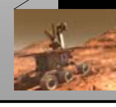
The Mars Exploration Program

A bit about what I do.



Brian Hynek

LASP/Geology

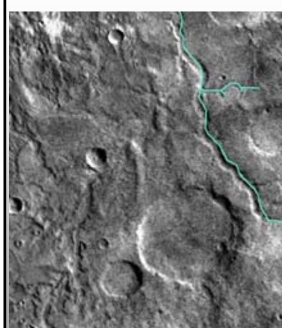
play

work

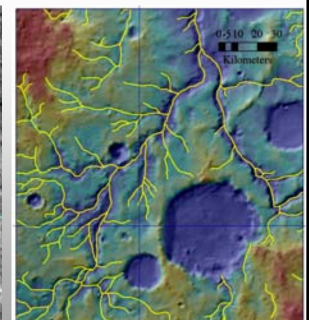
Evidence for Past Water on Mars

- The current thin, cold atmosphere prohibits liquid water from being stable on the surface.
- However, there is ample evidence for past water; indicative of a warmer and wetter climate.

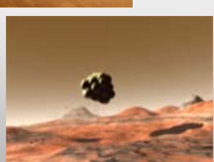
Comparison of Viking and MGS data

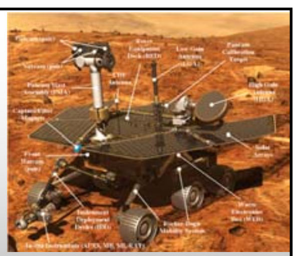


Viking image and previously mapped valley networks

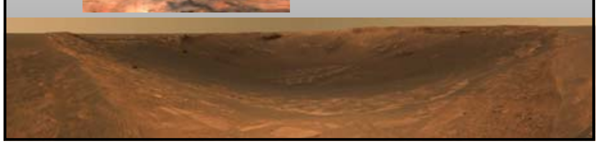


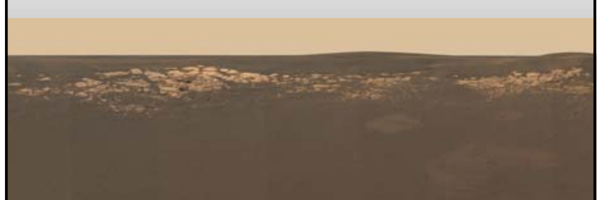
MGS data and newly recognized VN





2003 Mars Exploration Rovers





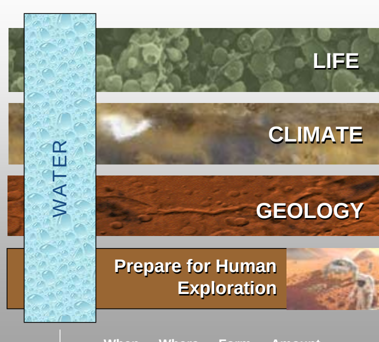
Cerro Negro, Nicaragua: An analog for early Mars

Inside the crater

Mars and NASA

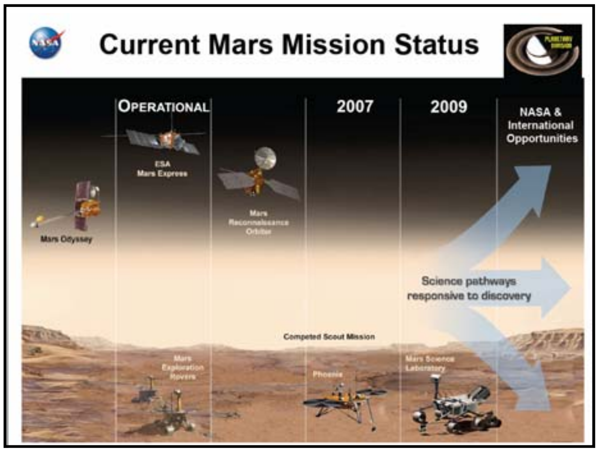
- Mars Exploration Program
  - Different than other solar system bodies in that it is an official program.
- Comprises about ½ of the *science* budget of NASA
  - Science = ~$5B/yr
- Results in an official "architecture" to the mission scheme.
  - Each mission builds on prior work and enables/enhances future missions.
  - Mix of mission types – competed and NASA-center

