Overview of NASA and the “new” Mars Exploration Program

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Agenda

• The President’s 2011 Budget

• MSL—2011 launch

• NASA-ESA Partnership for Mars Exploration—where are we now?

• Opportunities across the Solar System
FY 2011 President’s Budget: Changes in NASA’s Landscape

• Challenges NASA to embark on a new human space exploration program that focuses on
  – Obtaining key knowledge about future destinations
  – Demonstrating critical enabling technologies for human spaceflight

• Exploration Systems Mission Directorate (ESMD)
  – Challenged to extend human presence in the solar system
  – Recent progress reports at Galveston, TX

• Office of the Chief Technologist created

• Mars as the ultimate destination is typically the driving case
  – MEP has been engaged with the Exploration Robotic Precursor teams
    – Utilizing the extensive 2004-05 Safe on Mars roadmapping efforts.
  – MEPAG Goal IV becomes extremely relevant—again

• Internal NASA partnerships are critical to Agency success, building on existing expertise
2011 Mars Science Laboratory (MSL)

Cruise Stage

Backshell Interface Plate (BIP) Parachute Support Structure (PSS)

Parachute (EDL)

Backshell (EDL)

Descent Stage

Bridle & Umbilical Device

Rover

Heatshield with MEDLI (EDL)
MSL Assembly and Test Phase is Underway

CS Harness Install

MMRTG Install Demo (B170)

RVR (Wheels Down)

RVR Turn Over
MSL—A Hi-Bay Full of Hardware!
The Joint Mars Exploration Program (JMEP)
A NASA-ESA Partnership
In 2008, ESA and NASA were both having budget difficulties
- ESA was unable to obtain adequate funding for ExoMars
- NASA 2009 budget included a significant Program reduction, followed by the slip of Mars Science Laboratory launch from 2009 to 2011

Early in 2009, ESA and NASA began studies to merge resources of ESA’s ExoMars and NASA’s Mars Exploration Programs

Successful merger was endorsed through Statement of Intent in November 2009 by the NASA Administrator and ESA Director General.

“Initially focusing on 2016 and 2018, this initiative would span several launch opportunities … conducting astrobiological, geological, geophysical, climatological, and other high-priority investigations, and aiming at returning samples from Mars in the mid-2020s.”

2016 and 2018 missions are the foundations of the JMEP, moving the agencies towards a joint Mars sample return mission in the 2020s.
JMEP Management Structure

• Management structure in place
  – Neither the NASA MEP nor ESA ExoMars Programs were disbanded
  – Joint Mars Executive Board—governing Body; meets quarterly
  – Joint Engineering Working Group—for mission formulation and technical studies
    • Mars Sample Return Working Group established in April

• Governing documentation, review and approval processes, etc., maturing
  – Agency-level governance through Memorandum of Understanding (MOU)
  – Program governance and methodology through Joint Executive Program Plan

• Senior Agency Oversight—reviews progress/status/issues semi-annually in Bi-Lateral meetings (Dr. Southwood and Dr. Weiler)

• 2016 ESA orbiter/tech demo decent module, is under ExoMars program office
  – NASA project established in the Mars Program Office at JPL

• 2018 is in the Advanced Planning Group of the Mars Program Office at JPL
  – In ESA, the rover is also under ExoMars program office
Mission Overview—ESA Mission Lead
- Orbital science and refresh telecommunications infrastructure
  - Critical ESA secondary mission—Entry, Descent and Landing (EDL) demonstrator
- Primary Science—Trace gas detection and characterization, incl. methane
  - Potential Secondary Science—moderate resolution imaging (2-3m)
  - Tertiary science on ESA lander--<5kg battery-only payload, e.g. seismology or meteorology
  - All instruments jointly selected through AOs for orbiter & lander
  - Orbiter AO released January 15, 2010; selection process underway

- Key NASA roles/deliverables
  - Orbiter science payload
  - Launch vehicle – Atlas V 421-class
  - Proximity link/Ka-Band deep space-to-earth link
  - Science operation lead; aerobraking design/operation lead; relay lead

- Key Near-term Milestones
  - Aug.’10 Joint instrument selection
  - Nov ‘10: Mission PDR
  - Jun ‘11: Mission/System Confirmation Review (ØB -> ØC)
Mission Overview— NASA Mission Lead

