National Aeronautics and Space Administration

Mars Science Laboratory

NAC Technology And Innovation Committee

Nov. 15, 2012

Dave Lavery
Program Executive
Mars Science Laboratory

Mars Science Laboratory / Curiosity

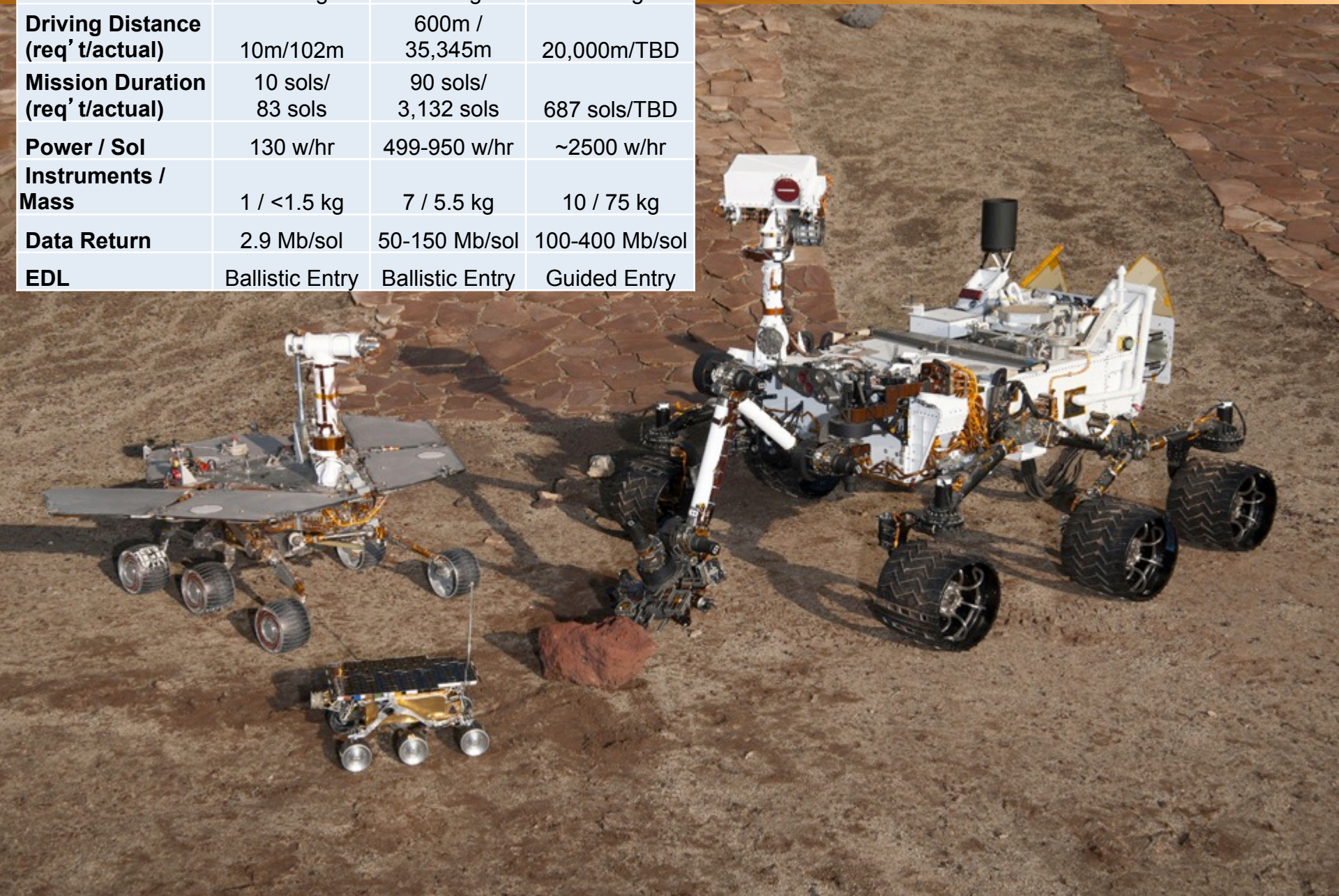
- **Mission Context**
- Spacecraft / Rover Overview
- Entry, Descent and Landing (EDL)
- Early Surface Operations
- Critical Technologies
- Effective Outreach

Mars Exploration Program
An Integrated, Strategic Program

2001	2003	2005	2007	2009	2011	2013	2016 & Beyond
Odyssey	Mars Express Collaboration	MRO				MAVEN	*Mars future planning underway!*
	Spirit & Opportunity		Phoenix (completed)		MSL/Curiosity		

Rover Family Portrait

	Pathfinder	MER	MSL
Rover Mass	10.5 kg	174 kg	950 kg
Driving Distance (req't/actual)	10m/102m	600m / 35,345m	20,000m/TBD
Mission Duration (req't/actual)	10 sols/ 83 sols	90 sols/ 3,132 sols	687 sols/TBD
Power / Sol	130 w/hr	499-950 w/hr	~2500 w/hr
Instruments / Mass	1 / <1.5 kg	7 / 5.5 kg	10 / 75 kg
Data Return	2.9 Mb/sol	50-150 Mb/sol	100-400 Mb/sol
EDL	Ballistic Entry	Ballistic Entry	Guided Entry



Science Goals

MSL's primary scientific goal is to explore a landing site as a potential habitat for life, and assess its potential for preservation of biosignatures

Objectives include:

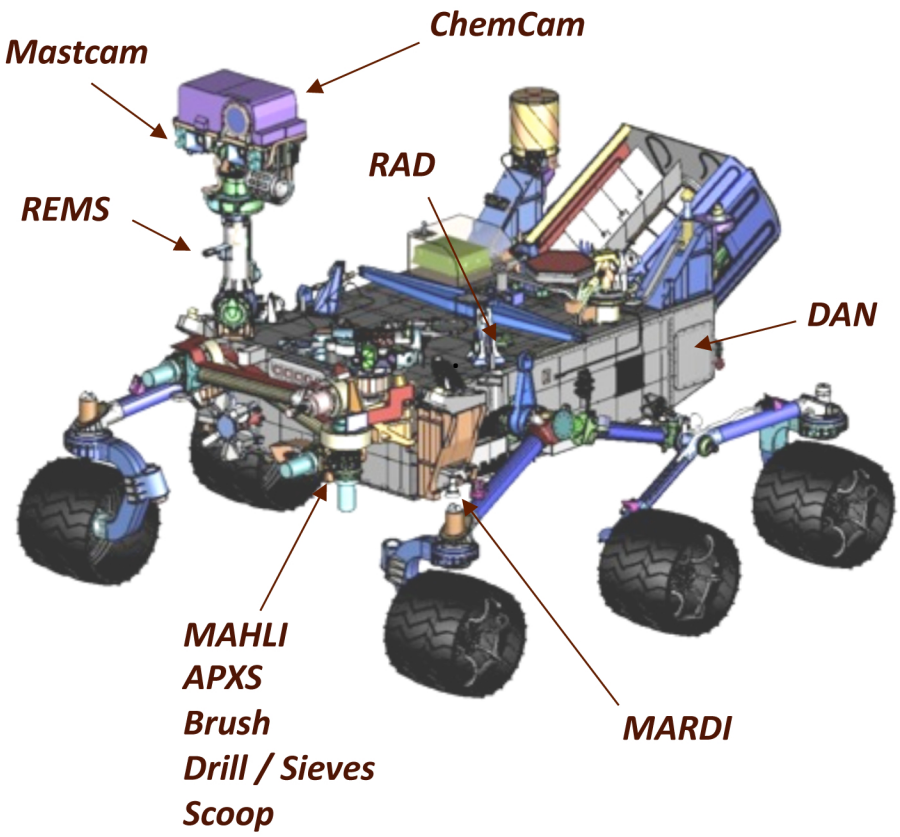
Assessing the biological potential of the site by investigating organic compounds, other relevant elements, and biomarkers

Characterizing geology and geochemistry, including chemical, mineralogical, and isotopic composition, and geological processes

Investigating the role of water, atmospheric evolution, and modern weather/climate

Characterizing the spectrum of surface radiation

MSL Science Payload



Rover Width:	**2.8 m**
Height of Deck:	**1.1 m**
Ground Clearance:	**0.66 m**
Height of Mast:	**2.2 m**

REMOTE SENSING

Mastcam (M. Malin, MSSS) - Color and telephoto imaging, video, atmospheric opacity

ChemCam (R. Wiens, LANL/CNES) – Chemical composition; remote micro-imaging

CONTACT INSTRUMENTS (ARM)

MAHLI (K. Edgett, MSSS) – Hand-lens color imaging

APXS (R. Gellert, U. Guelph, Canada) - Chemical composition

ANALYTICAL LABORATORY (ROVER BODY)

SAM (P. Mahaffy, GSFC/CNES) - Chemical and isotopic composition, including organics

