

Engineering Mars Rovers - Past, Present and Future

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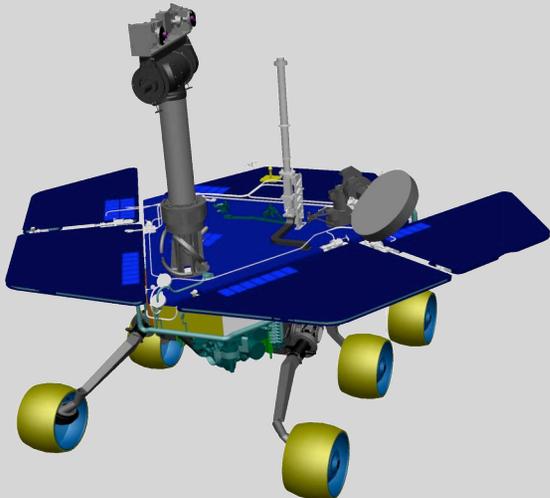
"La perfection est atteinte non quand il ne reste rien a ajouter, mais quand il ne reste rien a enlever. (You know you've achieved perfection in design, not when you have nothing more to add, but when you have nothing more to take away.)"

Antoine-Marie-Roger de Saint-Exupery

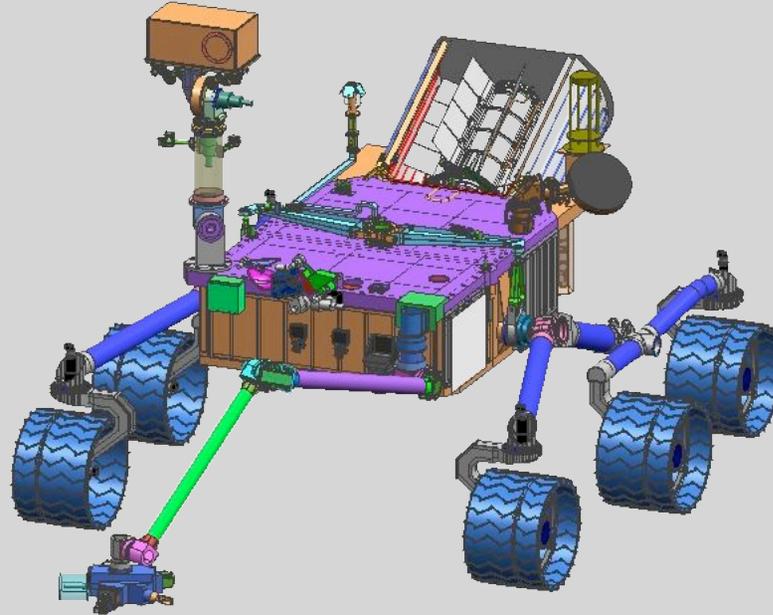


A tale of three rovers...

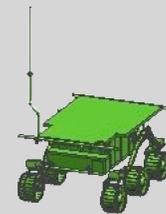
***Mars Exploration
Rovers - 2003***



***Mars Science
Laboratory - 2009***

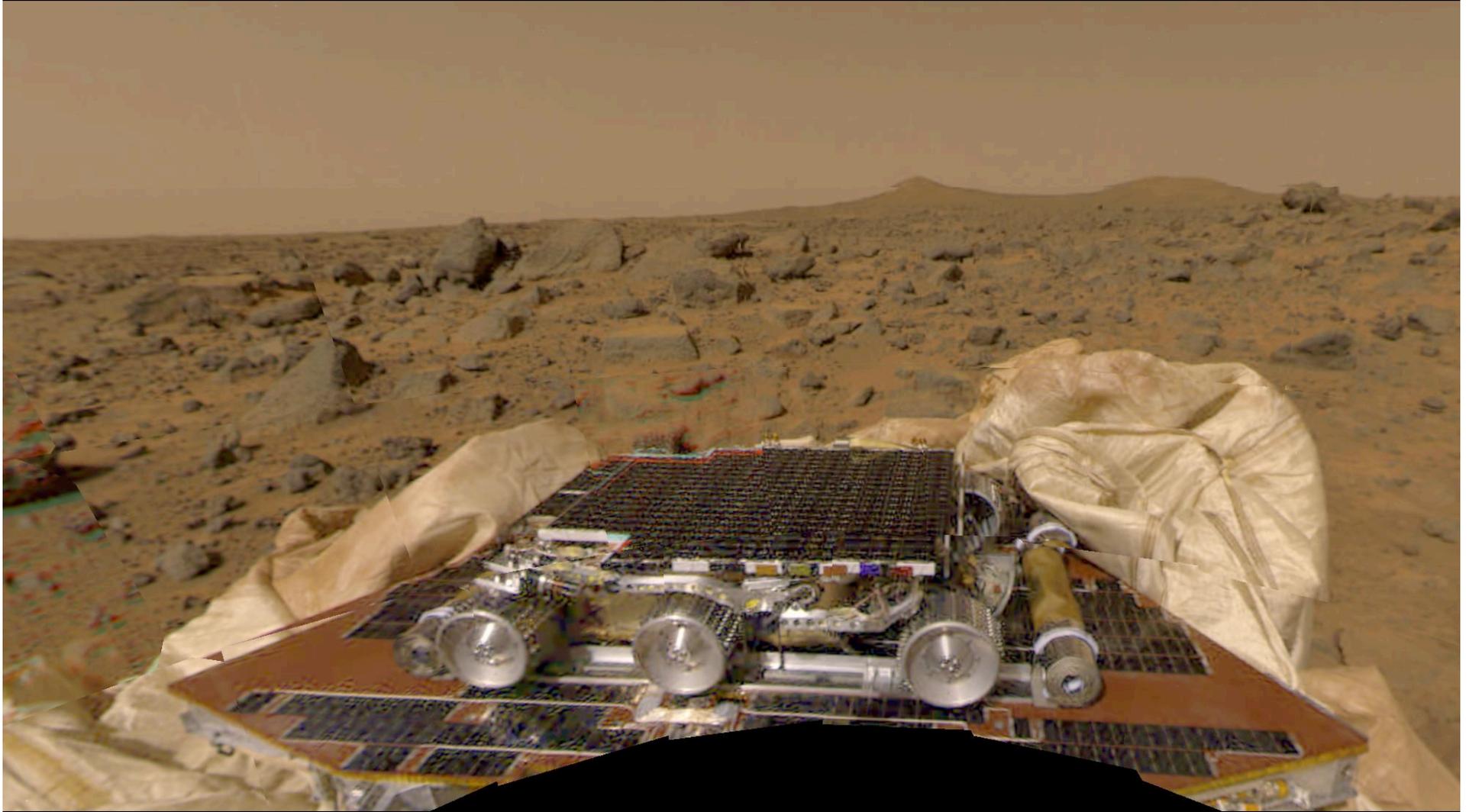


***Mars Pathfinder
Sojourner Rover - 1996***



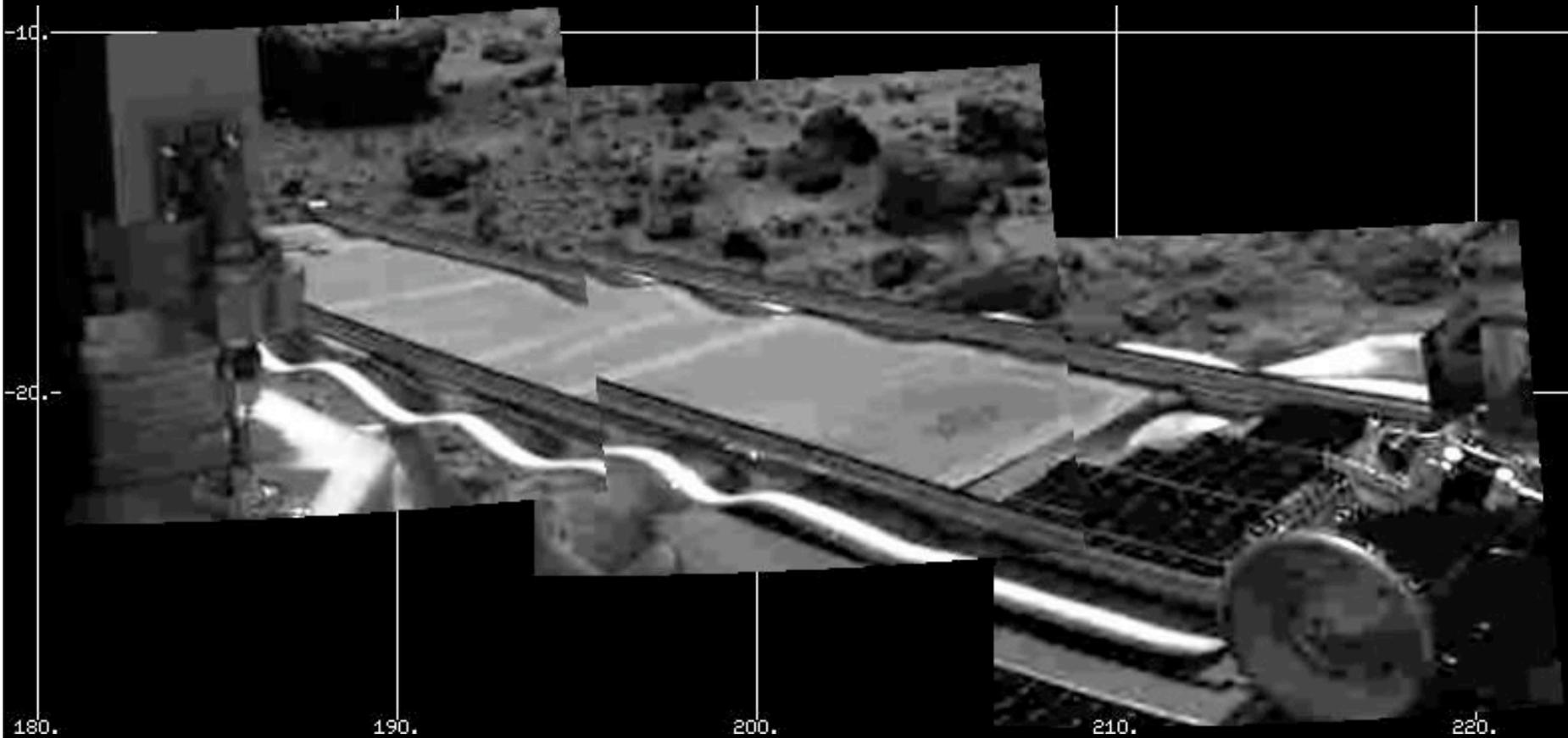


Mars Pathfinder - July 4, 1997



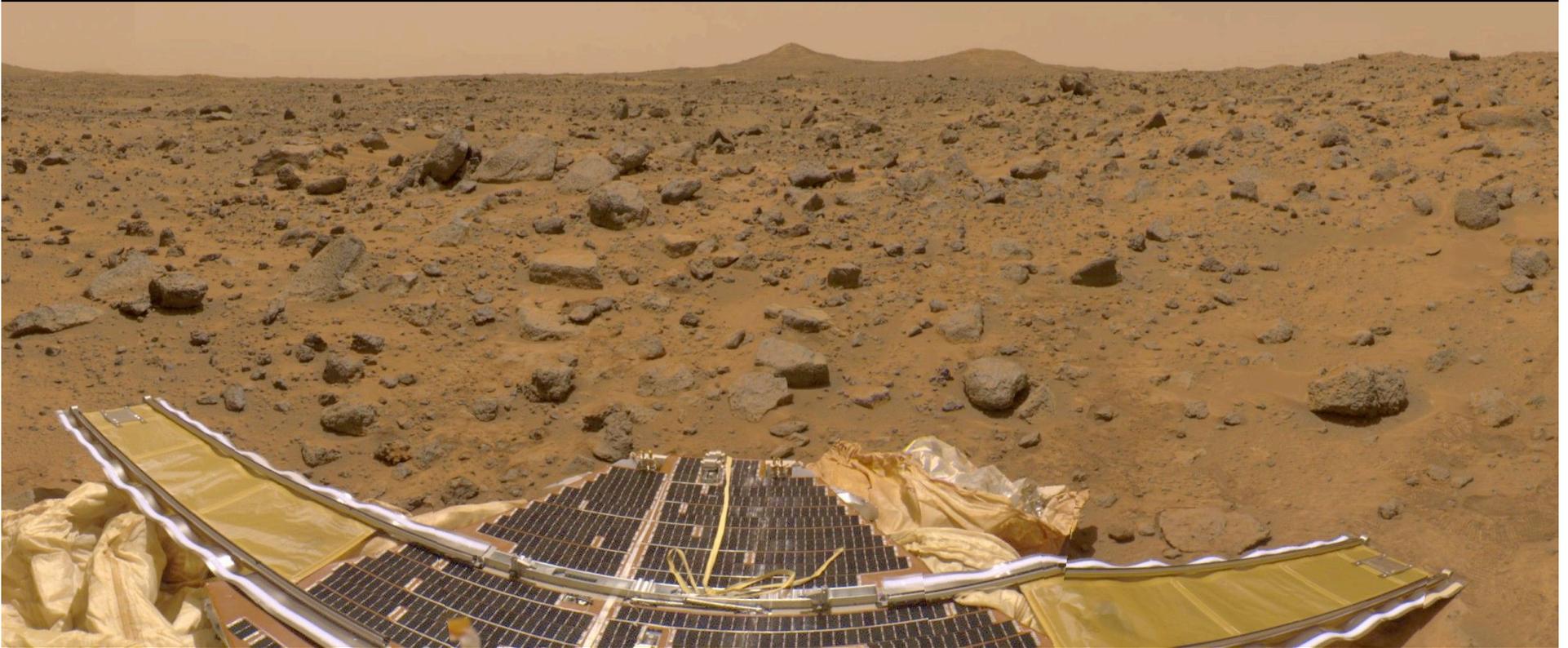


What do you mean the ramp isn't touching the ground?



