Mars Exploration Program Status

Planetary Science Subcommittee
NASA Advisory Council

MARS
—the search for life

Michael Meyer
Mars Exploration Program Lead Scientist
23 June 2008
AGENDA

- Program Status and Recent Accomplishments
- Science Highlights
- MEP Next Decade
<table>
<thead>
<tr>
<th>Program</th>
<th>TECH</th>
<th>COST</th>
<th>SCHD</th>
<th>PROG</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odyssey</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>Nominal spacecraft/instrument extended mission operations. Continuing MER UHF relay support; planned PHX support</td>
</tr>
<tr>
<td>Mars Exploration Rovers</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>Rovers both in good health; YELLOW status from concerns over Spirit survivability this winter</td>
</tr>
<tr>
<td>ESA/Mars Express</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>Nominal extended operations.</td>
</tr>
<tr>
<td>Mars Reconnaissance Orbiter</td>
<td>Y</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>Operations nominal; 4 of &gt;50 passes with ELECTRA anomalous early in PHX ops—under investigation</td>
</tr>
<tr>
<td>Phoenix</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>Landed in the Martian Arctic May 25! Ops going extremely well</td>
</tr>
<tr>
<td>Mars Science Laboratory</td>
<td>G</td>
<td>R</td>
<td>Y</td>
<td>R</td>
<td>Cost growth solutions being implemented for FY08/09; JPL claims growth under control; on track for 2009 LRD</td>
</tr>
<tr>
<td>Scout-13</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>Selection opn target for September '08</td>
</tr>
</tbody>
</table>

- **TECH**: Progress according to plan.
- **COST**: Area of concern; Problem can be resolved within reporting organization; Needs attention.
- **SCHD**: Significant problem; Solution not identified; Needs action/help beyond reporting org.
Mars Exploration: Well on Its Way

Launch Year

OPERATIONAL

Mars Global Surveyor
ESA Mars Express
Mars Reconnaissance Orbiter
Mars Odyssey
Mars Exploration Rovers
Phoenix
Mars Science Laboratory

2007
In Primary Science Phase
Landed: May 25, 2008

2009
Progressing technically
Science pathways responsive to discovery

10 productive years
Still going strong
## Restoration of the MEP to a Viable Architecture

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tr>
<td>2009</td>
<td>Competed Aeronomy Scout Mission (MAVEN or TGE)</td>
</tr>
<tr>
<td>2011</td>
<td>TBD mission based on budget and science feed-forward</td>
</tr>
<tr>
<td>2013</td>
<td>MSR Element #1</td>
</tr>
<tr>
<td>2016</td>
<td>MSR Element #2</td>
</tr>
<tr>
<td>2018</td>
<td>Sample Receiving Facility online by 2022</td>
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Launch Year

- **2020**
  - TBD mission based on budget and science feed-forward
- **2018**
  - MSR Element #1
- **2016**
  - MSR Element #2
- **2013**
  - Competed Aeronomy Scout Mission (MAVEN or TGE)
- **2011**
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  - Competed Aeronomy Scout Mission (MAVEN or TGE)
### Restoration of the MEP to a Viable Architecture

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Recent Accomplishments

• Senior Review - March 20-21
  – Extended missions (Odyssey, MER, MRO, and MEX) were reviewed for potential science and cost.

• Mars Architecture Tiger Team (MATT) asked to re-form after Stern’s departure
  – Propose a Mars exploration architecture(s) that will optimize the science return within fiscal and programmatic constraints
  – More on that later….

• MSL
  – Status briefing to NASA Administrator on 5/16
    • Continue to 2009 LRD
    • Cost solution strategy approved
  – Weekly and monthly reporting through to SMD AA
  – System Integration Review complete—excellent progress
  – PICA MRR/CDR complete—excellent progress and on schedule
  – Continuation review with NASA Administrator September 2008
Recent Accomplishments

• Phoenix Landed!!
  – May 25, 2008

• Scout-13
  – Concept Study Reports received
  – Selection planned September 2008

• ExoMars
  – ESA Implementation Review Board conducted in May
    – Next step is start of a series of PDRs in early to mid 2008
  – Extra funding provided for UREY and MOMA through Dec 2008
    – Instrument Definition Review in Dec. and approval to continue into Formulation in Jan