CheMin (D. Blake, ARC) - Mineralogy

ENVIRONMENTAL CHARACTERIZATION

MARDI (M. Malin, MSSS) - Descent imaging

REMS (J. Gómez-Elvira, CAB, Spain) - Meteorology / UV

RAD (D. Hassler, SwRI) - High-energy radiation

DAN (I. Mitrofanov, IKI, Russia) - Subsurface hydrogen

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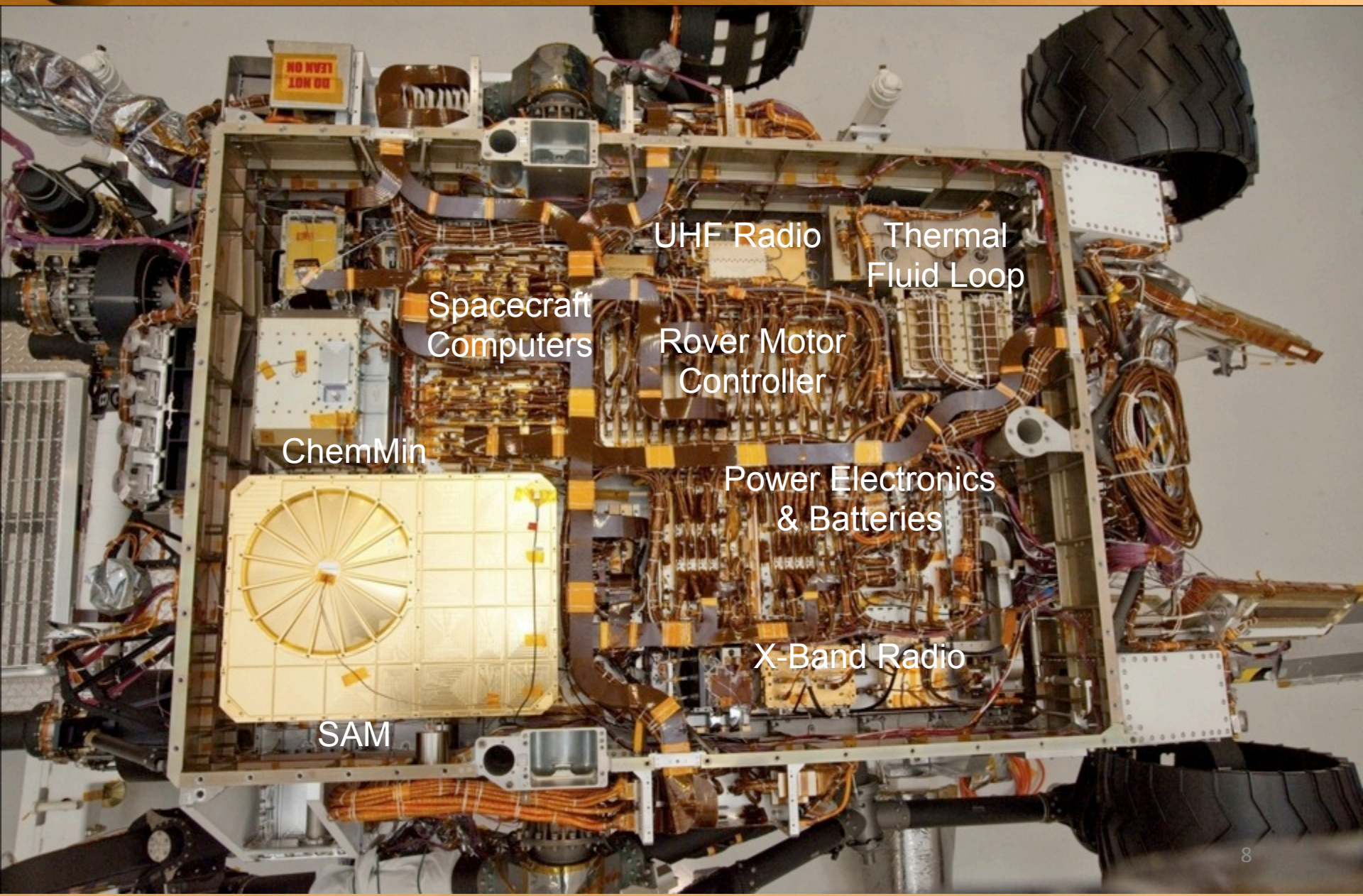
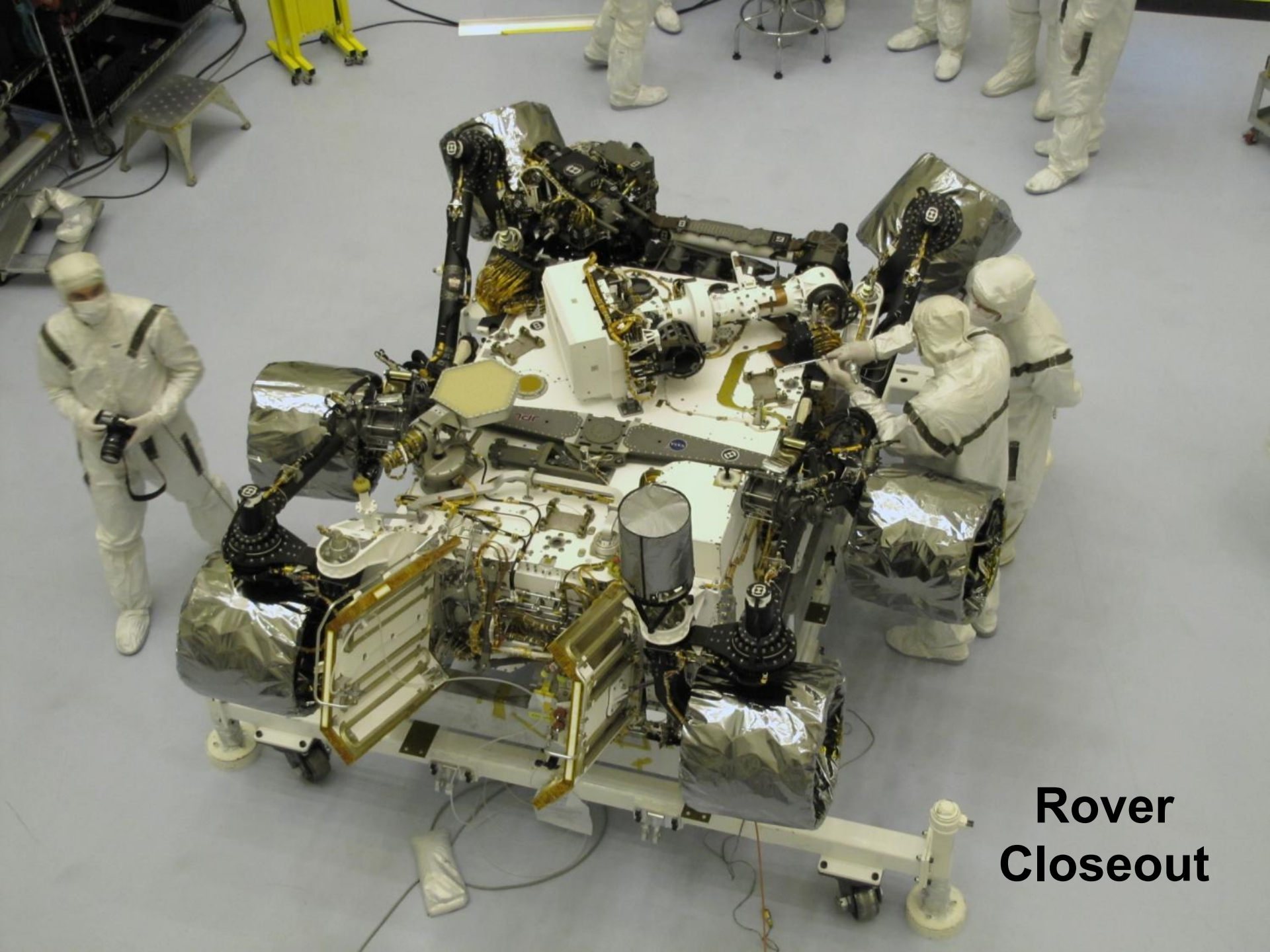
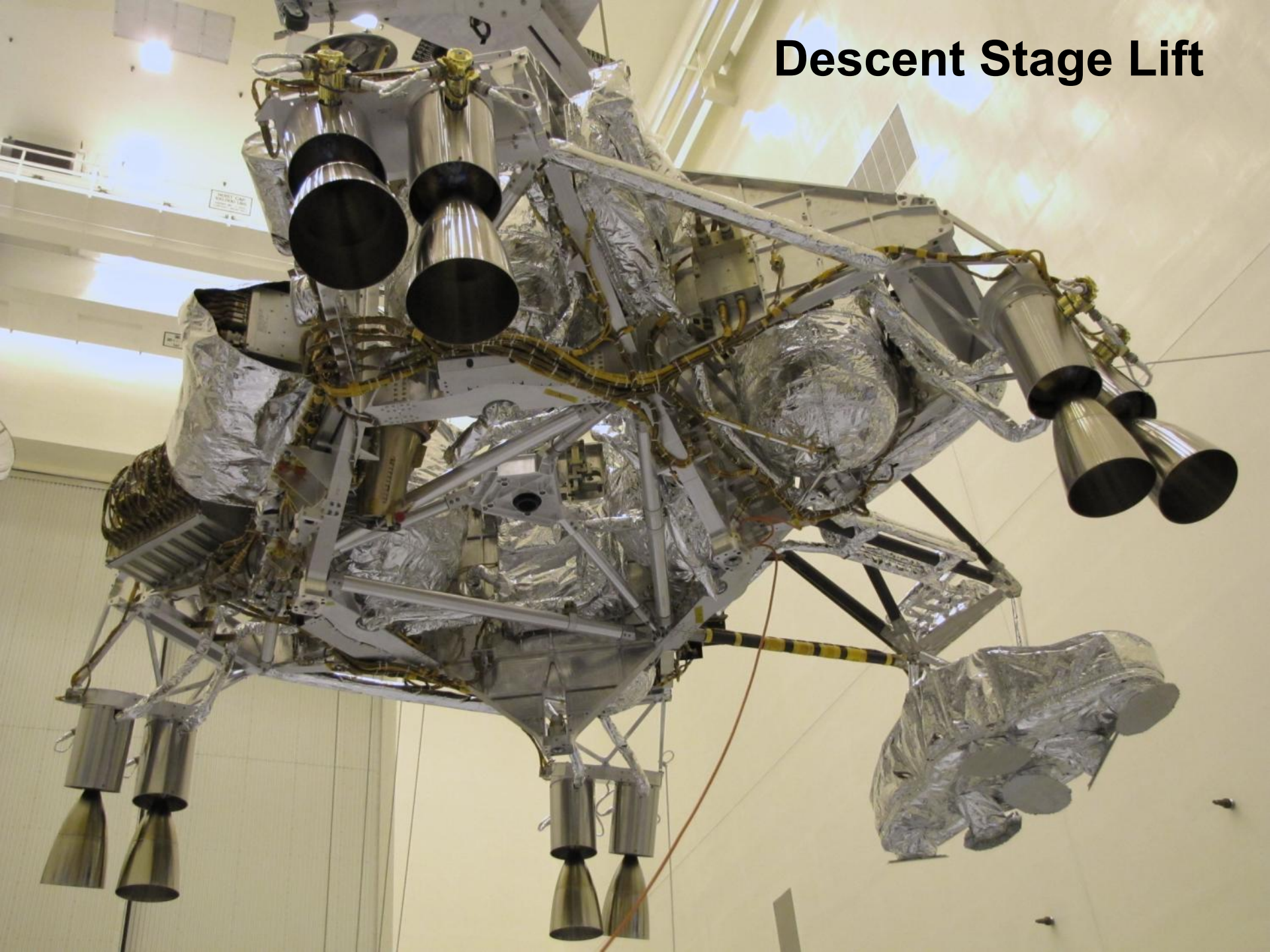
Whats under the Hood





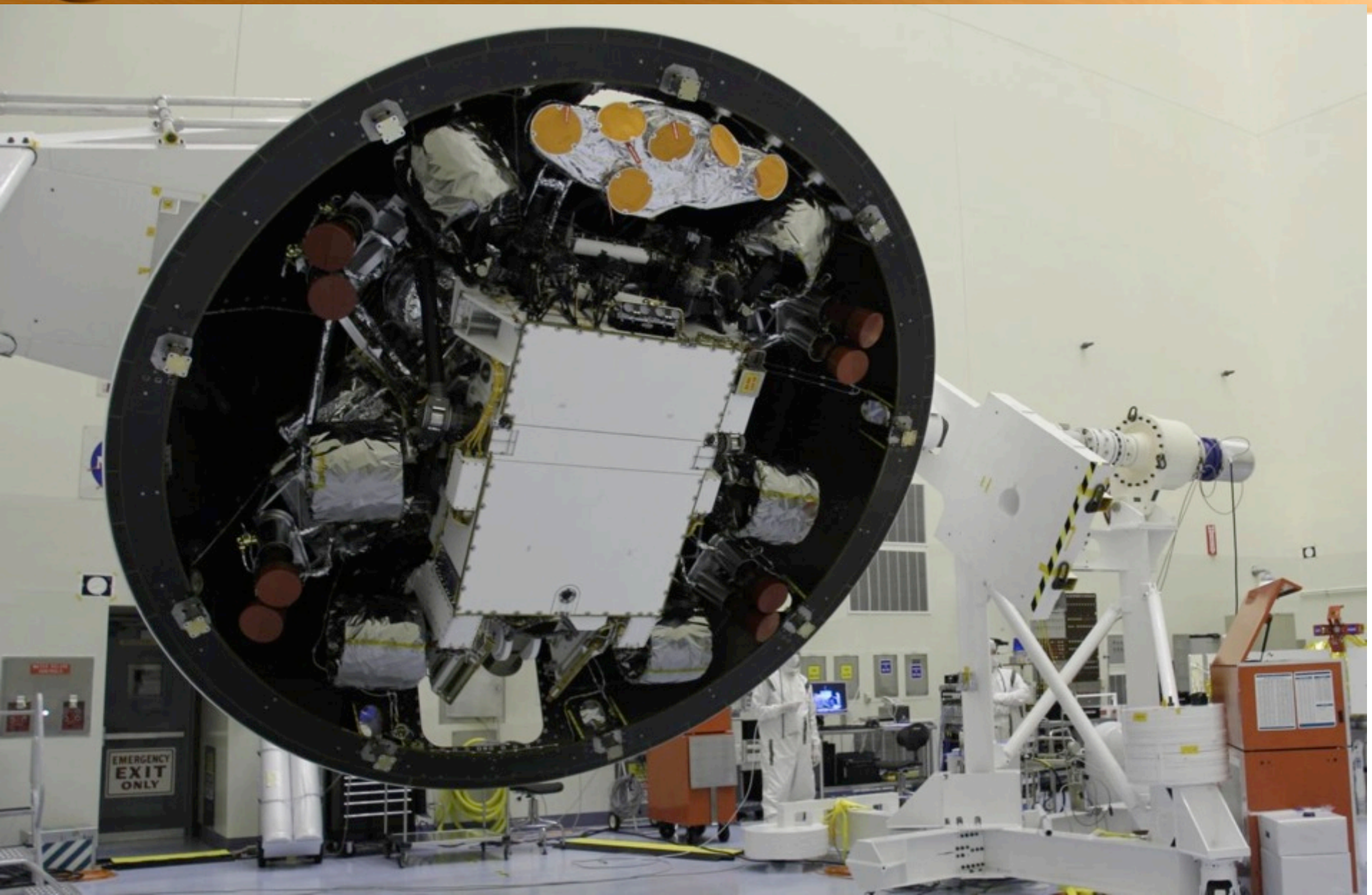
Rover Closeout

Descent Stage Lift



Mated Descent Stage and Rover

Backshell with *Curiosity* Rover



Final Stack

Ready to Encapsulate

Headed to the Launch Pad!

MSL Stacked on its ATLAS V

Vertical Integration Facility/SLC-41

Launch Vehicle Configuration:
AV-028/Atlas V 541,5.4M 68' PLF
4 SRBS, Single RL10A-4-2 Engine Block 2 Avionics
Centaur Ghe: (2) LHB' s

Launch Site: CCAFS LC-41

Launch Period: 25 Nov 2011 - 18 Dec 2011
Cont ingency Launch Period (TBD)

Launch Window:
Nov 25, 2011
10:19 AM EST (15:19:00 GMT)
15:21:00 - 17:13:00 GMT
48-120 minutes

Mission Type:
2 Burn, Hyperbolic Departure
415 sec 1st burn; 450-515 sec 2nd burn
12-31 minute park orbit coast

Spacecraft Mass:
4050 kg (8929 ibs), 3883 kg (8561 lbs)

Payload Processing Facilities:
PHSF, RTGF, and SSPF

NASA's Mars Rover Curiosity launched to Mars on Nov. 26, 2011, from Cape Canaveral, Florida.

Artist's Concept. NASA/JPL-Caltech

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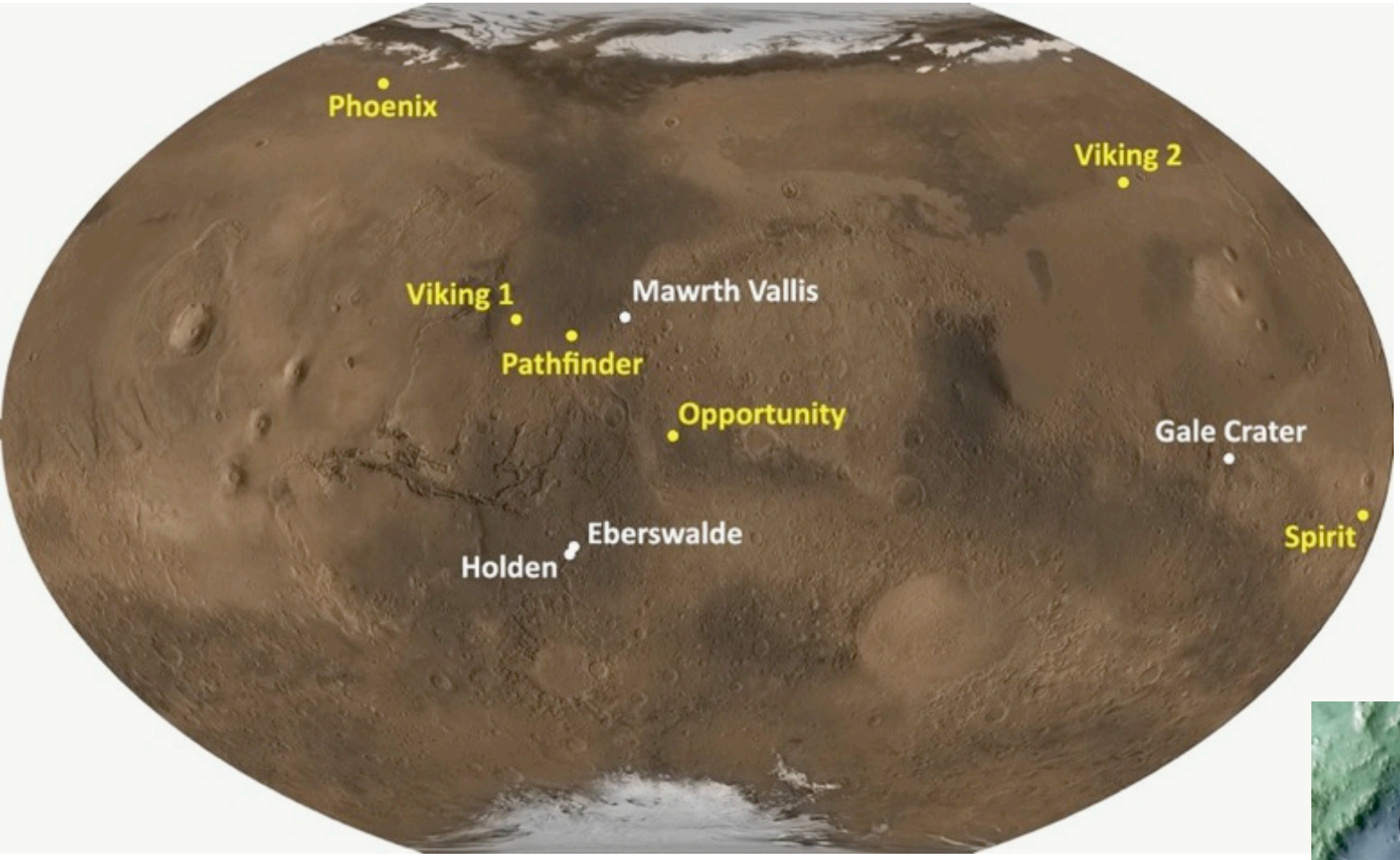
MSL Landing Site – Gale Crater

