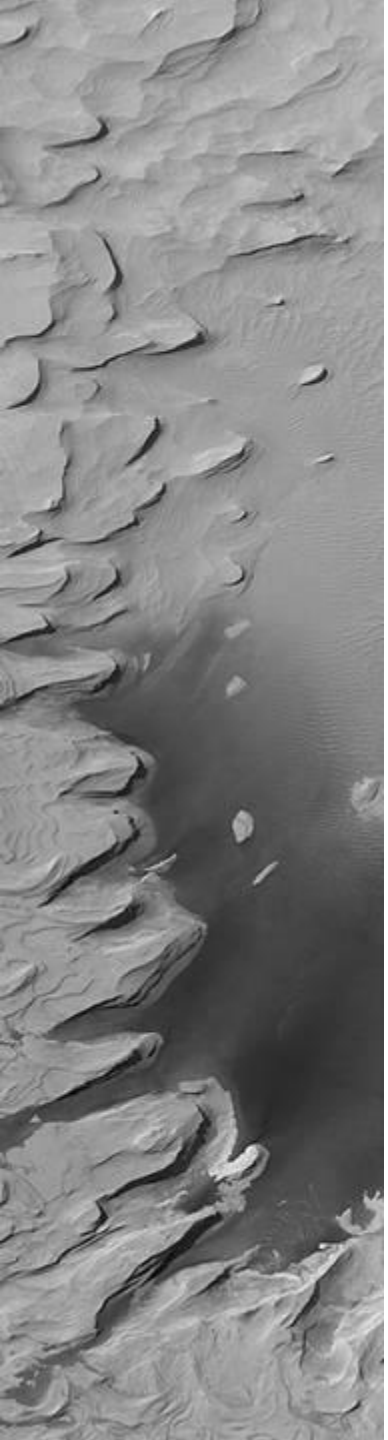

The Challenges of Landing Curiosity on Mars

A. Miguel San Martin

Jet Propulsion Laboratory, California Institute of Technology

AAS Rocky Mountain GN&C Conference

Breckenridge, Colorado

February 4, 2017

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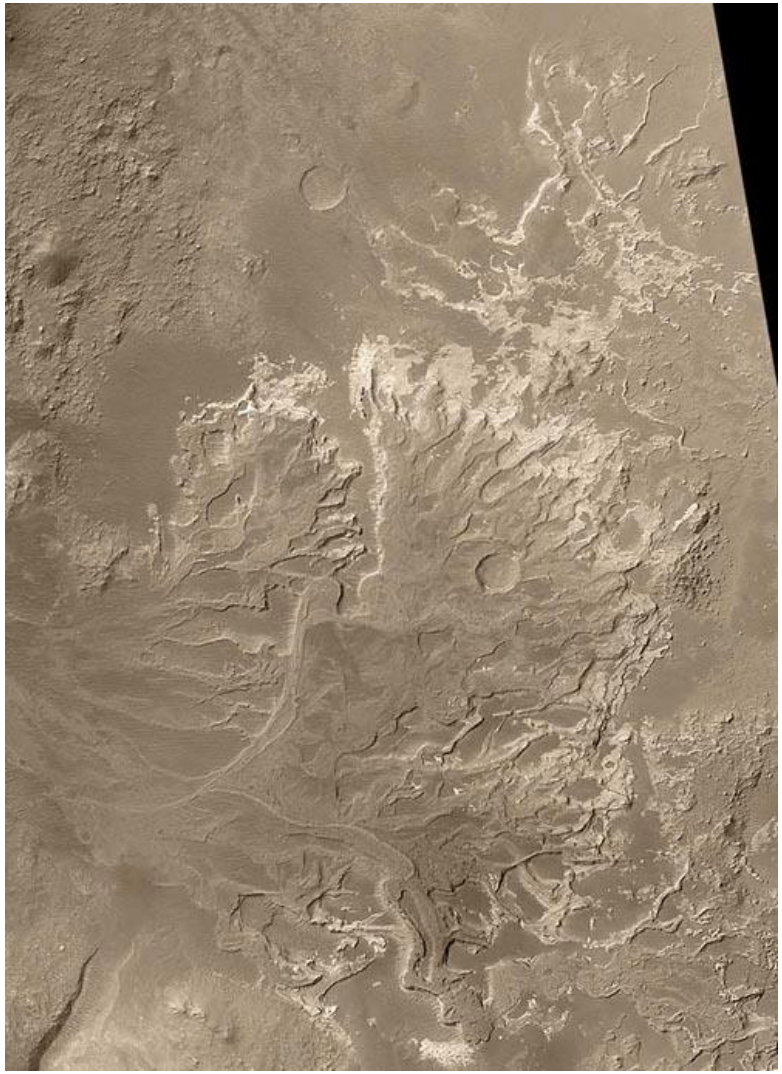
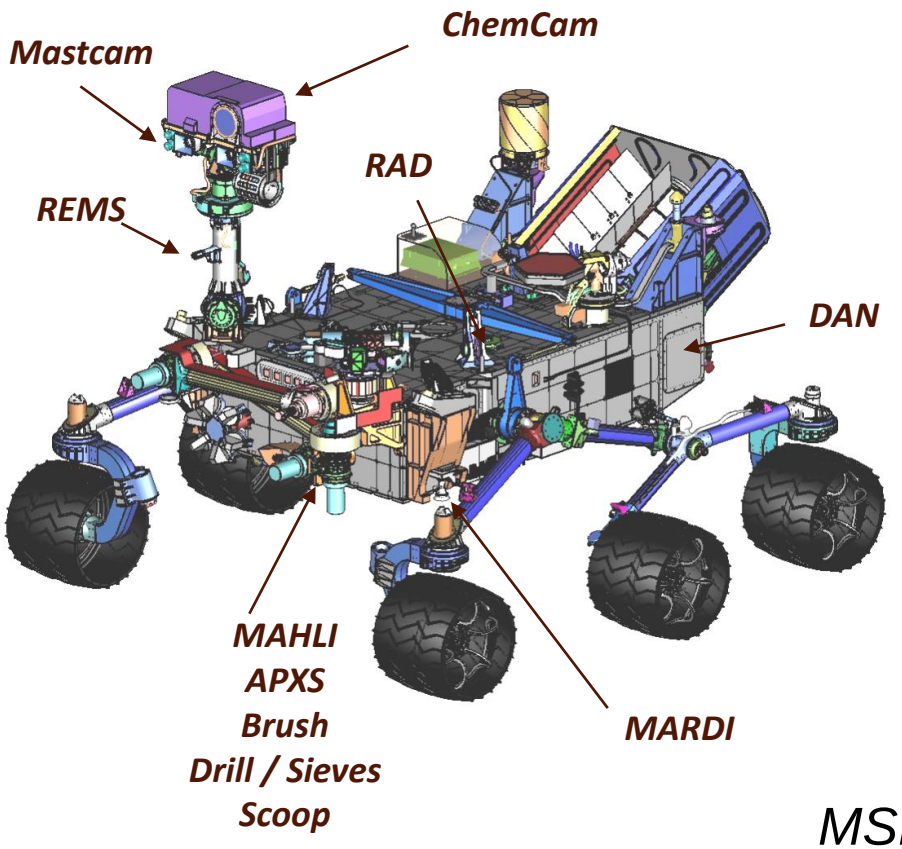
Why Mars?

- There is scientific evidence that Mars was in its past a planet wet and warm like Earth, that might have had the environmental conditions for the origin of life

- If we find evidence of microbial life on Mars, past or present, it would be a very important step in answering the eternal question of whether we are alone in the universe