- Deliver NASA’s and ESA’s rovers to the surface of Mars
- Primary Science—astrobiology and caching samples
  - NASA: astrobiology and contact science, sample caching
    - Based on community’s MAX-C mission concept
  - ESA: critical technologies—roving and drilling
    - Exobiology science payload
- ISAG formed to help define complimentary science (MEPAG outbrief)

Key NASA roles/deliverables

- Rover—science payload selected through AO
- Launch vehicle – Atlas V 531-class
- SkyCrane-based entry, descent and landing system
- Launch, cruise and EDL operations, operations for U.S. rover

Key Near-term Milestones

- Mar ‘10: Concept Feasibility Review
- Sept ‘11: ICD Version 1
- Dec ‘11: Mission Concept Review (leads to KDP-A)
The NASA 2018 Mars Rover will perform *in situ* exploration of Mars and acquire/cache dual sets of scientifically selected samples.

**Key mission concept features**
- Cruise/EDL system derived from MSL, launched on Atlas V 531-class vehicle.
- Land in ~10 km radius landing ellipse, up to -1 km altitude, within +25 to -15 degrees latitude.

### Major Rover Attributes

<table>
<thead>
<tr>
<th>Science Capability</th>
<th>Remote and contact science: Color stereo imaging, macro/micro-scale mineralogy/composition, micro-scale organic detection/characterization, micro-scale imaging Coring and caching rock samples for future return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payload Mass</td>
<td>~15 kg instruments</td>
</tr>
<tr>
<td></td>
<td>~60 kg including corer/abrader, dual cache, mast, arm</td>
</tr>
<tr>
<td>Traverse Capability</td>
<td>20 km (design capability)</td>
</tr>
<tr>
<td>Surface Lifetime</td>
<td>500 Sols (design life)</td>
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![Diagram of the 2018 NASA Mars Rover](image.png)

**Instrument/Sensing Mast**
- Quad UHF Helix
- High Gain Antenna
- Low Gain Antenna
- ~2m Ultraflex Solar Arrays

**Sampling/Science Arm**
- SHEC "Sample Cache"
- Hazard Cameras

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**Payload Mass**
- 360 kg
- 300 kg
- 2360 kg
- 500 kg
- 2860 kg
- 500 kg
- 590 kg
- 4440 kg

* * Artist's Renderings
2018 ESA ExoMars Rover

Mast, 1.7 m height:
- Navigation stereo
- Panoramic stereo
- High res. imager

Drill:
- Deployment joints
- Main drill tool
- 3 extension rods
- Back-up drill tool
- Ma_Miss Instr.

Nominal Mission: 180 sols
Nominal Science: 6 experiment cycles + 2 vertical surveys
Rover Mass: 270 kg
Payload: 8 instruments; 14.4 kg
- Pan Camera
- Ground Penetrating Radar
- ExoBio Lab

Solar Panels
- 1 fixed, 4 deploy.
- Tilt: sunrise/set

Main body:
- Structure frame
- Thermal insul.
- Radiator area
- Harness ducts

Locomotion SS:
- 6 wheels, 21 DoF
- Flexible wheels

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Land NASA rover and ExoMars rover together attached to a landing platform

- NASA rover and ExoMars rover perform *in situ* science exploration: assessing potential joint experiments
- NASA rover will cache scientifically selected samples for future return

**Study Concept Includes:**

- Landing platform (pallet), ‘proof-of-concept’
- Scaling of MSL aeroshell diameter (from 4.5 m to 4.7 m) to accommodate 2 rovers
  - Preserve MSL shape, L/D
  - Same thermal protection system
  - Same parachute
- Descent stage architecture/design based on MSL
  - Same MSL engines, avionics, radar, algorithms, etc
  - Mechanical structure updated to accommodate rovers/platform geometry/loads
  - Incorporates terrain-relative descent navigation capability
- Alternative architectures in study as well
Dual Rover ISAG: Key Recommendations

Collaborative science that could be done by the NASA and ExoMars Rovers, with and without changes to the rovers’ baseline hardware.