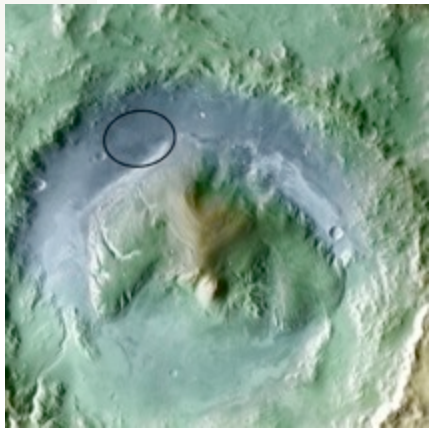


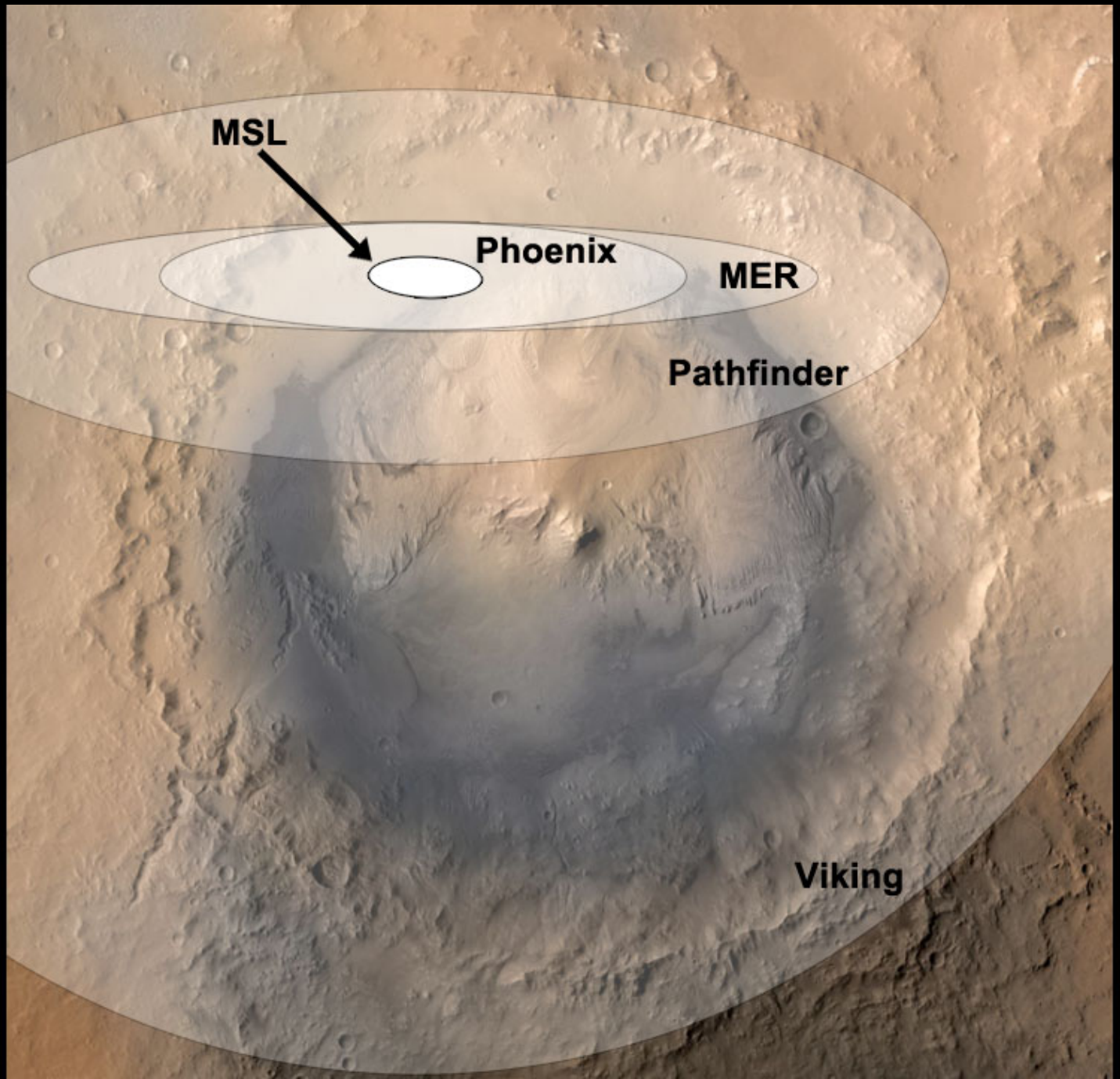
Gale crater spans 96 miles (154 kilometers) in diameter and holds a mountain rising higher from the crater floor than Mount Rainier rises above Seattle.

Gale is about the size of the combined area of Connecticut and Rhode Island.

Layering in the mound suggests it is the remnant of an extensive sequence of deposits.

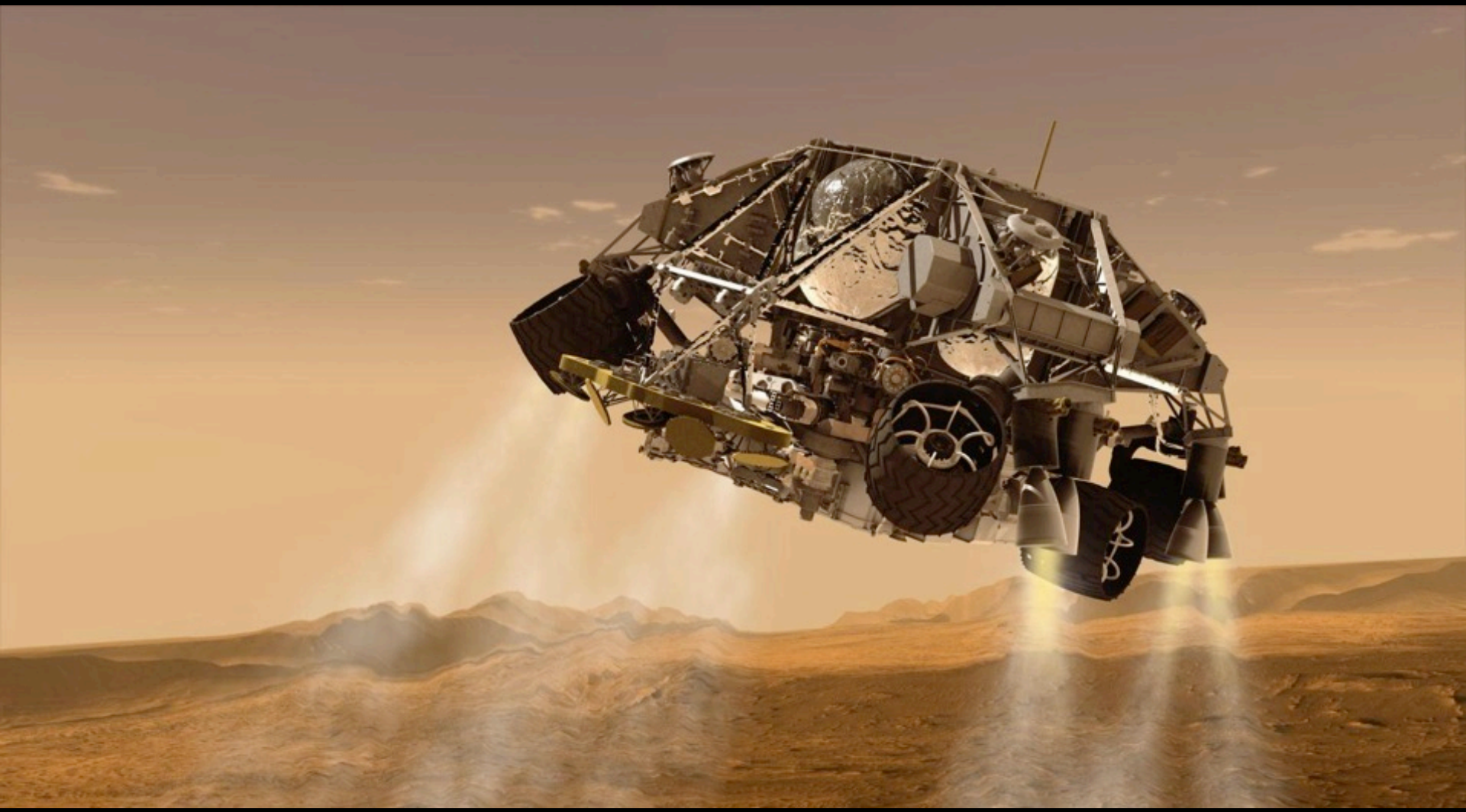
Gale Crater




MSL
Phoenix
MER
Pathfinder
Viking


(photos taken by Mars Reconnaissance orbiter)
Before
After

The descent stage engines fly the rover the last mile down to the surface.



As it descends, the rover uses radar to measure its speed and altitude, which it uses to land safely.

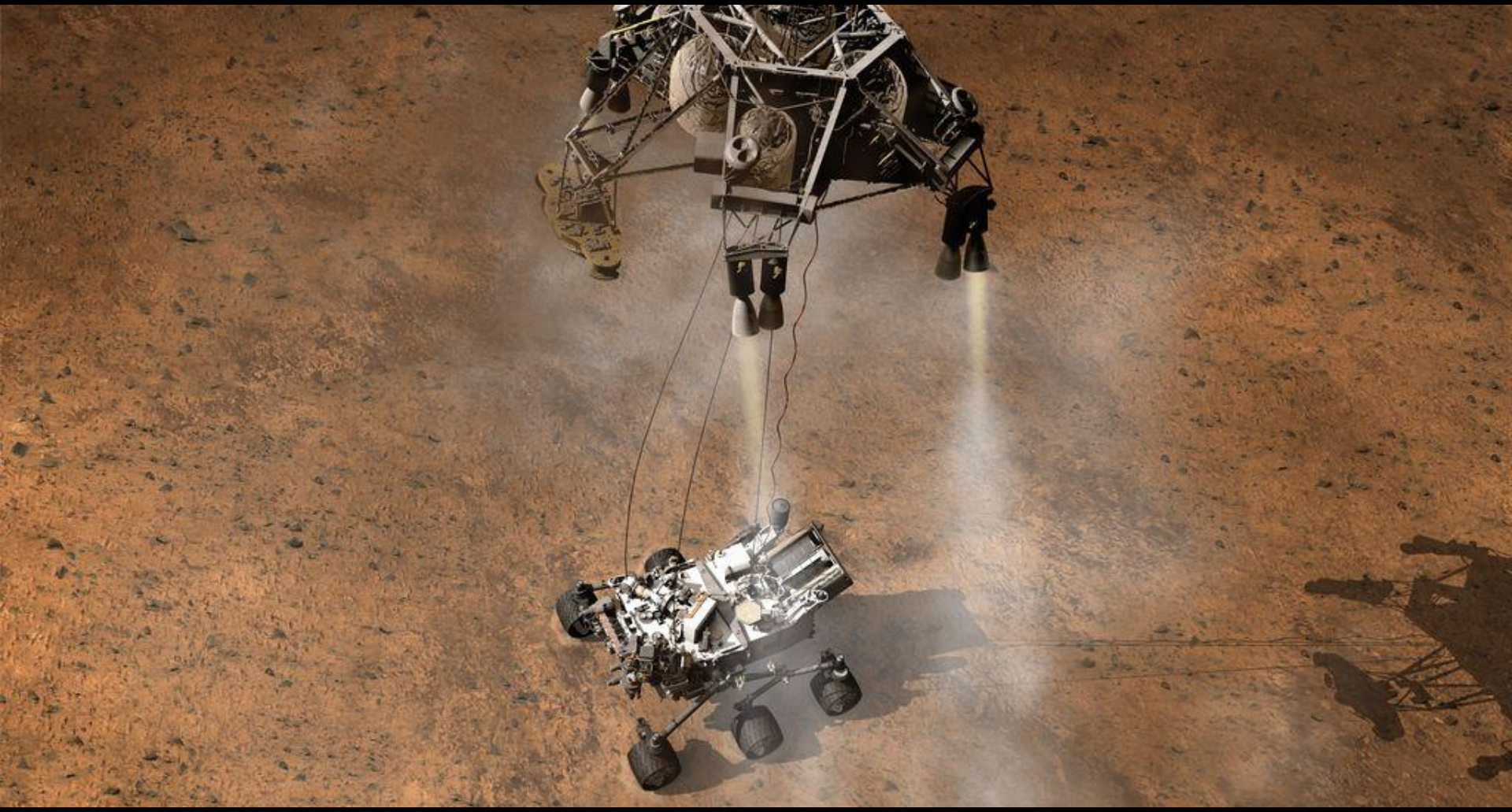
Artist's Concept. NASA/JPL-Caltech

The hovering descent stage lowers the rover on a bridle of three nylon ropes.

Coiled electronics and communications cables also unspool from the descent stage.