Scientific Instruments



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

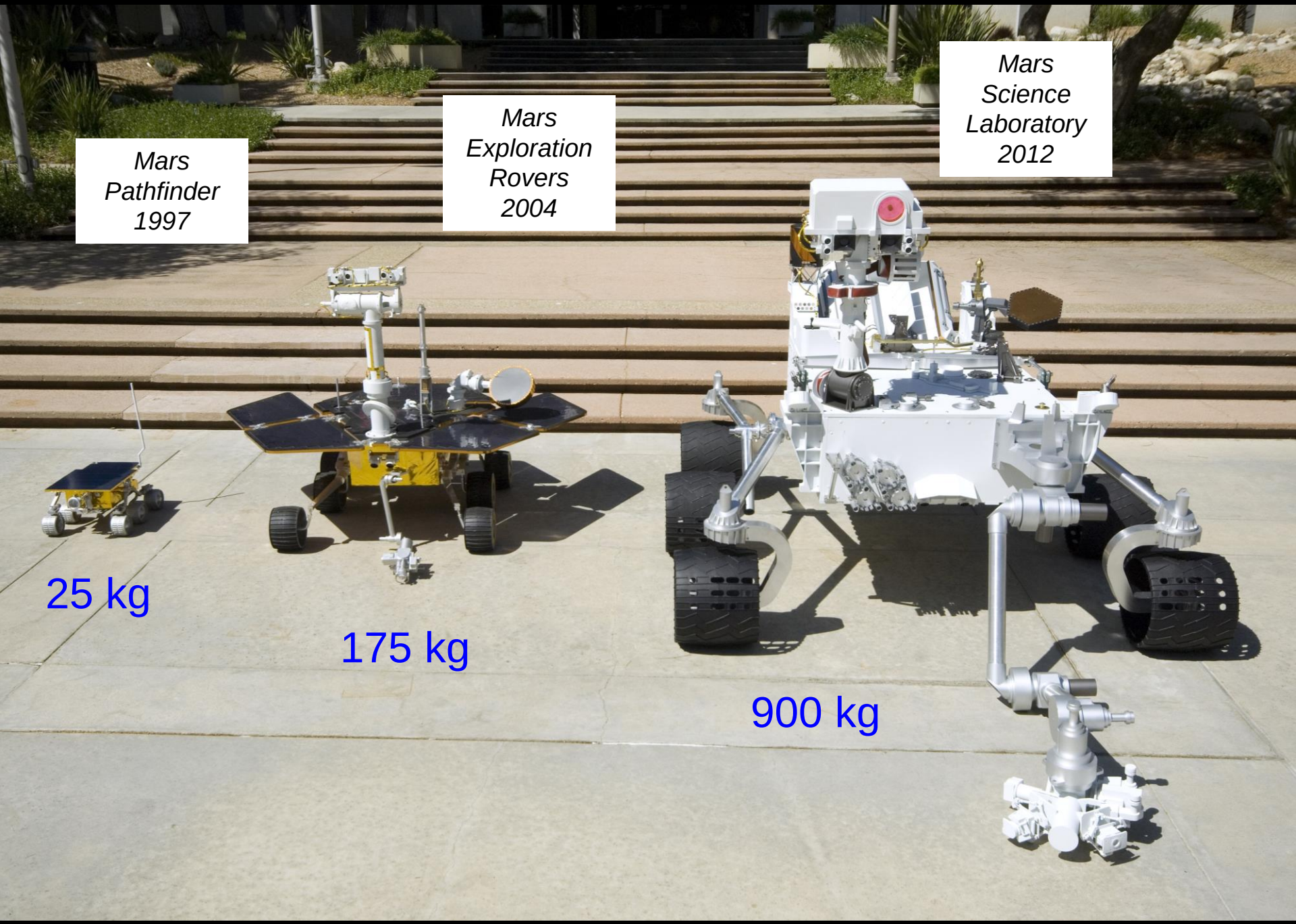
REMS (J. Gómez-Elvira, CAB, Spain) - Meteorology / UV

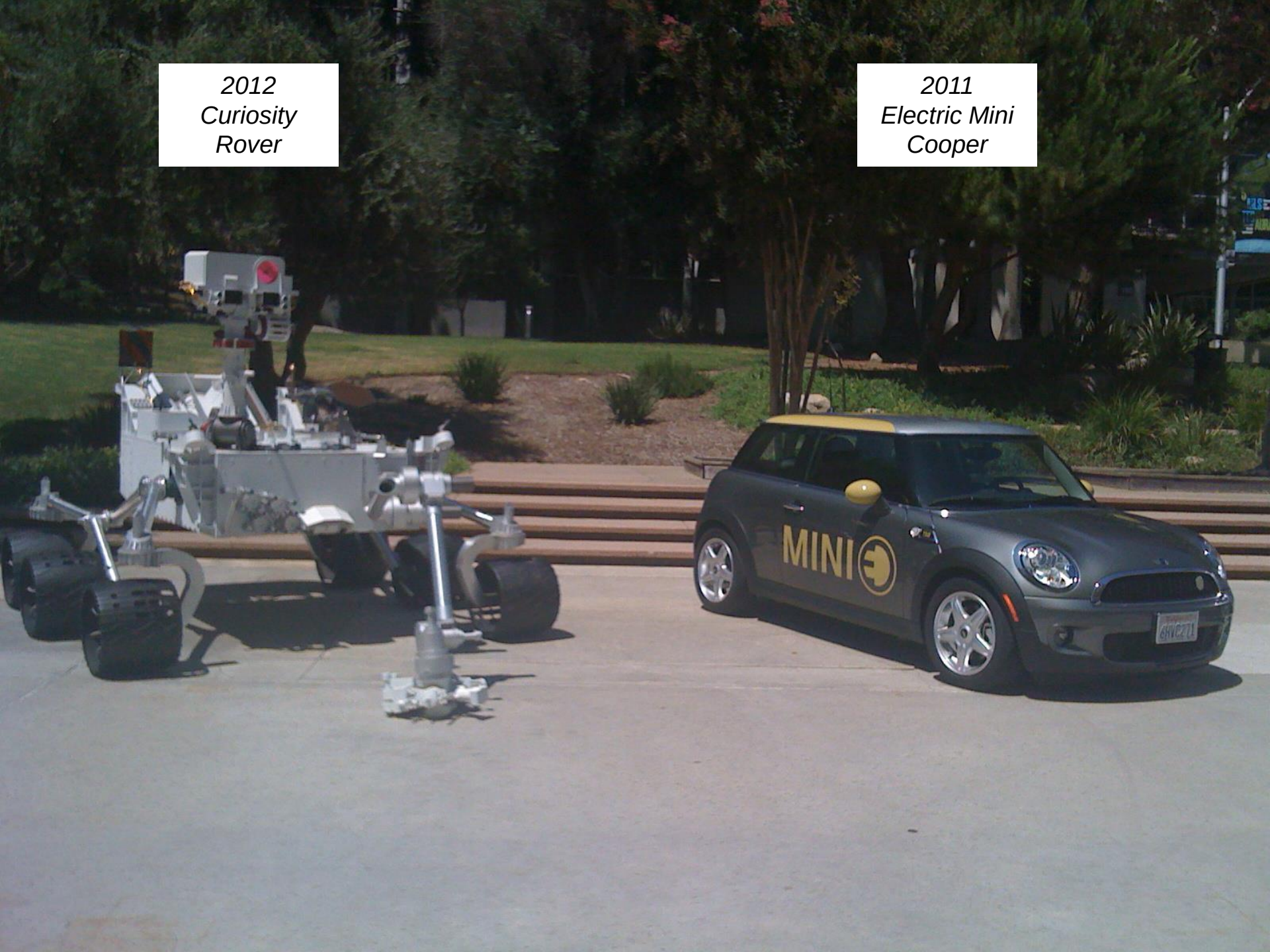
RAD (D. Hassler, SwRI) - High-energy radiation

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

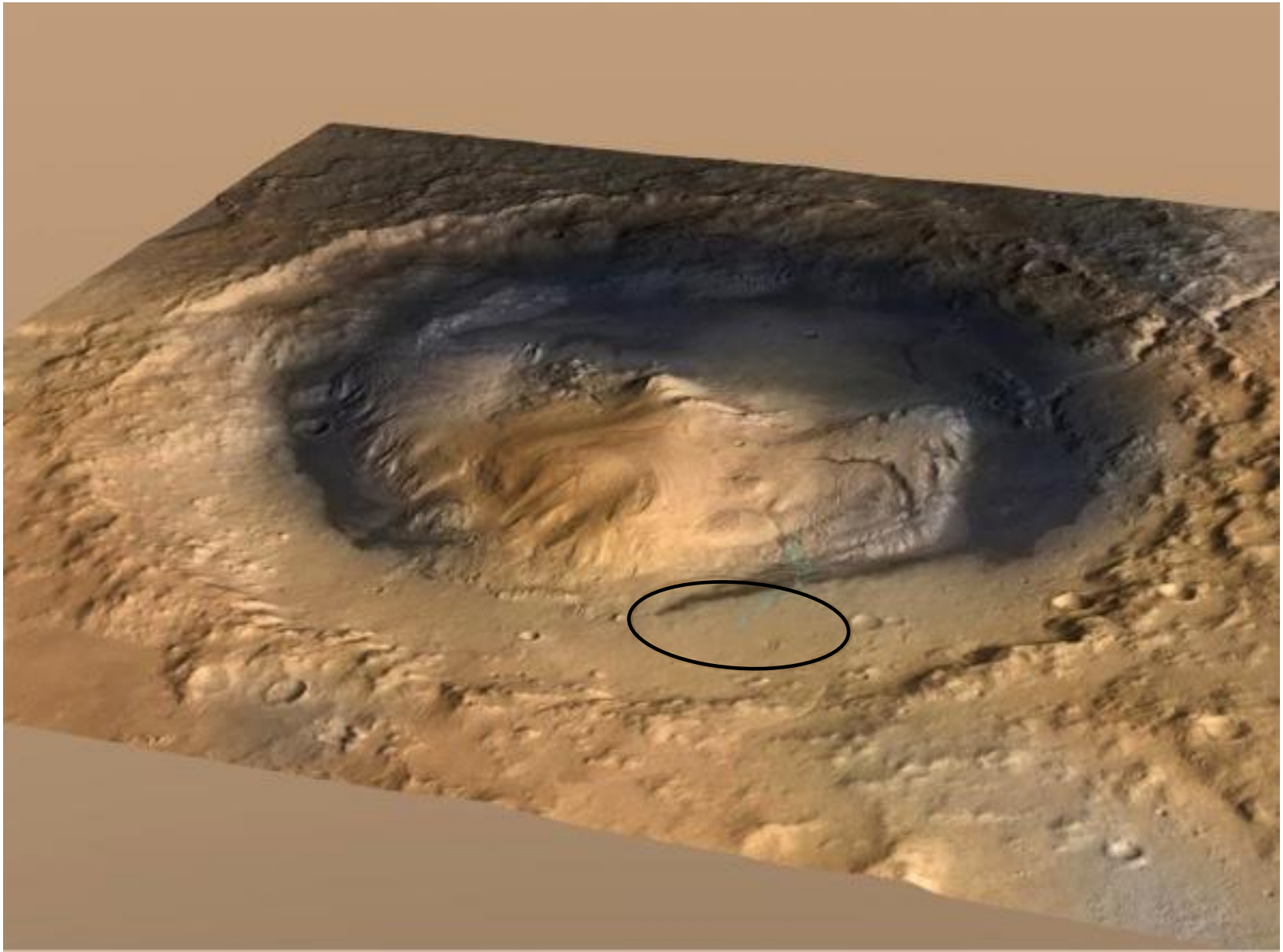
MSL 75 kg (165 lb) vs. MER 10 kg (22 lb)