• Mars Sample Return
  – International Mars Acquisition and Return of Samples (iMARS) working group Phase I complete
  – IMEWG to be briefed July 8th
    – iMARS Phase II will be considered as well
  – ESA-sponsored MSR conference July 9-10
    – Major precursor to ESA Ministerial in Nov ’08
    – US Community participants include representatives of MEP, NASA Centers, Science Community, & Industry
Science Highlights

- The Shallow Radar (SHARAD) on the Mars Reconnaissance Orbiter has imaged the internal stratigraphy of the north polar layered deposits
  - The packet/interpacket structure could be explained by approximately million-year periodicities
  - The small response to the ice load implies that the present-day thickness of an equilibrium elastic lithosphere is greater than 300 kilometers or Mars has a sub-chondritic abundance of radiogenic elements

- Spectrally distinct surface deposits consistent with chloride-bearing salts have been identified and mapped using data from the 2001 Mars Odyssey Thermal Emission Imaging System
  - Precipitate from evaporation of surface of ground water or volcanic outgassing
  - Only seen in early pm LMST

- In situ and orbital exploration of the martian surface has shown that acidic, saline liquid water was intermittently available on ancient Mars. However, the derived water activities are below values tolerated by microorganisms on Earth.
Fig. 1. (Top) Radargram from SHARAD orbit 5192. Range time delay, the usual ordinate in a radargram, has been converted to depth by assigning real permittivities of 1 and 3 above and below the detected ground surface, respectively. NPLD and the BU are labeled. Packet regions are numbered (see text). (Bottom) Ground track of orbit 5192 shown on a digital elevation model (DEM) derived from Mars Orbiter Laser Altimeter (MOLA) data. Elevation range is ~−4.5 (green) to −2 km (white).
Chlorides in Southern Highlands
Mineral Precipitation Curves

Fig. 1. Calculated mineral precipitation and $a_{H_2O}$ values as a function of evaporative concentration. The blue line represents modern terrestrial seawater evaporation. The red line represents the evaporation of a basaltic-weathering derived fluid most representative of inferred evaporation processes at Meridiani Planum. The green line represents the evaporation of a similar fluid but with an anion concentration that gives rise to the saline mineral assemblage observed in the Nakhla meteorite (and other members of the nakhli meteorite class).
### Restoration of the MEP to a Viable Architecture

**Launch Year**

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Sample Receiving Facility online by 2022

Mars Science Laboratory

ESA ExoMars cooperation
Fundamental MEP Topics for ‘09

• What is the baseline Program content regardless of MSR?
  – Flying in every opportunity directed by 2008 Congressional Appropriations Bill—it’s the law!
  – FY09 President’s Budget required Mars Sample Return studies and reporting

• How does Mars Sample Return fit in the architecture? Is it affordable?
  – The community is highly supportive, and believes we are scientifically “ready”
  – If not accomplished next decade, there may not be another opportunity until the ’30’s
  – Momentum is high
    • Mars community understands need to skip opportunities to execute this mission
    • NRC’s Astrobiology Report on the Exploration of Mars again endorsed MSR, and believes we know “enough” to make it meaningful
    • ESA Bi-Lat, IMARS and overall working relationships have put this mission within reach, recognizing partnership risk
  – Cost is high, even with International cooperation
    • It will require skipping opportunities, even with significant international partnership

• Communications infrastructure in the Next Decade is critical—how do we implement it?

• The FY09 budget is not reflective of a stable, executable program
  – Portfolio must reflect methodical scientific progress and stakeholder expectations

• Dependency on international cooperation should be limited to MSR
  – Traditional participation approaches in ExoMars (2013) and MarsNet (2016) are highly valuable
Mars Architecture Tiger Team

- Mars Architecture Tiger Team (MATT)
  - Reconstituted after February MEPAG meeting
  - Purpose: propose a Mars exploration architecture(s) that will optimize the science return within fiscal and programmatic constraints
    - Include program with MSR deferred
  - Meet through teleconferences
  - Develop preferred feasible architectures

- Report will be given to a Red Team headed by Scott Hubbard
  - Review with fiscal and systems engineering eyes
  - Report back before MEPAG

- Architecture and Red Team report out at MEPAG
  - Sept. 18, 2008, Monrovia, CA
Creating a Viable Next Decade w/Community Support