Artist's Concept. NASA/JPL-Caltech

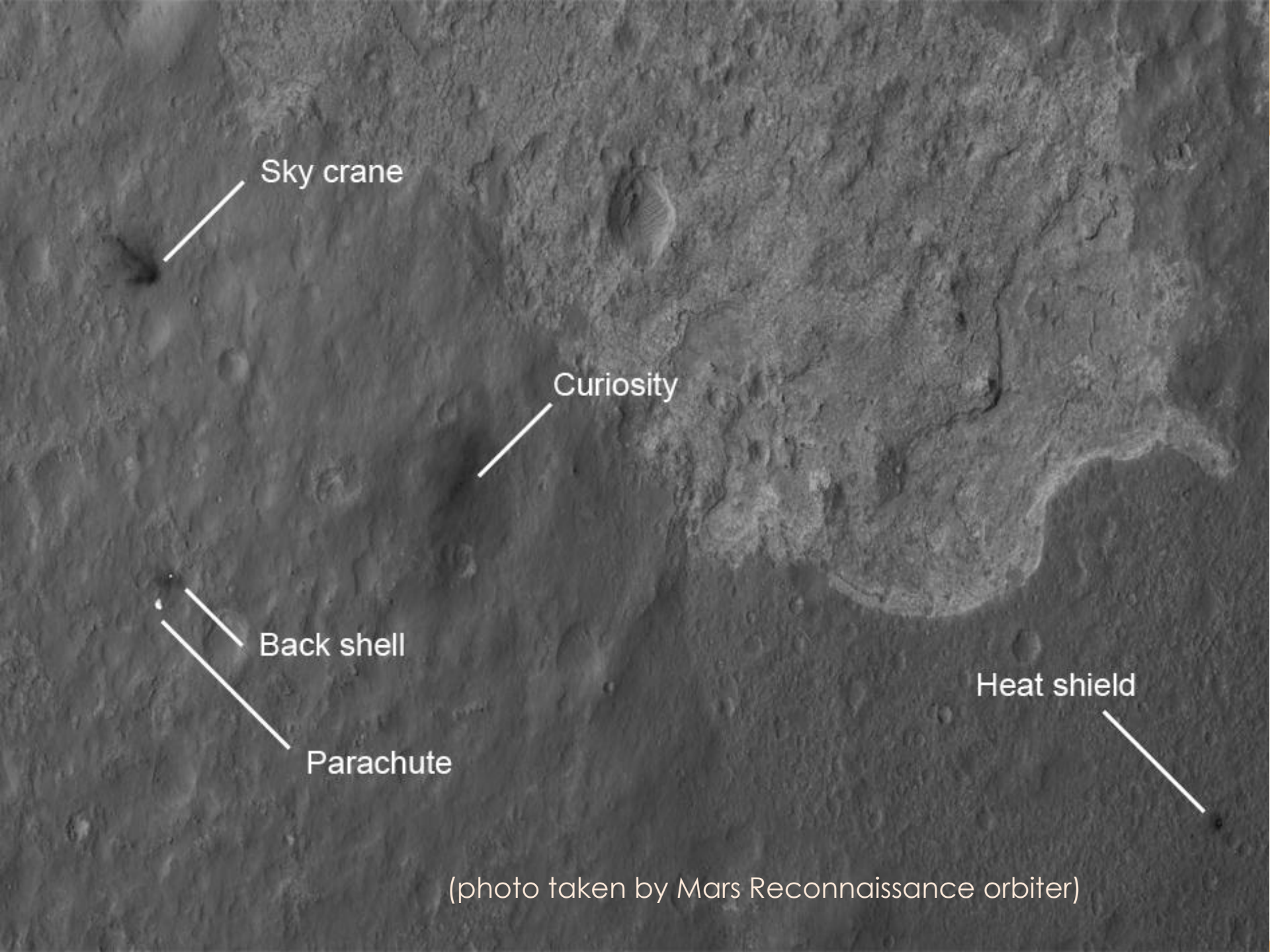
When the sky crane “senses” that Curiosity has touched down, the cables are cut.



The sky crane flies a safe distance away from the rover before crash-landing.

Artist’s Concept. NASA/JPL-Caltech


Dropping in on Mars
in High-Res



(photo taken by Mars Reconnaissance orbiter)

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NASA/JPL-Caltech

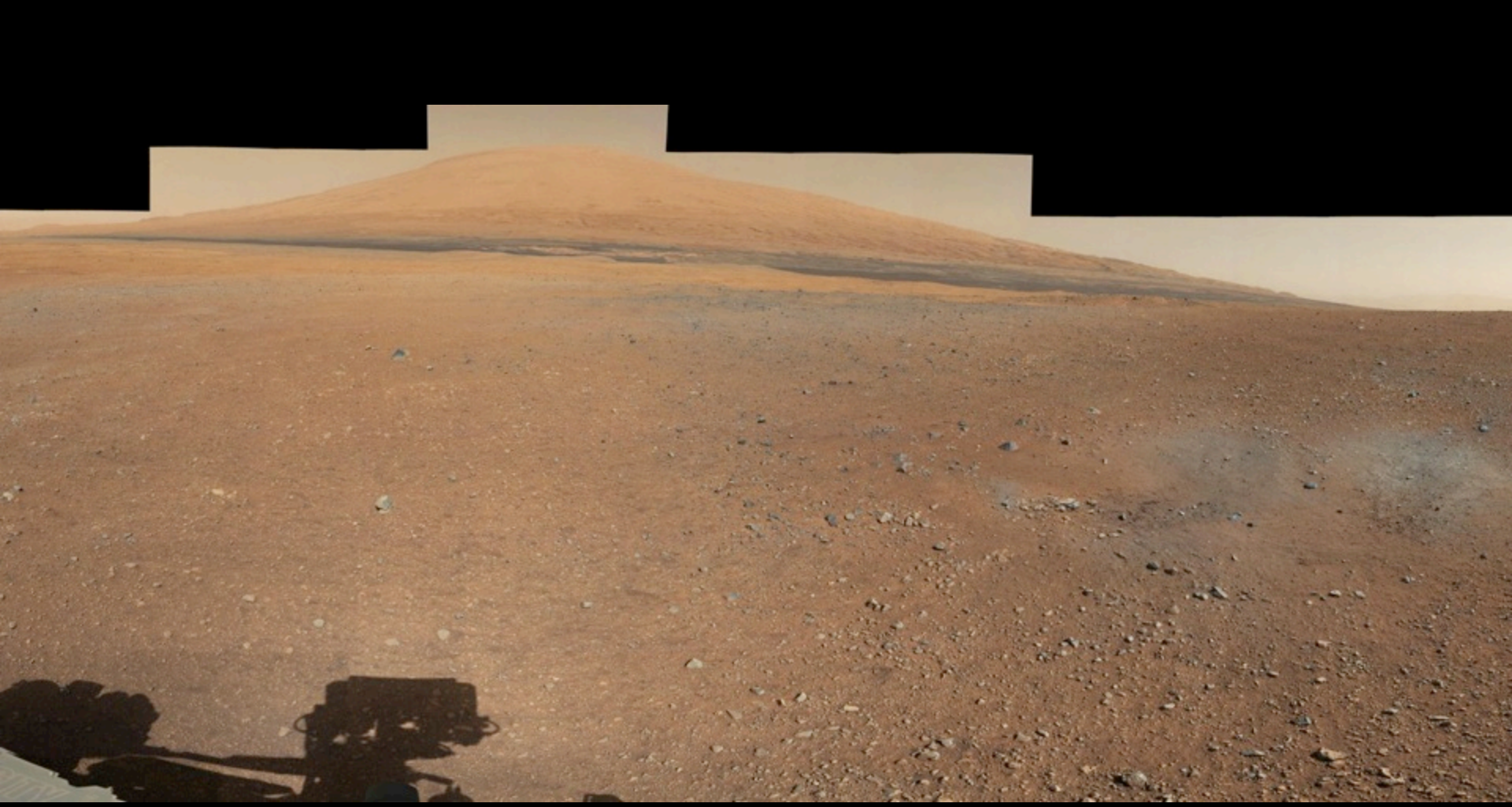
CURIOSITY

Navigation camera image showing the surface scour marks and rocks on the rover's deck

NASA/JPL-Caltech/MSSS

CURIOSITY

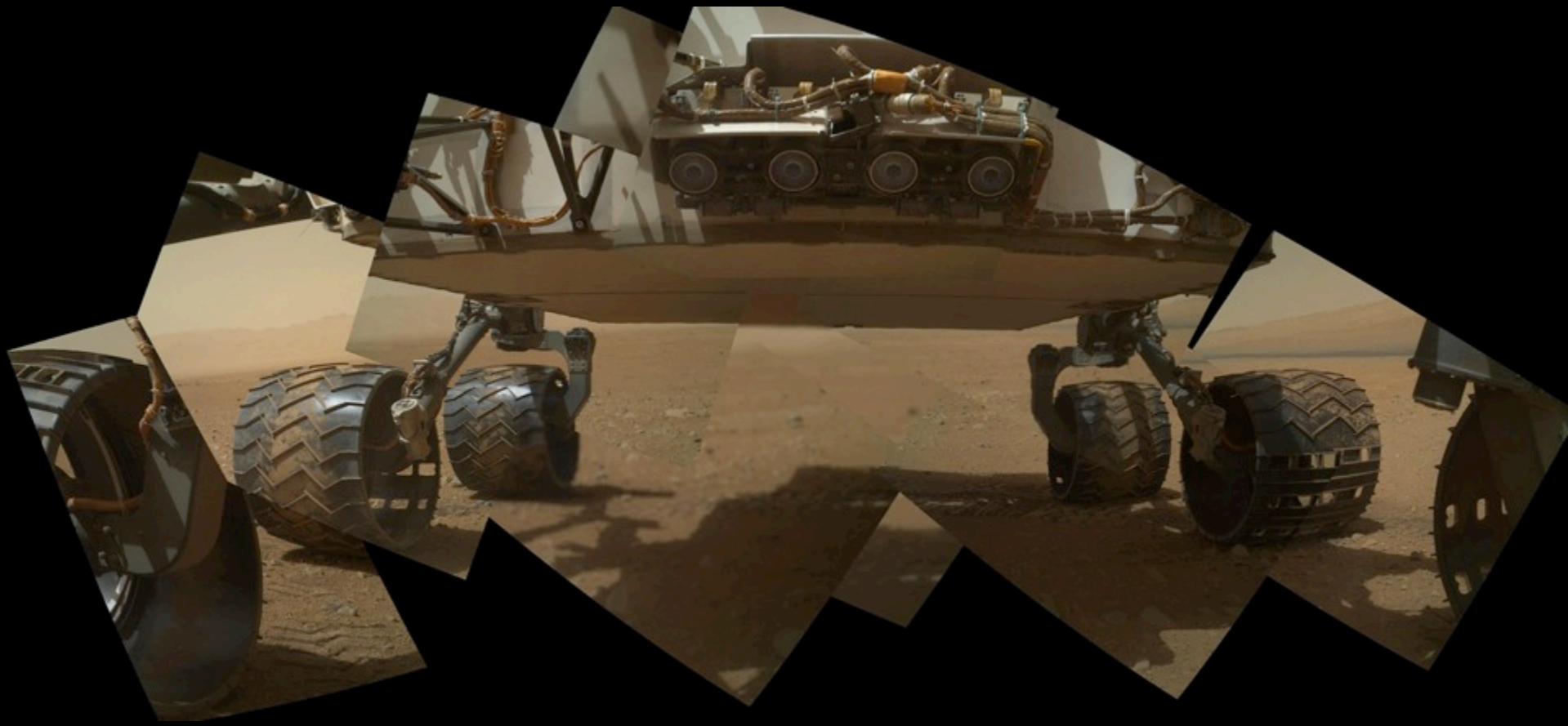
Bedrock exposed by the landing engines in the Goulburn scour mark



NASA/JPL-Caltech/
MSSS

CURIOSITY

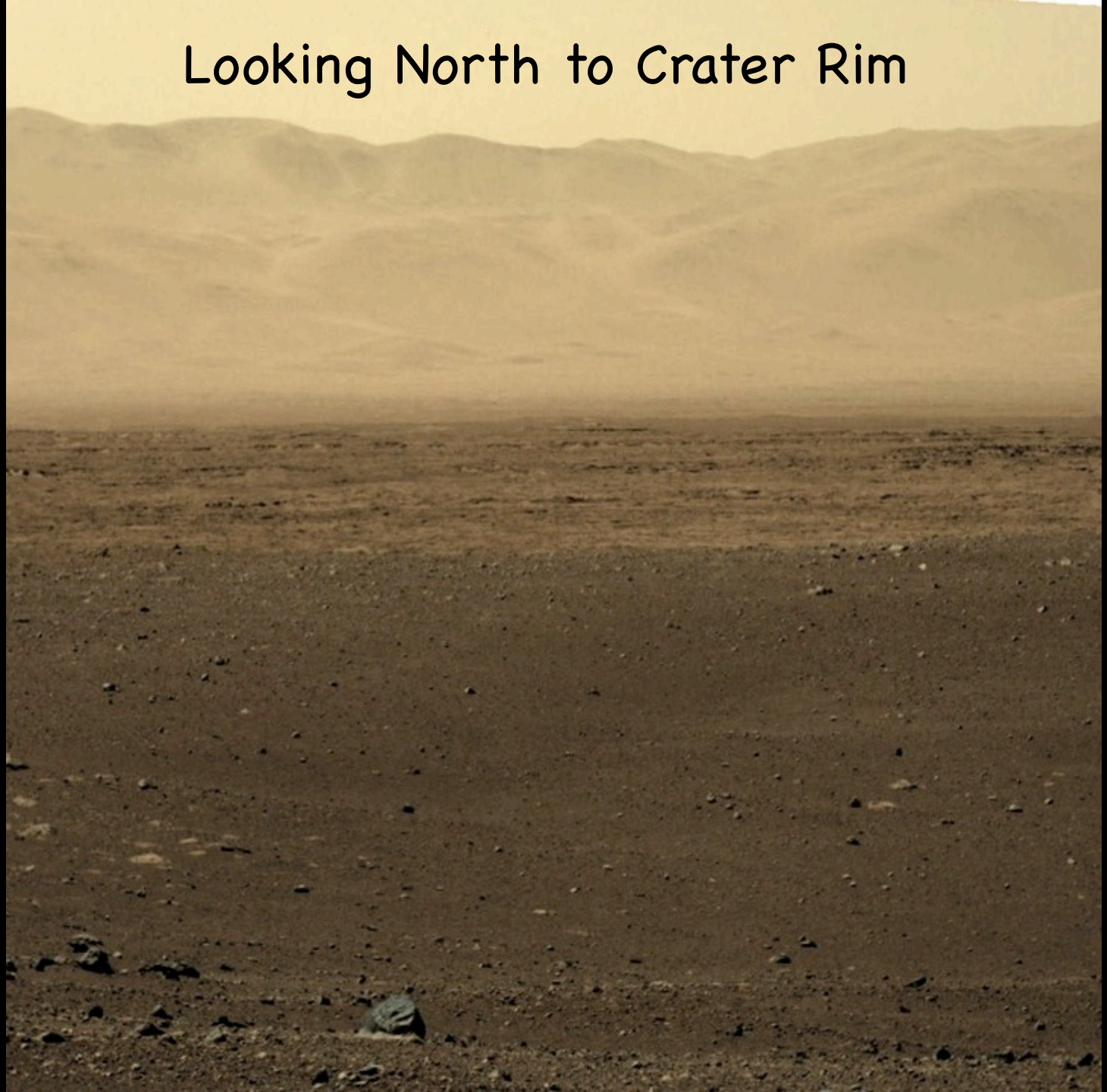
Mastcam-34 mosaic of Mount Sharp, descent rocket scours, and rover shadow