Weight:	**900 kg**
Wheel Base:	**2.8 m**
Height of Deck:	**1.1 m**
Ground Clearance:	**0.66 m**
Height of Mast:	**2.2 m**

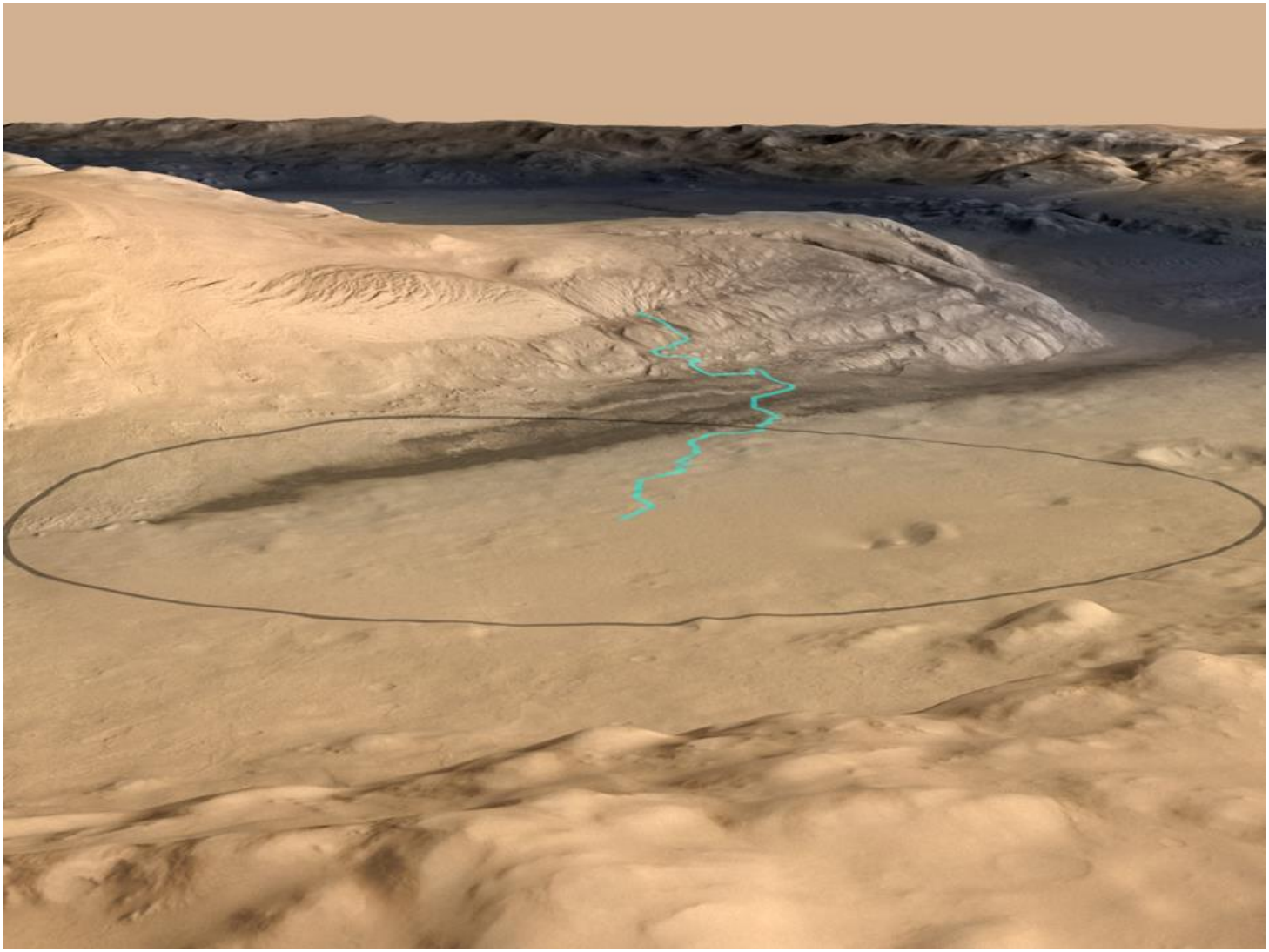

Mars
Pathfinder
1997
Mars
Exploration
Rovers
2004
Mars
Science
Laboratory
2012
25 kg
175 kg
900 kg