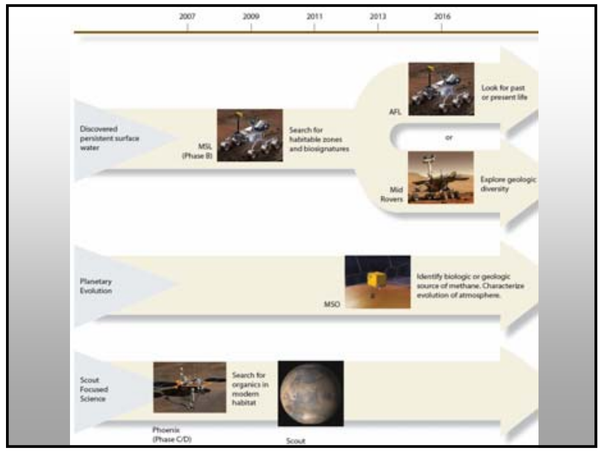
"Follow the Water"

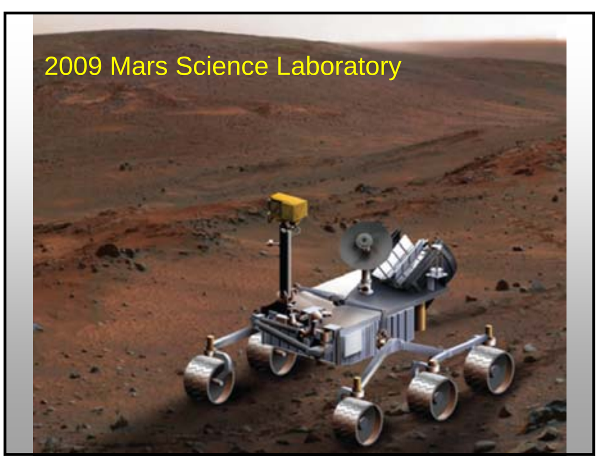


Current Mars Missions

- There are currently 5 spacecraft operating at Mars.
- Mars Odyssey – arrived 2001
  - Discovered huge regions of ground ice and has studied the composition of the surface
- Mars Express (ESA) – arrived start of 2004
  - High-resolution stereo imaging, subsurface radar
  - Released a lander (Beagle II), which failed.
- 2 Mars Exploration Rovers – arrived Jan 2004
  - Have proven a wet history for the planet.
- Mars Reconnaissance Orbiter
  - Started mapping a couple months ago with the highest resolution cameras and spectrometers.

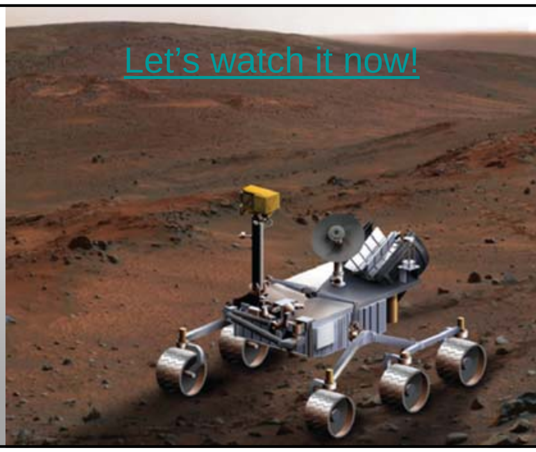






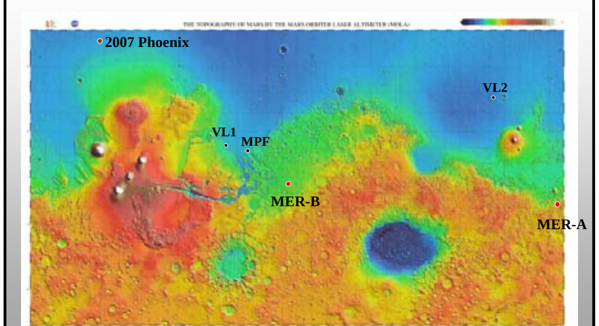
2009 MSL Key Goals

- Characterize a site that:
  - was a habitable environment.
    - What does this mean?
  - is likely to have preserved biosignatures.
  - can be related to the “Big Picture”.



