MSL landed August 6 (EDT) at Gale Crater

Continuing Mission Highlights

Senior Review in June

MEPAG Activities in Support of SMD/HEOMD Initiative

- Interactions with MPPG science
- P-SAG Results

Future Planning, Meetings and Milestones

Summary
Curiosity on Parachute Seen by MRO
Curiosity is progressing toward Glenelg, where three distinct terrain types meet.
Accessible rocks in Gale document key periods in Mars history where clay, then sulfate, deposition was widespread, and the transition between them.

Curiosity would be able to examine clear variations in mineralogy possibly linked to environmental changes.

- Lowermost strata exhibit sulfate signatures, sometimes with crystalline Fe-oxides (hematite).
- Clays are in thin, recessive beds located just below the lower/middle unit contact.
- A darker-toned unit with kieserite overlies the clays; some strata have polyhydrated sulfates and Fe-oxides; other strata may contain leached smectites.

Mineralogic changes are clearly linked to stratigraphic changes.
Mars Missions Status: MEPAG Perspective

- Benefits of programmatically integrated activities obvious with MSL successful landing and operation in a scientifically exciting locale
  - Landing Site Selection and Certification
  - EDL Support
  - Relay and ongoing operations support (> 20 Gbits returned from MSL thus far)
- Senior Review Results: Mars missions (MER, ODY, MRO, MEx-US) approved for extended operations in FY13-FY14 and funded at adequate levels to carry out both their PSD/MEP scientific and programmatic responsibilities
  - Exciting scientific objectives and new data products
    - Ground-truth for orbital remote sensing indicating phyllosilicates
    - New surface environments (e.g., potential brine flows and salt deposits)
    - Expanded coverage at highest spatial resolutions
    - Characterizing pre-Noachian (very early) Mars, etc.
  - Relay activities and monitoring for MER and for MSL
  - Site characterization and certification capabilities for future Mars missions
MRO in the News: HiRISE and MCS

HiRISE – perspective view

MSL Travels shown on EDL+12 HiRISE image (Astronomy Picture of Day)

MCS’ finding of dry-ice snow over the Mars south pole is AccuWeather good!

NASA Observations Point to 'Dry Ice' Snowfall on Mars

September 15, 2012; 6:08 AM

NASA’s Mars Reconnaissance Orbiter data have given scientists the clearest evidence yet of carbon-dioxide snowfalls on Mars. This reveals the only known example of carbon-dioxide snow falling anywhere in our solar system.

Frozen carbon dioxide, better known as "dry ice," requires temperatures of about minus 193 degrees Fahrenheit (minus 125 Celsius), which is much colder than needed for freezing water. Carbon-dioxide snow reminds scientists that although some parts of Mars may look quite Earth-like, the Red Planet is very different. The report is being published in the Journal of Geophysical Research.

"These are the first definitive detections of carbon-dioxide snow clouds," said the report’s lead author, Paul Hayne of NASA’s Jet Propulsion Laboratory in Pasadena, Calif. "We firmly establish the clouds are composed of carbon dioxide -- flakes of Martian air -- and they are thick enough to result in snowfall accumulation at the surface."

The snowfalls occurred from clouds around the Red Planet’s south pole in winter. The presence of carbon-dioxide ice in Mars’ seasonal and residual southern polar caps has been known for decades. Also, NASA’s Phoenix Lander mission in 2008 observed falling water-ice snow on northern Mars.

Hayne and six co-authors analyzed data gained by looking at clouds straight overhead and sideways with the Mars Climate Sounder, one of six instruments on the Mars Reconnaissance Orbiter. This instrument records brightness in nine wavebands of visible and infrared light as a way to examine particles and gases in the Martian atmosphere.

The data provide information about temperatures, particle sizes and their concentrations. The new analysis is based on data from observations in the south polar region during southern Mars winter in 2006-2007, identifying a tall carbon-dioxide cloud about 300 miles (500 kilometers) in diameter persisting over the pole and smaller, shorter-lived, lower-altitude carbon dioxide ice clouds at latitudes from 70 to 80 degrees south.
Surface thermal inertia map derived from THEMIS night time infrared data shows the high thermal inertia associated with the distal alluvial fan deposits studied by Curiosity in Gale Crater. Rocks interpreted to be well-cemented conglomerates are indicated in red. THEMIS TI image overlain on HiRISE-derived shaded relief DEM (NASA/JPL/ASU/U. of Ariz.).
Endeavour Rim Perspective

Cape Tribulation

Solander Point

Fe/Mg smectite signatures

Odyssey Crater

Sutherland Point

Nobbys Head

Botany Bay

Opportunity 12/7/11

Cape York

Endeavour Crater

North

View covers ~6 km in length

5 times vertical exaggeration (Cape Tribulation rises ~80 m above plains to west of Endeavour)

HiRISE-based Perspective View Looking Toward Northwest at Endeavour Rim Segments
Opportunity has nearly completed its survey of the Cape York region containing CRISM clay signatures, and is ready to perform detailed IDD investigations of candidate targets.

spectral principal component stretch – W. Farrand
MAVEN Objectives And Status

MAVEN will help us to understand the role played by loss to space in evolution of the Martian atmosphere and volatiles, and to understand the nature of planetary habitability.