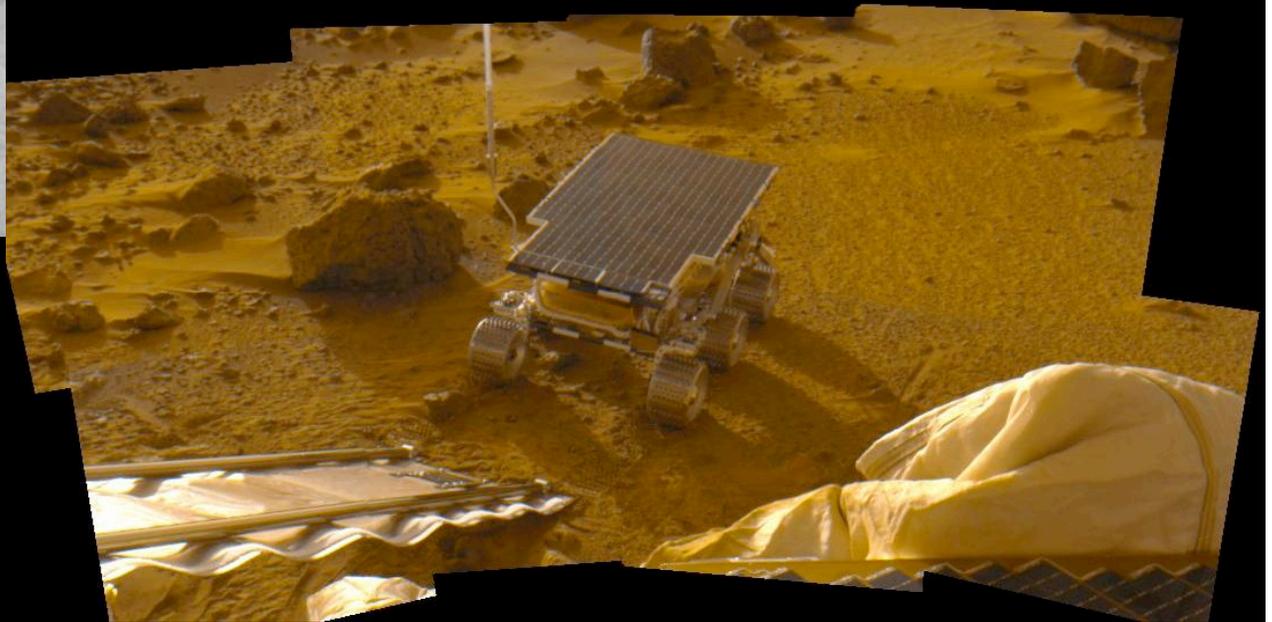
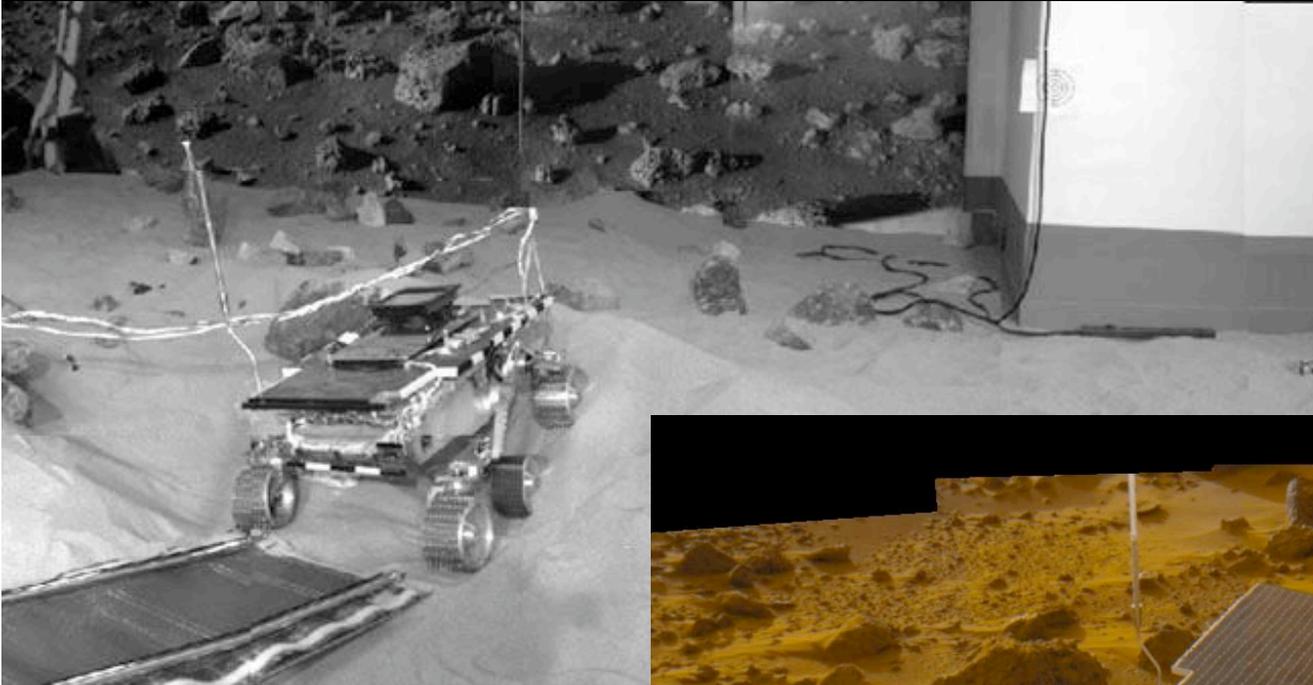


Well, at least one ramp is on the ground



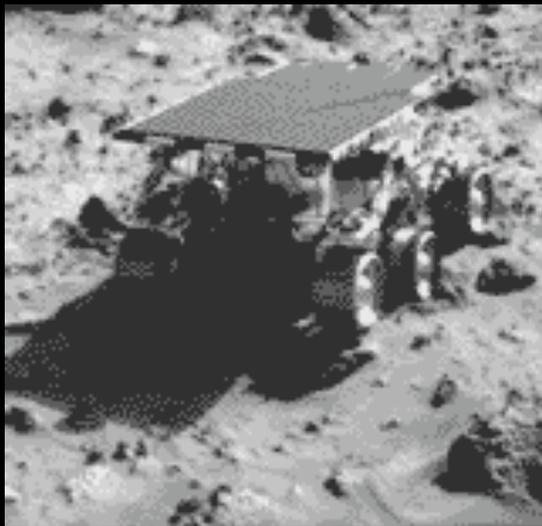


Just like on Earth...but not really





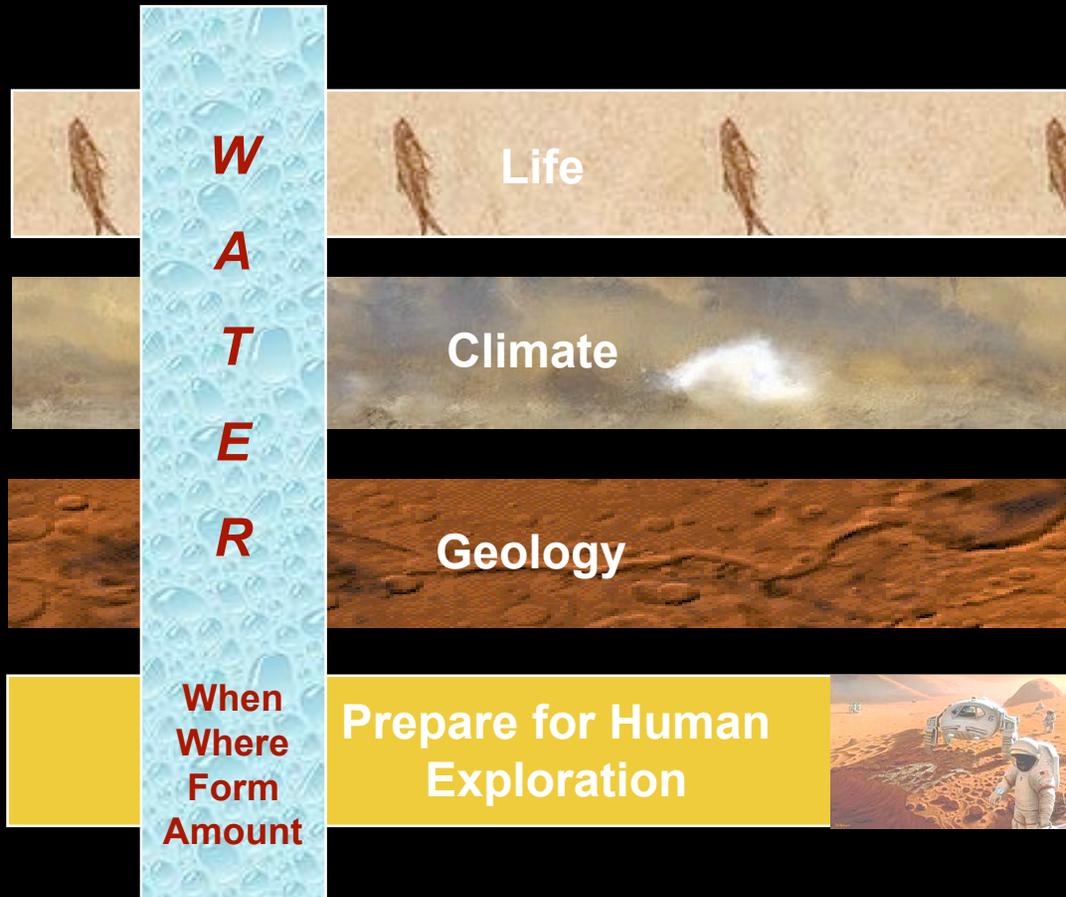
NASA Engineers work to get Mars rover unstuck...again





The Mars Science Strategy: “Follow the Water”

*Common
Thread*



**Understand the potential for
life elsewhere in the universe**

**Characterize the present and past
climate and climate processes**

**Understand the geological
processes affecting Mars’
interior, crust, and surface**

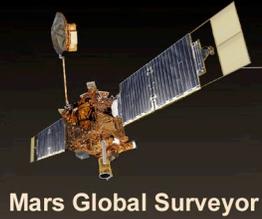
**Develop the knowledge &
technology necessary for eventual
human exploration**



Mars Exploration Program

Launch Year

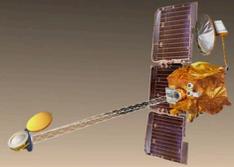
OPERATIONAL



Mars Global Surveyor

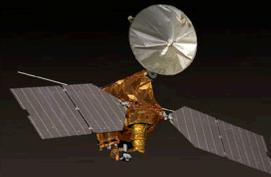


ESA
Mars Express



Mars Odyssey

2005



Mars
Reconnaissance
Orbiter
(Italian SHARAD)

2007

Competed Scout Mission



Phoenix

2009

Mars Science
Laboratory



...Next Decade

Explore the
Evolution of Mars

Search for
Evidence of Past Life

Science pathways
responsive to discovery

Search for Present Life

Explore
Hydrothermal
Habitats





Just getting to Mars is Hard



The international community has sent 27 orbiters, 12 landers, & 2 probes, totaling 41 attempts to gain an understanding of Mars.

