National Aeronautics and Space Administration

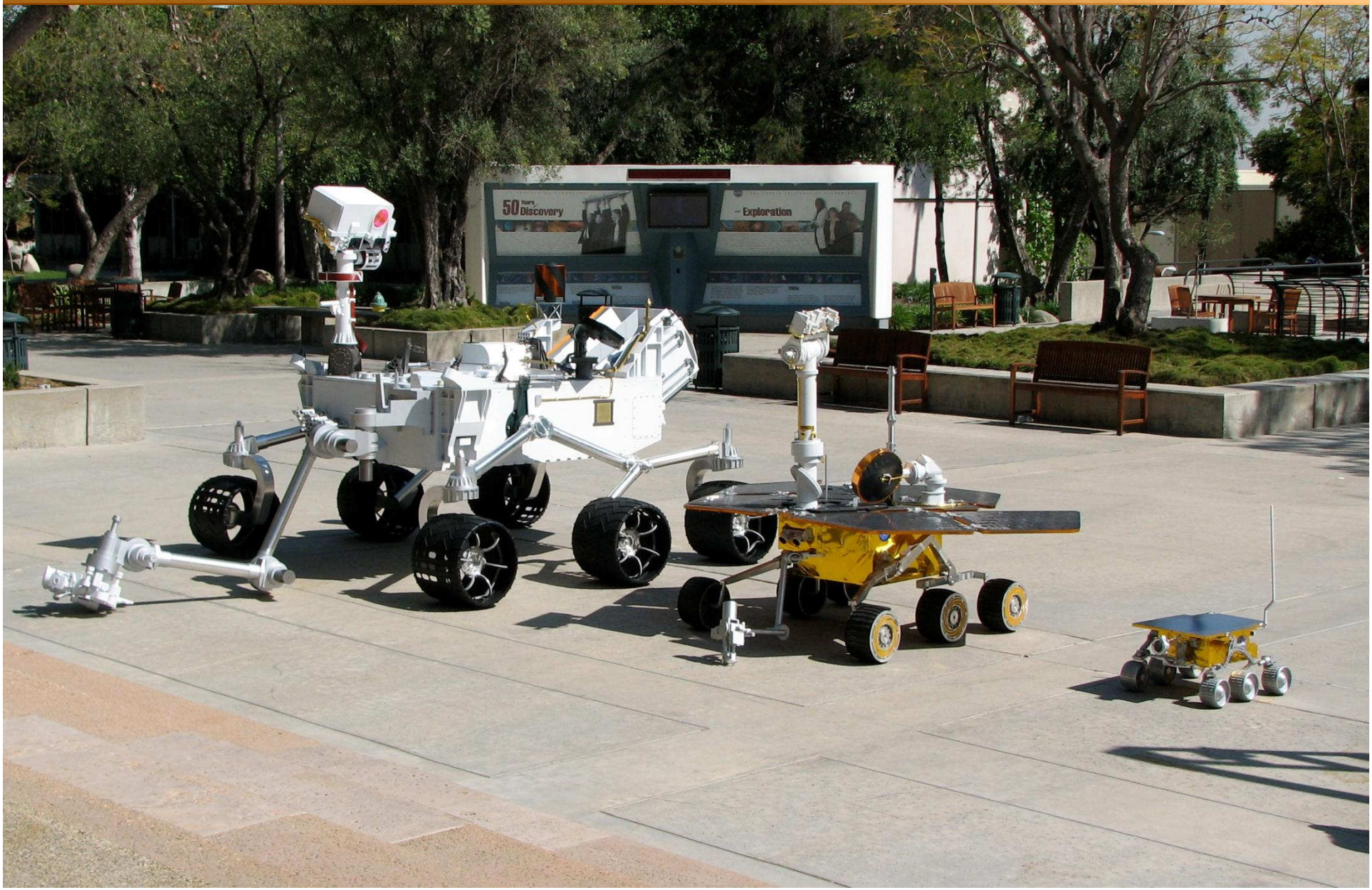
Mars Exploration Program Analysis Group

July 29, 2009

Michael Meyer

Lead Scientist, Mars Exploration Program

Rover Family Tree



The Exploration of Mars
Where to From Here?

NASA-ESA Joint Mars Initiative (in final planning)

Operational 2001-2009

Odyssey

MRO

Mars Express Collaboration

MER

Phoenix (deceased)

2011

Mars Science Lab

2013

MAVEN Aeronomy Orbiter

2016

ESA-NASA Trace Gas Mapper (+ teleccomm.)

2018

NASA and ESA Rovers (Astrobiology/ Sample Return Tech. and ExoMars)