2012
Curiosity
Rover
2011
Electric Mini
Cooper
MINI

Destination: Gale Crater

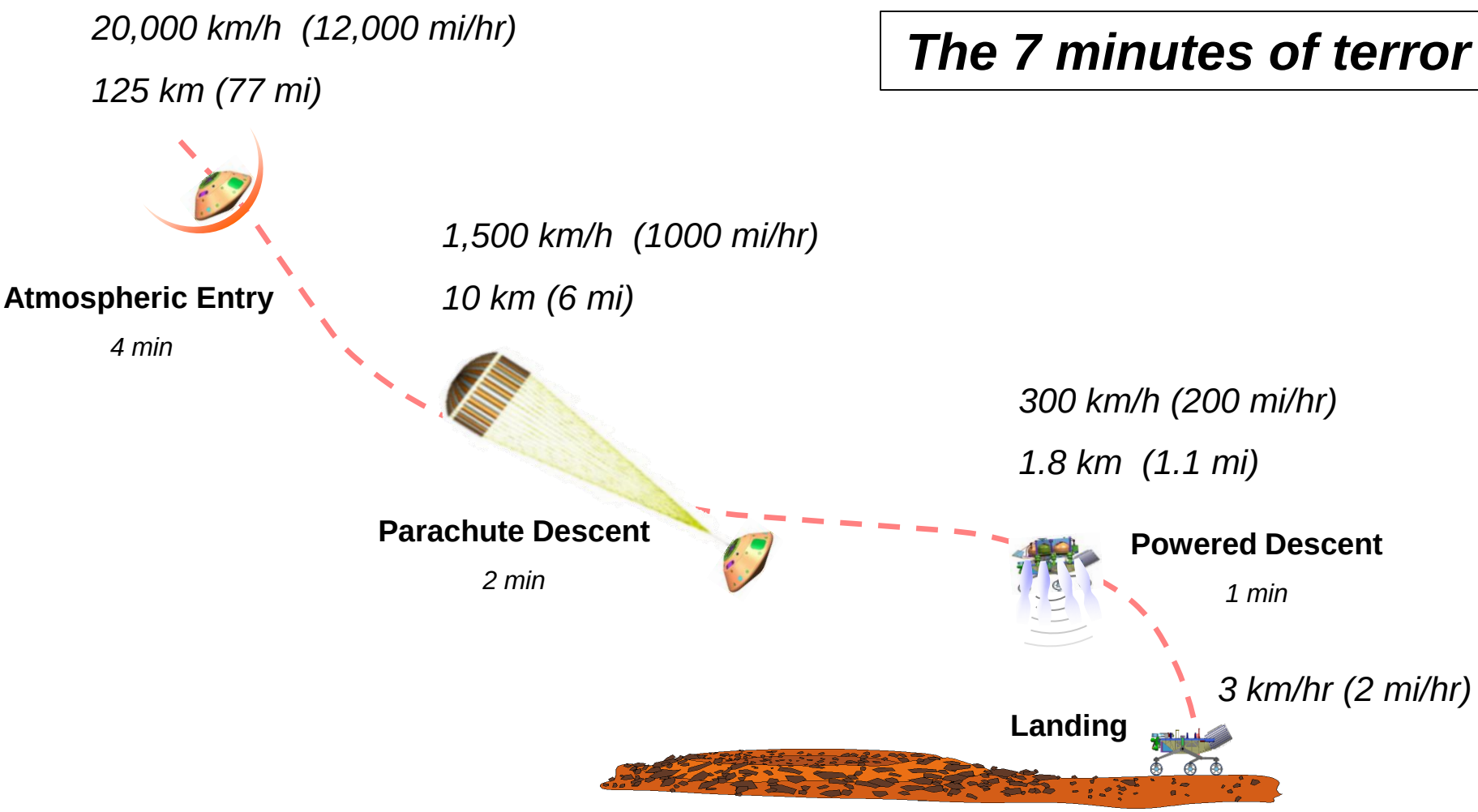


Destination: Gale Crater



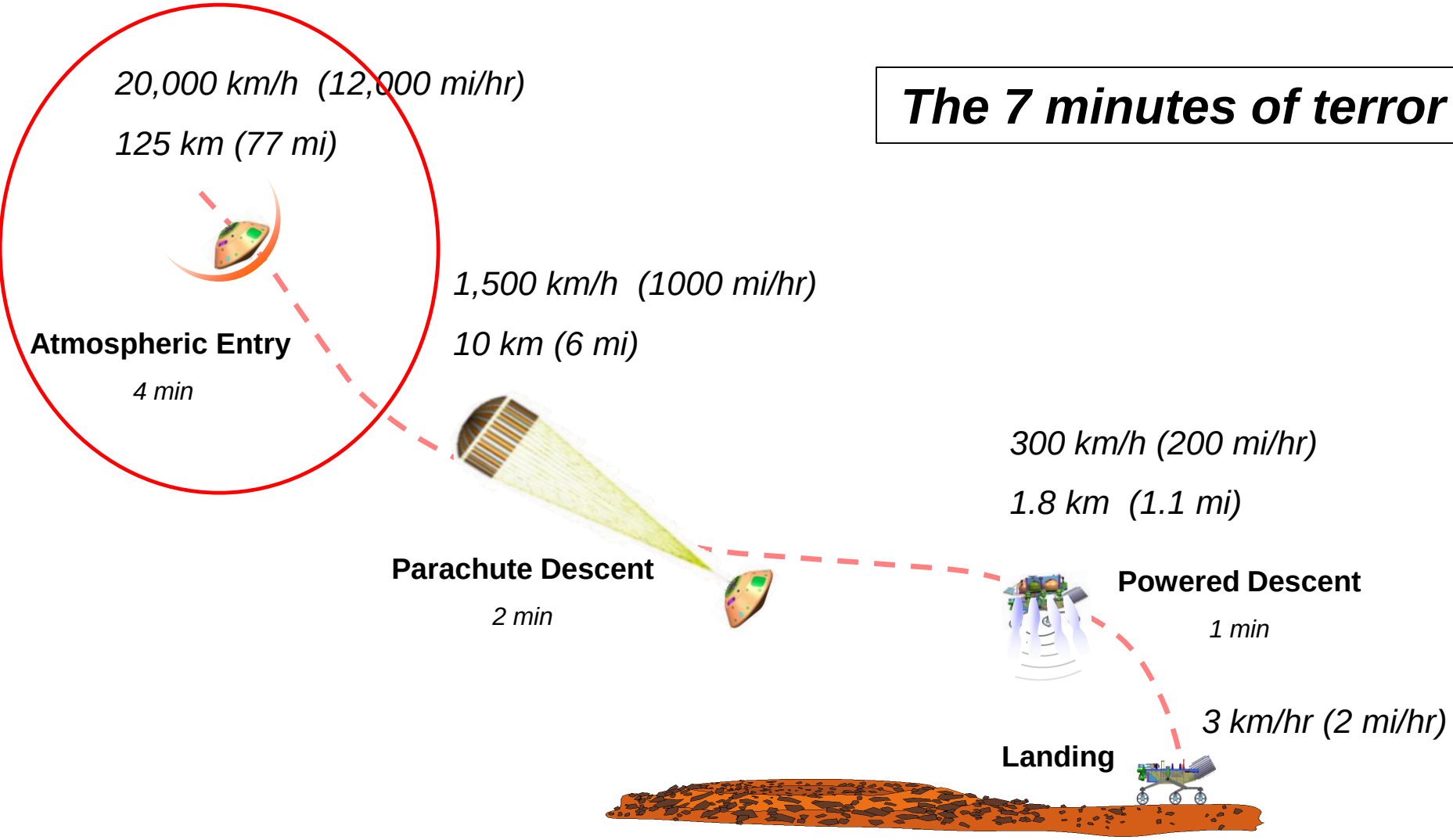
Mars Entry Descent and Landing

The 7 minutes of terror



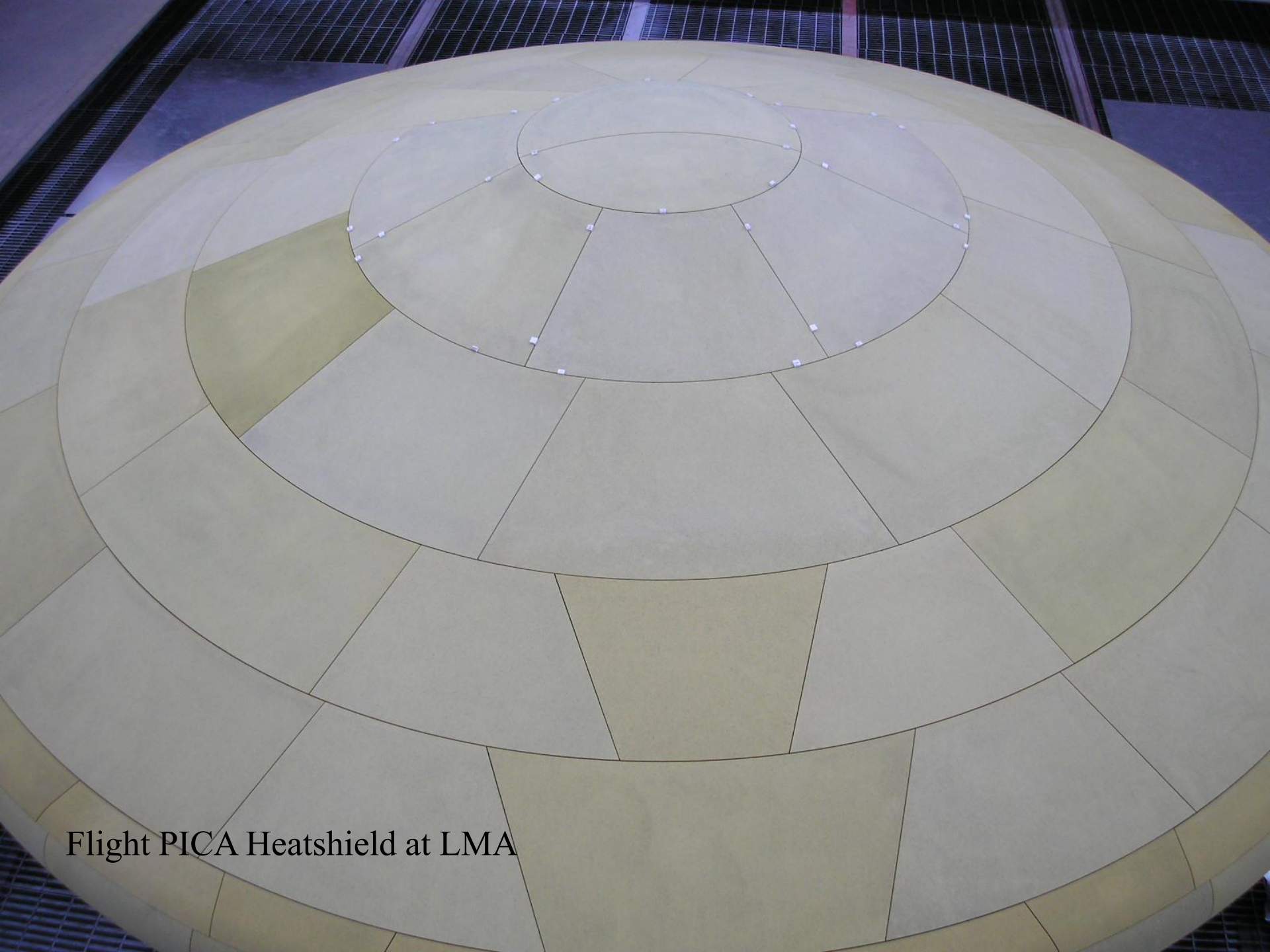
Mars Entry Descent and Landing

The 7 minutes of terror

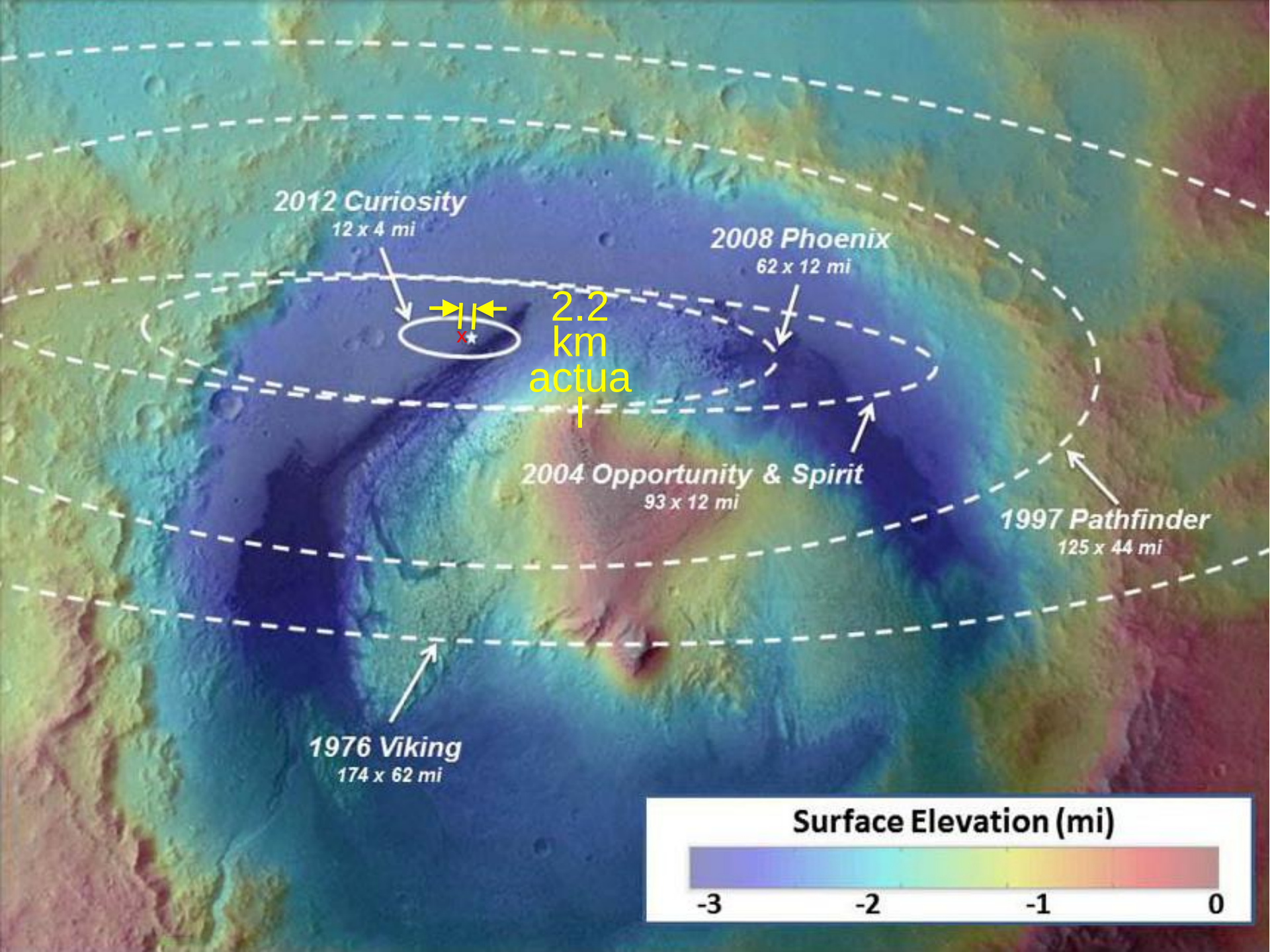


MSL Aeroshell