63% of the time, Mars has won!

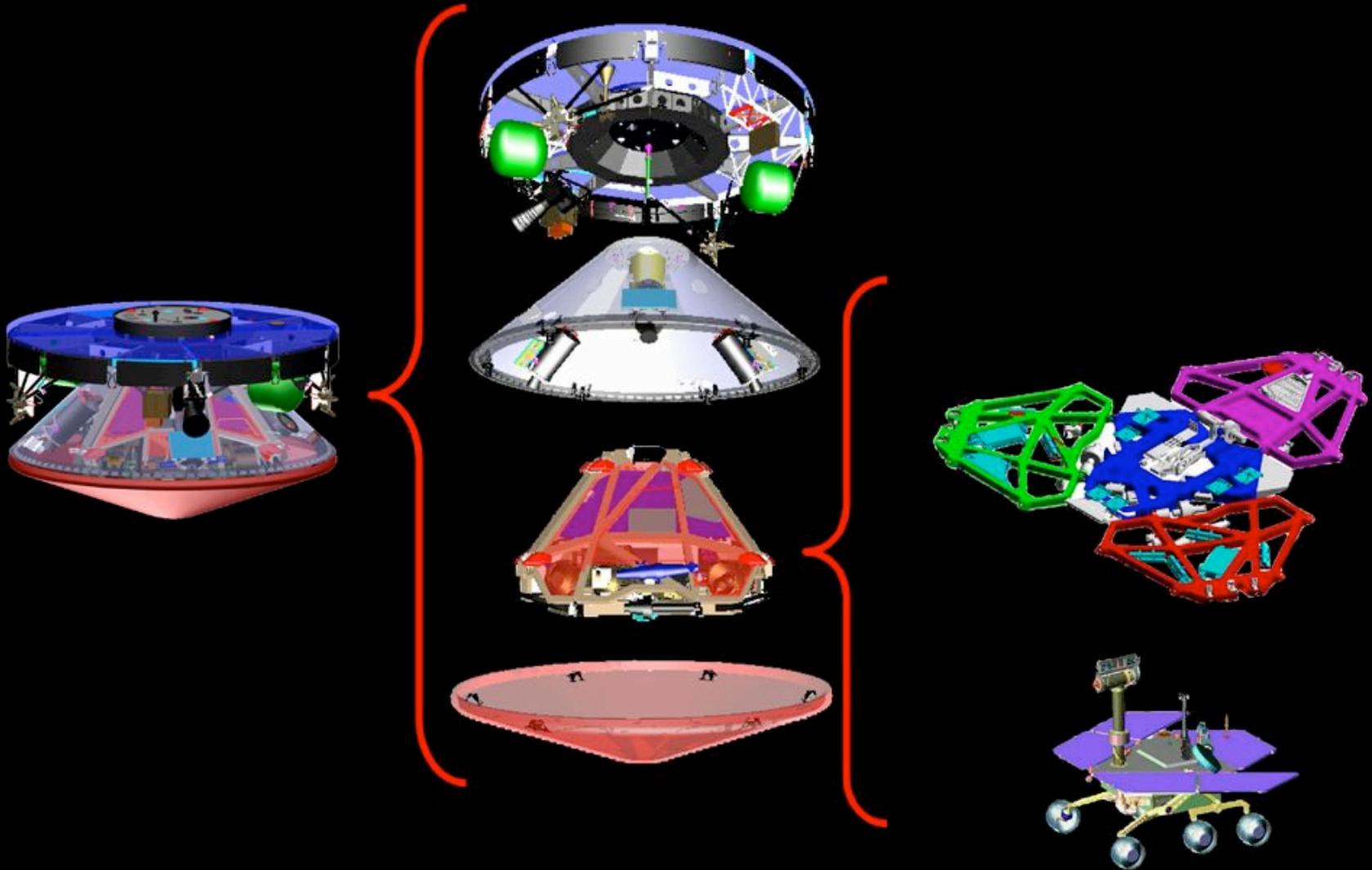


Spring 2000



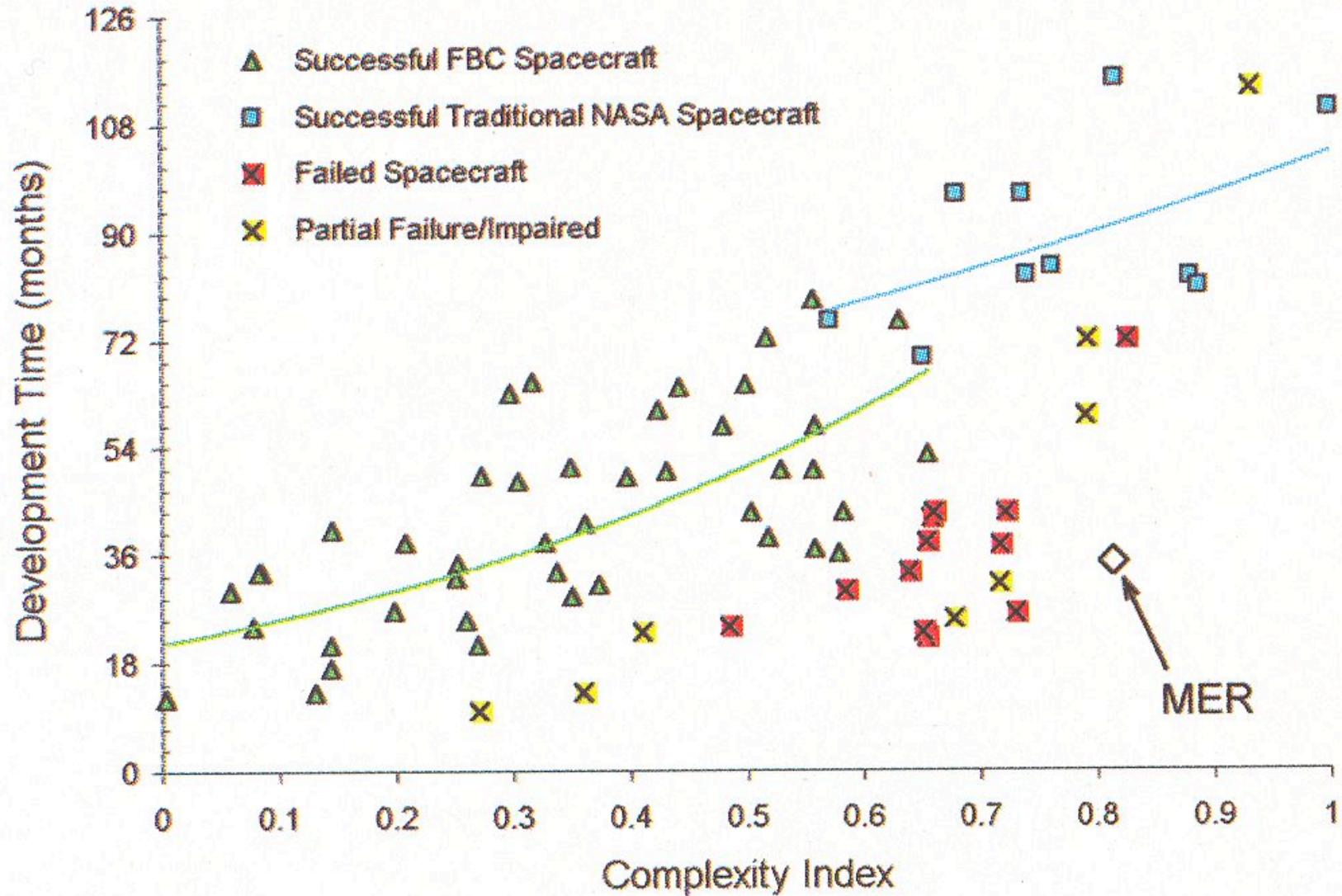


MER - Just put a big rover in Mars Pathfinder landing system