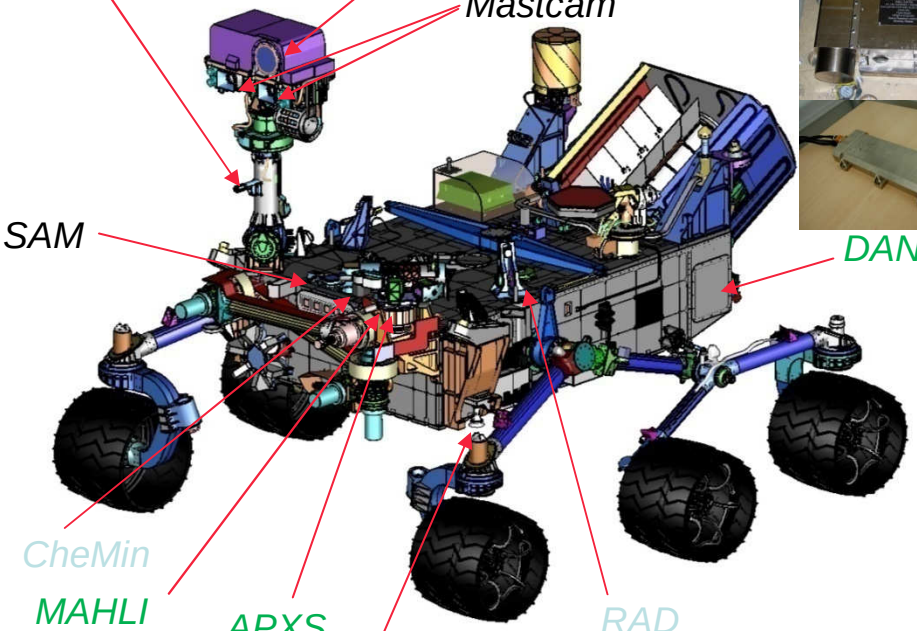
2020 & Beyond

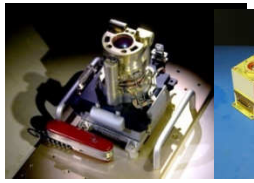
The Era of Mars Sample Return

MSL—The First Astrobiology Mission Since Viking

- Ten instrument packages with the objective to explore and quantitatively assess a region of Mars as a potential habitat for life, past or present.
  - MSL will carry an analytical laboratory of unprecedented capability,
    - SAM: Gas Chromatograph/Mass Spectrometer & TLS
      - In rocks, soil, and atmosphere, will be able to measure mineralogy, organics, and isotopes
    - Chemin: X-Ray Diffractometer for state-of-the-art mineral identification
    - ChemCam: New to planetary exploration instrumentation, is a laser induced breakdown spectroscope for meters-distant remote sensing of elemental/chemical composition.
  - The other instruments
    - MastCam – stereo camera, 12 filters, 10 frames/s, 7.4 cm/pixel @ 1km
    - MAHLI – color hand lens, 15 um/pixel with white and UV light sources
    - MARDI – Mars Descent Imager
    - RAD (ESMD) – high-energy radiation (direct & secondary)
    - APXS (Canada) – alpha Particle X-ray Spectrometer, all elements above sodium
    - REMS (Spain) – pressure, humidity, UV radiation, wind speed, & temperature
    - DAN (Russia) – water distribution in the near subsurface
- With its sophisticated instruments, MSL is the first astrobiology mission since Viking, and will characterize the nature of current and ancient Martian environments.

MSL Payload





Delivered to ATLO

In Storage @ Instrument Provider

In-Work @ Instrument Provider

Remote Sensing (Mast)

- **ChemCam**: Laser Induced Breakdown Spectrometer & Remote Micro Imager
- **Mastcam**: Color Medium and Narrow-Angle Imager

Contact Instruments (Robotic Arm)

- **MAHLI**: Hand-Lens Imager
- **APXS**: X-Ray Backscatter Spectrometer

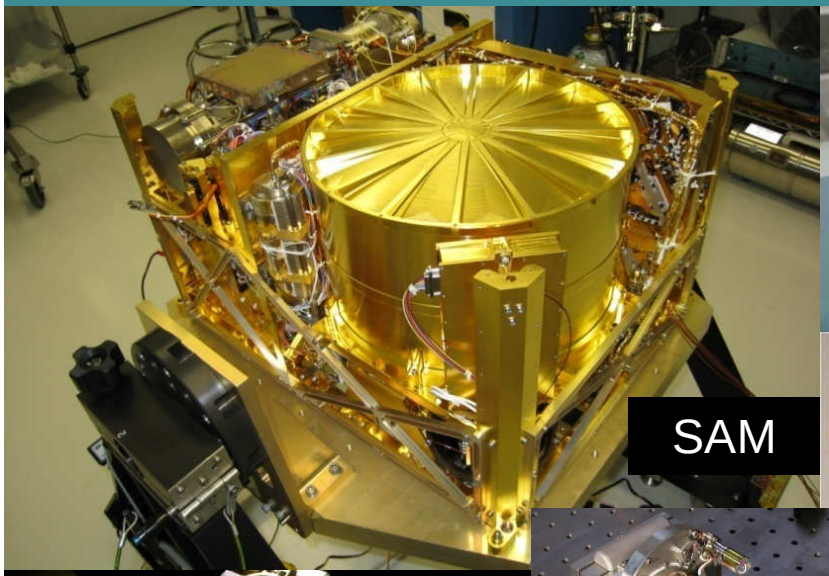
Analytical Laboratory

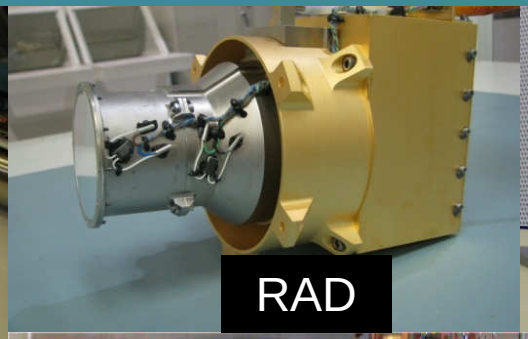
- **SAM**: Gas Chromatograph/Mass Spectrometer/Tunable Laser Spectrometer
- **CheMin**: X-Ray Diffraction

