Mars Exploration Rover

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Mission Overview and Mars Time Impact on Project Personnel
The Mars Science Strategy:
“Follow the Water”

Common Thread

Understand the potential for life elsewhere in the universe

Characterize the present and past climate and climate processes

Understand the geological processes affecting Mars’ interior, crust, and surface

Develop the knowledge & technology necessary for eventual human exploration

Prepare for Human Exploration
Mission Overview (1)

Images From Mission Animation by Dan Maas
Mission Overview (2)

- **Entry, Descent and Landing (EDL)**
  - Posigrade Entry
  - MPF-derived EDL System
    - Flight system capability: 825 kg entry mass, surface altitude ≤1.3 km relative to MOLA areoid
  - EDL Communications
    - Real-time X-band DTE (Direct-to-Earth) communications during EDL (Doppler and M-FSK tones)
    - MGS capture of MER telemetry transmitted via UHF-band link during EDL

- **Surface Mission**
  - Landing site latitude range: MER-A: 15° South to 5° North. MER-B: 10° South to 10° North
  - Science
    - Imaging science: Pancam, Mini-TES, engineering cameras
    - In-situ science: APXS, Mössbauer, Microscopic Imager, Rock Abrasion Tool
      - Instrument placement using Instrument Deployment Device (IDD)
  - Operations Strategy
    - Daily DTE / DFE (Direct-from-Earth commanding) each morning, daily DTE session each afternoon
    - Data return via X-band DTE link and UHF-band link with MGS and Mars Odyssey
    - Scenario margins in: activity duration, comm opportunities, DSN coverage, energy, and environments
  - Key Mission Success / Mission Return Criteria (per mission)
    - 90 sols of surface science operations (after the landing sol)
    - 600 meter odometer traverse (system qualified to 1000 meters)
    - ~4 distinct locations (including landing location)
    - ~6 targets: one soil, five rock (one of which is abraded with RAT)
    - ~3 Gbits total data return (~4 Gbits for MER-A)
Interplanetary Trajectory

MER-A Open
Launch 30 May 2003
Arrival 4 Jan 2004

MER-B Open
Launch 6/25/03
Arrival 1/25/04

View from Ecliptic North Pole
20 day tick marks

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Entry, Descent & Landing (EDL) Scenario

Entry Turn & HRS Freon Venting: E- 70m
Cruise Stage Separation: E- 15m

Entry: E- 0 s, 125 km, 5.7 km/s, \( \gamma = -11.5 \) deg.
Parachute Deployment: E+ 295 s, 11.8 km, 430 m/s
Heatshield Separation: E+ 315 s
Lander Separation: E+ 325 s

Bridle Deployed: E+ 335 s
Radar Ground Acquisition: L- 18 s
Airbag Inflation: 355 m, L - 10.1 s
Rocket Firing: L- 7 s, ~150 m, 90 m/s

Bridle Cut: L- 3 s, ~20 m

L = Landing: ~E+420 s
Roll-Stop: L+2 min
Airbags Retracted: L+74 min
Deflation: L+20 min
Petals & SA Opened: L+90 min

TCM-5: E-12 hrs.
Concurrent with EDL, but commanded from ground.

Landing Times (Mars local solar time)
MER-A: ~2:30 PM
MER-B: ~1:00 PM
Earthset: ~3:30 PM
Spacecraft Configuration

Cruise Stage

Backshell

Rover

Lander

Heat Shield
Lander Configuration

ARA (4 Places, Typ.)
Rover Wheel Tiedown (6 Places)
Rover Cabling
Rover Lift Mechanism
DRL
Bridle
+Y PETAL
Parachute Roller (3 Places, Typ.)
Shear Panel
LPA Electronics (3 Places, Typ.)
Primary Battery Packages
LPSA
LPA (3 Places, Typ.)
Radar Electronics
Gas Generator (3 Places, Typ.)
BIP/Lander Sep Nut (6 Places, Typ.)
-X PETAL
Avionics LEM

Power LEM
+X PETAL
Radar Altimeter Bracket
Flight Rover ready for installation on Lander
Rover Configuration

Navcams
Pancams
Pancam Mast Assembly (PMA)
Rover Equipment Deck (RED)
Front HAZCAMs
Warm Electronics Box (WEB)
Instrument Deployment Device (IDD)

UHF Monopole Antenna
Low gain Antenna (LGA)
High Gain Antenna (HGA)
Solar Arrays
Mobility System

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Instrument Positioning System

Instrument Deployment Device (IDD) - 5 DOF
Robotic Arm with 4 instrument turret at end
In-Situ Instruments

Alpha Particle X-Ray Spectrometer (APXS)