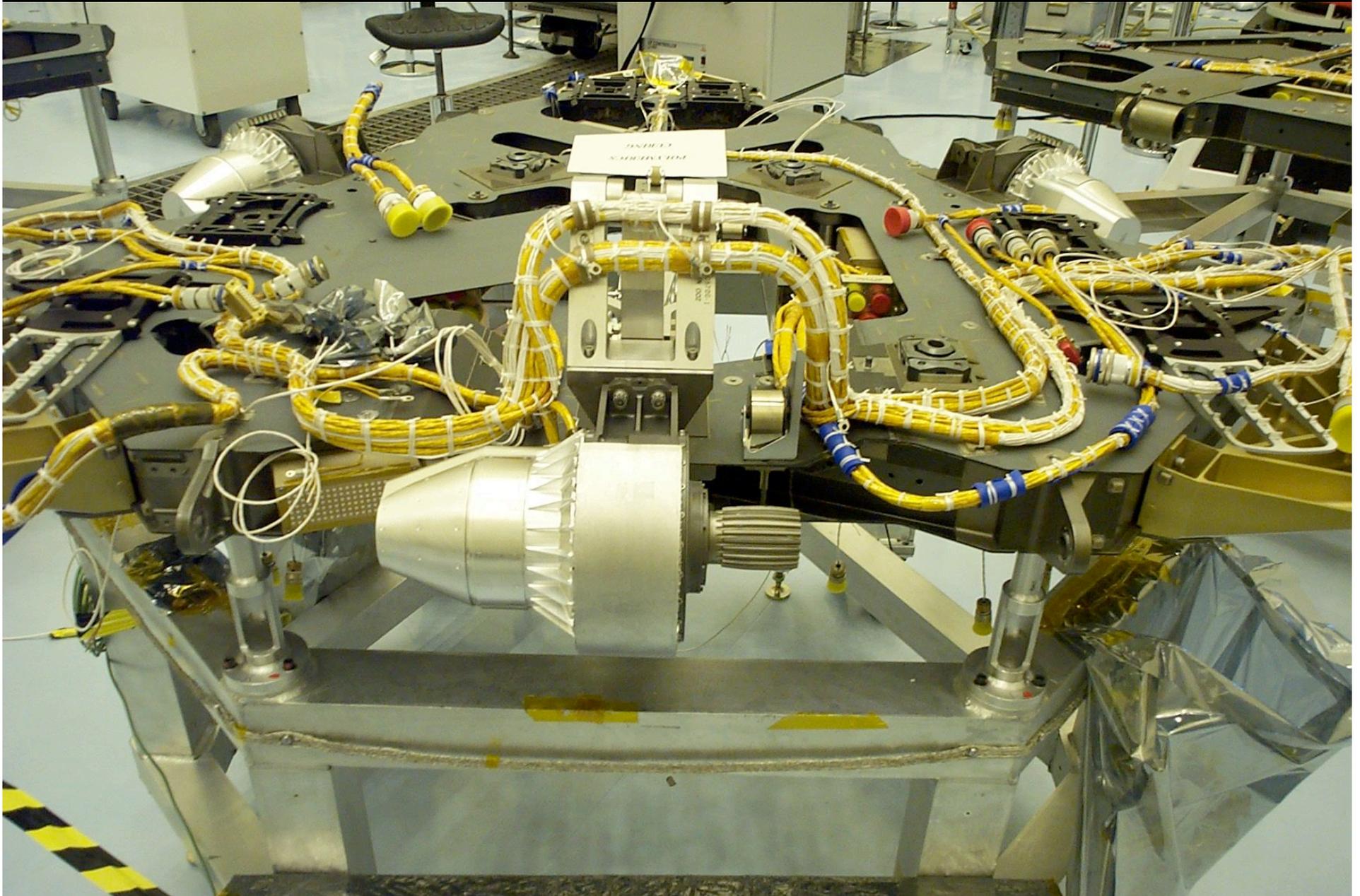


Schedule as function of Complexity



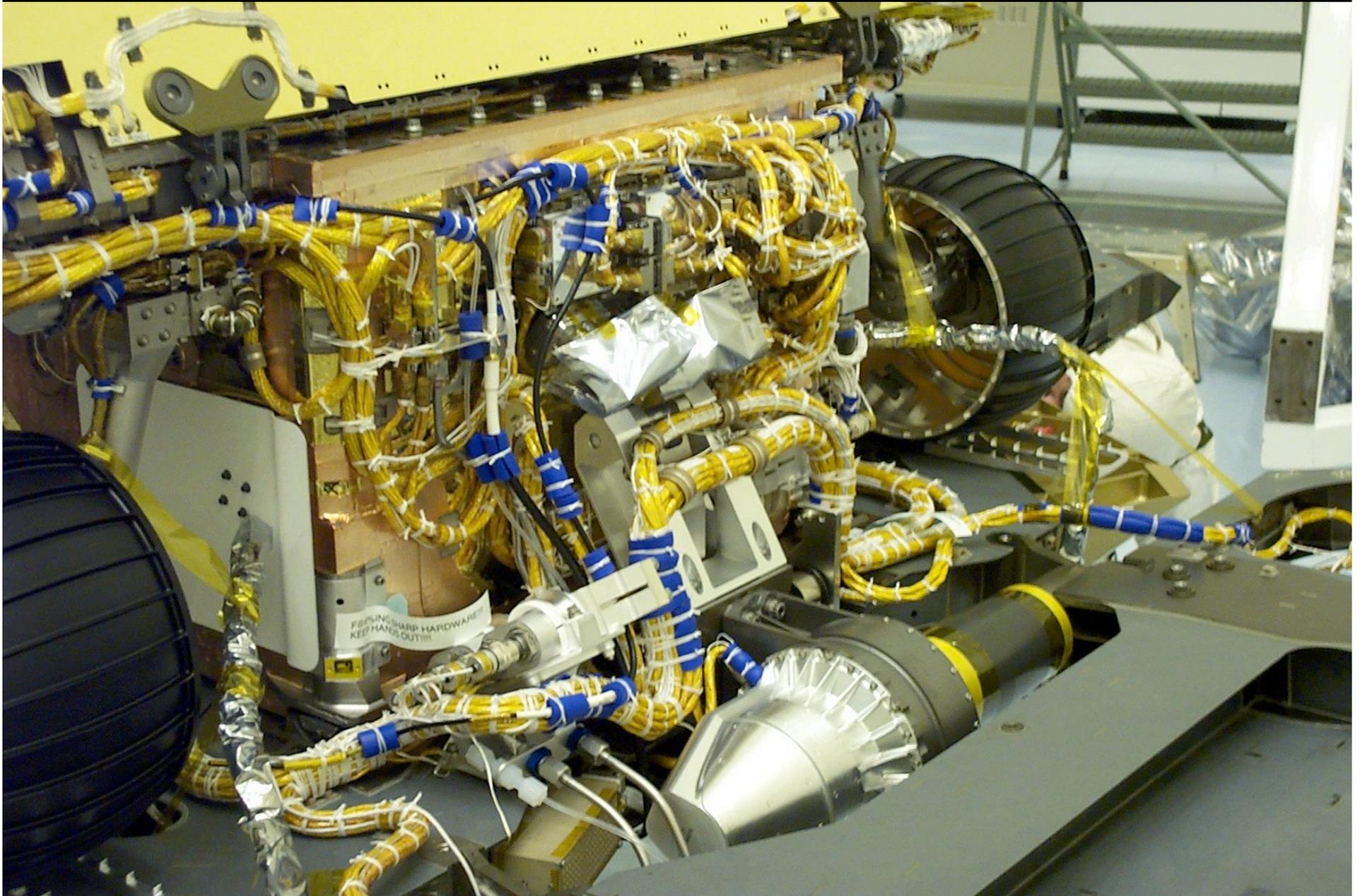


Cabling...



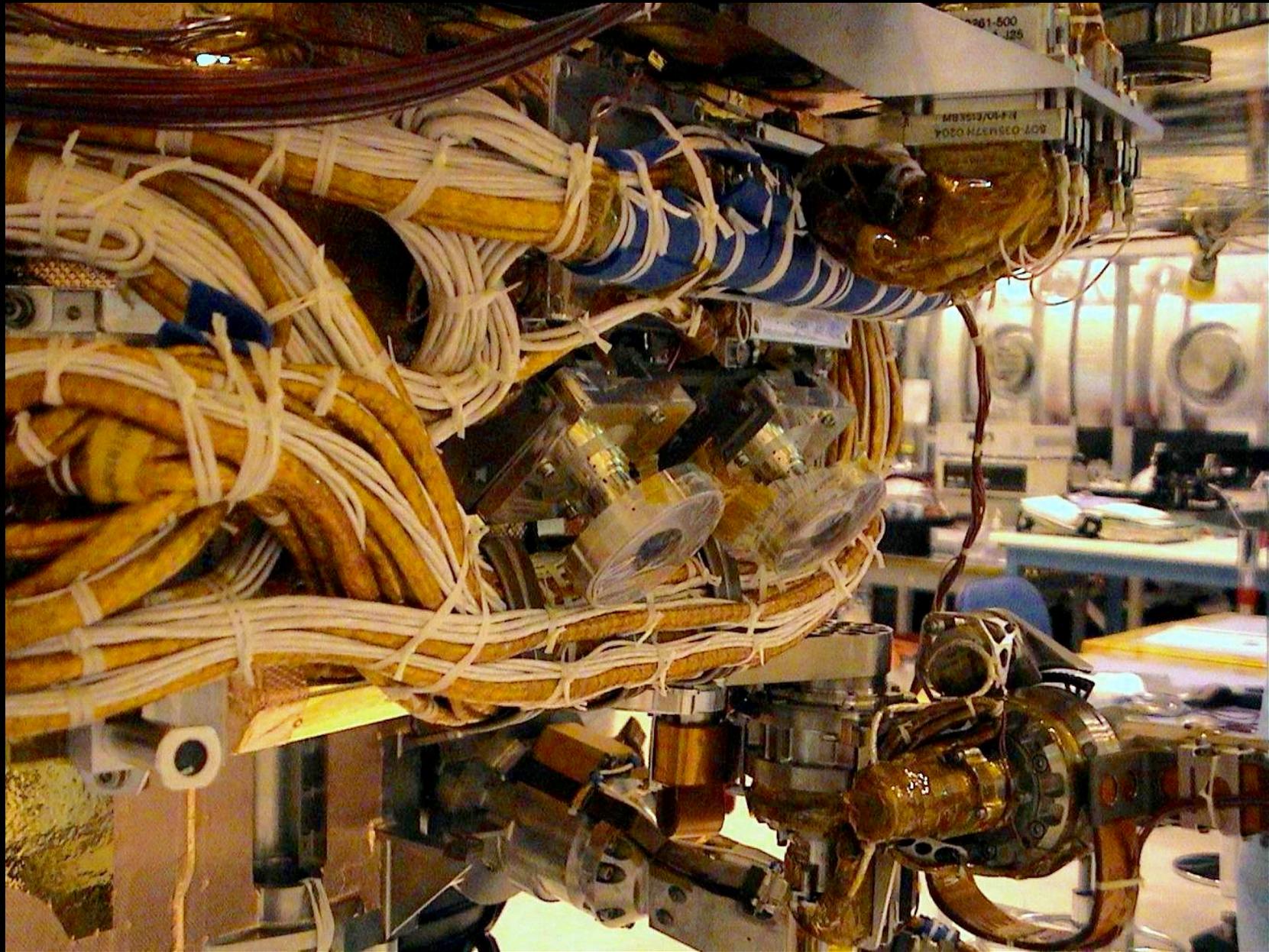


More Cabling...





More Cabling...







