mass (kg)
  - Viking 1 & 2: 930
  - Pathfinder: 355
  - Spirit & Opportunity: 830
  - Phoenix: 602
  - Curiosity: 3,602
  - InSight: 606
  - Perseverance: 3,389
- Landed Mass (kg)
  - Viking 1 & 2: 603
  - Pathfinder: 360
  - Spirit & Opportunity: 529
  - Phoenix: 364
  - Curiosity: 599
  - InSight: 375
  - Perseverance: 1,026

Getting Back off the Surface

- Mars 10 launches
  - Little to no margin for delays
  - Little to no real-time ground support
  - Vehicle likely arrives unprepared for launch

New paradigm needed for Human Class Landers

Humans have ascended from only two celestial bodies to date, usually with significant ground support

Mission Abort Risk Posture?

- Mars mission aborts will be very different from past or current experience
  - For LEO or Lunar operations, abort can return crew to Earth within hours or days
  - For Mars missions, Earth return will be months or years after abort initiation
  - Abort may only shorten mission duration by a few weeks

New paradigm needed for risk buy-down and contingency planning