2009 Mars Science Laboratory

Where would you land a $1.7B spacecraft?

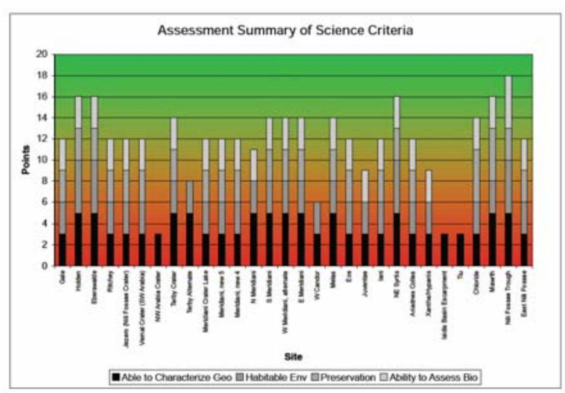


MSL Landing Sites to Be Discussed at the Second Landing Site Workshop, v. 4

LANDING SITES FROM 1st MSL WORKSHOP DISCUSSED AT 2ND WORKSHOP

NAME	LOCATION	ELEVATION	TARGET	PROPOSER
Nili Fossae Trough	20.93°N, 74.35°E	-0.6 km	Phyllosilicates	J. Mustard
Holden Crater Fan	26.32°S, 325.30°E	-2.3 km	Layered Materials	Irwin, Grant, Malin, Edgett, Rice
Terby Crater	27.7435°S, 74.1137°E	-5 km	Layered Material	S. Wilson, Cohen, Dobrea
Marwth Vallis	24.65°N, 340.1°E	~-3.1 km	Phyllosilicates	J-P Bibring, J. Michalski
Eberswalde Crater	23.85°S, 326.75°E	-1.4 km	Delta	J. Schieber, J. Dickson, J. Rice
Gale Crater	4.50°S, 137.35°E	-4.5 km	Interior Layered Deposits	J. Bell, N. Bridges
W Candor	5.80°S, 284.17°E	1.8 km	Sulfate Deposits	N. Mangold
N Meridiani	2.37°N, 6.69°E	-1.5 km	Sedimentary Layers	Edgett Malin
Juventae Chasma	4.45°S, 298.09°E	-2.8 km	Layered Sulfates	J. Grotzinger
Nilo Syrtis	29.16°N, 72.97°E	~-0.5	Phyllosilicates	J. Mustard
Melas Chasma	9.81°S, 283.62°E	-1.9 km	Paleolake	C. Quantin
E. Meridiani	0.01N°, 3.66°E	~-1.3 km	Sedimentary Layers	B. Hynek
Iani Chaos	2.06°S, 342.41°E	Below -2 km	Hematite, Sulfate	T. Glotch
Nili Fossae Crater	18.44°N, 77.58°E	-2.6 km	Valley Networks, Delta sediments	R. Harvey, J. Rice
Eos Chasma	10.7°S, 322.05°E	~-4 km	Chert	V. Hamilton
Meridiani Crater Lake	5.72°N, 358.03°E	~-1.5 km	Crater lake sediments	L. Posiolova
NE Syrtis Major	~16.21°N, ~76.63°E	~1 km	Volcanics	R. Harvey
Hellas/Dao Vallis	39.5°S, 82.7°E	-6 km	Valley Terminus, Layered Deposits	L. Crumpler
Xanthe/Hypanis Vallis	11.4°N, 314.65°E	-2.6 km	Layered Deposits	L. Crumpler
SW Arabia Terra	6.01°N, 355.60°E	-1 km	Sed. Rocks, Methane	C. Allen
W. Arabia Crater	8.45°N, 359.09°E	-1.2 km	Sedimentary Rocks	E. Heydari
W. Meridiani	1.7°S, 352.39°E	~-1.0 to -1.5 km	Sediments, Hematite	H. Newsom
Elysium/Avernus Colles	3.05°S, 170.60°E	-2.5 km	High iron abundance	L. Crumpler