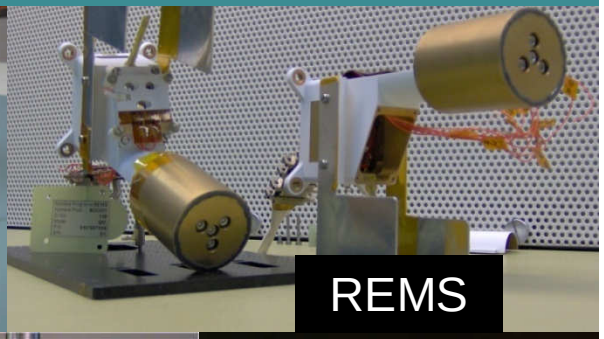
Environmental Characterization

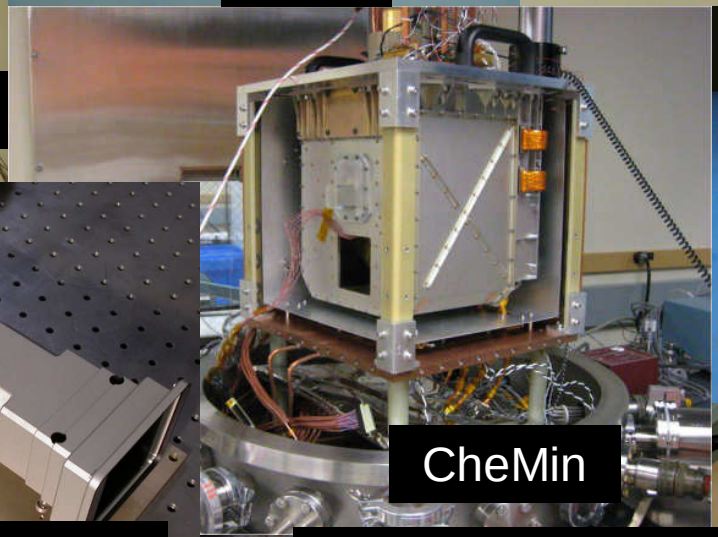
- **MARDI**: Descent Imager
- **REMS**: Meteorological Monitoring
- **RAD**: Surface Radiation Environment Monitor
- **DAN**: Neutron Backscatter Subsurface Hydrogen Detection

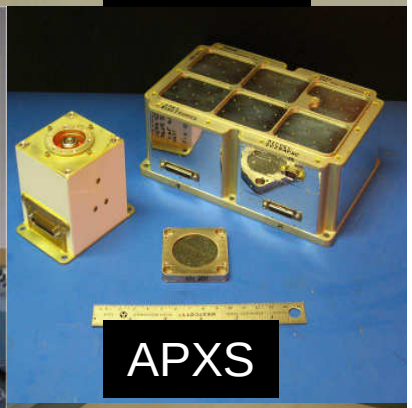
MSL Science Payload Status July 2009


SAM

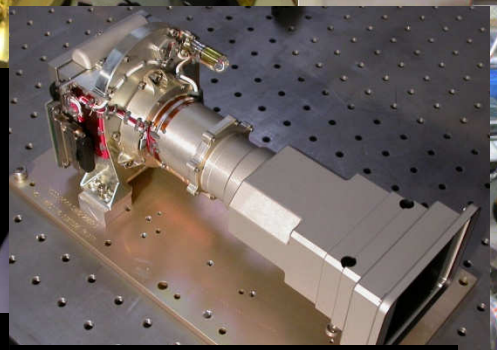

RAD


REMS

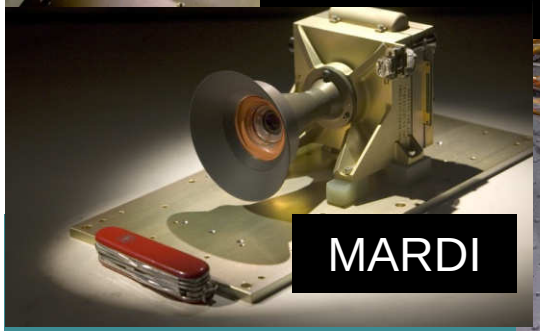

CheMin


APXS


MAHLI


Mastcam (1 of 2)