Mössbauer Spectrometer (MB)

Microscopic Imager (MI)

Rock Abrasion Tool (RAT)

Dust Cover Stepper Motor

Contact Sensor

MI Optics

Dust Cover

MI Electronics Box
Possible Landing Sites
Typical Landing Error Ellipse
The Four Candidate Landing Sites for MER:
as of September 2002

Hematite: safest site (low rock abundance, winds and slopes), high science priority

Gusev: high science priority, high wind shear, moderate slopes

Isidis: moderate science priority, high horizontal winds and wind shear, high rock abundance, low slopes

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Grey Strips = MOC coverage. Ellipses are 100 to 150 km long

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Mars Time Impact on Project Personnel

• Mars Time - What a difference 39 minutes makes!
• A Martian Day is 24 hours, 39 minutes long (called a “Sol”)
  – Almost exactly an Earth day, but not quite
  – MER is Solar powered - we operate when the Sun is up on Mars
  – Sunrise on Mars changes by 39 minutes (later) every day
  – Our team will wake up and go to work on Mars time, 39 Earth minutes later every day
• There are three basic shifts Martians will work
• And just to make it worse, we’ve got two different rovers on two different parts of Mars
  – Similar to one landing in England, and the other in New York
Mars Schedule At *Odds* with Rest of World

JPL Mars Odyssey MER Operations
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What does Mars Time mean to Housing Providers (1)

- Martians want to sleep during the day one third of every month - we want dark, quiet bedrooms, even during the day! This means we want the quietest places you have, and help controlling housekeeping and gardening personnel with leaf blowers!
- Martians want to have breakfast, lunch and dinner at weird times
- Martians will want to buy groceries at weird times
- Close to JPL!
What does Mars Time mean to Housing Providers (2)

• We will need housing for about TBD (40-60?) Science personnel during the training period from 7/15/03 to 12/1/03, and housing for 60 to 80 personnel during mission operations from 12/1/03 until about 5/30/04
  – This includes several Holiday periods!
  – We may also want some housing for JPL personnel too tired to drive home

• Martians are going to be coming from different countries - cultural differences will exist.

• Personnel will come and go. Who will do the reservation scheduling?

• What are your thoughts?
A Global Endeavor
World-renown Scientists from Many Places
Backup
Mission Timeline

**MER-A**
- **Mission Phase Events**
  - **Launch A**
  - **Interplanetary Cruise A**
  - **Mars Approach A**
  - **EDL A**
  - **Egress**
  - **Surface Operations A**
- **Events in Mars Inversion Period**:
  - **11/20**
  - **1/24**
  - **6/25**
  - **12/27**

**MER-B**
- **Mission Phase Events**
  - **Launch B**
  - **Interplanetary Cruise B**
  - **Mars Approach B**
  - **EDL B**
  - **Egress**
  - **Surface Operations B**
- **Events in Mars Inversion Period**:
  - **12/11**
  - **1/25**

**Earth/Sun Range (AU)**
- **Minimum Cruise value**
- **Maximum Cruise value**

**Mars Season**
- **Southern Spring**
- **Southern Summer**

**Other Project Events in Mars Viewperiod**
- **Cassini Conjunction**
- **Stardust DM9 Cleanup TCM**
- **Contour Earth Gravity Assist**
- **Mars 01 Mapping**
- **Galileo End of Life Sept '03**
- **SIRTF Prime Science**

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Mars is Hard!!

- The international community has sent 33 missions to Mars

<table>
<thead>
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<th></th>
<th>USA</th>
<th>USSR/Russia*</th>
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<th>Failure</th>
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<tr>
<td></td>
<td>-</td>
<td>15</td>
<td>4</td>
<td>11 (5 LV)</td>
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<tr>
<td>Landers</td>
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<td>-</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>8</td>
<td>0**</td>
<td>8 (2 LV)</td>
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<tr>
<td>Totals</td>
<td>18</td>
<td>23</td>
<td>15</td>
<td>26</td>
</tr>
</tbody>
</table>

* Japanese Nozomi mission is expected to arrive in Dec 2003
** Mars 3 in 1971 apparently transmitted for 20 sec after landing but no significant information was returned
# Tactical Mission Operations Timeline

| Time  | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | 18:00 | 19:00 | 20:00 | 21:00 | 22:00 | 23:00 | 0:00 | 1:00 | 2:00 | 3:00 | 4:00 | 5:00 | 6:00 | 7:00 |
|-------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Mon   |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
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|       | Shift C |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Tues  |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|       | Shift A |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
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| Wed   |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
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| Thurs |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
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| Fri   |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
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| Sat   |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
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| Sun   |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
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| Mon   |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|       | Shift A |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
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