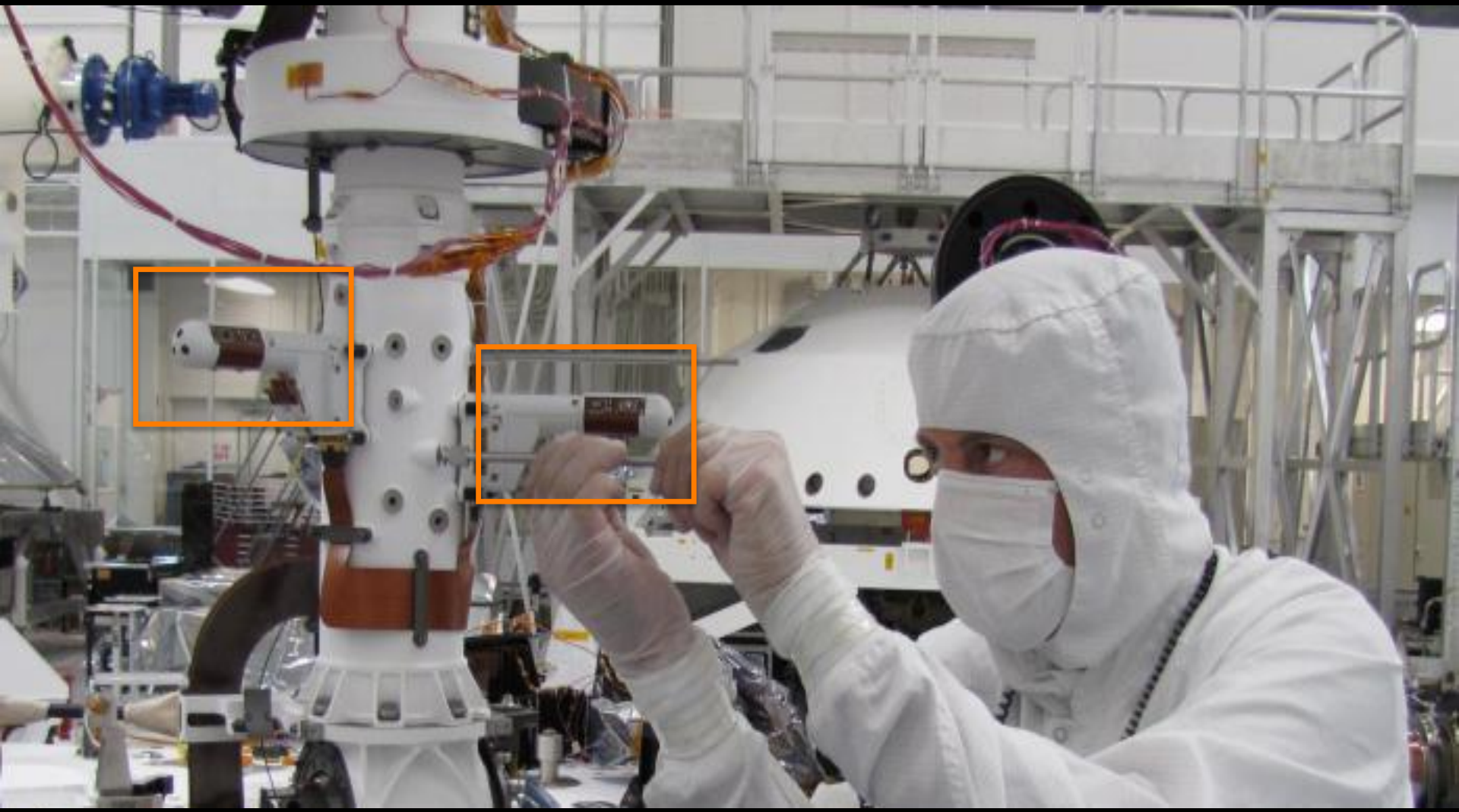
NASA/JPL-Caltech/
MSSS

Curiosity images its undercarriage with its Mars Hand-Lens Imager

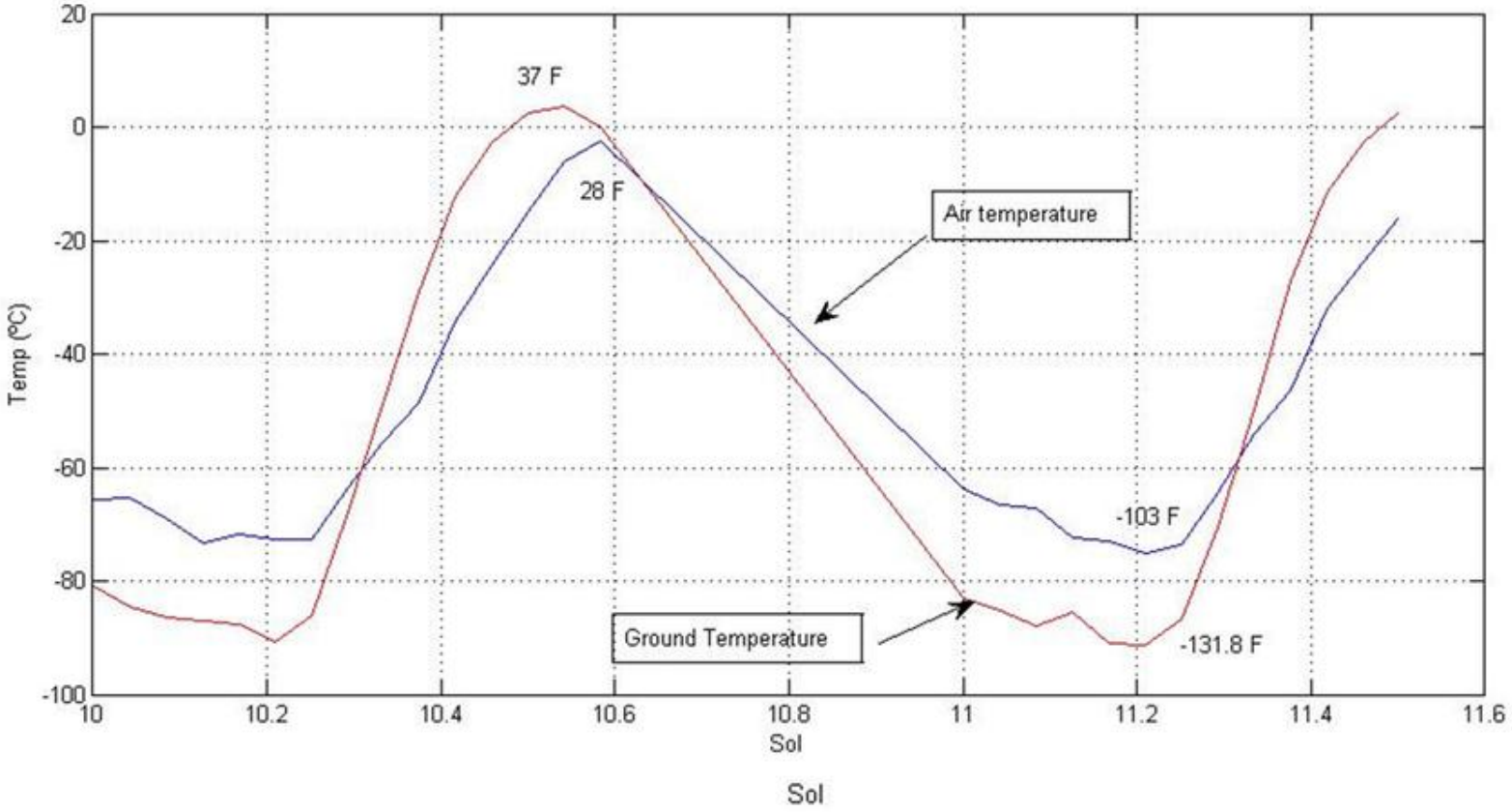
Looking North to Crater Rim

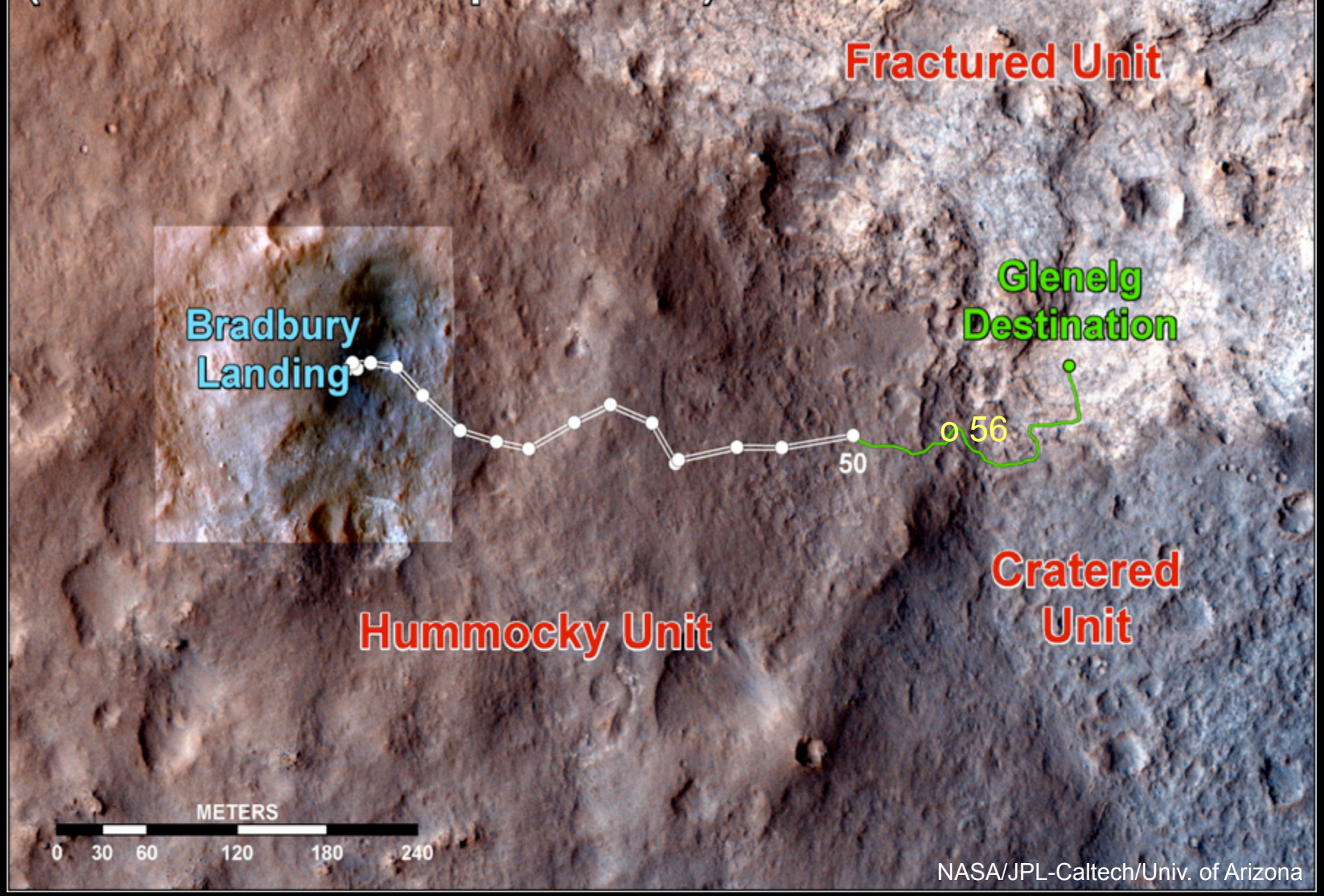


Curiosity will be able to send weather reports from Mars too! Two little booms on the rover's mast ("neck") called REMS will monitor temperature, wind speed and direction. REMS also measures pressure and ultraviolet light.