DAN PNG


MARDI


DEA

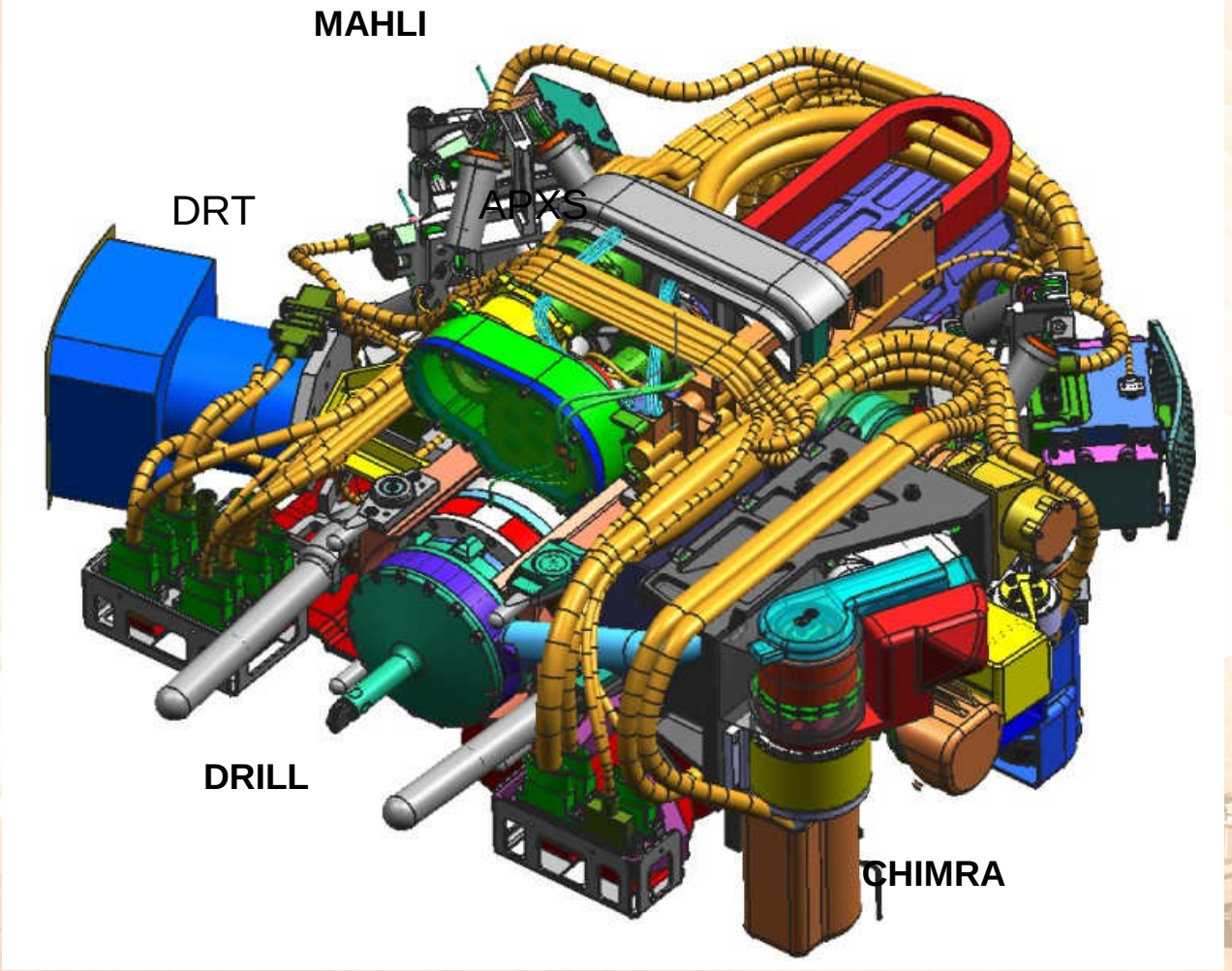
ChemCam Mast Unit

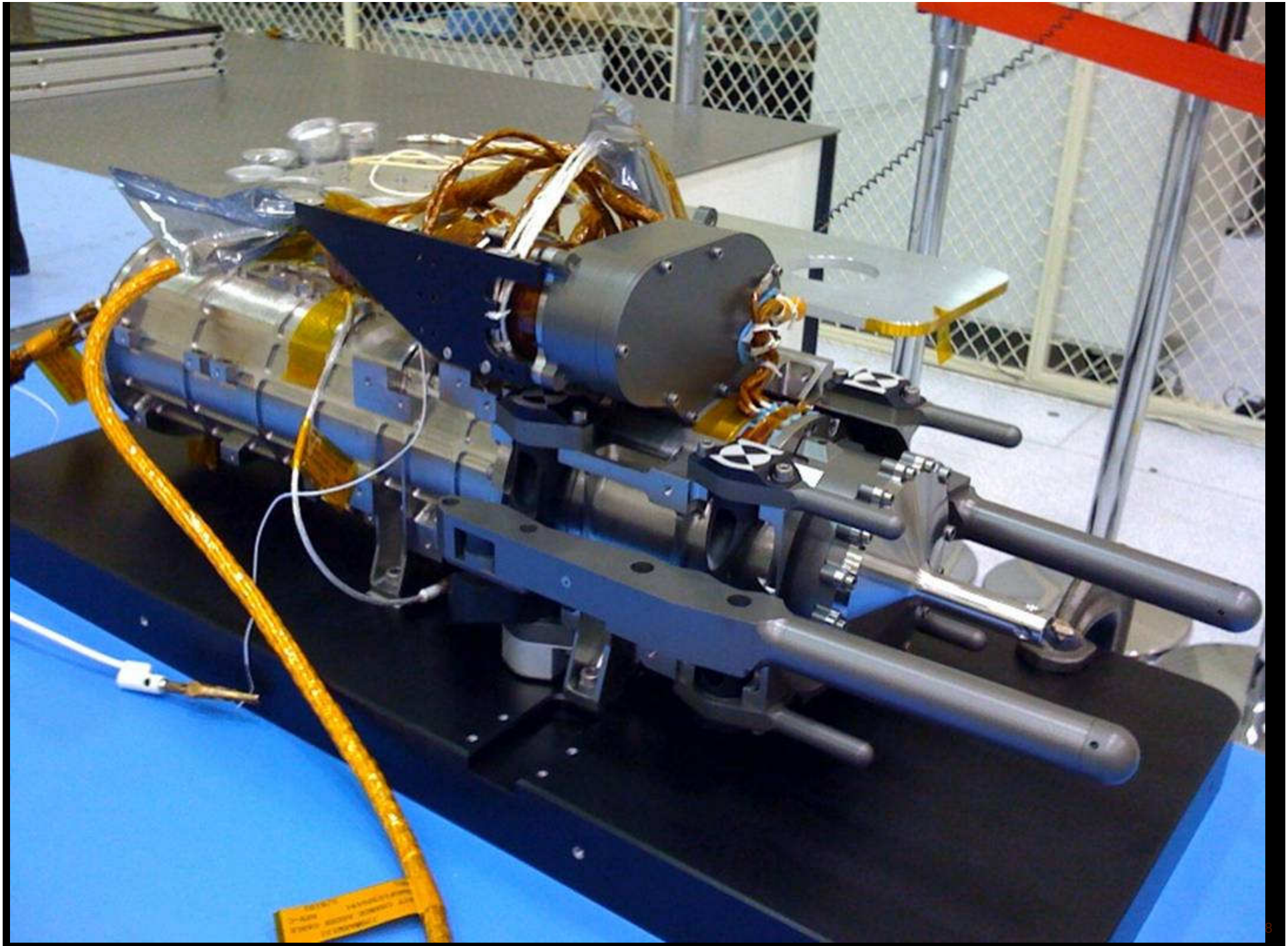
ChemCam Body Unit


DAN DE

Sample Processing System

Turret





MSL Upcoming Milestones

2009

July 31: AA review of SAM

Aug 6: REMS Risk Technical Interchange Review

Aug 19: SAM Go-Forward Review