Entry, Descent & Landing (EDL) *aka 6 minutes of terror*



12,000 mph



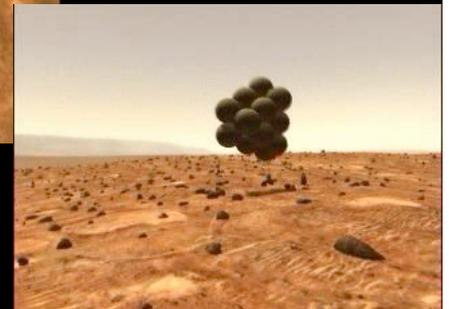
1,200 mph



120 mph

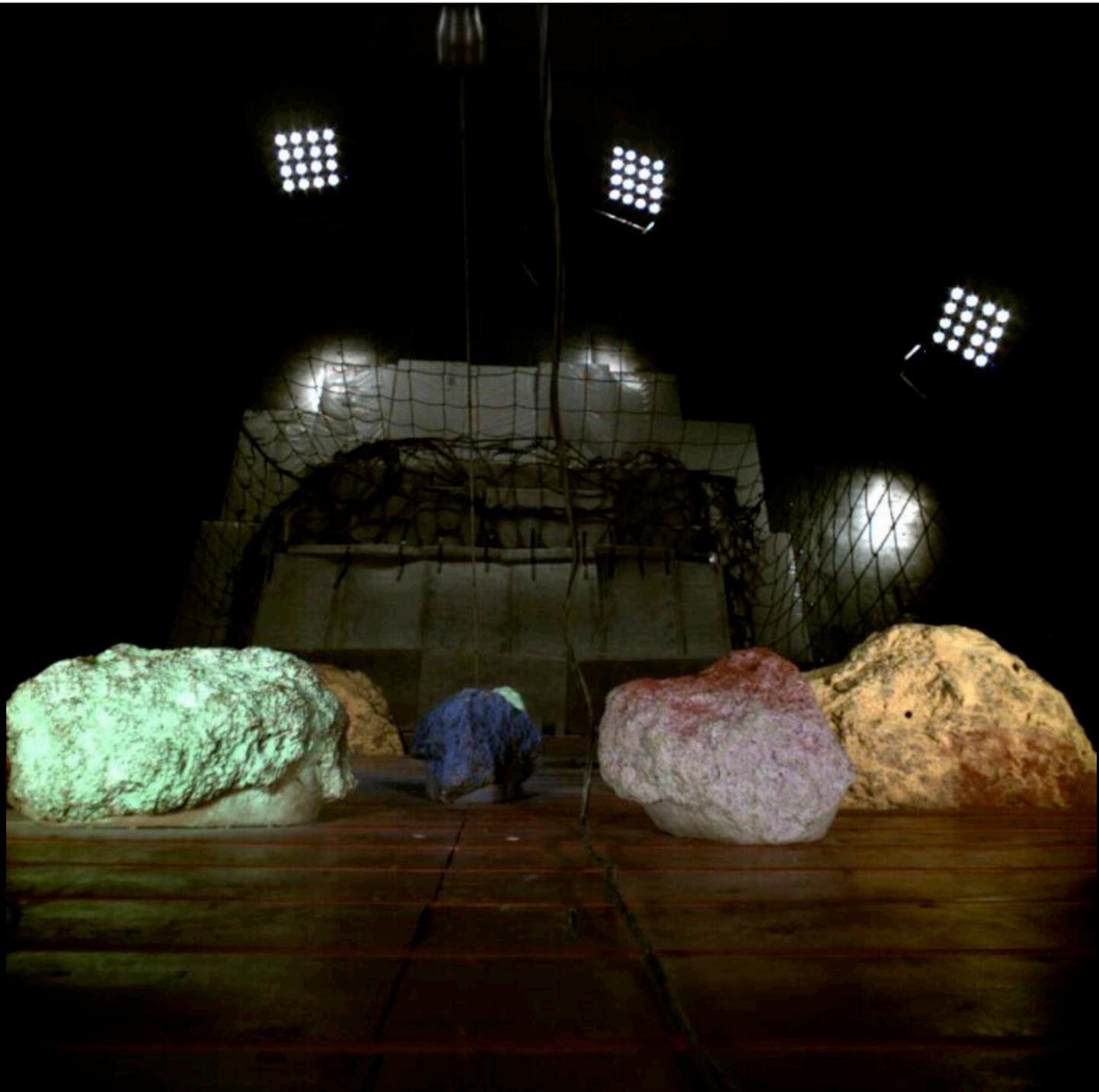


0 mph

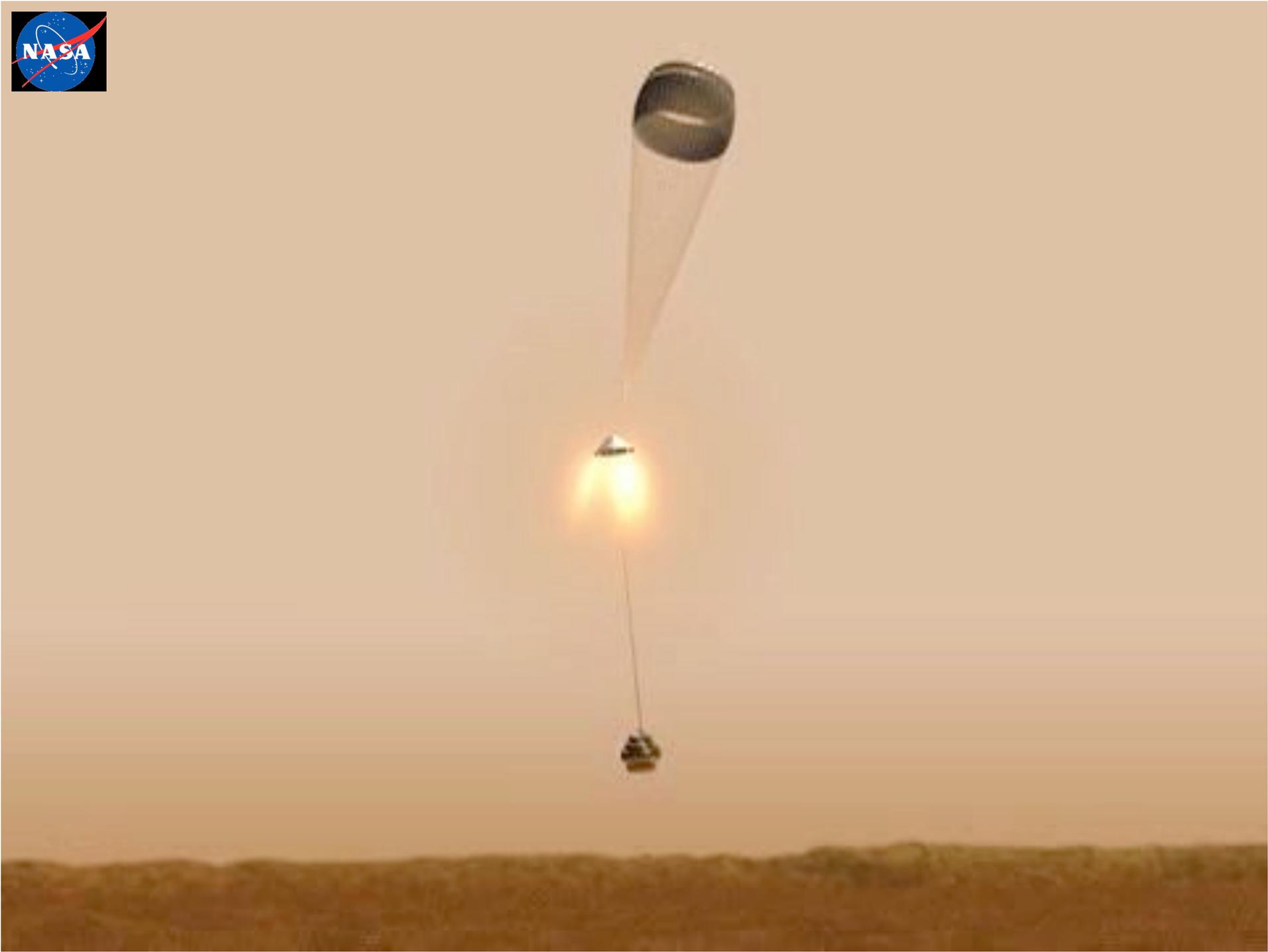


NASA Airbags

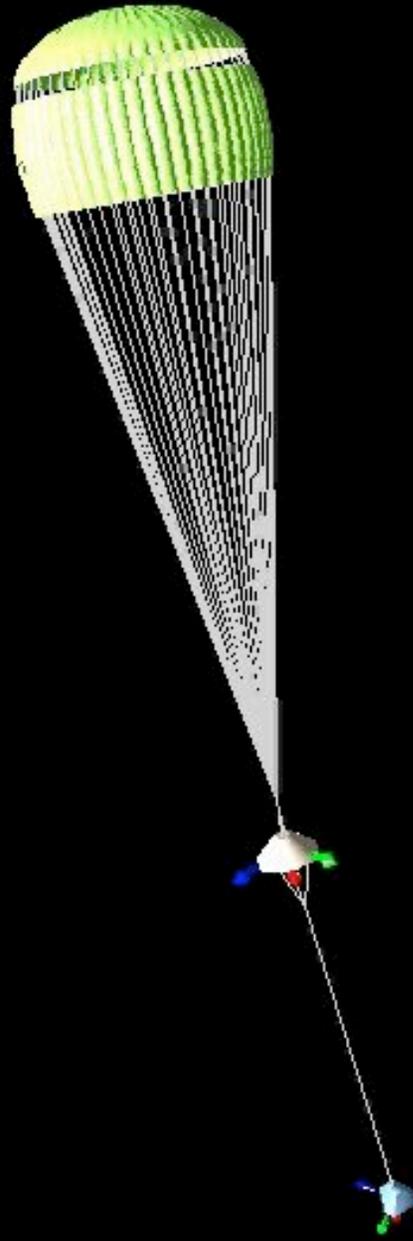




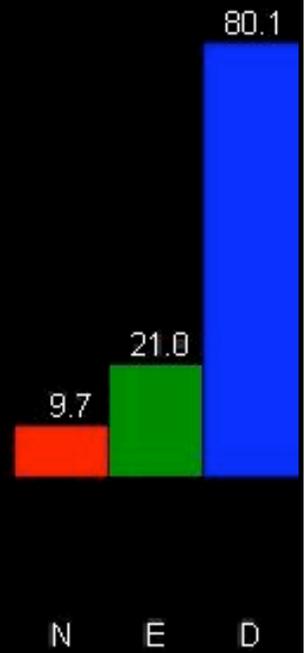