GROUND AND AIR TEMPERATURE SENSOR





CURIOSITY

Curiosity is progressing toward Glenelg, where three distinct terrain types meet

NASA/JPL-Caltech/
MSSS

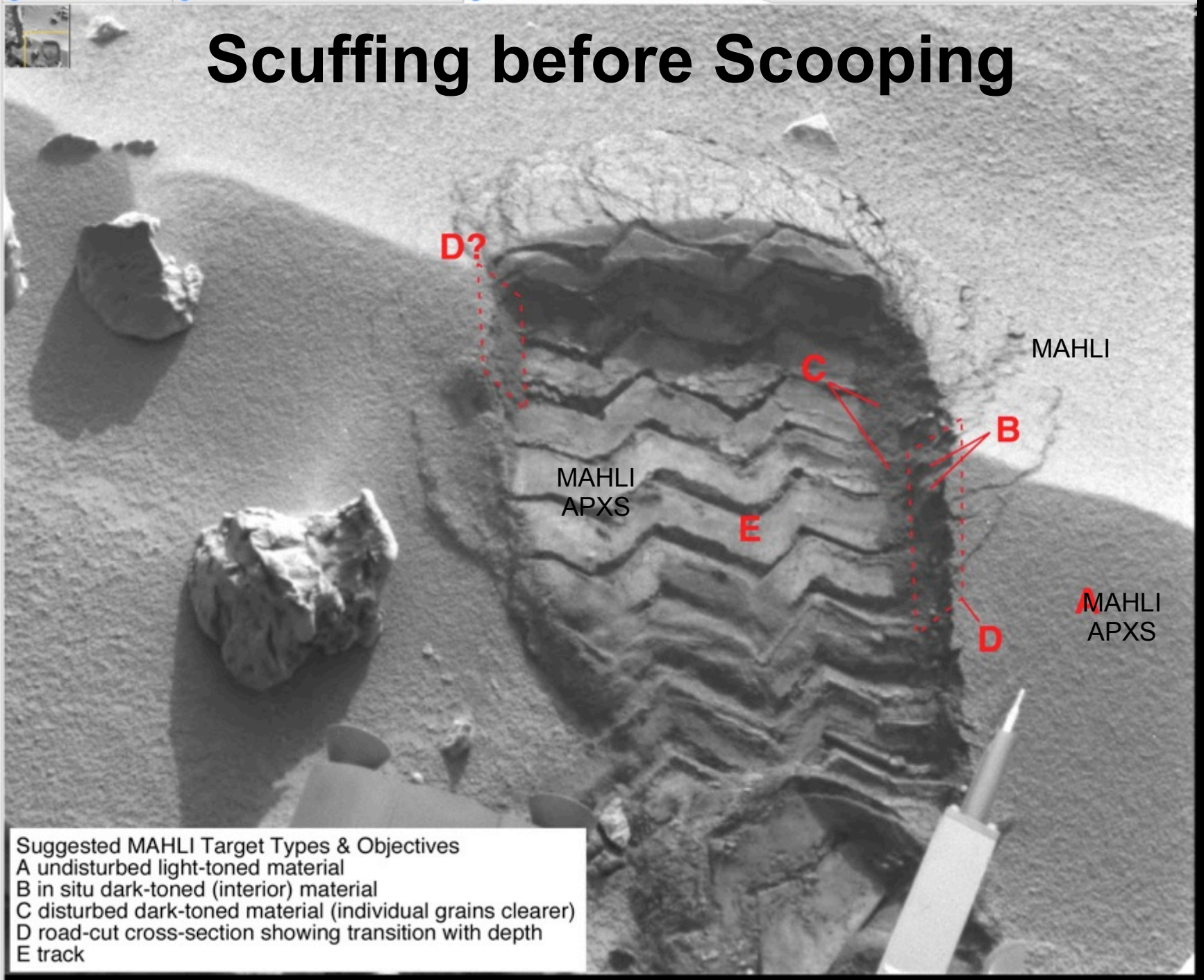
CURIOSITY

The conglomerate “Link” with associated loose, rounded pebbles

Rocknest

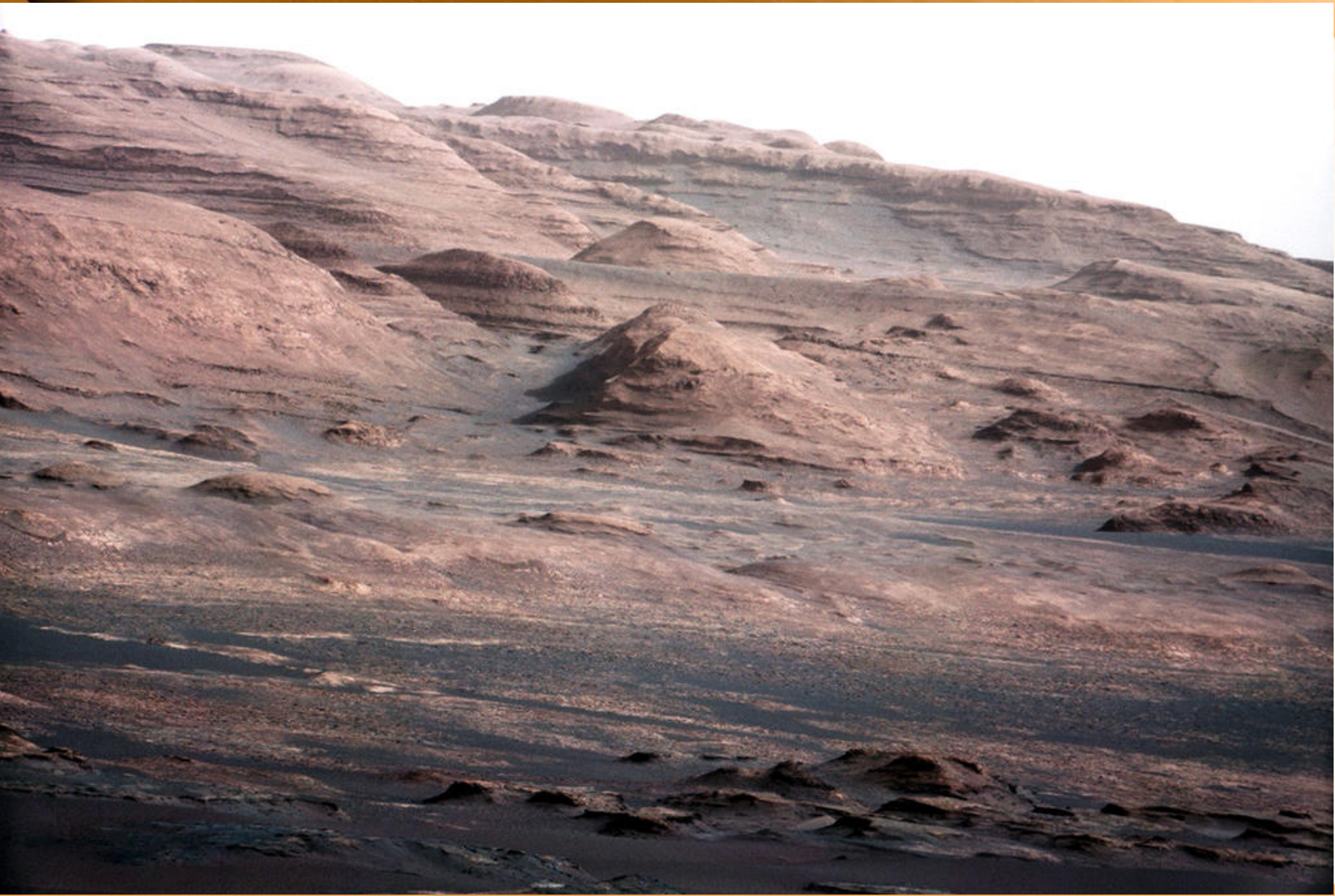
MAHLI
Self Portrait

Scuffing before Scooping

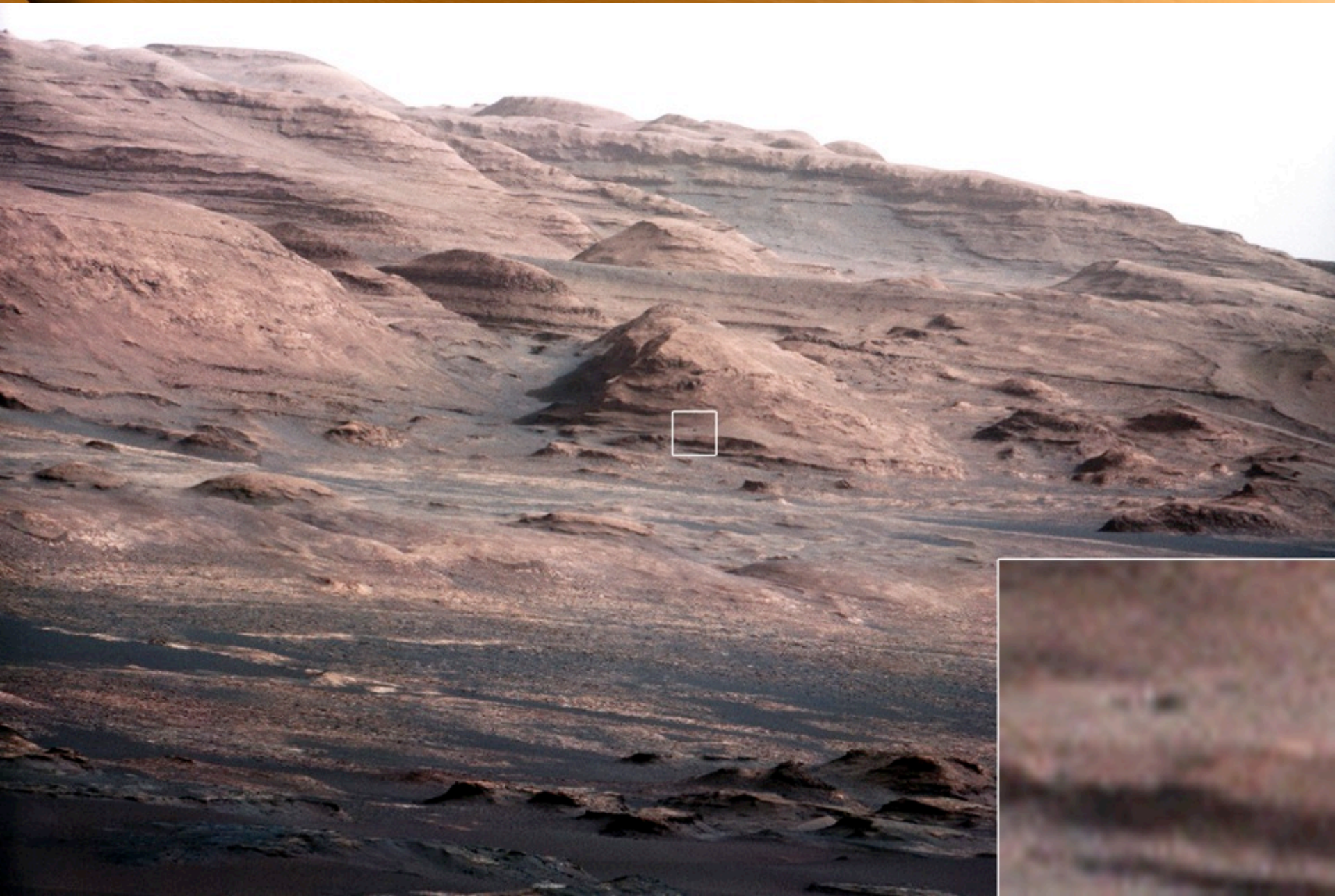


Suggested MAHLI Target Types & Objectives
A undisturbed light-toned material
B in situ dark-toned (interior) material
C disturbed dark-toned material (individual grains clearer)
D road-cut cross-section showing transition with depth
E track

Foothills of Mt. Sharp



Foothills of Mt. Sharp



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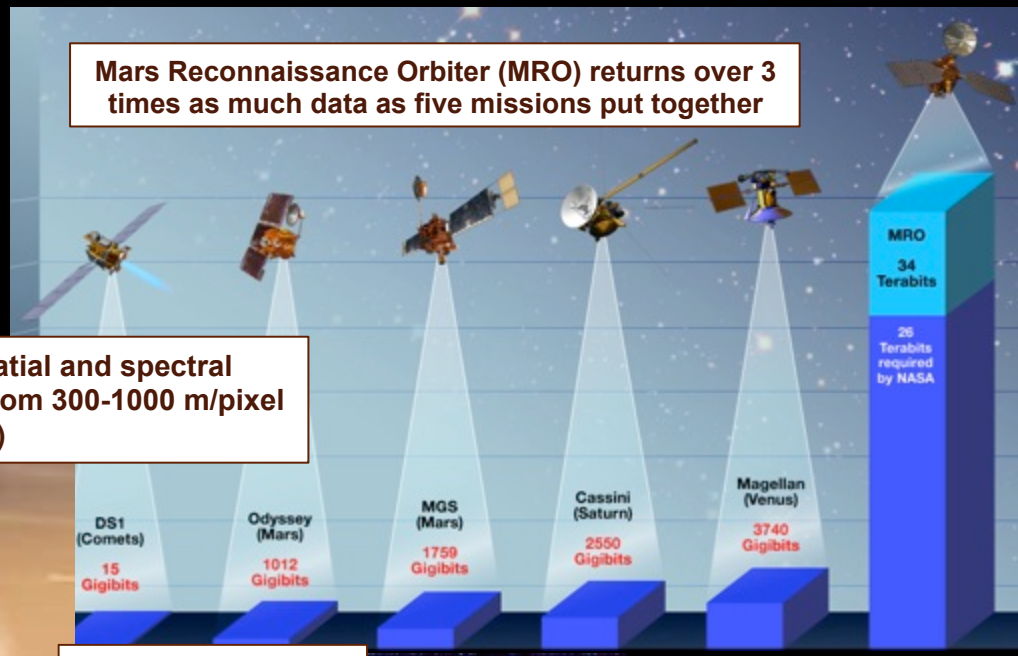
MSL Technology Advancements – Mars Technology Program Heritage

MSL MMRTG

Power systems providing significantly greater mobility, operational flexibility and enhanced science payload.