Aug 13: Mastcam Review and Delivery

Aug 22: CheMin Delivery

Sep 24: MSL V&V Plan Review

Oct: Call for Potential 5th Landing Site Candidate

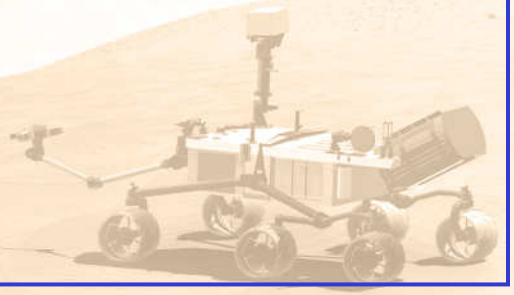
Oct: REMS: Review and Delivery

Nov 17-19: MSL Readiness-to-Proceed Review

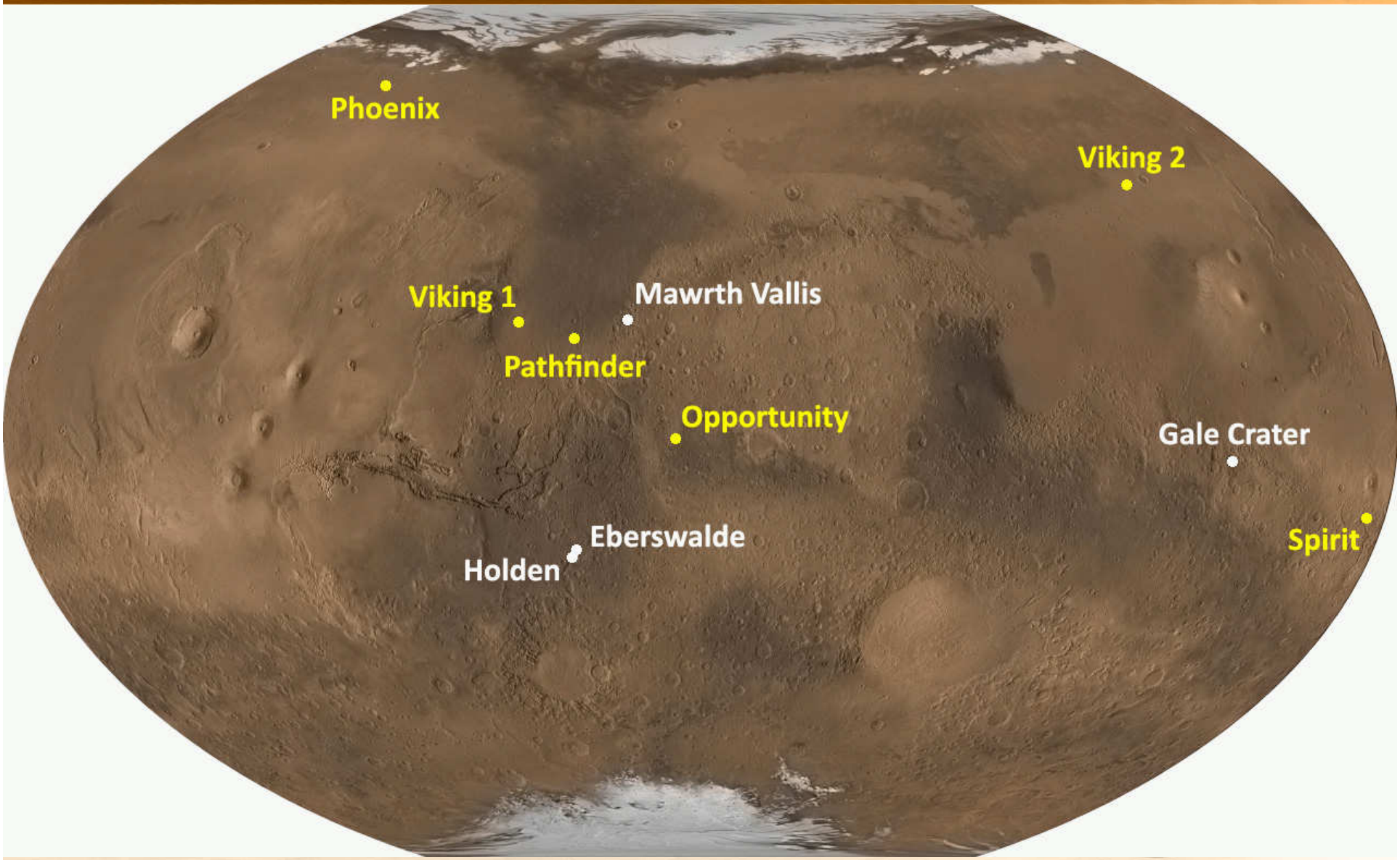
2010

Summer: SAM delivery (TBD Aug 19)