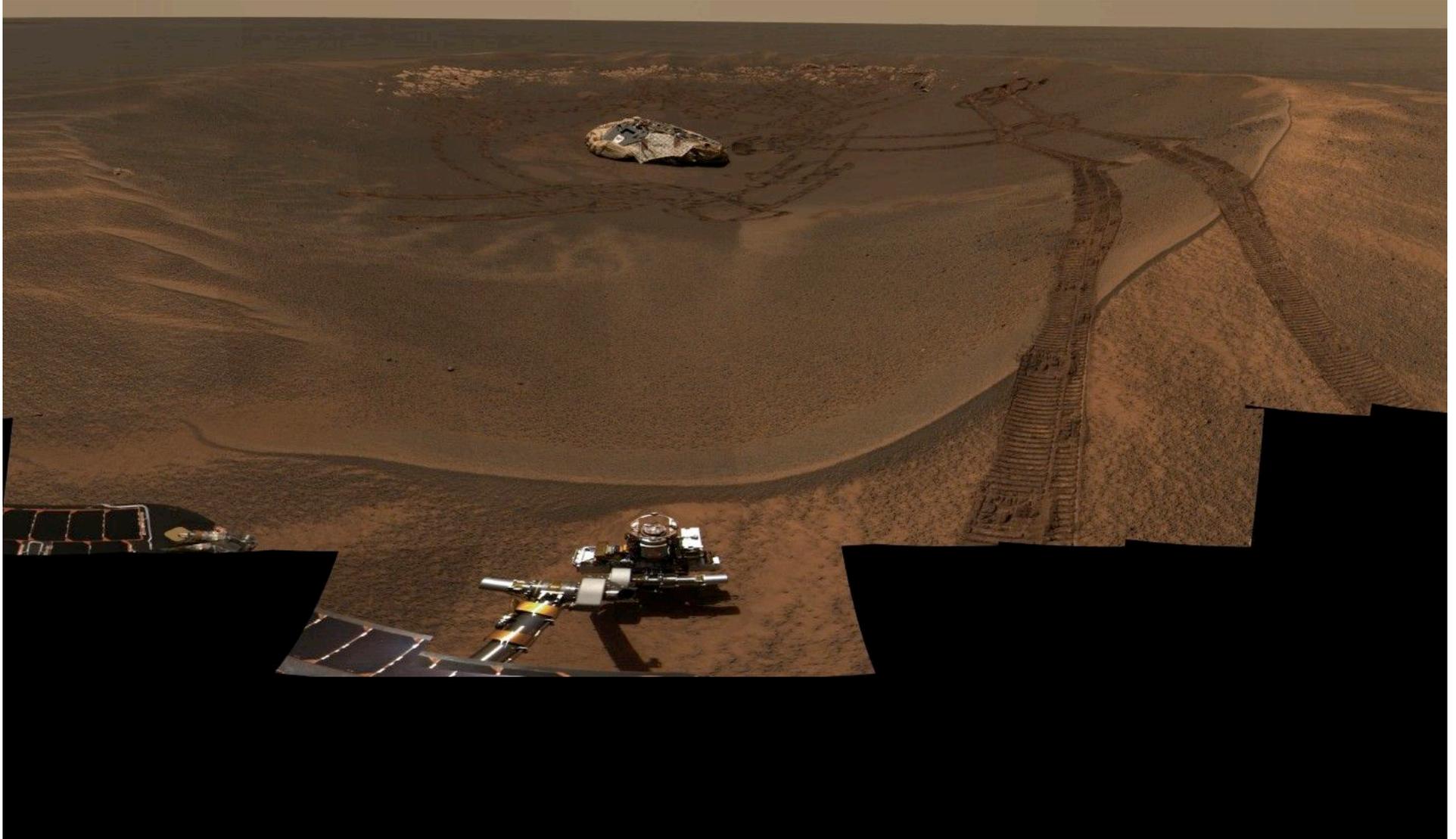


time to rocket firing = 43.22 sec



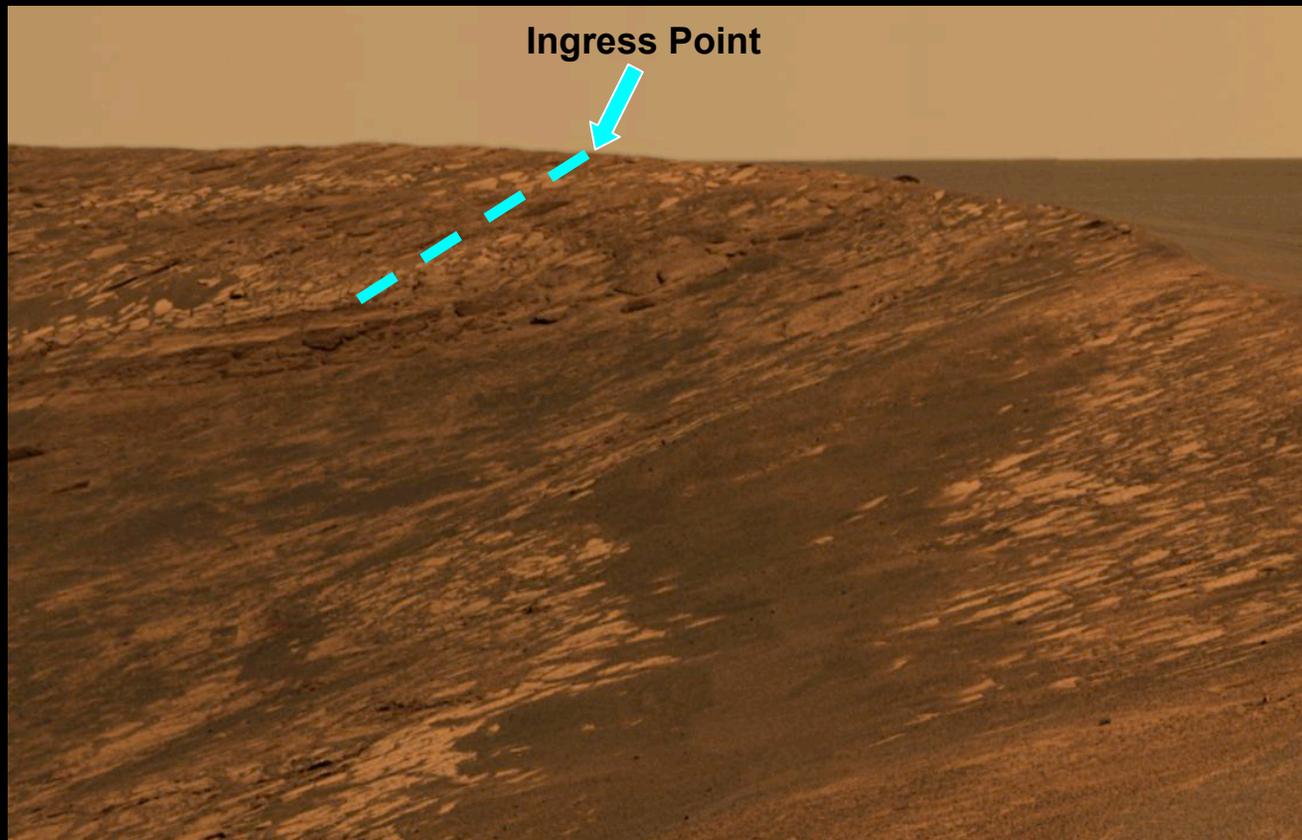


MER - Roving on Mars



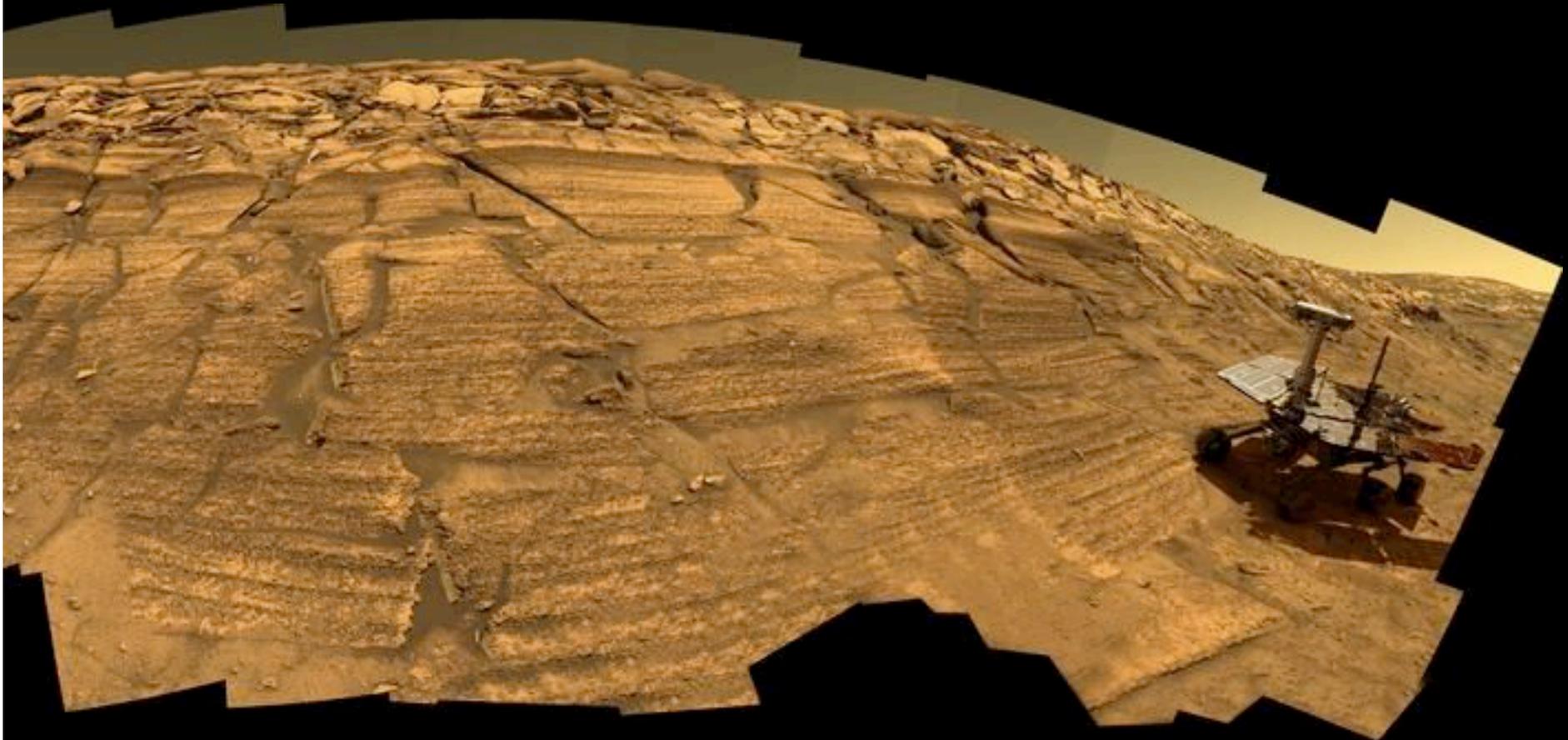


Endurance Crater - You want to drive INTO there?





Ok, but 30 degrees is the limit





MER - The likely end of mission is insufficient power due to dust build up on the solar arrays