Mars Reconnaissance Orbiter (MRO) returns over 3 times as much data as five missions put together



Improved spatial and spectral resolution (from 300-1000 m/pixel to 20 m/pixel)

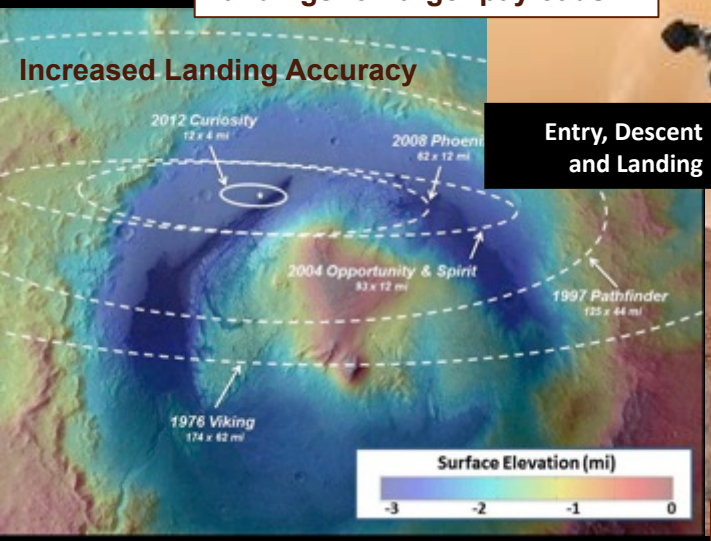
Ensuring precise and safe landings for larger payloads

Advanced actuators

CheMin – first x-ray view of Martian soil

SAM Instrument

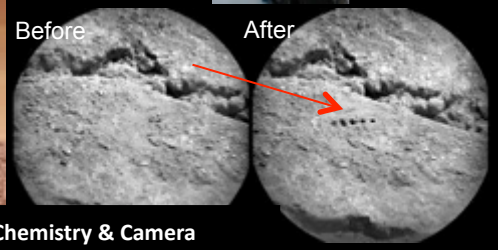
Increased Landing Accuracy



Entry, Descent and Landing

Advancements in scientific instruments

Rover navigation and mobility



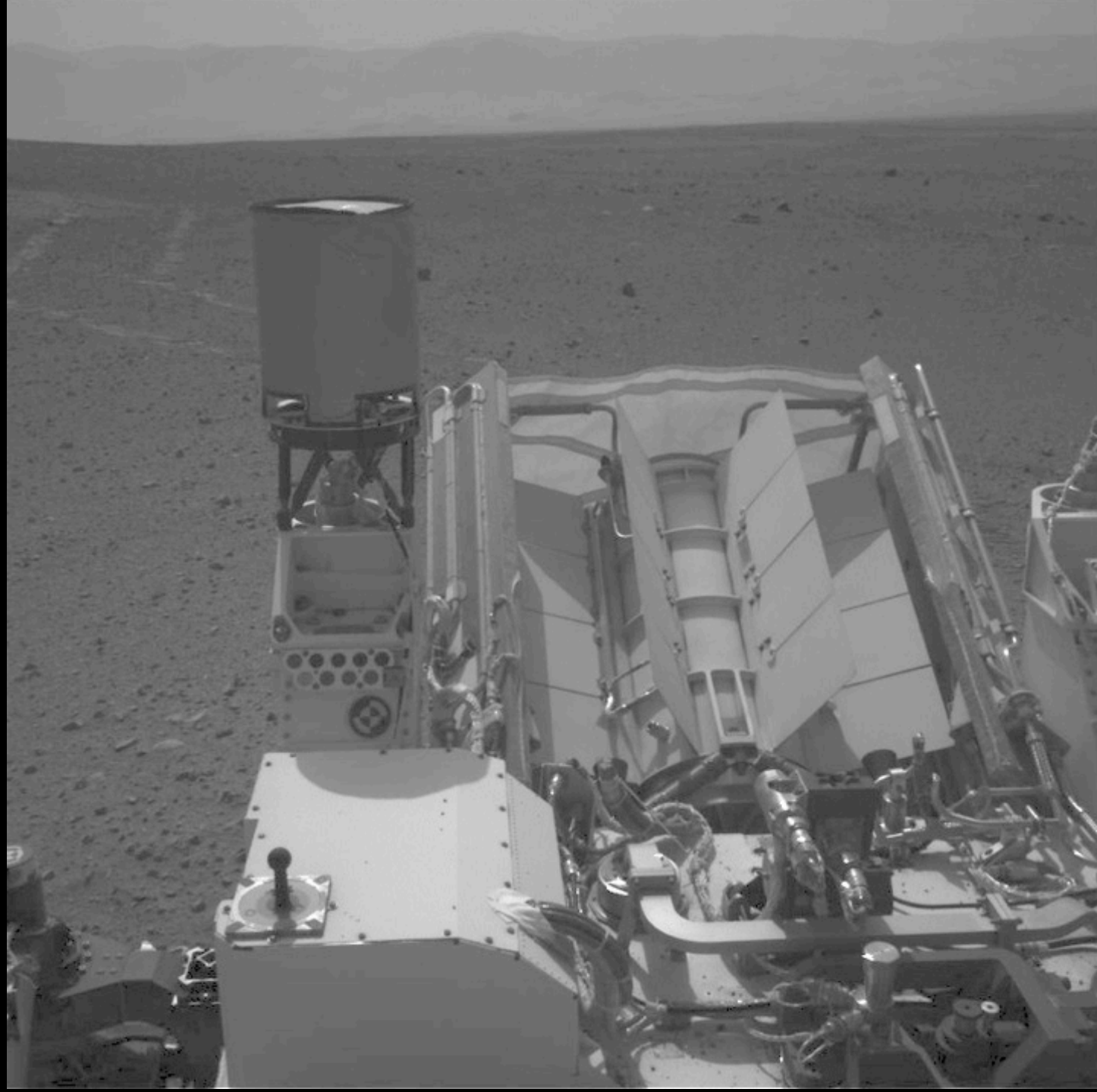
ChemCam – Chemistry & Camera

EDL Technologies:

- PICA TPS
- Heat shield Instrumentation
- Precision Landing
- Parachute
- Descent Engines
- Descent Radar
- Sky Crane

Artist's Concept. NASA/JPL-Caltech

Multi-Mission Radioisotope Thermal Generator

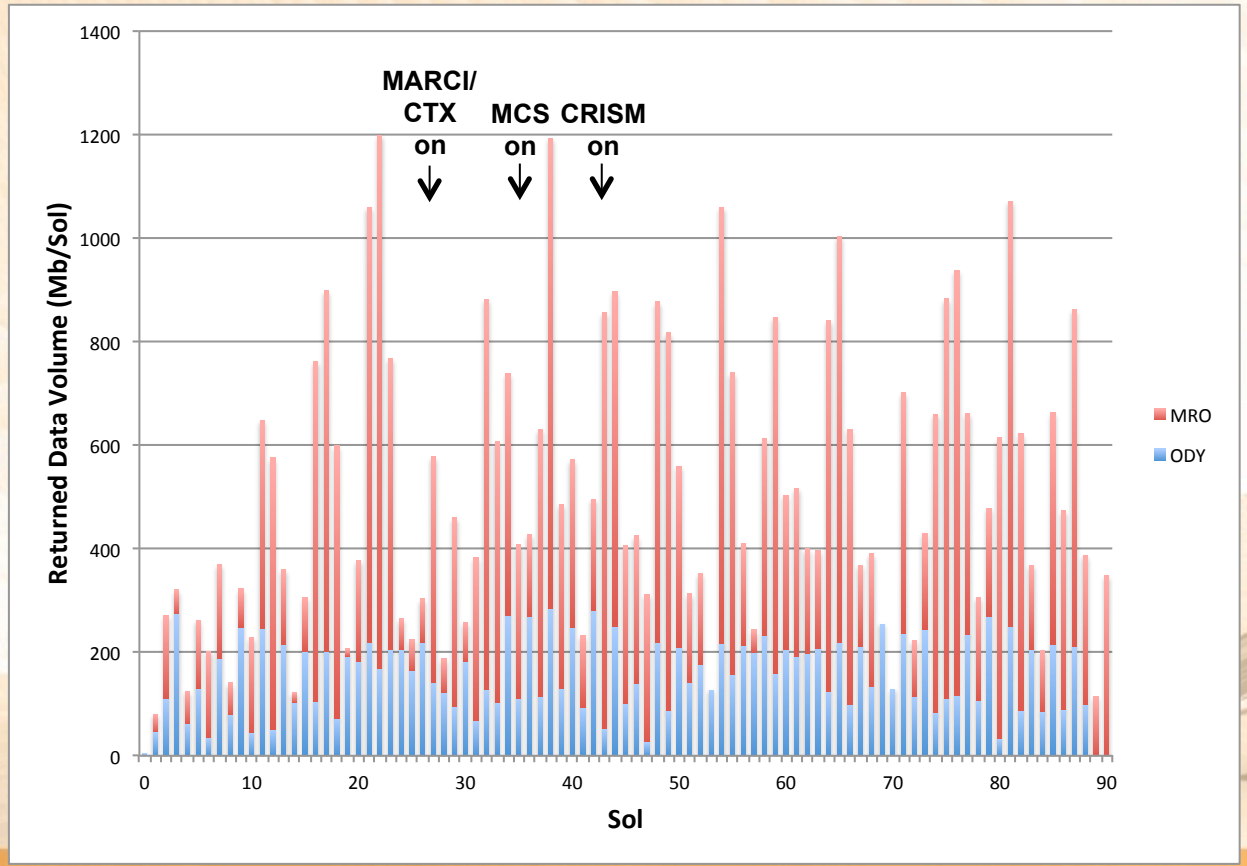


Autonomous Rover Navigation

CURIOSITY

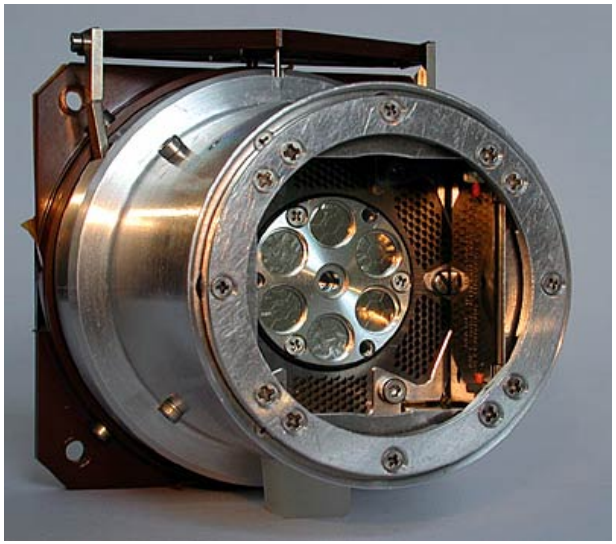
Fantastic Comm Support to Curiosity

- Through Sol 90, over 45 Gb of Curiosity data have been returned via ODY and MRO
  - Average data return per sol exceeds 500 Mb/sol
  - Some days <1Gb!
- Electra's Adapative Data Rate (ADR) is now being used routinely for MRO passes



Curiosity rock analysis instruments

APXS:
Identifies Chemical Elements in Rocks



On Hand

CHEMIN:
Identifies Minerals, including those formed in water

In Body

SAM:
Identifies Organics, the Chemical Building Blocks of Life

In Body

Mars instrument technology heritage, sourcing from Mars Instrument Development Program (MIDP), Astrobiology Science and TEchnology Program (ASTEP), Mars Technology Program, PIDDP

Curiosity's Drill

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Hot Wheels
MARS ROVER CURIOSITY
2012 NEW MODELS


Los Angeles Times
7 shot dead at Sikh temple
'Wheels down on Mars'
BIG news


7 MINUTES OF TERROR

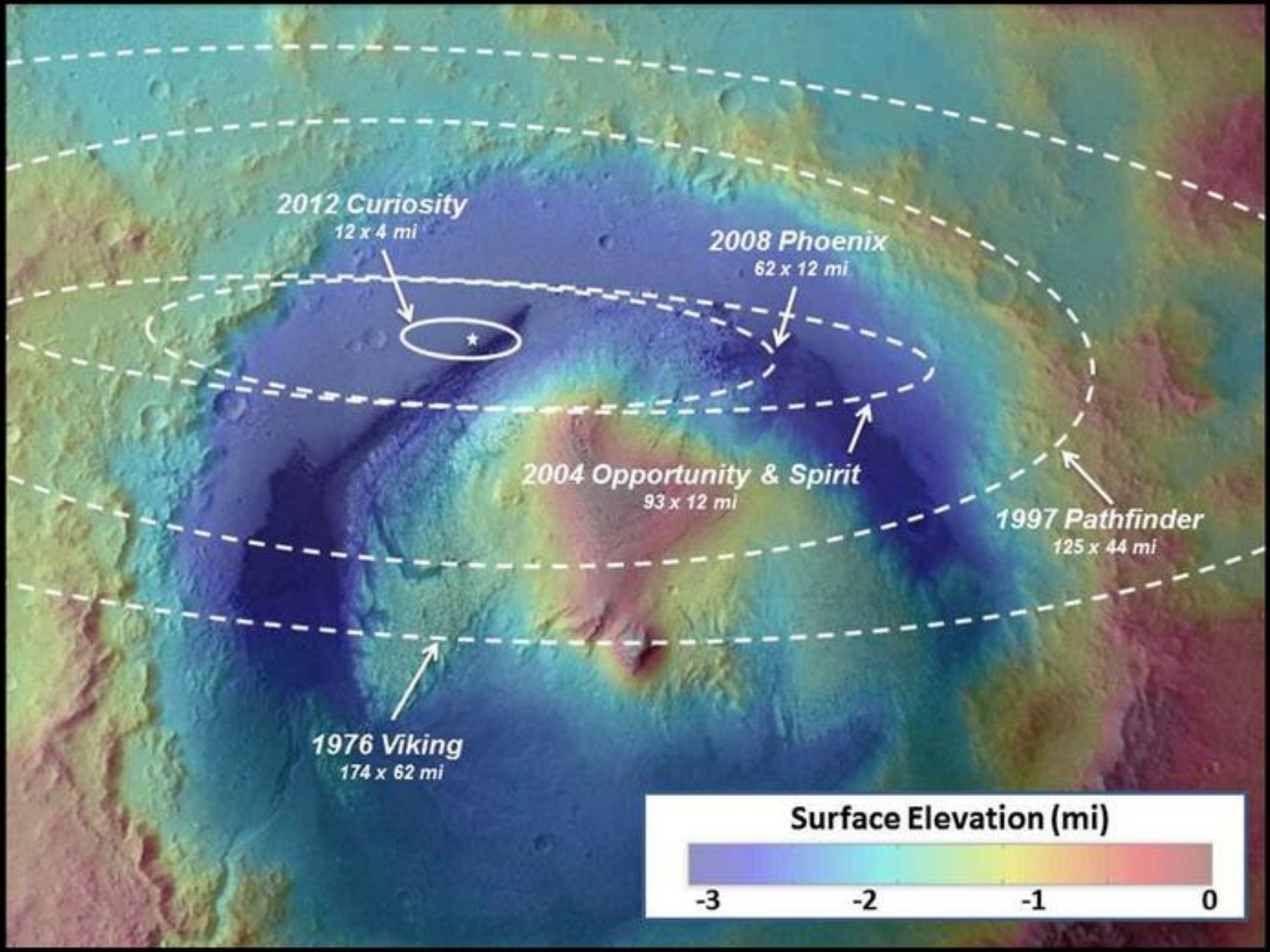

10 10 10
MARS OLYMPICS
"...REALLY STUCK THE LANDING!!"

