Concepts and Approaches for the Robotic Exploration of Mars

Lunar and Planetary Institute
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"What: Basic Mars Science" Session

Summary for Mars Program Synthesis Retreat
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What: Basic Mars Science (56 talks)

- Overview
  - Exploration strategy (5 talks)
  - Concepts: Life, climate,volatiles, crust, interior (7)
- Orbital observations
  - Selected instruments (1)
  - Novel concepts (6)
- Surface observations
  - Selected instruments (9)
  - Novel concepts (9)
- Subsurface water, organics and life
  - Overview (3)
  - Novel concepts (9)
- Chronology
  - Overview (1)
  - Novel concepts (3)
- Magnetic field and deep structure (3)

Mars Exploration Program (6/20/00)

- Determine if life ever arose on Mars
  - Determine if life exists *today*
  - Determine if life existed on Mars in the *past*
  - Assess the role of prebiotic chemical evolution on Mars
- Determine the climate history for Mars
  - Characterize the *present* climate
  - Determine if there was a *recent* climate change
  - Determine the *ancient* climate record
- Determine the resources available on Mars
  - Determine spatial and temporal evolution of Martian crust
  - Characterize near-surface/shallow sub-surface structure of *crust*
  - Characterize interior structure, dynamics and history of *interior*
  - Conduct technology experiments to support longer term exploration, including eventual presence of *humans*

Key Broad Science Recommendations

- Endorse existing Mars science goals & objectives
- Mars program should be balanced with respect to studies of interior, crust, atmosphere & life
- Balanced program requires international cooperation regarding science, technology and implementation
- Build global databases: understand Mars as a system
  - Formation & evolution of the whole planet
  - Understanding water in all of its ramifications
- Focussed interdisciplinary studies of key regions
  - e.g., Thermally-active regions with multidisciplinary significance (life, climate,resources, solid planet)
- Sample returns are a crucial program component
  - Must be coordinated with global & regional observations
  - Couple *in situ* to sample return analyses (e.g., sample selection)

Mars Exploration

Primary Goals

Formation and Evolution of the Planet

Water

When
Where
Form
Amount

Life	Evidence of Past or Present Life	Understand the potential for Life elsewhere in the Universe
Climate	Weather, Processes & History	Understand the relationships to Earth's climate change processes
Resources	Environment & Utilization	Understand what resources the solid planet provides for future exploration

Orbital Investigations (8 talks)

- Complete global survey of composition/mineralogy
  - Complete global VIS, NIR & MIR spectral datasets
  - Support data analysis to create mineralogy maps
- Observe additional wavelengths/phenomena
  - Radio, microwave, far-IR,γ-wave, magnetism, neutrons
- Support atmospheric studies
  - Follow the water: global circulation models, local plumes
  - Long-term evolution, e.g., processes controlling losses to space
- Support regional surface studies
  - Follow the water: mineralogical maps
  - Improve spatial resolution: mesh with ground observations
- Support subsurface and interior studies
  - Follow the water: sounding
  - Interior: sounding, seismic, magnetism

Surface Investigations, ~26 talks (Page 1 of 2)

Define compositional/mineralogical diversity of surface

- Calibrate spectroscopic remote sensing observations
- Observe both rocks & fine-grained regolith

Maintain and diversify suite of *in situ* observations

- Utilize full Athena package: an example of valuable synergy
- Develop others: e.g., calorimetry, chronology, GPR, imaging spectroscopy, IR microscopy, life detection, magnetism, mass spectrometry, organic chemistry, seismology, X-ray diffraction

Follow the water

- Study impact upon atmospheric circulation, physical state of surface, minerals & subsurface
- Map evidence of earlier habitable conditions & their duration

Surface Investigations (Page 2 of 2)

- Life and prebiotic chemistry
  - Search aqueous deposits for all types of biomarkers
  - Organic studies: progress from general to specific species
  - Geophysical & geochemical search for subsurface aquifers
- Support studies of subsurface and deep interior
  - e.g., Sounding, seismic, magnetism, new geophysical methods
  - Develop ongoing program that parallels surface & atmospheric programs
- Improve access to the surface for sample analysis
  - Precision landing
  - Surface mobility: far-ranging rovers, rough-terrain robots, balloons
  - Micromissions

Trends

- Improved program balance: Life, climate, solid planet, coordination with other Enterprises
- Greater need for effective international cooperation
- Discovery of fluid (H_20) flows adds realism & priority to search for habitable environments and life
- New technologies will continue to modify investigations, e.g., organic & biological measurements, spectroscopy, etc.
- Growing emphasis on diverse *in situ* analyses: broaden geographic coverage, calibrate orbital databases, add network science, do focussed regional studies, strengthen Mars chronology, pioneer observations for sample return & other future exploration
- Stronger Earth-based program to support sample return: e.g., LIFARS, PP, biomarkers, meteorites, site selection, etc.

Key Comments Made in Final Discussion

- Not emphasized during session talks, but important:
  - Sample return science, e.g., LIFARS, biomarkers, geochronology
  - Upper atm.-space processes, esp. as relates to atm. evolution
- Chemical/mineralogical/geochronological measurements need emphasis to address future major goals
- *In situ* experiments will play key roles throughout the program, even into the human mission phase
- The program must combine flexibility (wrt science and technology) with stability (wrt infrastructure, technology development and flight systems)