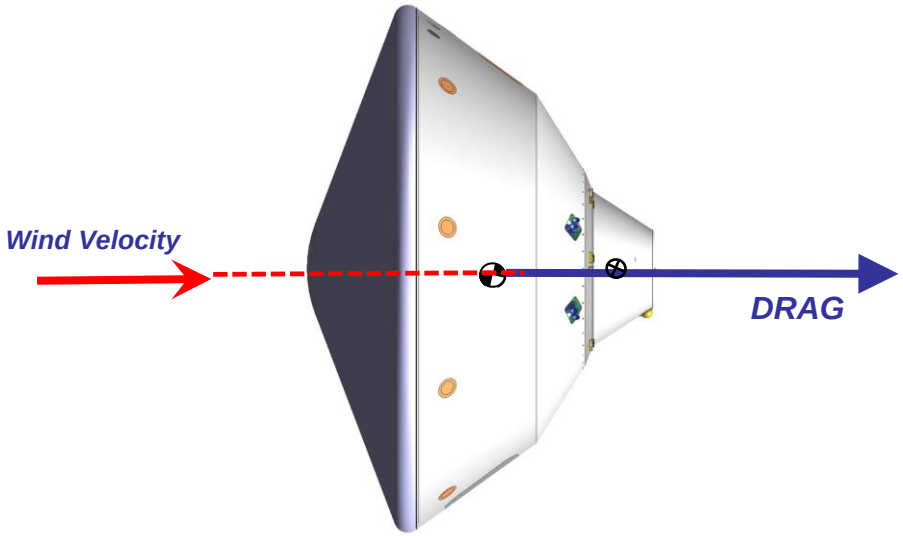
117-MFJ



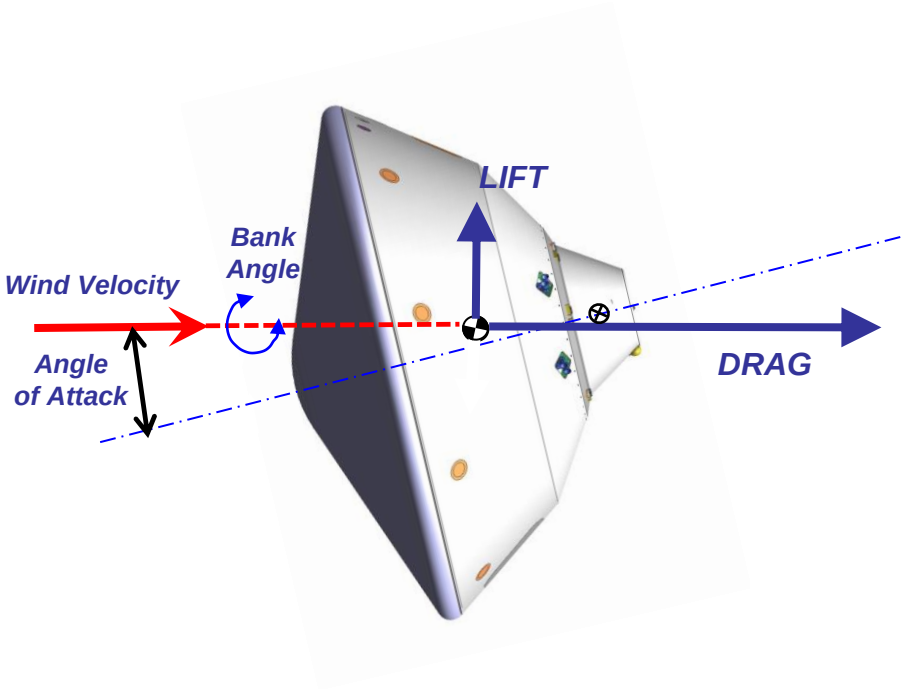
Flight PICA Heatshield at LMA


2012 Curiosity
12 x 4 mi
2008 Phoenix
62 x 12 mi
2.2 km actual
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

Entry Guidance



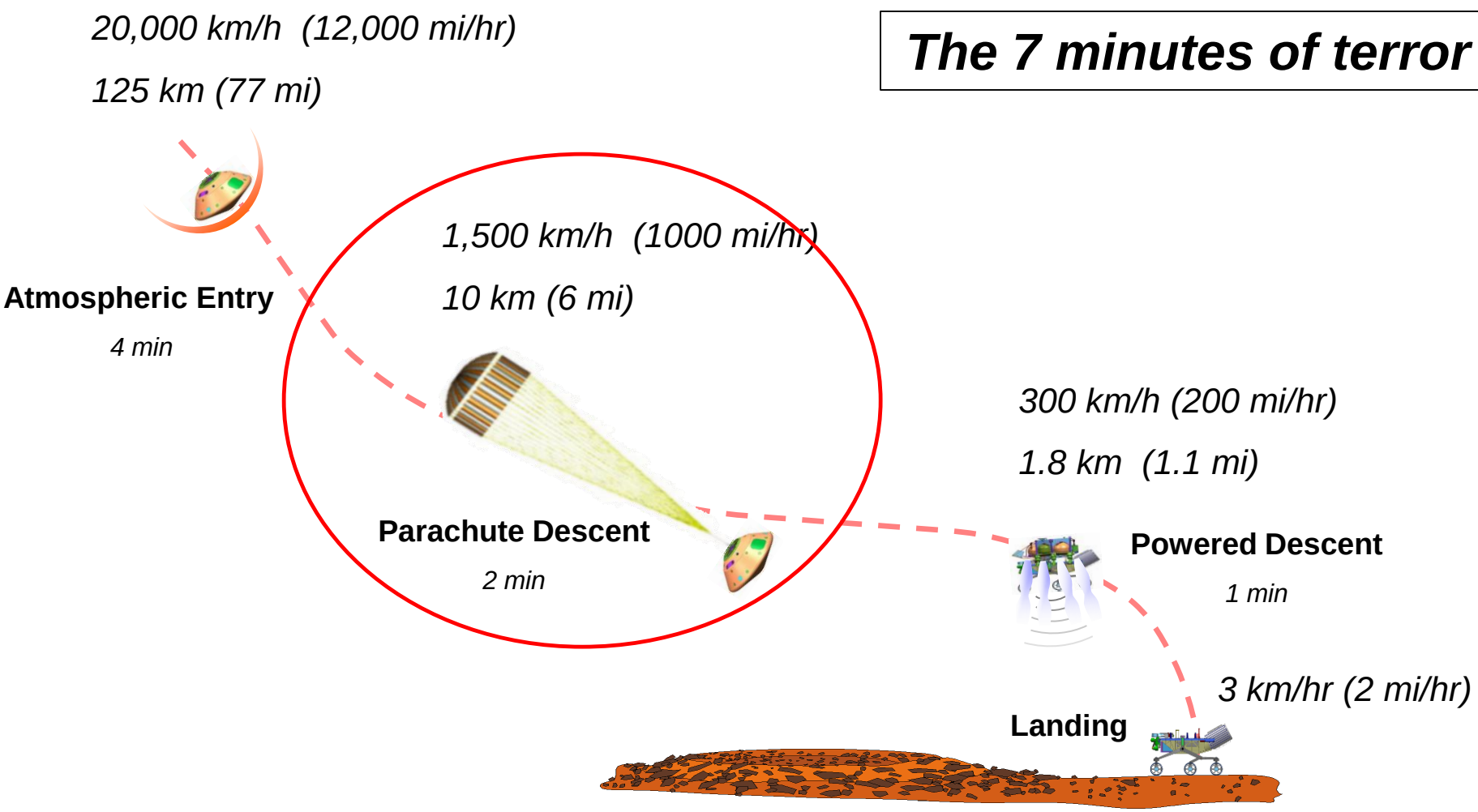
Ballistic Entry



Guided Entry

Mars Entry Descent and Landing

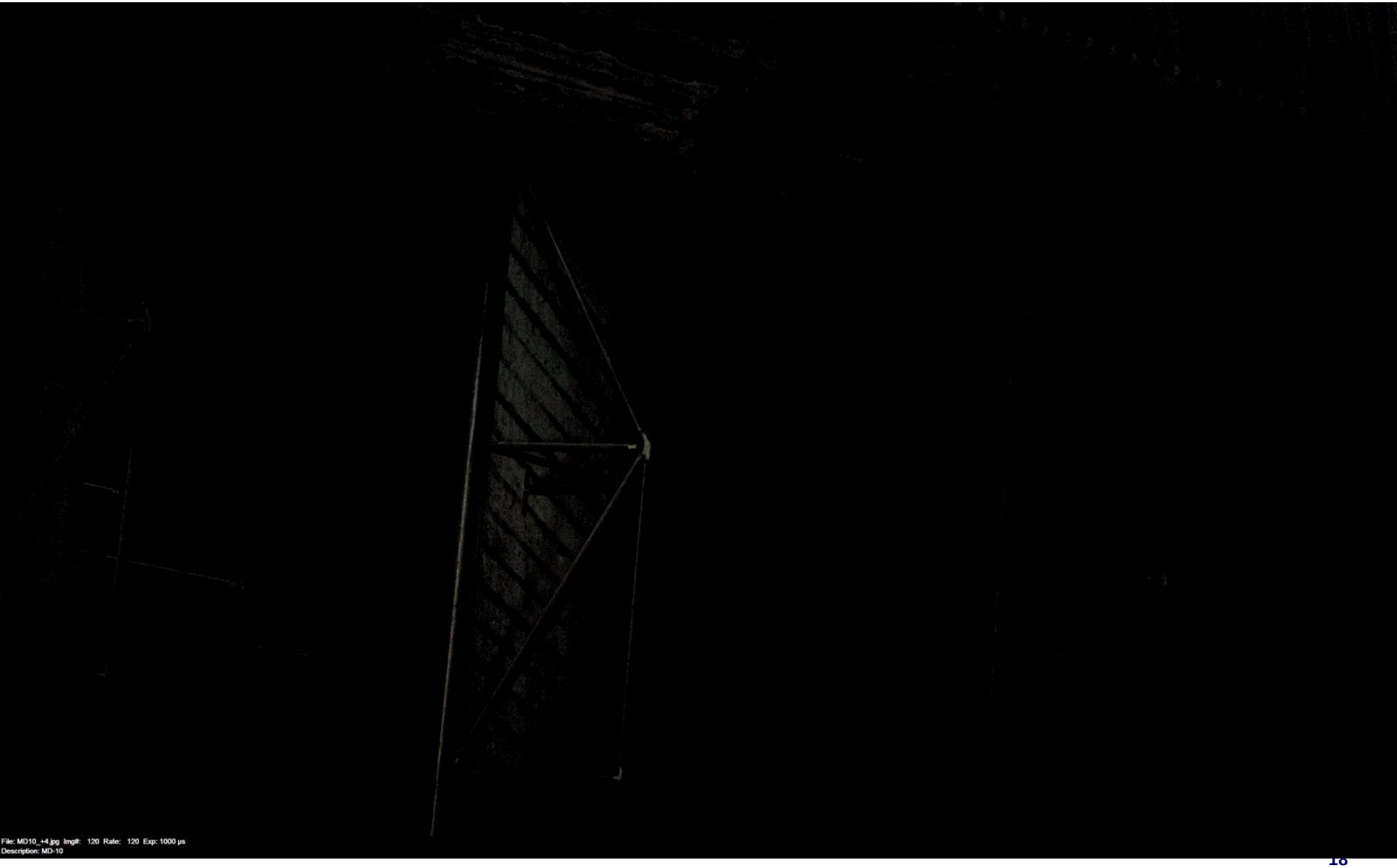