Name	Location	Elevation (m)	Target	Proposer
Ariadnes Colles	35.03 S, 174.17 E	-71	Clay-bearing outcrops	E. Noe Dobrea
Ritchey Crater	28.28 S, 308.93 E	-1178	Clays, fan deposit	R. Milliken
Mawrth Vallis B1	24.5 N, 338.9 E	-3076	layered clays	J-P. Bibring
Mawrth Vallis B2	23.95 N, 341.2 E	-2220	layered clays	Bibring
Mawrth Vallis B3	23.2 N, 342.5	-2104	layered clays	Bibring
Nili Fossae	21.8 N, 78.6 E	-1158	Clays, mafics	Mangold
Terby alternate	27.4 S, 73.5 E	-4509	clays, possible paleolacustrine	E. Noe Dobrea, S. Wilson
Nili Fossae trough alternate	21.73 N, 74.73 E	-695	clays, mafics	Mustard, Elhman
S. Meridiani Clays	3.35 S, 352.64 E	-1948	clays, sulfates	Wiseman, Arvidson
W. Meridiani Alt	3.01 S, 352.1 E	-1881	clays, sultfates	Ollila, Newsome
Chloride site 1	11.4 S, 343.4 E	-1473	chloride salts	Christensen
Chloride site 2	31.5 S, 180.8 E	1388	chloride salts	Christensen
Chloride site 3	27.9 S, 339.1 E	-44	chloride salts	Christensen
Chloride site 4	25.4 S, 346.6 E	-41	chloride salts	Christensen
Chloride site 5	34.36 S, 177.76 E	1373	chloride salts	Christensen
W. Candor Chasma alternate	5.75 S, 285.19 E	-1517	sulfates	Murchie
Tiu Valles	22.9N, 32.25W	~<-3000	Chemolithotrophic habitat	F. Gomez
Gale alternate	5.66 S, 137.53 E	-3385	Interior Layered Deposits	N. Bridges, B. Thomson
Juventae alternate	4.88 S, 297.01 E	-2600	Layered sulfates	J. Bishop
Meridiani B1	3.84 N, 359.04 E			Bibring
Meridiani B2	1.60 N, 3.55 E			Bibring
Meridiani B3	3.19 S, 352.20 E		Same as S, Meridiani Clays	Bibring
Meridiani B4	5.0 S, 354.52 E			Bibring
N. Meridiani			Sedimentary	



2009 Mars Science Laboratory

- Currently is running $75M over budget (~3%).
- The new Associate Administrator is working hard to curtail mission overruns across the board.
  - (overruns add up to >$5B over the past 5 years)

MSL Descopes

- The Project/Program Office recommended descopes in 3 categories from their analyses:
- Group 1 Recommended/Recommended ($19M taken)
  - Eliminate spare RTG
  - Limit to 5 landing sites by Oct '07 site selection workshop
  - Descope MASTCAM zoom capability
  - Eliminate MARDI
  - Replace Surface Removal Tool with a brush
  - Defer Participating Scientist call until Phase E
  - Descope Surface GNC capability
  - Reduce Mission System Development budget (Visualization)
  - Eliminate EDL Hot Swap capability
  - Replace system vibe with acoustics as in past Mars missions
  - Delete Heat Rejection System characterization test
  - Delete Stand Alone S/C Testbed
- Group 2: Recommended with programmatic implications ($6.5M taken)
  - No additional funds to ChemCam
  - Replace (i) MAHLI with MER MI spare and (ii) MASTCAM with MER PANCAM spare
  - Remove REMS and DAN
- Group 3: Not recommended due to high science or technical risk (None taken)
  - Delete redundant RCE
  - Delete second stage SDST
  - Convert MMRTG Qual unit to protoflight
- Other ($0.5M taken)
  - Descope TLS re-integration capability (follow up from early-07 descope round)
  - Cost Cap SAM and Chemin

