Science and Mission Concepts:

Panel Summary by
Doug Stetson
Steve Clifford
Jorge Vago

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Science and Mission Concepts

Topic Areas

- Using Mars Moons
  - Rationale and mission concepts
- Motivating Science
  - Identification and exploration of modern aqueous/icy environments
  - Strategic investments and imperatives
- Compositional Investigations
  - New and improved sensors and instruments
- Geophysical Investigations
  - Subsurface exploration techniques
  - Martian interior
- Organic Molecule and Life Detection
  - Measurement strategies
  - Sensors and instruments

Cross-Cutting Themes

- Enhancing the value of Mars Sample Return: Site and sample selection
- Preparing for human exploration: Precursors, locations, resources
- Ensuring human safety and productivity
- Unlocking the mysteries of Mars: New opportunities for the next decade

Enhancing MSR

- Our understanding of Mars, especially evidence for an active hydrologic cycle, has advanced significantly even since the Decadal Survey
  - Possible/likely present-day water and brines (gully processes/RSLs)
  - Amount and distribution of ice, esp. mid-latitude ice
  - Geology/geomorphology indicative of past water and habitable environments
- There are significant investigations that could/should be done prior to committing to a specific MSR site and mission architecture
  - Imaging radar and and atmospheric composition to localize interesting sites
  - Detailed imaging and compositional mapping from orbit
  - In situ exploration of diverse sites (surface and subsurface)
  - GPR for geological context and detection of ice/habitable environments
  - Detailed chemical/biological analysis to fine-tune sites and sample selection
- Ensuring the scientific success and operational safety of MSR
  - In situ sample assessment: Micro-imaging, mineralogy, wet chemistry
  - Sample caching and monitoring: Smart containers
  - High-resolution mapping of specific sites

Preparing for Human Exploration

- Continued scientific study of Mars is a key to enabling targeted, cost-effective human exploration
  - Extensive characterization of environments (surface/subsurface)
  - High-resolution mapping of mineralogy, resources – site selection
  - Subsurface sounding and imaging radar
  - Bioassays
  - Polar locations are scientifically compelling and potentially resource-rich human destinations, and merit further study
- Understanding the subsurface is an important step (resources/habitability)
- Phobos/Deimos are important destinations that may provide much of the value of human surface exploration at reduced cost and risk
  - Natural space stations and a potential “base camp”
  - Teleoperation of surface payloads and habitat build-up; alleviates some planetary protection issues
  - Accessible resources
  - Compositional studies, and possibly sample return, are critical robotic precursors

Ensuring Human Safety and Productivity

- Robotic science missions will provide critical knowledge for safe and effective human exploration
  - New sensor and instrument concepts hold the promise of providing significant new data at relatively low cost
  - Characterization of atmosphere and landing sites, and correlation of orbital and in situ data
  - High-resolution imaging and detailed topographical maps
  - Understanding toxicity ("some Mars locations would be Superfund sites")
- Evolution of robotic science instruments will lead to devices that allow humans to conduct effective science on Mars, *for example:*
  - "Chemical laptop" for rapid assessment of biological activity or potential
  - Backpack GPR to determine drilling sites
  - "Tricorder" for sample selection – interior of rocks with minimal preparation
- Exploit terrestrial analogs to establish a culture of field work
- Enhance systems engineering approach – requirements flowdown from human needs to robotic/science missions and measurements

Unlocking the Mysteries of Mars: Fundamental Planetary Science

There is a tremendous amount of important planetary science to do at Mars, independent of MSR and human exploration

- Exploration of unique environments to understand planetary evolution and habitability
- Martian interior through seismic studies
- Climate evolution and atmospheric processes/escape
- Search for past and present life
  - Diverse suite of sensors and techniques to detect and characterize biological activity and potential
  - Broad approach recommended: Surface and atmosphere from orbit, in situ sample analysis (chemical and morphological), subsurface
- Phobos and Deimos – origin and composition

A reformulated Mars program should preserve these important aspects of the overall solar system exploration program

Key Issues and Recommendations

- Readiness for Mars Sample Return
  - New findings since Decadal should be considered during program reformulation
  - Value of MSR would be enhanced by further robotic missions
  - Need to factor in results from MSL and ExoMars, especially in regards to habitability and subsurface
  - New life detection concepts hold great potential to enhance understanding prior to MSR and could lead to optimum mission architecture
- Near-term opportunities
  - 2018/2020 opportunities should be considered for site/atmosphere characterization from orbit, and lander/small rover to specific interesting locations
- Internationalize MSR and restore some (limited) participation on ExoMars
- Re-establish a regular means to conduct small focused Mars missions
- Ensure a well-funded R&A program including studies of martian meteorites and development of sample analysis techniques