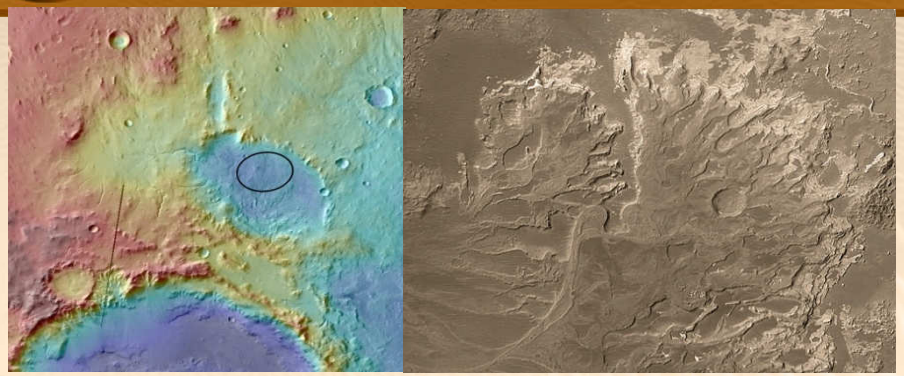
Sep : Landing Site Workshop



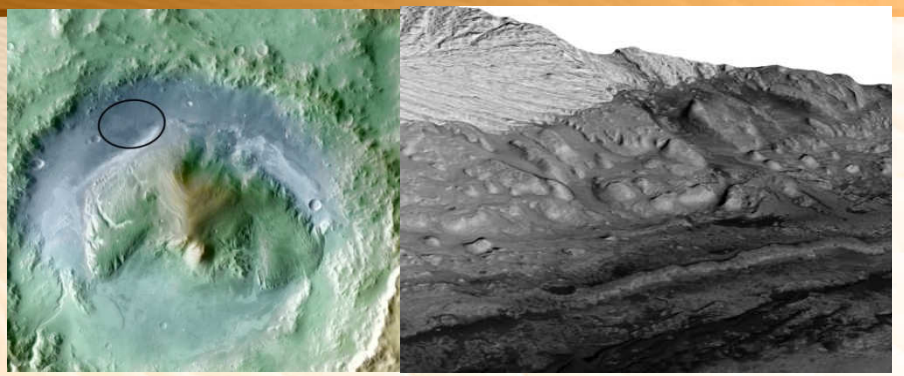
Previous and MSL Landing Sites



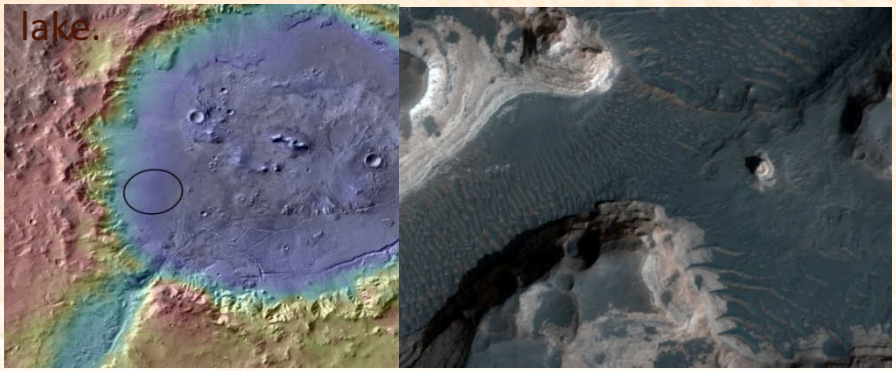
MSL Landing Sites



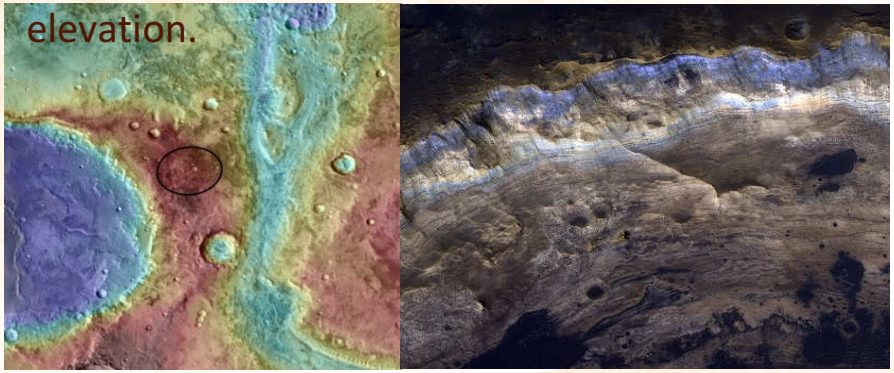
Eberswalde Crater (24°S, 327°E, -1.5 km) contains a clay-bearing delta formed when an ancient river deposited sediment, possibly into a lake.



Gale Crater (4.5°S, 137°E, -4.5 km) contains a 5-km sequence of layers that vary from clay-rich materials near the bottom to sulfates at higher elevation.



Holden Crater (26°S, 325°E, -1.9 km) has alluvial fans, flood deposits, possible lake beds, and clay-rich sediment.



Mawrth Vallis (24°N, 341°E, -2.2 km) exposes layers within Mars' surface with differing mineralogy, including at least two kinds of clays.

Project has baselined the *option* of adding a new site by early summer 2010

– Bar will be very high from science perspective; Site must be at least as safe as current sites

