Roving Mars: 2000+ sols into a 90-sol mission

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Why Mars?

- There are well over 100 worlds in our solar system, not including the flotsam. Why does Mars hold such interest?
- Mars is an end-member by which we can better understand Earth.
- Mars gives us historical context in which we can put our own planet.
- Mars is a geologic world, with rocks to play with and dirt to dig in and important questions to answer.
Mars

- Mars has the most Earth-like geology.
- Numerous volcanic features

Apollinaris Patera

Olympus Mons
Lava tubes on Pavonis Mons
- Fluvial and sedimentary features
Possible gullies, showing layering
An active planet

The most significant finding: Evidence of recent liquid water activity.

- Gully as it appeared in 2001
- Gully as it appeared in 2005
Wind-transported features

Dunes along the edge of Mars’ North Pole

Elysium dune field
Wind tail behind Barnacle Bill, Ares Valles
Martian dust devil

Arizona dust devil
Mars

- Atmospheric disturbances on two planets.
Oregon as Mars analog
MER Mission: explore two sites on Mars where water may once have been present, assess the suitability of past environmental conditions for possibility of life.
MER Timeline


The first image of the interior of a Mars Rock by Spirit.
Mission highlights

- Rovers were designed to last (at least) 90 martian days (we call them sols).
- Spirit is up to sol 2065; Opportunity planned sol 2043 today.
- Rovers together have clocked over 25 km (Opportunity alone has gone over 18 km)
- Mission highlights from both sides of the planet.
The Berry Bowl: First solid proof of the action of water on Mars.
MER Opportunity results

- Rock formations that were formed by liquid (standing) water.
Opportunity at Victoria Crater
HiRISE image
Water inside Victoria Crater

Fins, Gilbert layer
Dust storm, June-July, 2007
Opportunity Traverse Map (Sol 2042)
Block Island
a Large Iron-Nickel Meteorite

Vail Beach
Block Island Target Names

- Siahs Swamp
- Great Salt Pond
- Middle Pond
- Fresh Pond
- Sachem Pond
- Middle Pond
- Harbor Pond
- Centinental Pond
- Sands Pond
- Clayhead Swamp
Spirit images itself.
Spirit science results

- Gusev crater was formed in basaltic rock. This is a rocky landscape.
- Evidence for impacts and eolian activity, but no standing water at initial site.
- Bedrock regions show more significant alteration by water.
Flutes and ventifacts, Gusev Crater
Mars fights back, and Spirit gets lucky.
Crisis for some, Opportunity for others

- Arad, in the Dead Sea region, is a bed of evaporites (salts).
- Salts are commonly transported dissolved in water....
HiRISE image of Spirit location and the rover itself.

Home Plate: A possible hydrovolcanic remnant?
Staying over in our second Winter Haven
Winter #3

- Because of the latitude of Spirit’s landing site, winter means very little sunlight.
- Present tilt of 29.9° gives us the most sunlight per day on our solar panels.
Winter #4 is coming: Free Spirit!

- We’ve been stuck since about sol 1886.
- Contrary to statements of others, Spirit is NOT dead and we have NOT given up on her extrication.
- November 8 is the earliest possible date to start the attempt.
A simple scientist roving Mars

- The best job in the world.
An old technique for a new world

- Morphology (size, shape, roundness) contains much of the record of a clast’s history.
- These characteristics can be quantified.
- Quantification allows correlation with other numerical data such as spectral signature.
- Important for Mars because it provides a numerical characteristic that is independent of non-lithologic factors.
Benefits to using this technique

- Morphology is presumably independent of all these except the physical nature of the rock itself.

Spectral inputs

- Atmosphere
- Sun angle
- Coatings
- Dust
- Rock composition
Flat facets, smooth

Vesicular

Flat facets, rougher
One more milestone...

- For a mission of so many milestones, one more occurred on February 22, 2008.
- All rover operational roles for Spirit were “manned” by women.
- This is the first time for any spacecraft that enough trained women were available to do this.
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The Mars Estrogen Rover Mission
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2. The Mini-TES mirror will be used to apply makeup.

3. Pancam images of the back deck will be repeatedly taken to see if the rover’s rear end really does look fat.
Time for fun

- Every mission is actually a collection of people.
- The smart PI will find ways for their crew to let off steam.
- The smart agency will understand that allowing scientists to be human beings (as much as that injects unpredictability into the mix) is a crucial way of drawing new, young scientists to the agency.
Calibrating our discussion

- **Robots vs. Humans:**
  - More instruments available
  - More people available to make good decisions
  - WAY safer

- **BUT**
  - More people available to complain about decisions
  - The amount of work that can be done is severely limited by:
    - Time
    - Data rate
    - Power
    - Spacecraft needs/limitations
Mars Exploration Rovers

- Day to day operations

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+-----------------+   +-----------------+   +-----------------+
| Panorama        |   | Feature of interest chosen? |   | Science target chosen? |
| - B&W imaging   |   | yes                         |   | no                 |
| - Color imaging where power, data rate allow |   | no                          |   | yes                |
|                 |   |                            |   | New science target chosen? |
|                 |   | no                         |   | yes                |
|                 |   |                            |   | Spectroscopic analysis |
| - Image feature at 0.5 m resolution |   |                            |   | - Image at 30μm and 10 μm/pixel |
| - Color imaging if possible |   |                            |   | - Gather representative hand samples |
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Trends in Energy and Tau

MERA Array Input sol 1250 - 1469
Tau sol 1250 - 1469

n+1 predict: 225 Whrs

Tau: 0.381
Energy: 247 W-hrs
Trends in Dust Factor

sol1469
dust factor: 0.3762
Data Volume and Power

Flash Status as of Sol 1471 ODY-1

Data Products on Board: 1565 DP
Flash Available: 1080 Mb
Unsent data (Pancam tracking): 274 Mb
Acquired Data: 101 Mb

Sol 1472-1474
Predicted Downlink: 59 Mb (recharge)

Predicted Deletes
Sol 1472: 87 Mb (410 dp)
Flash Available to science: 930 Mb

Sol 1472-1474 Recommendation: 200 Mb

Battery charge, Sol 1469: 11.9 A-hr (predict)
Solar array energy, Sol 1470: 247 W-hr (actual) shunt:6whrs
Tau, Sol 1470 (actual): 0.381
Dust Factor, Sol 1467: 0.377