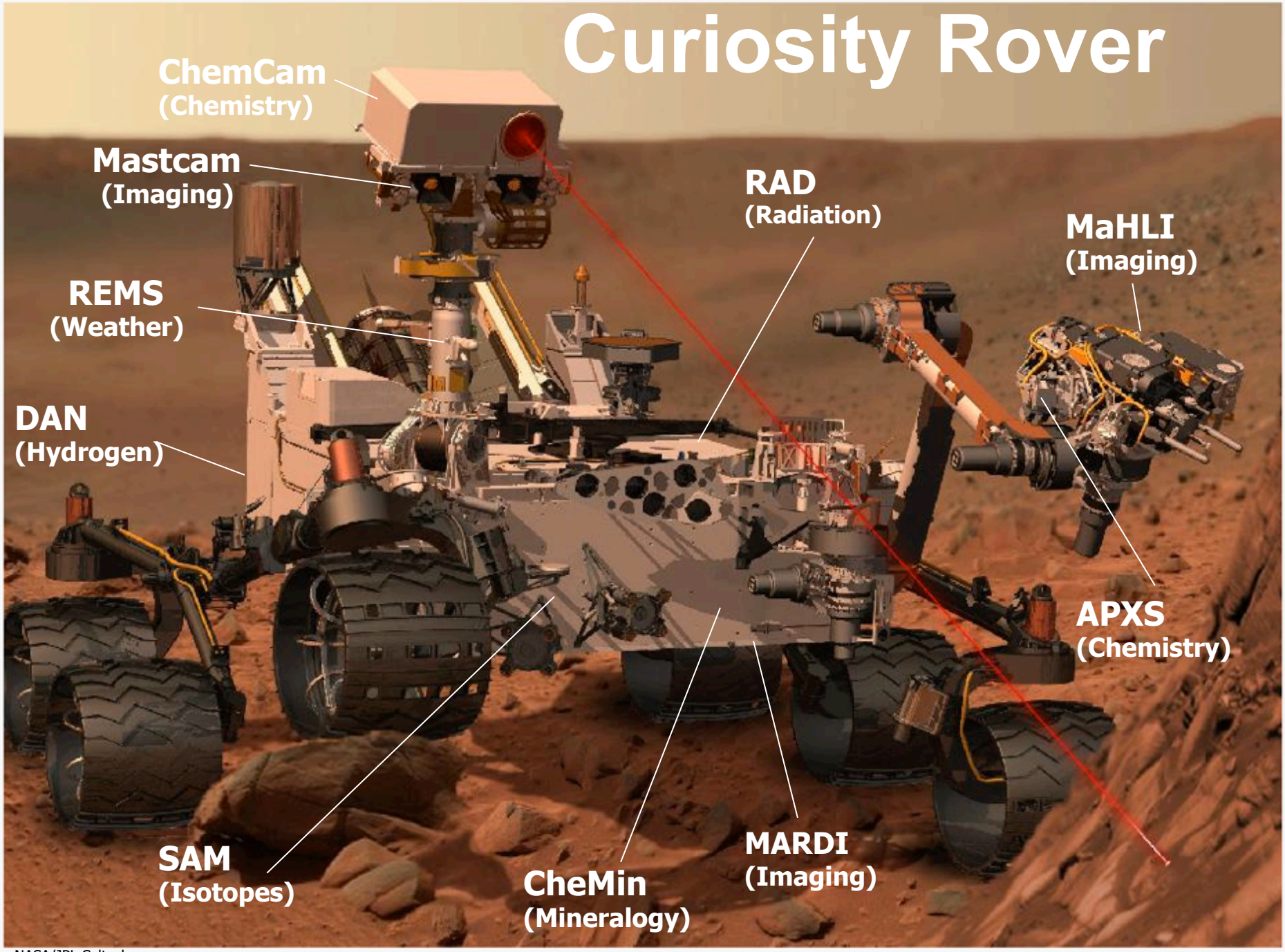

Google


NASA MARS ROVER LANDING
LANDING IN
52:12:49:22
LAUNCH

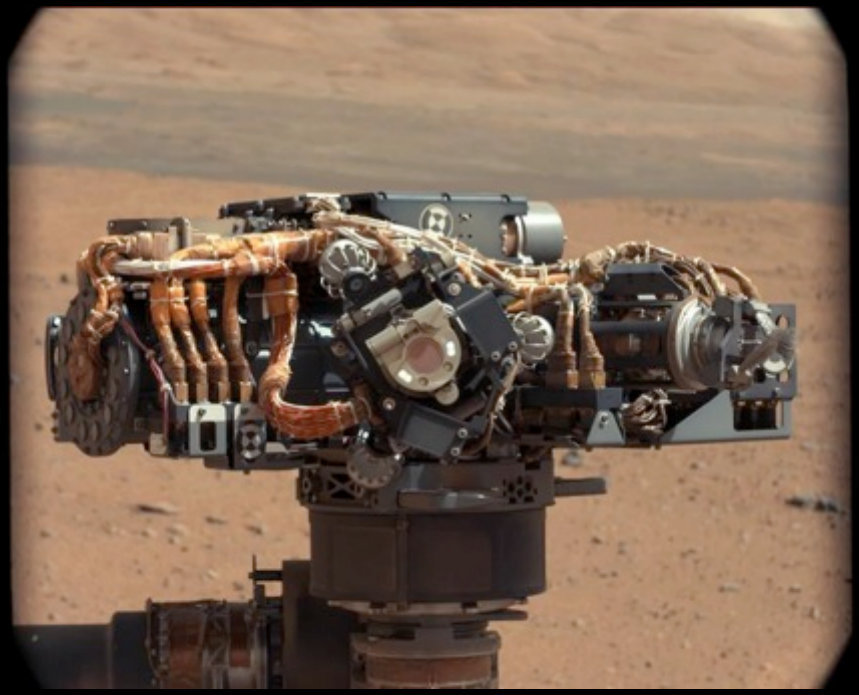

RED PLANET
1877150
60.0

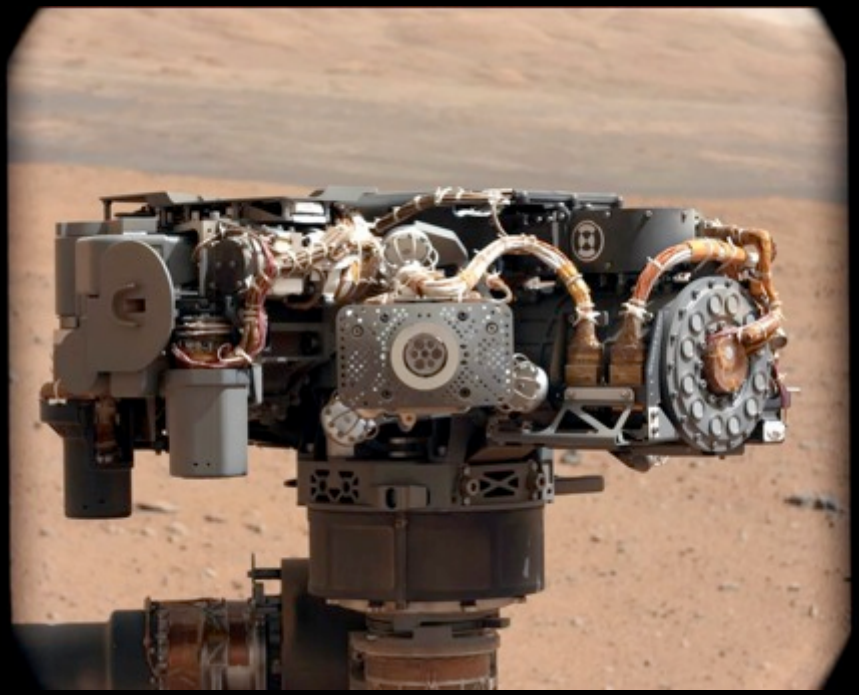
- BACKUP


2012 Curiosity
12 x 4 mi
2008 Phoenix
62 x 12 mi
2004 Opportunity & Spirit
93 x 12 mi
1997 Pathfinder
125 x 44 mi
1976 Viking
174 x 62 mi
Surface Elevation (mi)
-3
-2
-1
0



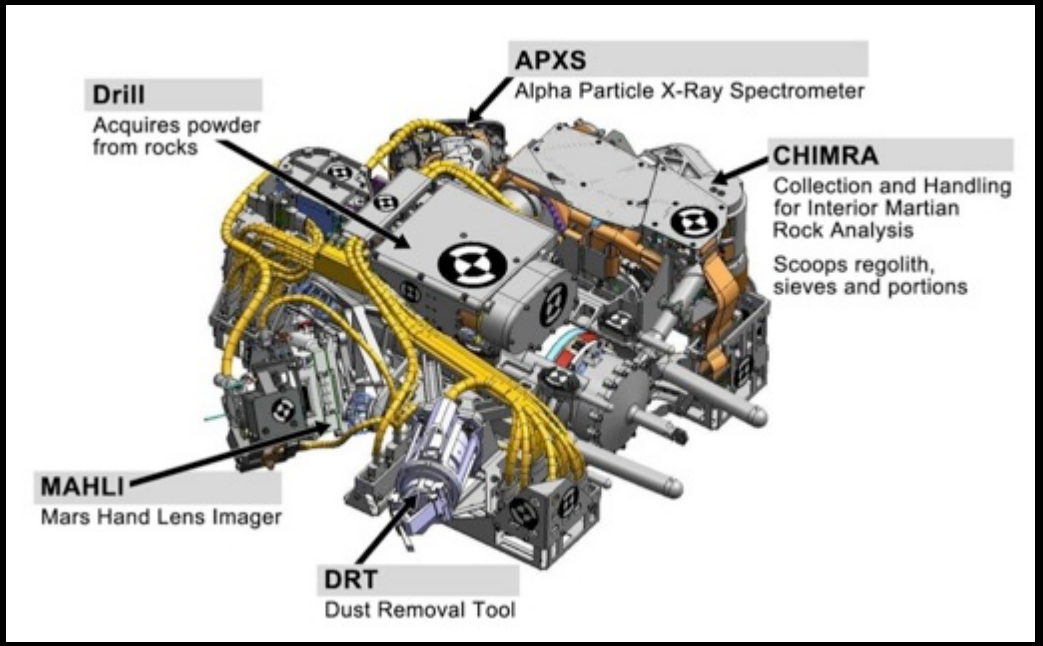
NASA/JPL-Caltech





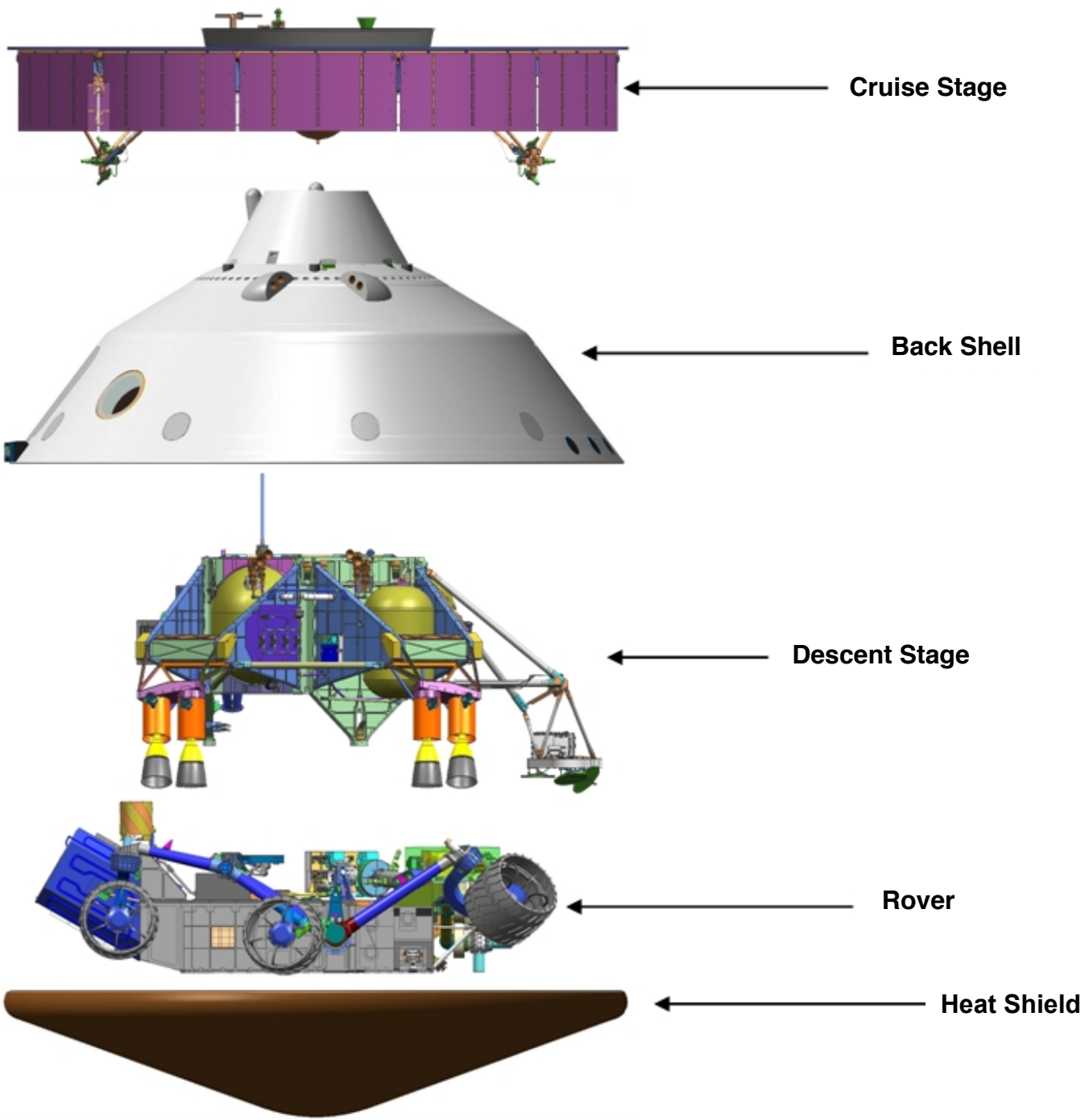
NASA/JPL-Caltech/
MSSS

Images of Curiosity's turret centered on MAHLI (left) and APXS (right)



CURIOSITY

To get to Mars, Curiosity will travel tucked safely inside a protective shell.



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