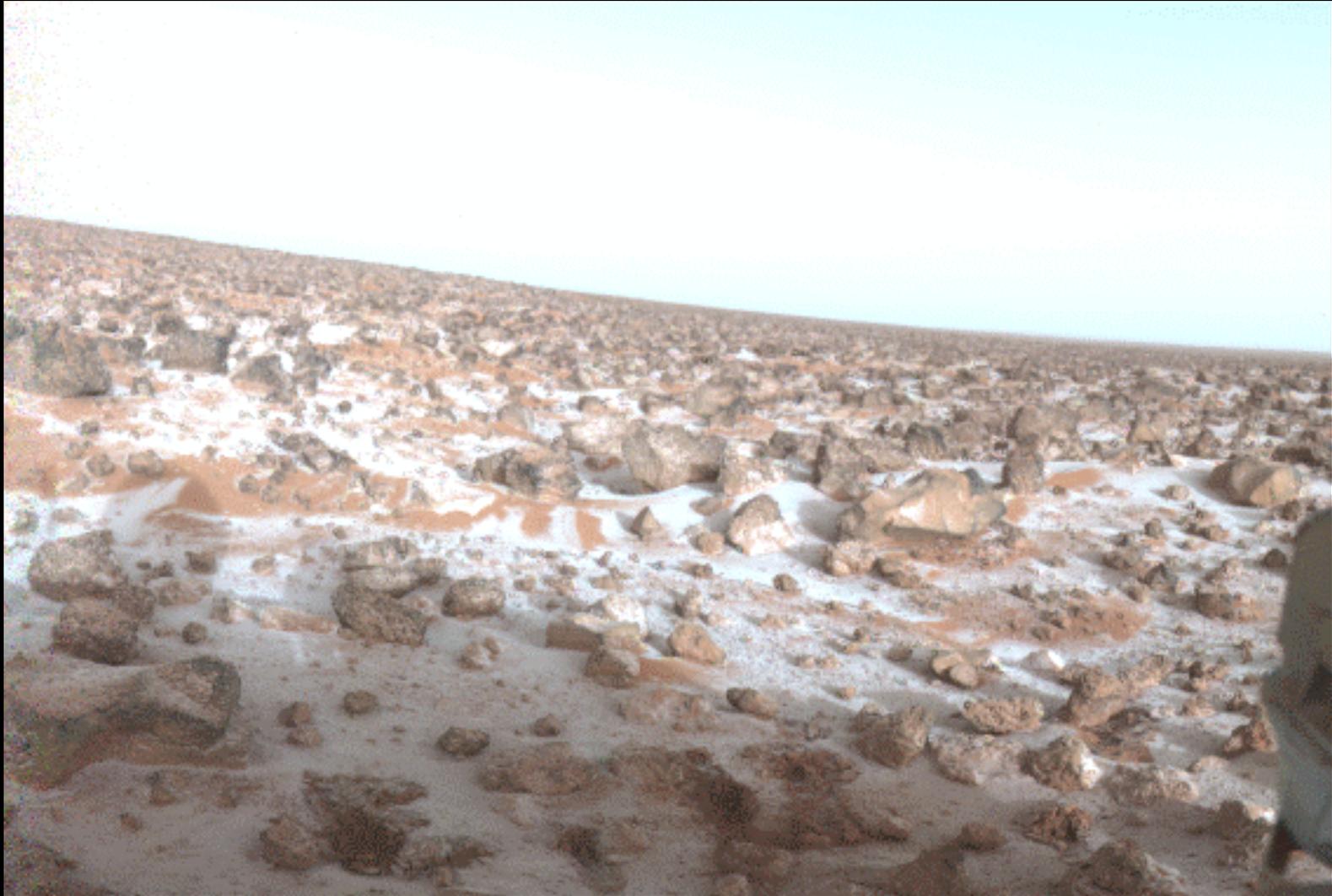


Spirit Calibration target sol 426 and 433





Frost at the Viking Lander Site



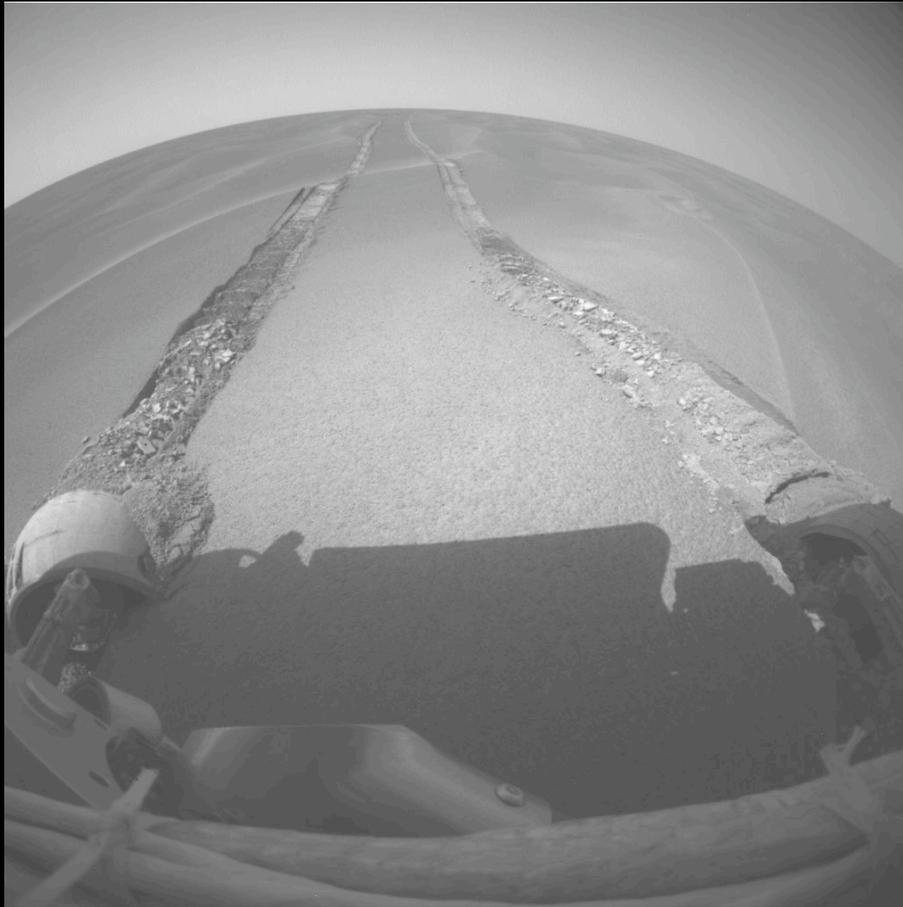


Spirit wheel digs up a “Potato” sized rock





Opportunity enters Purgatory - Sol 446



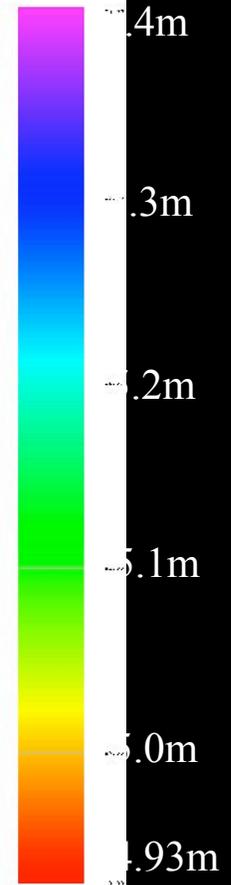
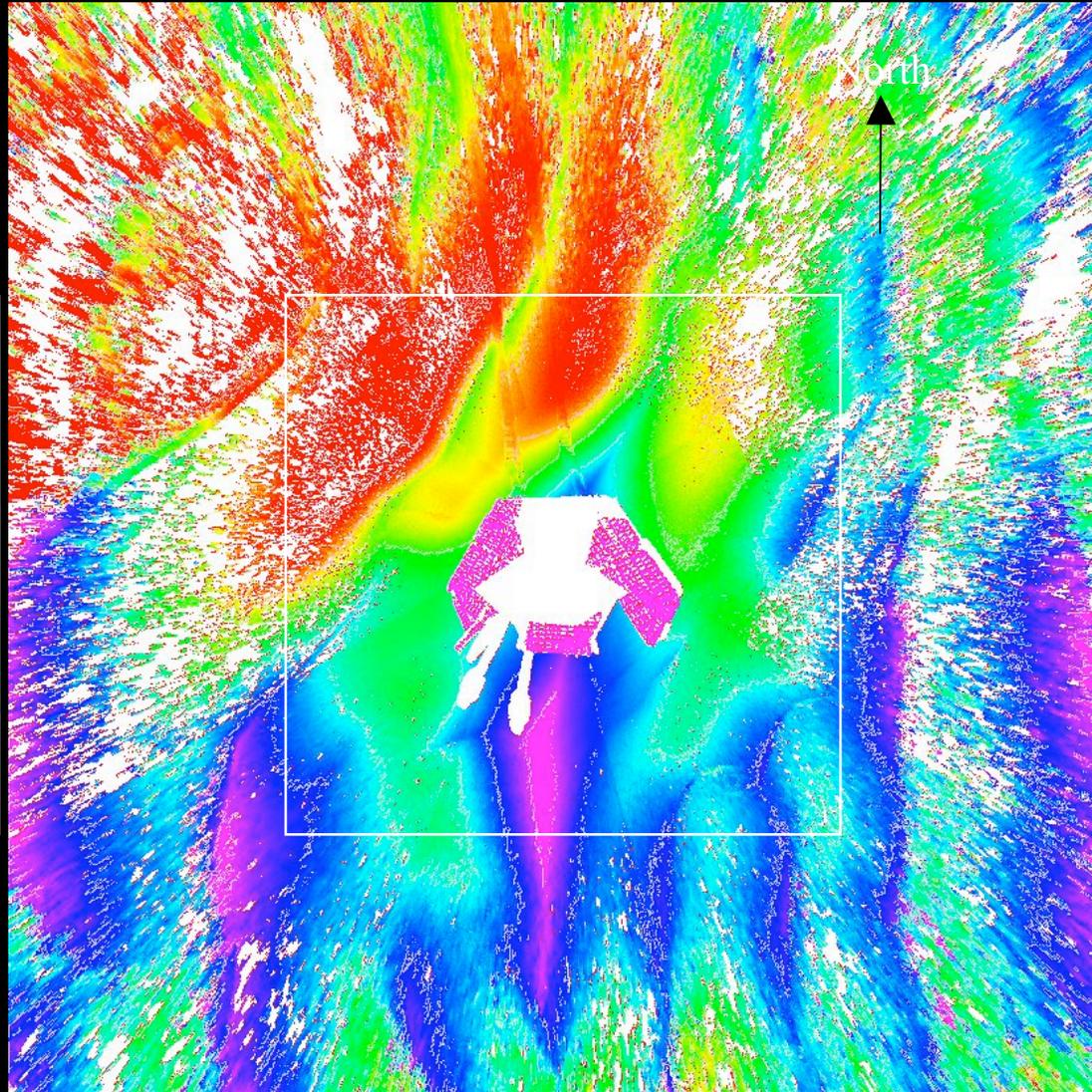
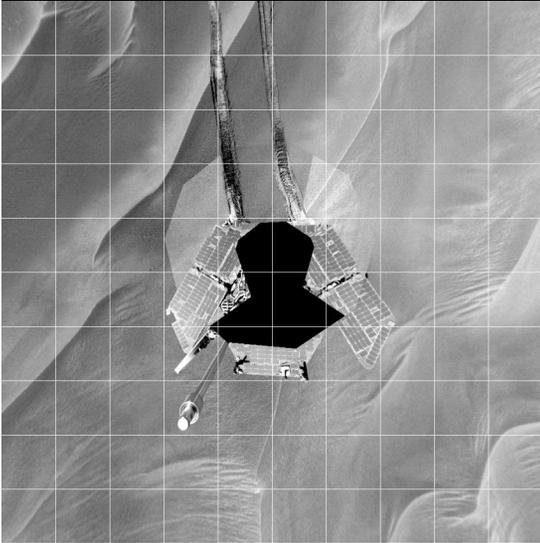
Front Hazcam



Rear Hazcam



Terrain Elevation Map



20m



Sol 484 Hazcams



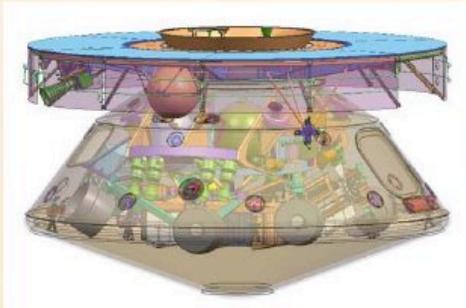
Front Hazcam



Rear Hazcam



MSL Mission Overview



CRUISE/APPROACH

- 10-12 month cruise
- Spinning cruise stage
- Arrive N. hemisphere summer ($L_s=120-150$)

LAUNCH

- Sept. 15 to Oct. 4, 2009
- Atlas V or Delta IV

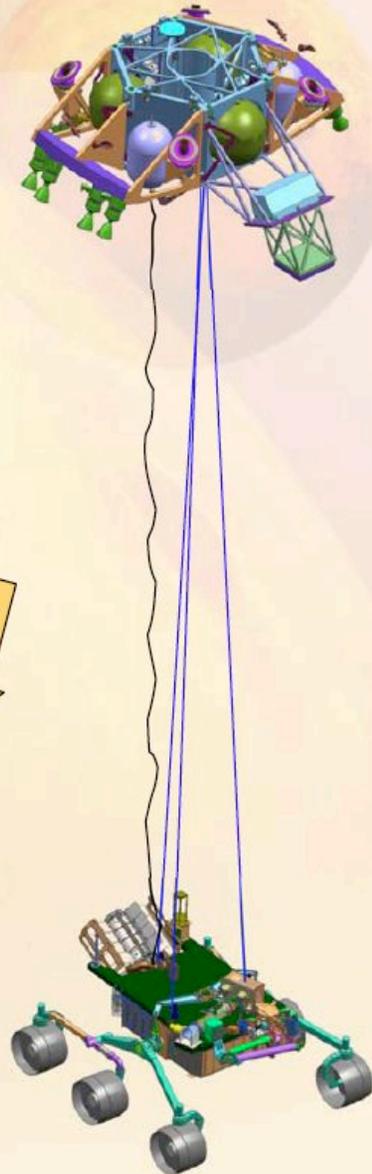


ENTRY, DESCENT, LANDING

- Guided entry and controlled, powered “sky crane” descent
- 20-km diameter landing ellipse
- Discovery responsive for landing sites $\pm 60^\circ$ latitude, $< +2$ km elevation
- 775-kg landed mass

SURFACE MISSION

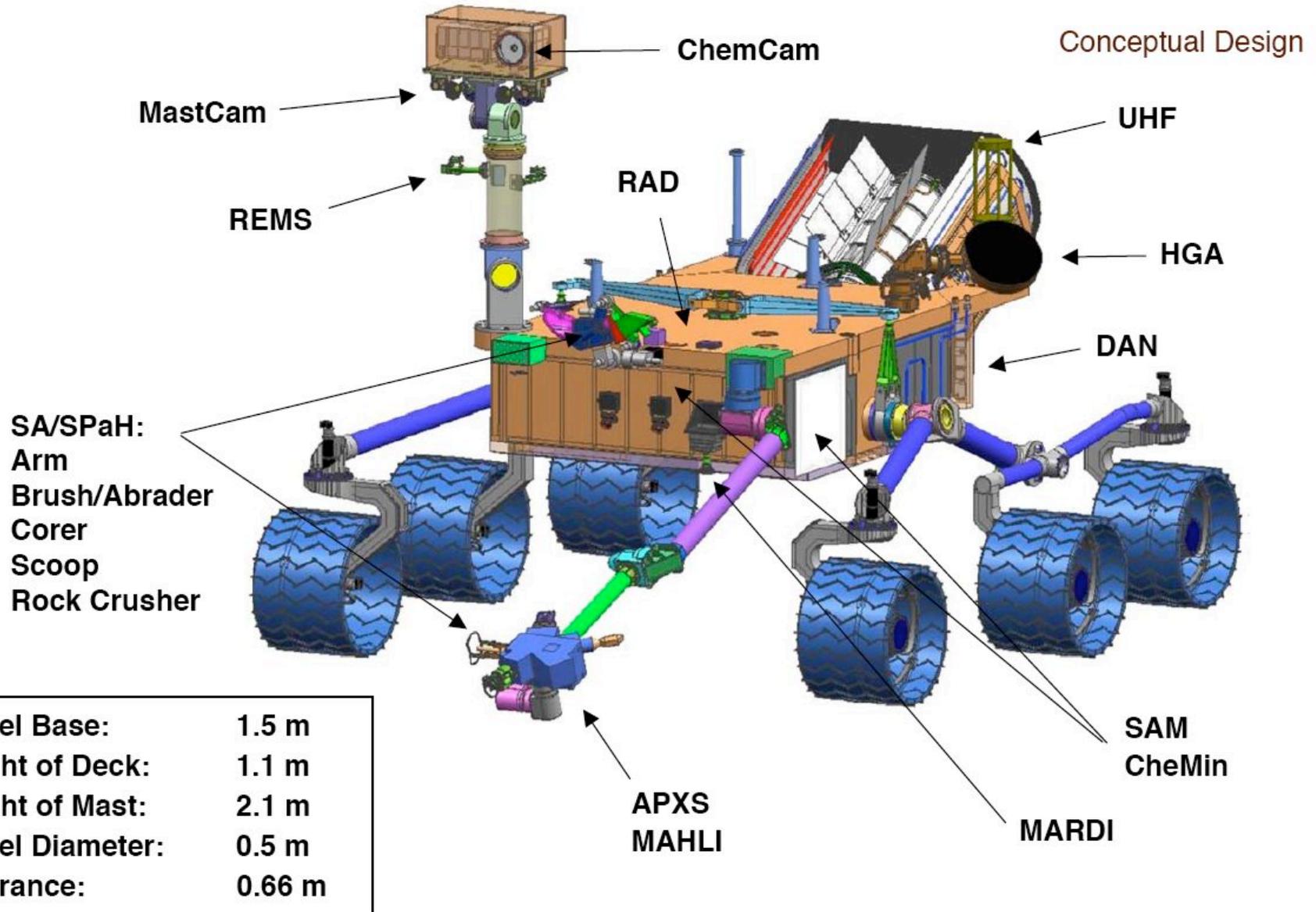
- Prime mission is one Mars year
- Latitude-independent and long-lived power source, pending approval
- 20-km range
- 75 kg of science payload
- Acquire ~ 70 samples of rock/regolith
- Large rover, high clearance; greater mobility than MPF, MER



