Richard V Welch
Jet Propulsion Laboratory,
California Institute of Technology

“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 Pathfinder Sojourner Rover - 1996
Mars Science Laboratory - 2009
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

- **W**: Understand the potential for life elsewhere in the universe
- **A**: Characterize the present and past climate and climate processes
- **T**: Understand the geological processes affecting Mars’ interior, crust, and surface
- **E**: Develop the knowledge & technology necessary for eventual human exploration

**When**

- **Form**
- **Amount**

**Life**

**Climate**

**Geology**

**Prepare for Human Exploration**

Climate
Life
Prepare for Human Exploration
Geology
WATER
WhenWhereFormAmount
CommonThread
Mars Exploration Program

Launch Year

OPERATIONAL

- Mars Global Surveyor
- Mars Odyssey
- ESA Mars Express
- Mars Reconnaissance Orbiter (Italian SHARAD)

2005
- Competed Scout Mission

2007
- 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

- Successful FBC Spacecraft
- Successful Traditional NASA Spacecraft
- Failed Spacecraft
- Partial Failure/Impaired

Development Time (months)

Complexity Index

MER
More Cabling…
Entry, Descent & Landing (EDL) aka 6 minutes of terror

12,000 mph
1,200 mph
120 mph
0 mph
Controlling Horizontal Velocity
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

5.4m
5.3m
4.93m
5.0m
5.1m
5.2m
North
20m
20m
Sol 484 Hazcams

Front Hazcam

Rear Hazcam
**MSL Mission Overview**

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

**Entry, Descent, Landing**
- Guided entry and controlled, powered “sky crane” descent
- 20-km diameter landing ellipse
- Discovery responsive for landing sites ±60° 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

**Launch**
- Sept. 15 to Oct. 4, 2009
- Atlas V or Delta IV
Current Rover Configuration

Wheel Base: 1.5 m
Height of Deck: 1.1 m
Height of Mast: 2.1 m
Wheel Diameter: 0.5 m
Clearance: 0.66 m
MSL Landing Site?

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

60 North
Opportunity
Spirit
Viking 1
Pathfinder
Viking 2

60 South

Mars elevation map generated from Mars Global Surveyor Laser Altimeter (MOLA) data
Sunset at Gusev Crater
Spirit at Barnhill