The 7 minutes of terror



Worlds Largest Supersonic Parachute

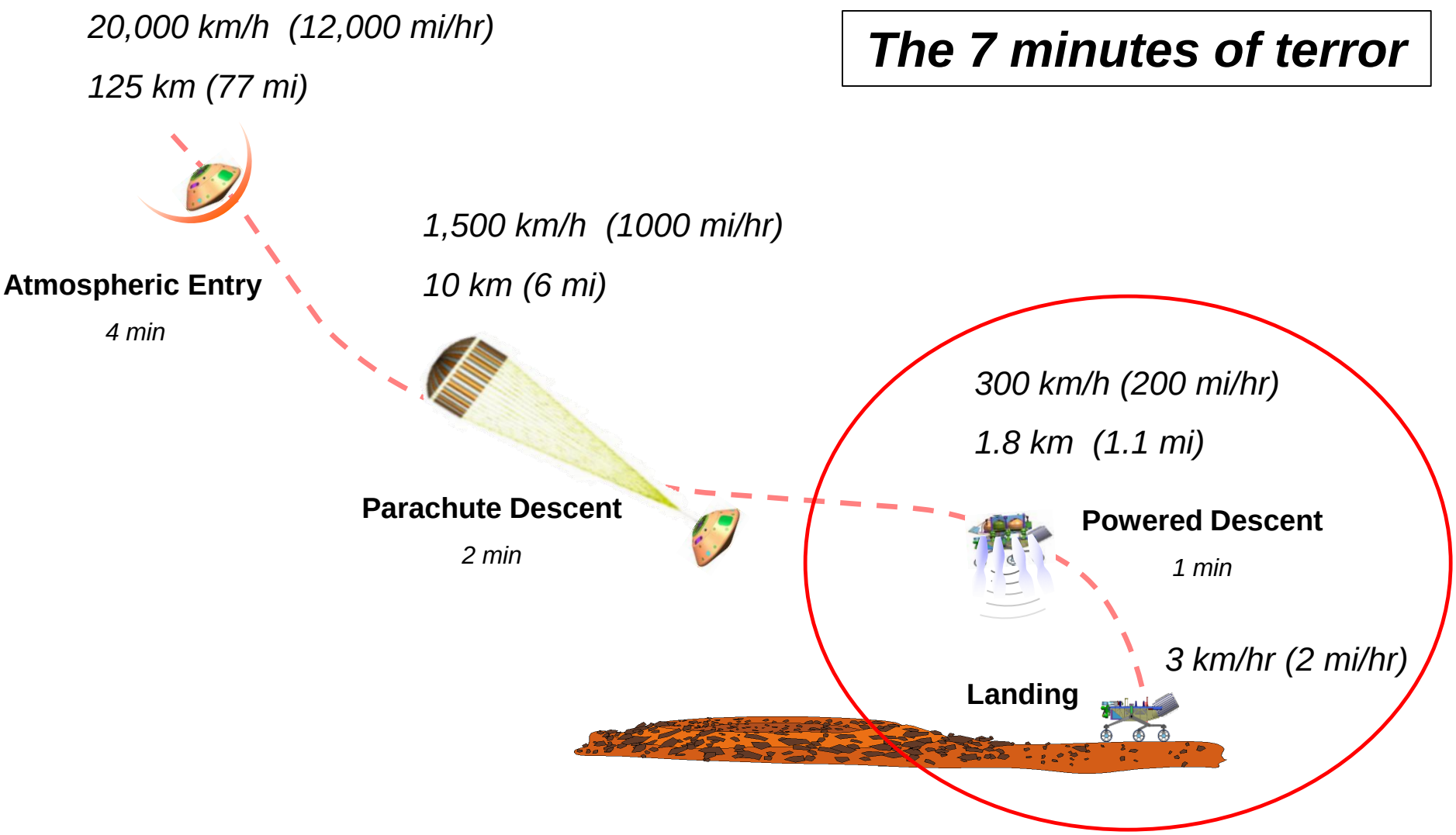
Worlds Largest Supersonic Parachute

Worlds Largest Supersonic Parachute

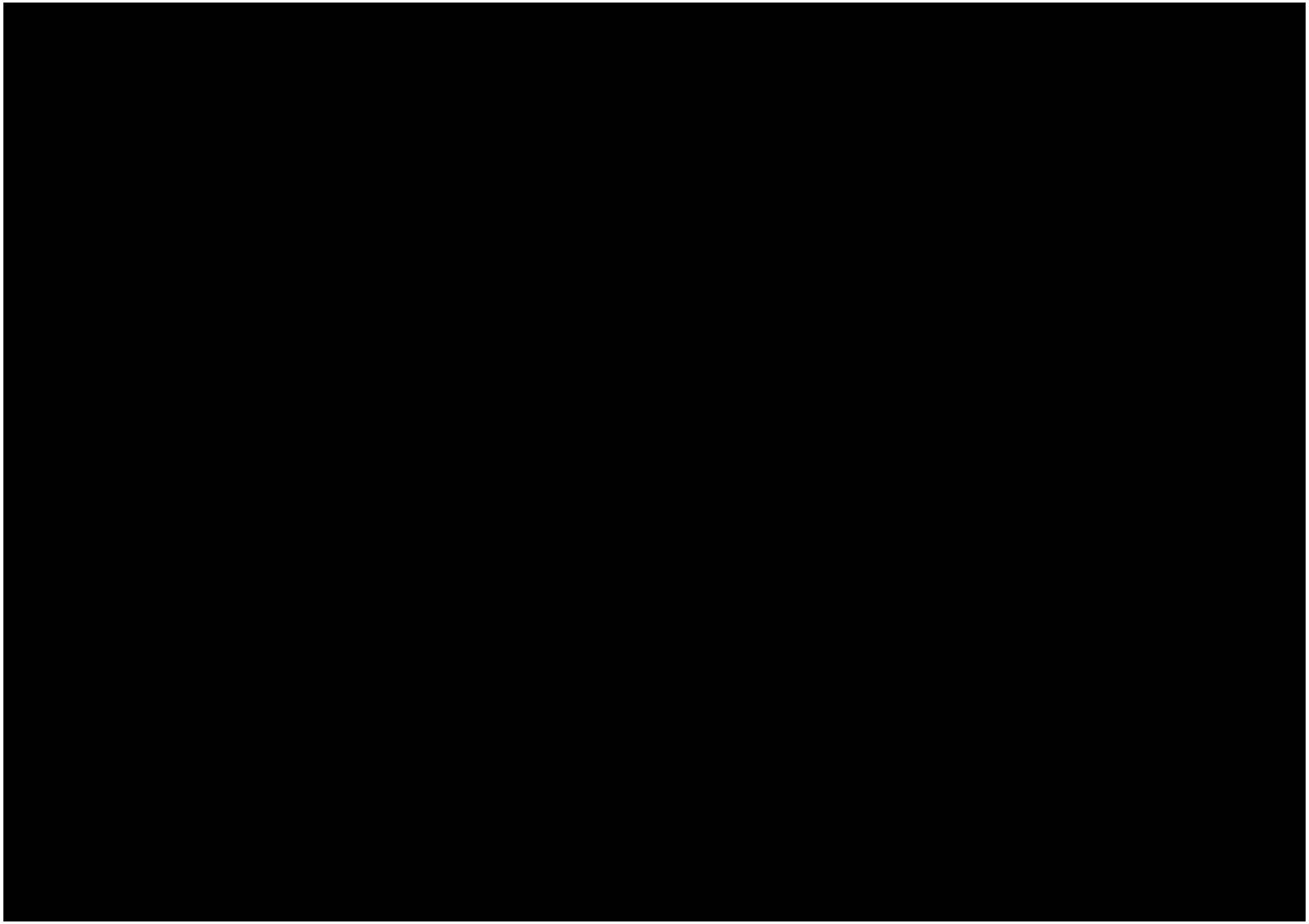


Mars Entry Descent and Landing

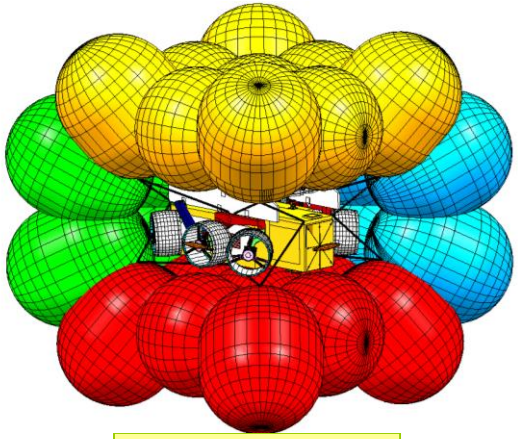
The 7 minutes of terror



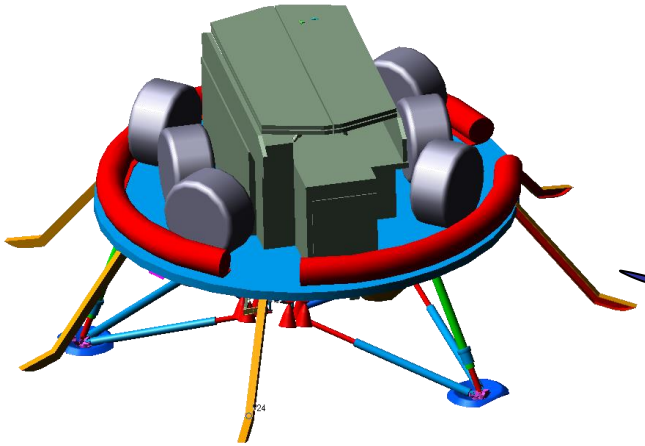
Spirit Landing in January, 2004