MATT identified the following mission building blocks to address the key scientific objectives for 2015-2025:

• **Mars Sample Return Lander (MSR-L) and Orbiter (MSR-O)**
  - Two flight elements: Lander/Rover/Ascent Vehicle & Orbiter/Capture/Return Vehicle
  - High-priority in NRC reports and Decadal Survey; must address multiple science goals with samples meeting the minimum requirements set out in the ND-SAG report

• **Network (NET):**
  - 4 or more landed stations arrayed in a geophysical network to characterize interior structure, composition, and process, as well as surface environments
  - Meteorological measurements would be leveraged by contemporary remote sensing from orbit (e.g., MSO)
  - High-priority in NRC reports and Decadal Survey

• **Mars Science Orbiter (MSO)**
  - Atmospheric composition, state, and surface climatology remote sensing plus telecom

• **Mars MER+ Rover (aka Mars Prospector Rover)**
  - MER+ rover deployed by “Sky Crane” to new water-related geologic targets
  - Precision landing (<6-km diameter error ellipse) enables access to new sites
  - Conducts independent science but with scientific and technical feed-forward to MSR
  - As a precursor, this opens the possibility for payload trade-offs with MSR Lander

• **Mars Scout Missions (Scout)**
  - Competed missions to pursue innovative thrusts to major missions goals
## Architecture Smorgasbord
### MATT-provided Options for Consideration

<table>
<thead>
<tr>
<th>Option</th>
<th>2016</th>
<th>2018</th>
<th>2020#1</th>
<th>2022#1</th>
<th>2024</th>
<th>2026</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018a#1</td>
<td>MSR-O</td>
<td>MSR-L</td>
<td>MSO</td>
<td>NET</td>
<td>Scout</td>
<td>MPR</td>
<td>Funded if major discovery?</td>
</tr>
<tr>
<td>2018b#1</td>
<td>MSO</td>
<td>MSR-L</td>
<td>MSR-O</td>
<td>NET</td>
<td>Scout</td>
<td>MPR</td>
<td>Restarts climate record early; trace gases</td>
</tr>
<tr>
<td>2018c#1</td>
<td>MPR</td>
<td>MSR-L</td>
<td>MSR-O</td>
<td>MSO</td>
<td>NET</td>
<td>Scout</td>
<td>Gap in climate record; telecom?</td>
</tr>
<tr>
<td>2020a</td>
<td>MPR</td>
<td>MSO</td>
<td>MSR-L</td>
<td>MSR-O</td>
<td>NET</td>
<td>Scout</td>
<td>MPR helps optimize MSR</td>
</tr>
<tr>
<td>2020b</td>
<td>MPR</td>
<td>Scout</td>
<td>MSR-L</td>
<td>MSR-O</td>
<td>MSO</td>
<td>NET</td>
<td>Gap in climate record, early Scout</td>
</tr>
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<td>2022a</td>
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<td>Early NET; MPR helps MSR</td>
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<td>2022b</td>
<td>MSO</td>
<td>MPR</td>
<td>NET</td>
<td>MSR-L</td>
<td>MSR-O</td>
<td>Scout</td>
<td>Early NET, but 8 years between major landers (MSL to MPR)</td>
</tr>
<tr>
<td>2024a</td>
<td>MPR</td>
<td>MSO</td>
<td>NET</td>
<td>Scout</td>
<td>MSR-L</td>
<td>MSR-O</td>
<td>Early NET; 8 years between major landers; late sample return</td>
</tr>
</tbody>
</table>

**FOOTNOTES:**

#1 Requires early peak funding well above the guidelines
#2 Celestial mechanics are most demanding in the 2020 and 2022 launch opportunities, but ATLAS V-551 capabilities presently appear to be adequate

**Definitions:**

- **MSO** = Mars Science Orbiter
- **MPR** = Mars Prospector Rover (MER or MSL class Rover with precision landing and sampling/caching capability)
- **MSR** = Mars Sample Return Orbiter (MSR-O) and Lander/Rover/MAV (MSR-L)
- **NET** = Mars Network Landers (“Netlander”) mission
Lisa May will present the status of our international activities for Mars Sample Return
Phoenix On Mars

May 25, 2008!
HiRISE Captures Phoenix EDL

HEIMDALL CRATER