Conceptual Design



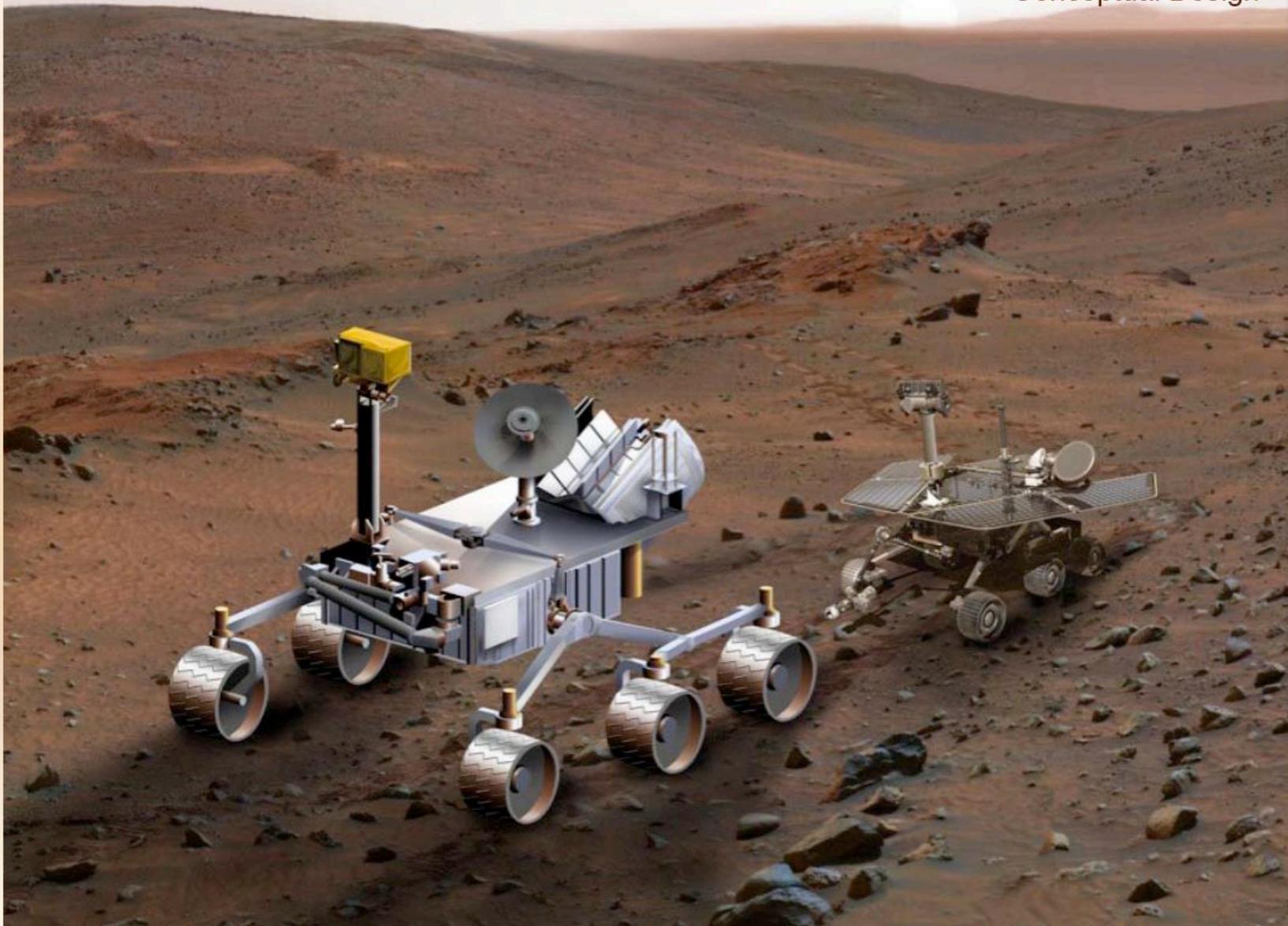
Current Rover Configuration





Current Rover Configuration

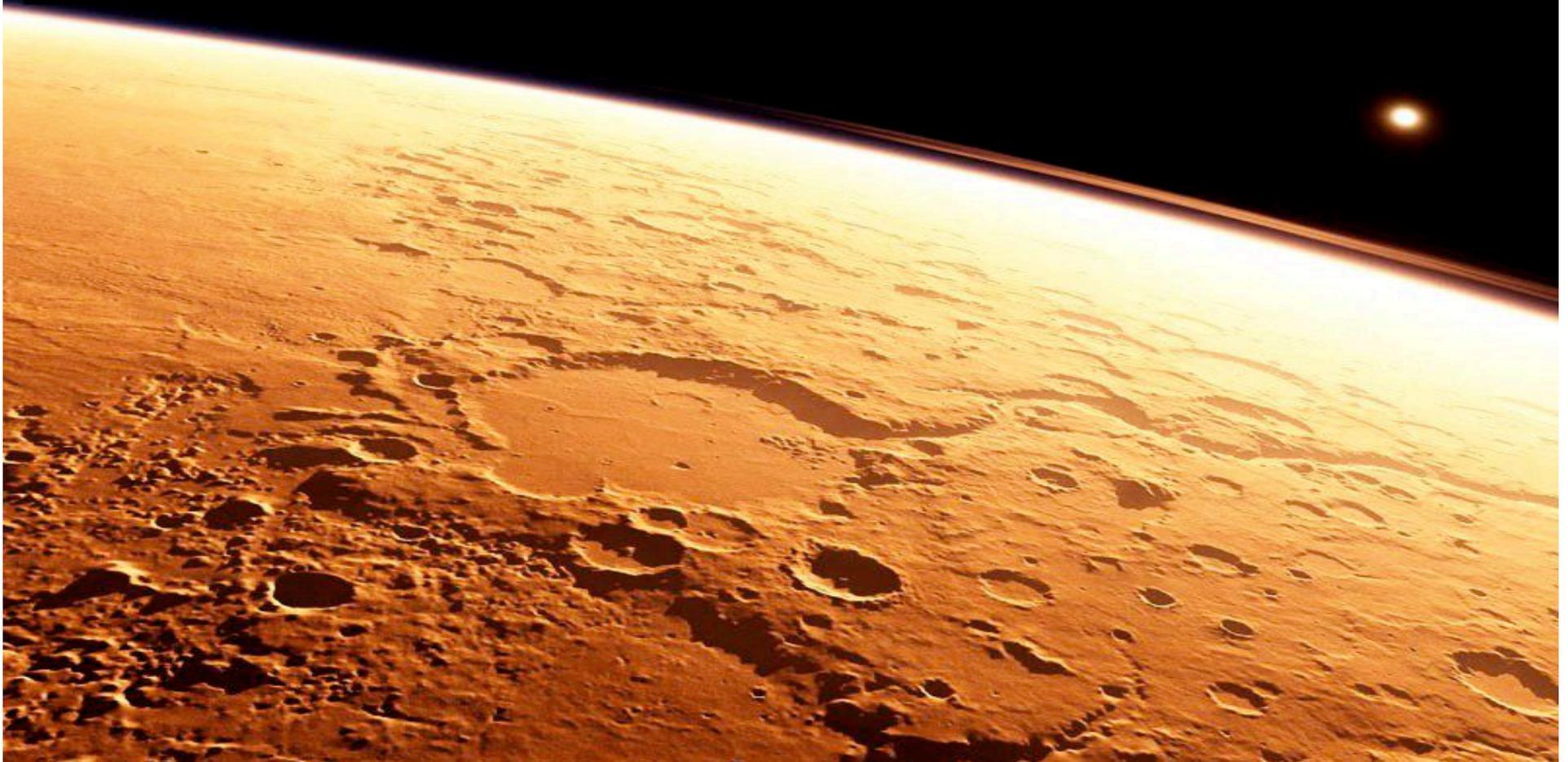
Conceptual Design





Join The Adventure!

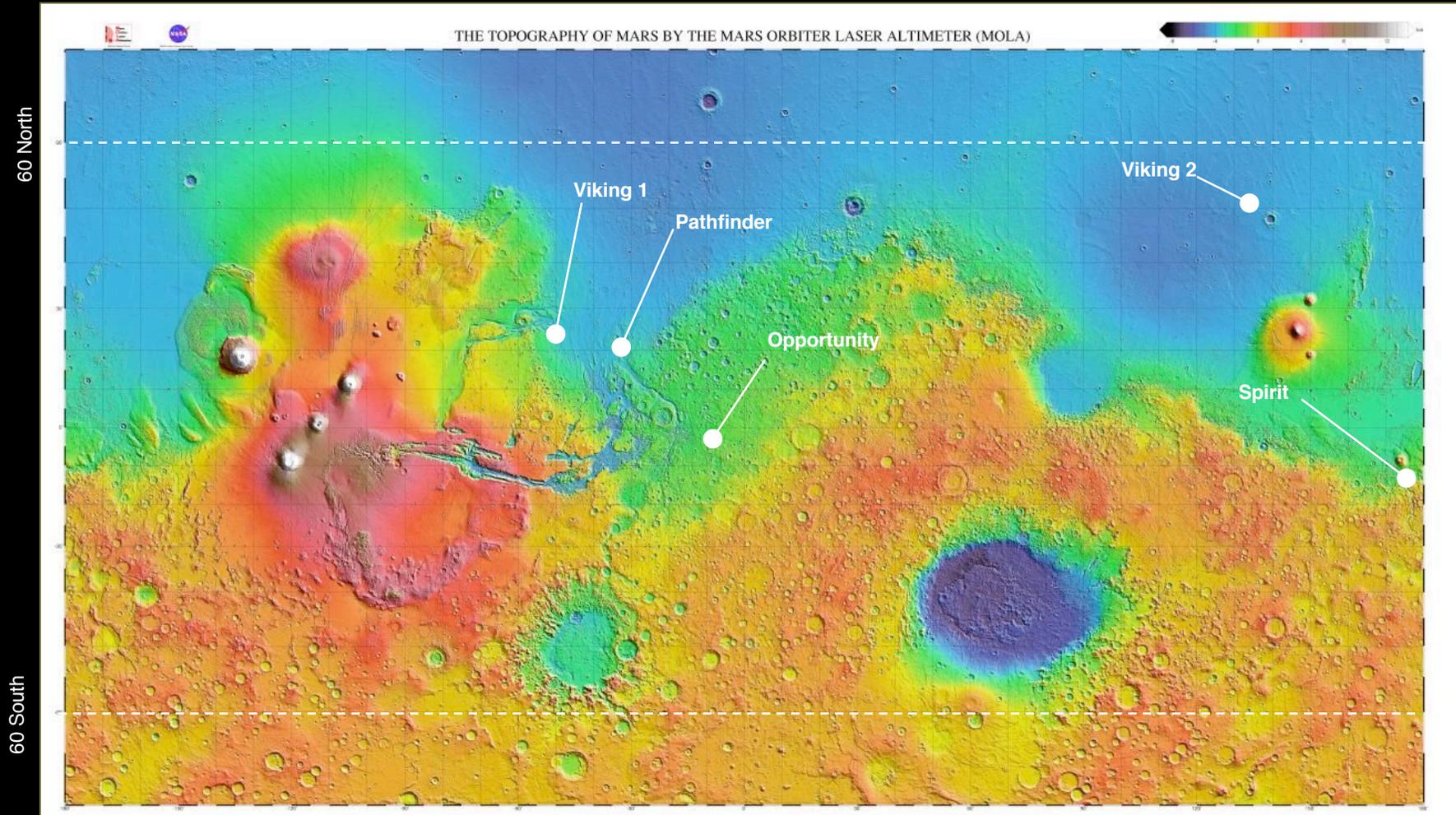
<http://mars.jpl.nasa.gov>







MSL Landing Site?



Mars elevation map generated from Mars Global Surveyor Laser Altimeter (MOLA) data



Sunset at Gusev Crater





Spirit at Barnhill