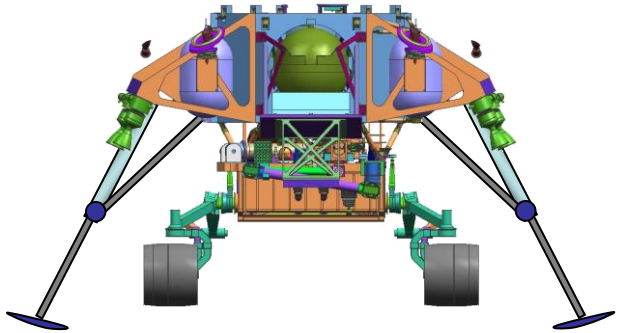


Diferentes Conceptos para el Aterrizaje

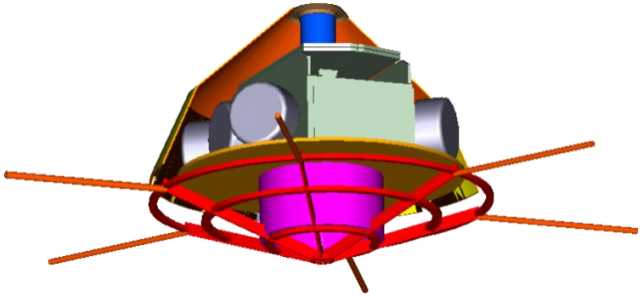


Airbags

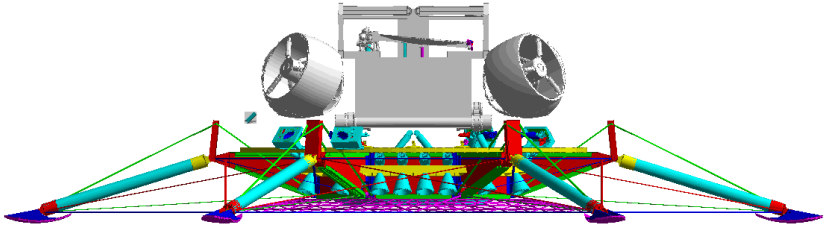




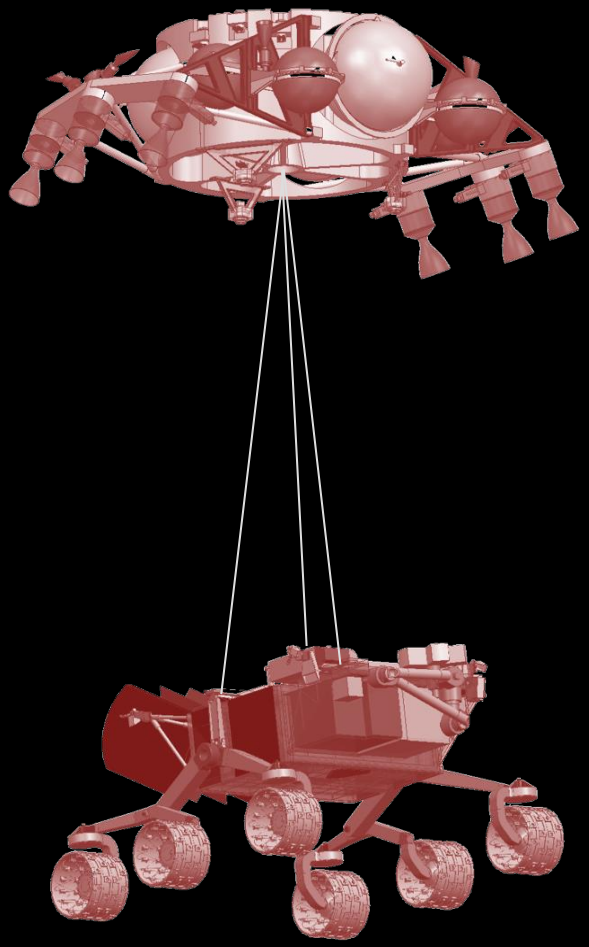
Legs



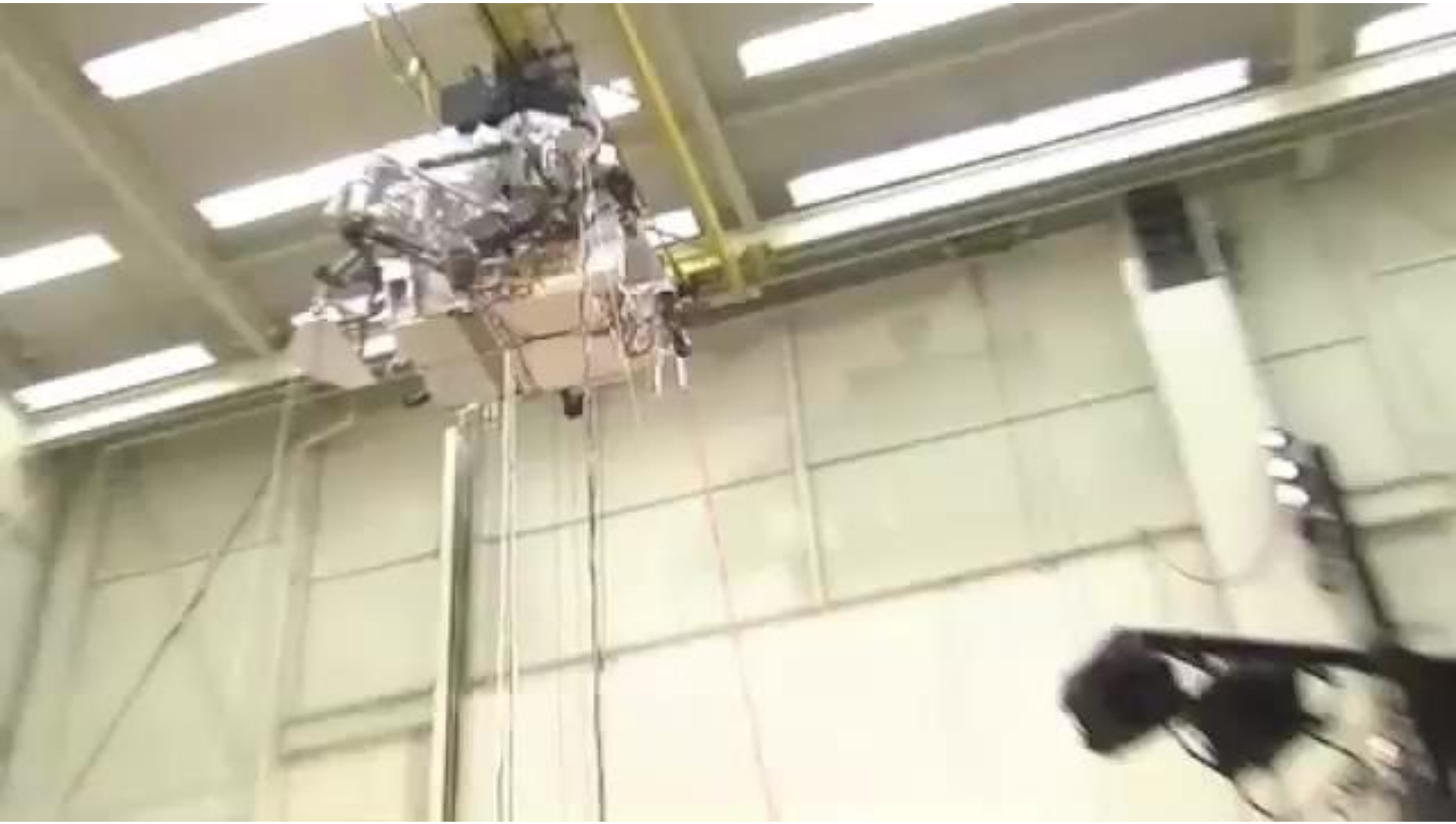
Pallet



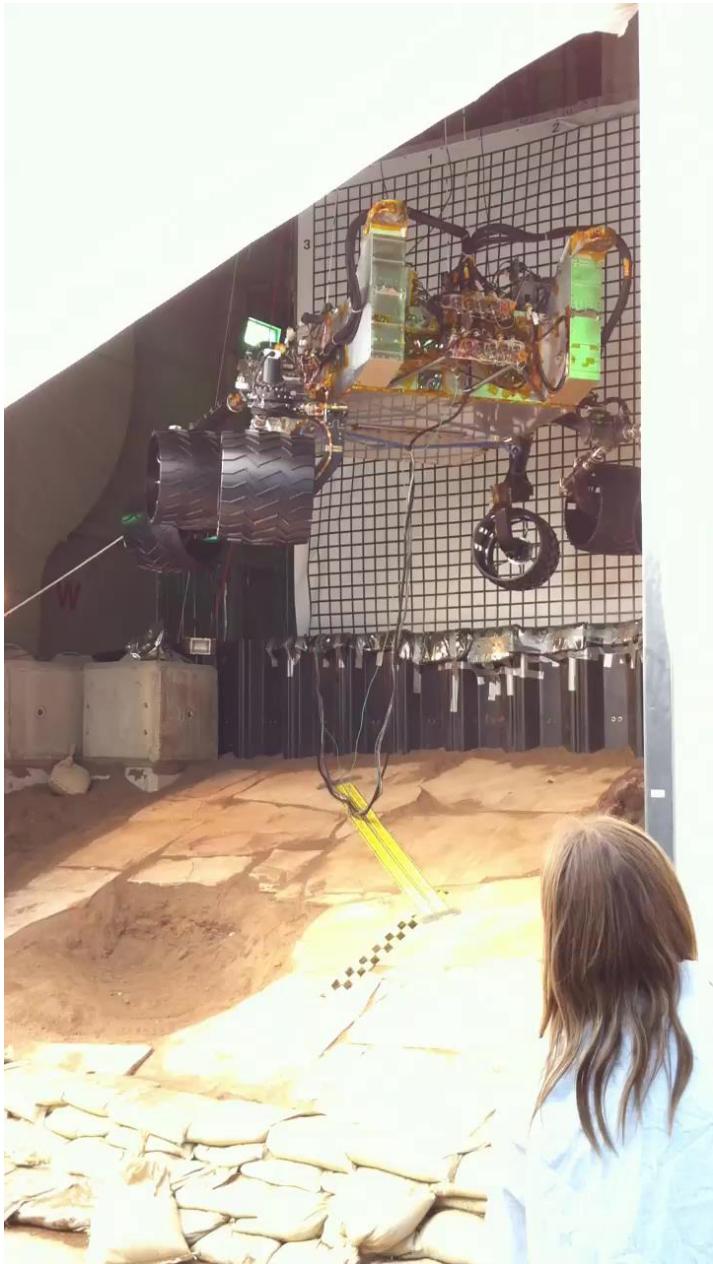
2003: The Skycrane maneuver is born



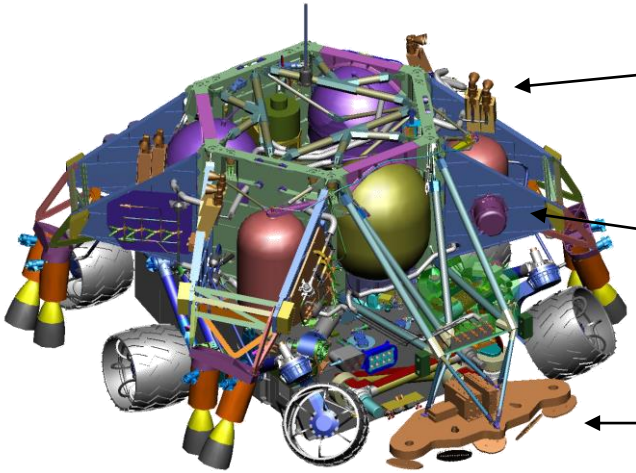