Descopes executed are in green

MSL PAYLOAD RESCOPES

MSL Rescoped Payload September 2007

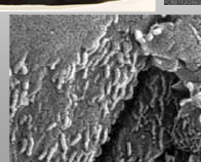
INSTRUMENT	SCOPE CHANGE	
Mast Camera (MastCam)	Zoom capability deleted and cost capped	After a combined 60% cost growth
Mars Hand Lens Imager (MAHLI)	Cost capped	
Mars Descent Imager (MARDI)	Instrument deleted	
Alpha Particle X-Ray Spectrometer (APXS)	No change	
Chemistry Camera (ChemCam)	No funding beyond FY'07 after a 77% cost growth	
Chemistry & Minerology Instrument (ChemMin)	Cost capped after a 160% cost growth	
Sample Analysis at Mars (SAM)	Cost capped after a 60% cost growth	
Radiation Assessment Detector (RAD)	No change	
Dynamic Albedo of Neutrons (DAN)	No change	
Rover Environmental Monitoring Station (REMS)	No change	

Mars Scout Selections

- **MAVEN: Mars Atmosphere and Volatile EvolutioN** - Bruce Jakosky (Univ. of Colorado) - Mars climate and habitability and improve understanding of dynamic processes in the upper atmosphere and ionosphere.
- **TGE - The Great Escape** - Jim Burch (SWRI) - Determine basic processes in Martian atmospheric evolution by measuring the structure and dynamics of the upper atmosphere.
- Mission down-selection to be announced January 2008
- Mission of Opportunities include:
  - Mars Organic and Oxidant Detector - J. Bada (UC at San Diego)
  - Mars Organic Molecule Analyzer - L. Becker (UC Santa Barbara)
  - Co-I for Raman-LIBS ExoMars instrument (Alian Wang, WashU)

Mars Sample Return

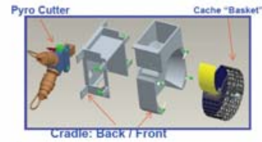
Why is a sample return mission from Mars so important?

MSR is a High Priority Mission

- Sample return is critical to solar system exploration:
  - Increased emphasis on returning samples from various bodies in the solar system within PSD - Stardust success!
  - Interest in Lunar sample missions increasing at NASA
- MSR remains a MEP and US NAS priority.
  - MEP budget cuts in 2005/06 "pushed" MSR well beyond 2020
  - NRC's *Astrobiology Strategy for the Exploration of Mars* reinforced importance of sample return in astrobiology as well as geology, geochemistry.
    - Most recent emphasis of MSR importance
- New Strategy: *Advance Mars Sample Return to 2020*
- Sample return must be thought of as a series of missions with the 2020 mission the first one
- In order to get started on MSR NASA is making plans to place a sample cache on MSL

MSL SAMPLE CACHE



- **MSL Sample:**
  - **At least 5 samples with goal of 10.**
  - **Materials chosen to minimize contamination.**
  - **Inlet supports same range of solid sample orientations as SAM and CheMin.**
  - **Inlet and exposed covers visible to at least one camera**
  - **Forward contamination satisfied by methods comparable to those used on other hardware (e.g., wheels).**
  - **MSR responsible for back contamination.**

Mars Sample Return

- Changing the entire architecture of the Mars Exploration Program
- Is this a good thing?
- Is it worth giving up a mission or two to get a sample back from Mars???