1. **Group 1 (no change) highest priority science:**
   1. **NASA rover as Scout.** Use NASA rover to scout for drill locations for EXM, requiring rovers to co-locate for a period of time.
   2. **Discovery Follow Up.** Several variations on following up on either rover’s discovery of interesting or contentious samples using the other rover, requiring rovers to co-locate for a period of time.
   3. **Explore the Territory.** Send the rovers in different directions to improve spatial coverage, requiring little change to operations plans at this time.

2. **Group 2 (some change) highest priority science:**
   1. **ExoMars Sample Return.** Return an EXM-acquired sample to Earth via a possible future MSR, requiring changes to sampling systems of both rovers and potential co-location of rovers for extended time.
   2. **Increase NASA rover Payload.** Several different kinds of instruments considered for addition to the proposed NASA rover payload (additional recon tools, methane sensor, GPR), increasing mass/power/data requirements.
The Planned JMEP Portfolio

- **Operational (2001-2007):**
  - Odyssey
  - Mars Express Collaboration

- **2009:**
  - MRO

- **2011:**
  - MAVEN Aeronomy Orbiter

- **2013:**
  - NASA—ESA Rovers (Astrobiology/Sample Return Cache)

- **2016:**
  - ESA—NASA ExoMars Trace Gas Orbiter

- **2018:**
  - NASA—ESA Rovers (Astrobiology/Sample Return Cache)
  - The Era of Mars Sample Return begins

- **2020 & Beyond:**

"For Planning and Discussion Purposes Only"
A Multi-Element Architecture for Returning Samples from Mars

- Scientifically selected samples
- Sample integrity protected for multi-years
- Sample launched into stable Mars orbit
- Sample awaits capture
- Mars sample returned to Earth
- Retrieved and protected in transport to Mars Returned Sample Handling Facility
- Hazard assessments and science

- Science Robustness—adequate and replaceable surface collection and operations
- Technical Robustness—spread technical challenges across multiple elements & keeps landed mass in family with MSL EDL capability
- Programmatic Robustness—spreads budget needs and reduces peak-year program budget demand and involves mission concepts with sizes similar to our implementation experience
- Facilitates cooperation from multi-national partners
Note: Launch of MSR Orbiter can precede the MSR Lander: provides updated infrastructure on Mars to support EDL and surface operation of MSR-Lander, especially observation of MAV launch.
Other NASA Opportunities
NASA Planetary Science Decadal Survey
Provides a Glimpse of Possible Probes

• Planetary Sciences Decadal Survey in process; tasked to
  – Develop science priorities for the next decade for ALL planetary missions
  – Recommend New Frontiers topics

• Decadal survey *not* tasked to
  – Prioritize competed mission science (e.g. Discovery/Mars Scout-class)

• NASA conducted studies for panels and Steering Group
  – Some more detailed full mission studies
  – Some low-maturity concepts

• Recommendations and priorities will be in the report—due in early 2011
Decadal Survey-Requested Full Mission Studies

- **INNER PLANETS**
  - Lunar Geophysical Network
  - Venus Climate Mission

- **MARS**
  - Max-C*
  - MSR Lander/MAV*
  - MSR Orbiter
  - Mars Geophysical Network*

- **GIANT PLANETS**
  - Saturn Probe*
  - Uranus Mission

- **PRIMITIVE BODIES**
  - Comet Surface Sample Return
  - Trojan Tour

- **OUTER PLANET SATELLITES**
  - Europa Jupiter System Mission
  - Titan Saturn System Mission*
  - Ganymede Orbiter
  - Enceladus Orbiter

(*) Entry into a planetary atmosphere
Decadal Survey Requested Concept Studies

• Explored at a very low maturity level

• Landed concepts included:
  – Venus Tessera Lander
  – Venus Mobile Explorer
  – Mercury Lander
  – Titan Lake Lander
  – Mars Polar Science
Conclusions

• Increasing number of NASA-wide mission types and opportunities as NASA transforms its human space flight and technology programs

• Robotic exploration opportunities may also increase, with greater challenges, under new Decadal priorities

• NASA Mars Program Objectives have shifted for the Next Decade as well
  – Embed the Joint ESA/NASA Mars Exploration Program in US and European space agencies
  – Implement joint ESA/NASA 2016 mission
  – Begin sample return campaign with 2018 dual rover mission
  – Develop key sample return technologies
    • Joint MSR Working Group to define responsibilities
  – Plan and initiate the next missions and sequence