**MAVEN Science Objectives:**

- Determine the structure and composition of the Martian upper atmosphere today (and the controlling processes)
- Determine rates of loss of gas to space today (and the controlling processes)
- Measure properties and processes that will allow us to determine the integrated loss to space through time

**MAVEN Status:**

- *On track, on schedule, on budget!*
- Spacecraft being integrated at Lockheed Martin in Colorado.
- Instruments to be delivered this fall and winter.
- Spacecraft-level testing in spring, ship to Cape in August
- Launch period 18 November – 7 December, 2013
The MAVEN Science Instruments
(All Pictures Are Flight Hardware)

Mass Spectrometry Instrument
Neutral Gas and Ion Mass Spectrometer; Paul Mahaffy, GSFC

Particles and Fields Package
SupraThermal and Thermal Ion Composition; Jim McFadden, SSL
Solar Energetic Particles; Davin Larson, SSL

Remote-Sensing Package
Imaging Ultraviolet Spectrometer; Nick Schneider, LASP

Particles and Fields Package
Solar Wind Electron Analyzer; David Mitchell, SSL
Solar Wind Ion Analyzer; Jasper Halekas, SSL

Langmuir Probe and Waves; Bob Ergun, LASP
Magnetometer; Jack Connerney, GSFC
MEPAG appreciates that non-strategic Mars missions are allowed to compete in Discovery, per the Decadal Survey recommendation:

- “the committee recommends that NASA continue to allow proposals for Discovery missions to all planetary bodies, including Mars”
  - Visions and Voyages, 2012.
Summary of the Final Report

25 September 2012

MPPG report scheduled for discussion/review by MEPAG on Oct. 4.
- MEPAG ExCom provided input during MPPG process
MEPAG Recent Activities

Telecon presentation to MEPAG Executive Committee from science members of the MPPG
- Discussed ongoing formulation of pathways addressing Decadal Survey and human exploration goals
- MEPAG provided P-SAG input to MPPG
- MEPAG will continue to support ways to engage the Mars community as fully as possible in the discussion

Precursor SAG (P-SAG) final report delivered
- Mike Carr and Dave Beaty co-chairs
- Participants from both science and human exploration communities
- Preliminary report on updated Strategic Knowledge Gaps (SKGs; provided in June 2012); material posted on MEPAG website where it can be linked to LPI workshop activities

MEPAG Goal IV updated based on P-SAG report
### Analysis of Strategic Knowledge Gaps Associated with Potential Human Missions to the Martian System

**Technical experts consulted:**
- Atmosphere/EDL: Alicia Dwyer Cianciolo (LaRC), Farzin Amzajerdian (LaRC), Hunter Waite (SwRI), Dave Hinson (Stanford)
- Resources: R.M. Hembree (JSC), Bill Larson (KSC), Bruce Campbell, Mike Wolff (SSI), Diane Linne (GRC), Phil Metzger (KSC), R.T. Clancy, M. Smith (GSFC), T. McConnochie (GSFC), Patrick Peplowski (APL).
- Radiation, Human health/performance: Francis Cucinotta (JSC), John James (JSC), Insoo Jun (JPL),
- Humans to Mars orbit/Phobos/Deimos: Julie Castillo-Rogez (JPL), Dan Mazanek (LaRC), and Lee Graham (JSC).
- Mars surface operations: Chirold Epp (JSC), Paul Hintze (KSC), Philip Metzger (KSC), Sandra Wagner (JSC).
- Technology Planning: Scott Vangen (KSC), Mars Program Office technical staff

### Co-chairs

<table>
<thead>
<tr>
<th>Co-chairs</th>
<th>Institution</th>
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<tbody>
<tr>
<td>Carr, Mike</td>
<td>USGS (ret)</td>
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<td>Beaty, Dave</td>
<td>MPO</td>
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### Team members

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<td>Abell, Paul</td>
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### Ex-officio team members

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**P-SAG Contributors**

Precursor Strategy Analysis Group (jointly sponsored by MEPAG and SBAG)

**Facilitation/Support:**
- Rich Zurek (MPO), Deborah Bass (MPO)
P-SAG Summary

1. Identified 17 **Strategic Knowledge Gaps (SKGs)** associated with the four HEO goals:
   A. First human mission to martian orbit (Goal IV-).
   B. First human mission to land on either Phobos or Deimos (Goal IV- P/D).
   C. First human mission to the martian surface (Goal IV).
   D. Sustained human presence on Mars (Goal IV+)

2. The SKGs have been broken down into ~60 **Gap-Filling Activities (GFAs)**, and each has been evaluated for priority, timing, and platform.