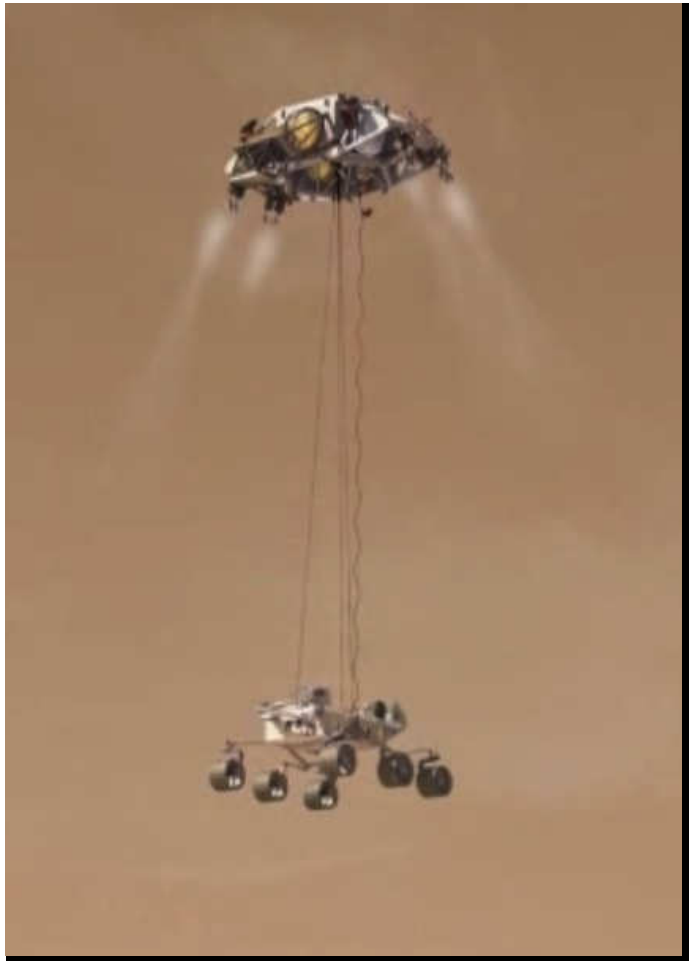
Mars Science Laboratory

- MSL is the first astrobiology mission since Viking. Ten instrument packages with the objective to explore and quantitatively assess a potential habitat for life, past or present. Analytic and in-situ measurements will provide essential ground truth to anchor regional and global remote sensing mineralogy data
  - These in-situ data will:
    - Test hypotheses of early Martian environmental evolution, including climate history
    - Determine which environments might have best preserved environmental signals, and possibly biosignatures
    - Test interpretations of global mineralogy inferred from orbit
- Feed Forward Engineering:
  - New EDL system will enable future high-mass landings
  - Develop experience with sample collection, manipulation, and sample preparation
  - Targeted landing—critical capability for accessing high-priority science targets
  - Next generation of complex lab instruments to another planetary surface

- Mars Missions -
Progress of Capabilities for Mars Exploration

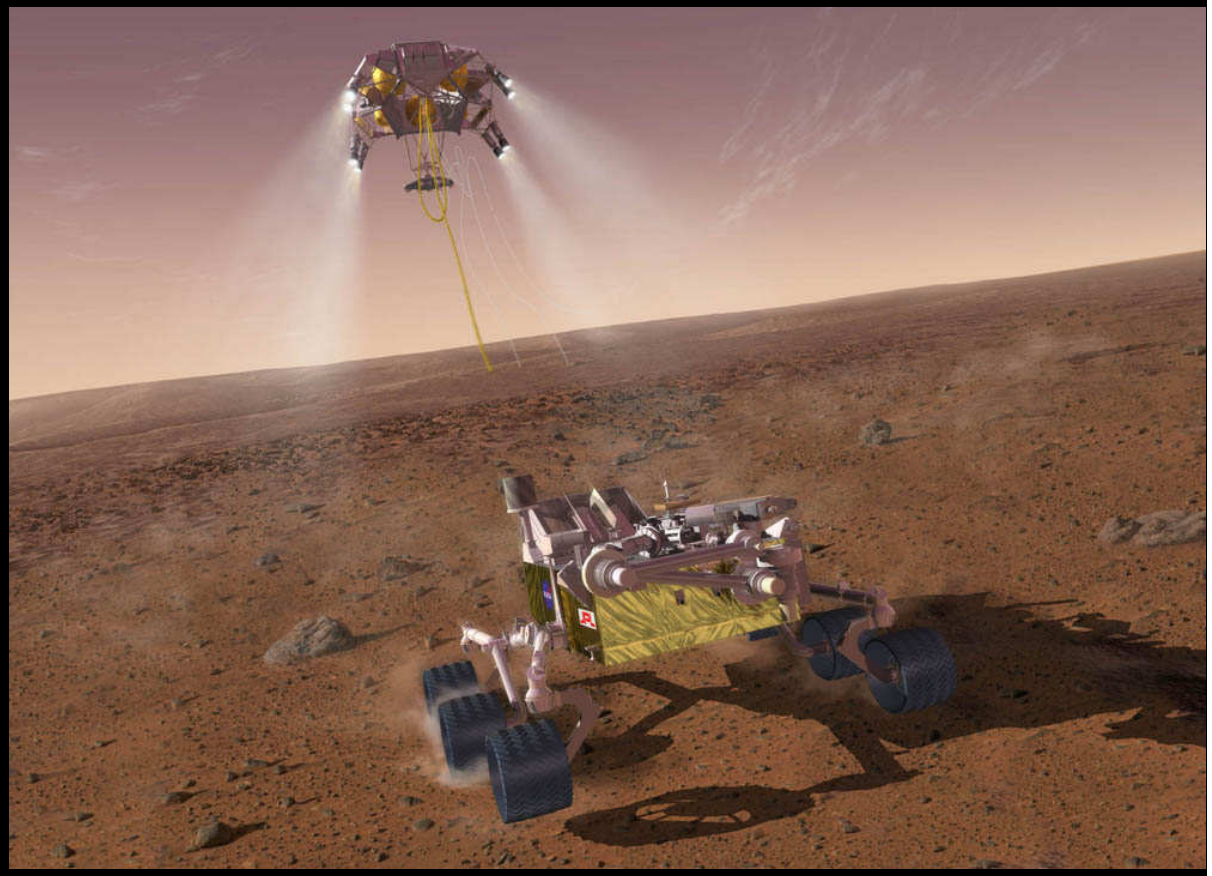
Kg	Pathfinder 1994	MGS 1996	MPL 1998	Odyssey 2001	MER 2003	MRO 2005	Phoenix 2007	MSL 2011
Launch Mass	894	1,060	576	725	1,063	2,180	670	4,000
Fuel	94	300	64	348.7	50	1,149	67	450
Cruise Stage or Orbiter	200	600	82	330	193	860	570	650
EDL System	230	N/A	140	N/A	287	N/A	172	2000
Landed Mass	370	N/A	290	N/A	348 + rover	N/A	350	900
Mobile Mass	10.6	N/A	N/A	N/A	185	N/A	N/A	900
Science Instru-ments	8 kg .75 kg on rover	6 instr. (75kg)	3 instr.	3 instr. (45 kg)	5 instr (5.5 kg)	6 instr. (130 kg)	6 instr. (35 kg)	13 instr. (75.5 kg) (3 shell)