3. The relationship of the above to the science objectives for the martian system (using existing MEPAG, SBAG, and NRC scientific planning), has been evaluated.

4. The priorities relating to the Mars flight program have been organized by mission type, as an aid to future mission planners: orbiter, lander/rover, Mars Sample Return (MSR), and Phobos/Deimos.
### Summary of Findings (first 5 of 6)

<table>
<thead>
<tr>
<th>Finding #1</th>
<th>The high-priority gaps for a human mission to Mars orbit relate to a) atmospheric data and models for evaluation of aerocapture, and b) technology demonstrations.</th>
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<td>Finding #2</td>
<td>A human mission to the Phobos/Deimos surface would require a precursor mission that would land on one or both moons.</td>
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| Finding #3 | The early robotic precursor program needed to support a human mission to the martian surface would consist of at least:  
  - One orbiter  
  - A surface sample return (the first mission element of which would need to be a sample-caching rover)  
  - A lander/rover-based *in situ* set of measurements (which could be made from the sample-caching rover)  
  - Certain technology demonstrations |
| Finding #4 | P-SAG has not evaluated whether it is required to send a lander or rover to the actual human landing site before humans arrive. |
| Finding #5 | For several SKGs, simultaneous observations from orbit and the surface need to be made. This requires multi-mission planning. |
FINDING #6. There are five particularly important areas of overlap between HEO and science objectives (in these areas, mission concepts with dual purpose would be possible).

1. Mars: Seeking the signs of past life (Goal I)/ Water ISRU (SKG #D1).
2. Mars: Seeking the signs of present life (Goal I)/Modern surface water/ice (Goals I,II&III/ SKG #D1)/ Forward and back PP (SKG #B2-B5).
3. Mars: Atmospheric dynamics, weather, dust climatology (Goal II/SKG #A1-A2-B1)
4. Mars: Surface geology/chemistry (Goals I&III/SKG #B3-B4-B7)
5. P/D: General exploration of P/D (SBAG/SKG #C1-C2)
HEOMD, MEPAG and SBAG share several high priority measurement objectives in the Martian system. These common objectives could be achieved by flying several kinds of precursor robotic missions.

- At least one orbiter
- Mars surface sample return. This is an essential part of the robotic precursor campaign to retire early SKGs and to address the highest science priority for solar system exploration
- A lander or rover (possibly the MSR sample caching rover, if configured properly)
- A mission to Phobos and/or Deimos

Follow-up actions for future study teams

- Technology development/demonstration. Which require flight demonstration at Mars or Phobos/Deimos and when do we need these?
  - Is a robotic precursor mission to the actual human landing site(s) on the surface of Mars required?
  - Is a precursor sample return mission from Phobos/Deimos required before sending a human mission there?
- A comparative study of the strategic value to Mars missions of water-based resources at various locations in the solar system, including P/D, the martian surface, the Moon, and small bodies.
Future Planning, Meetings and Milestones

<table>
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<tr>
<th>Event</th>
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<tr>
<td>MEPAG Meeting (Fall 2012; Pasadena) *</td>
<td>October 4</td>
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<tr>
<td>MAVEN Science Community Workshop (San Francisco)</td>
<td>December 2</td>
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<tr>
<td>MEPAG Meeting (Winter 2013; Washington, DC)</td>
<td>February 26-27</td>
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<tr>
<td>8th International Conference on Mars (Pasadena, CA)</td>
<td>July 15-19</td>
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* Agenda to include reports from P-SAG, MPPG & MEP; status of continuing missions; and early MSL science results
Goals for October 4 MEPAG Meeting

1. Discuss Mars Program planning in light of the President’s proposed budget
   - Final Report from the joint MEPAG/SBAG Precursor Strategic Analysis Group (P-SAG)
   - Results from the Mars Program Planning Group (MPPG) regarding options for an integrated Mars program
     - Capture the community’s reaction for PSS
   - Current interactions with Human Exploration (HEOMD)
2. Receive an update on ESA’s Mars missions, current & planned
3. Overview of scientific objectives and plans for InSight, the Discovery Program’s recently selected Mars mission
4. Discuss updates to the MEPAG Goals document
5. Hear selected meeting reports:
   - Workshop on the Mantle of Mars
   - Workshop on Planetary Caves
6. Discuss possible new analysis initiatives
The Mars community is encouraged by Congressional actions attempting to restore some of the funding cut from the Mars program and the accompanying language underlining the importance of the Decadal Survey recommendations.

MEPAG again notes the high scientific and programmatic value of the currently operating Mars missions and of the research and analysis programs that exploit the full value of data already in hand or soon to be acquired.

The MPPG “pathways” seem a reasonable way to capture options. MEPAG strongly urges all future planning groups to take full advantage of the recent work by MEPAG SAGs (e.g., ND-SAG, MRR-iSAG, E2E-iSAG) and to involve the community wherever possible.

MEPAG looks forward to a successful Curiosity surface mission!