MSL EDL



Powered Descent

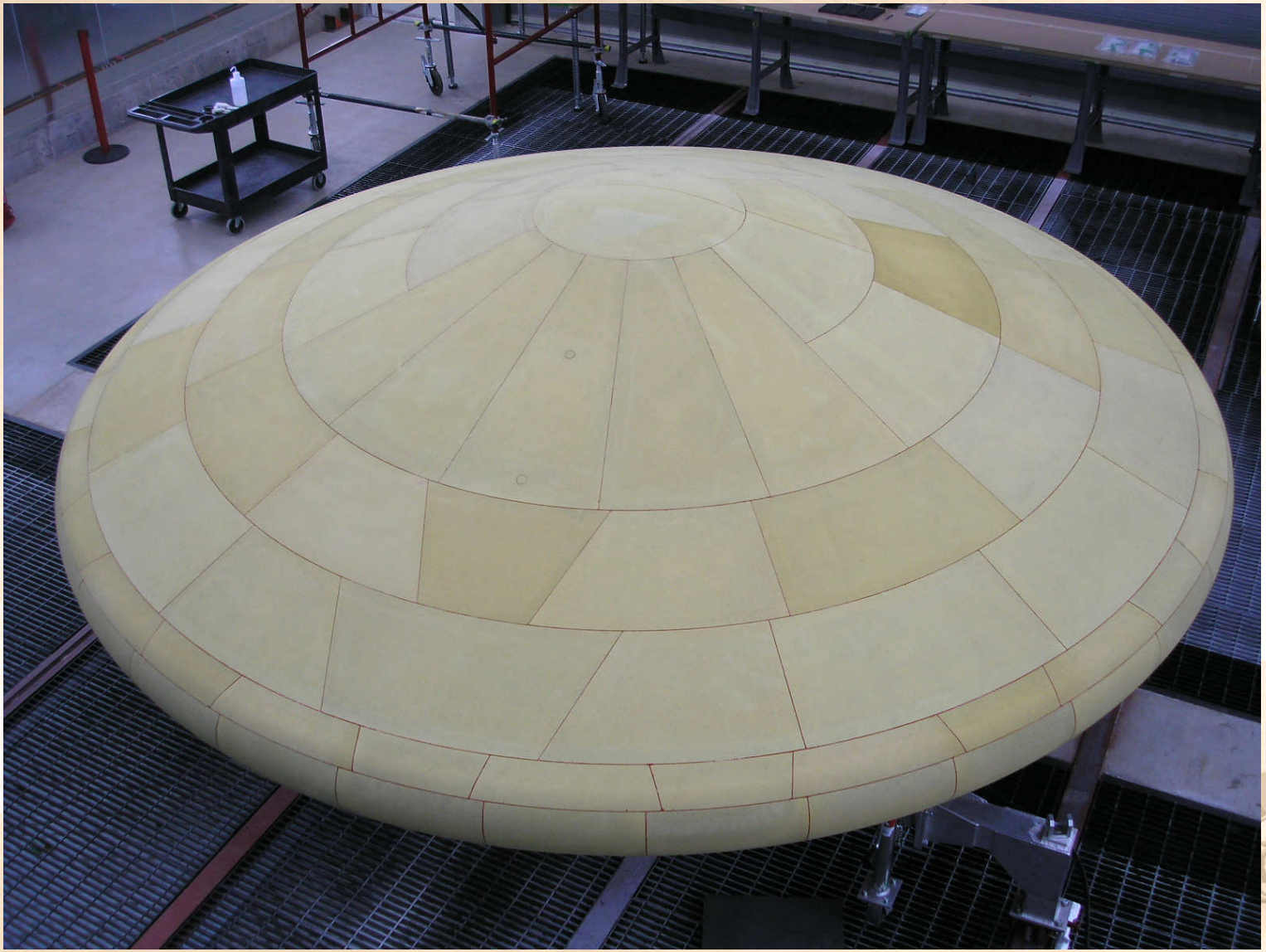
Sky Crane



Touchdown

Bridle/Umbilical Cut, Flyaway

Flight Heat Shield with PICA



Integrated Spacecraft

ATLO EDL SkyCrane Testing

MSL's value to Society

- MSL will quantitatively assess the habitability through time of a region, based on well-chosen site with stratigraphic sequences demonstrating clear evidence of hydrated minerals and morphologic attributes evincing former interaction with water

- MSL is a critical step towards answering, is there life outside Earth
  - We now believe that Mars preserves a record of habitable environments, some of which may be active today
  - Mars' environmental record is both diverse and dynamic – it has changed in time and space and is preserved in the stratigraphic record
  - Our next step is to determine whether or not life ever started on Mars