Full Motion Test



Touchdown Test



Descent Stage Configuration

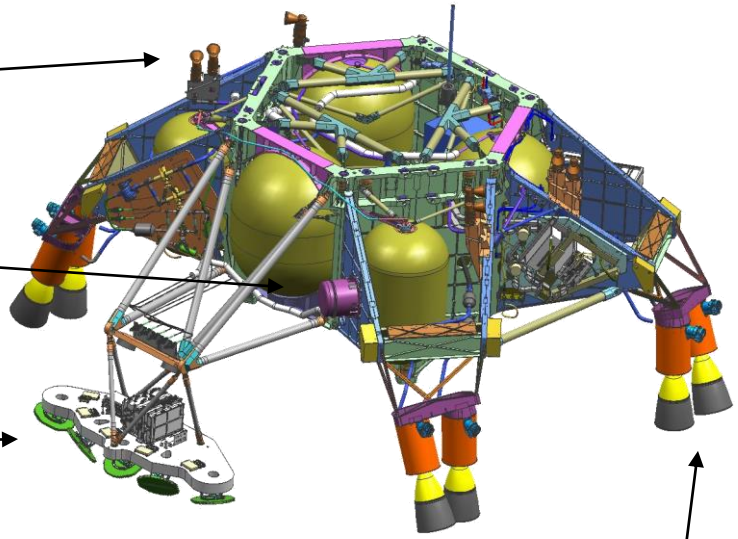


Descent Stage
Entry Configuration

Entry RCS 8x

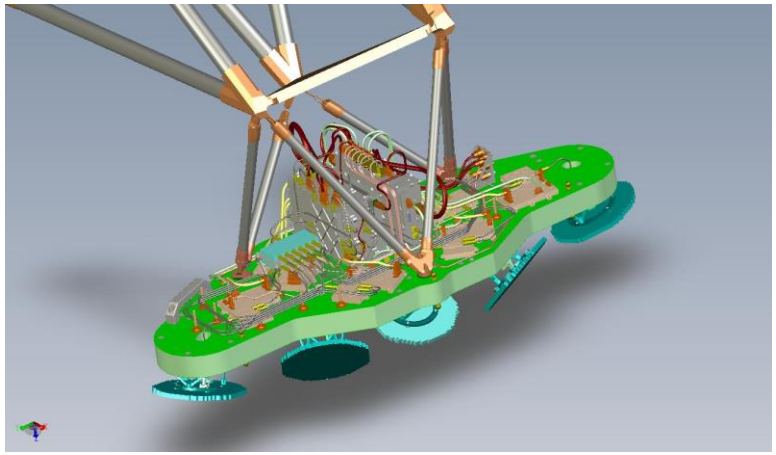
Descent IMU
(DIMU) 2x

Terminal
Descent
Sensor
(TDS) 1x



Descent Stage
Skycrane Configuration

Mars
Landing
Engines
(MLEs) 8x



Terminal Descent Sensor (TDS)

Flight Descent Stage and Rover

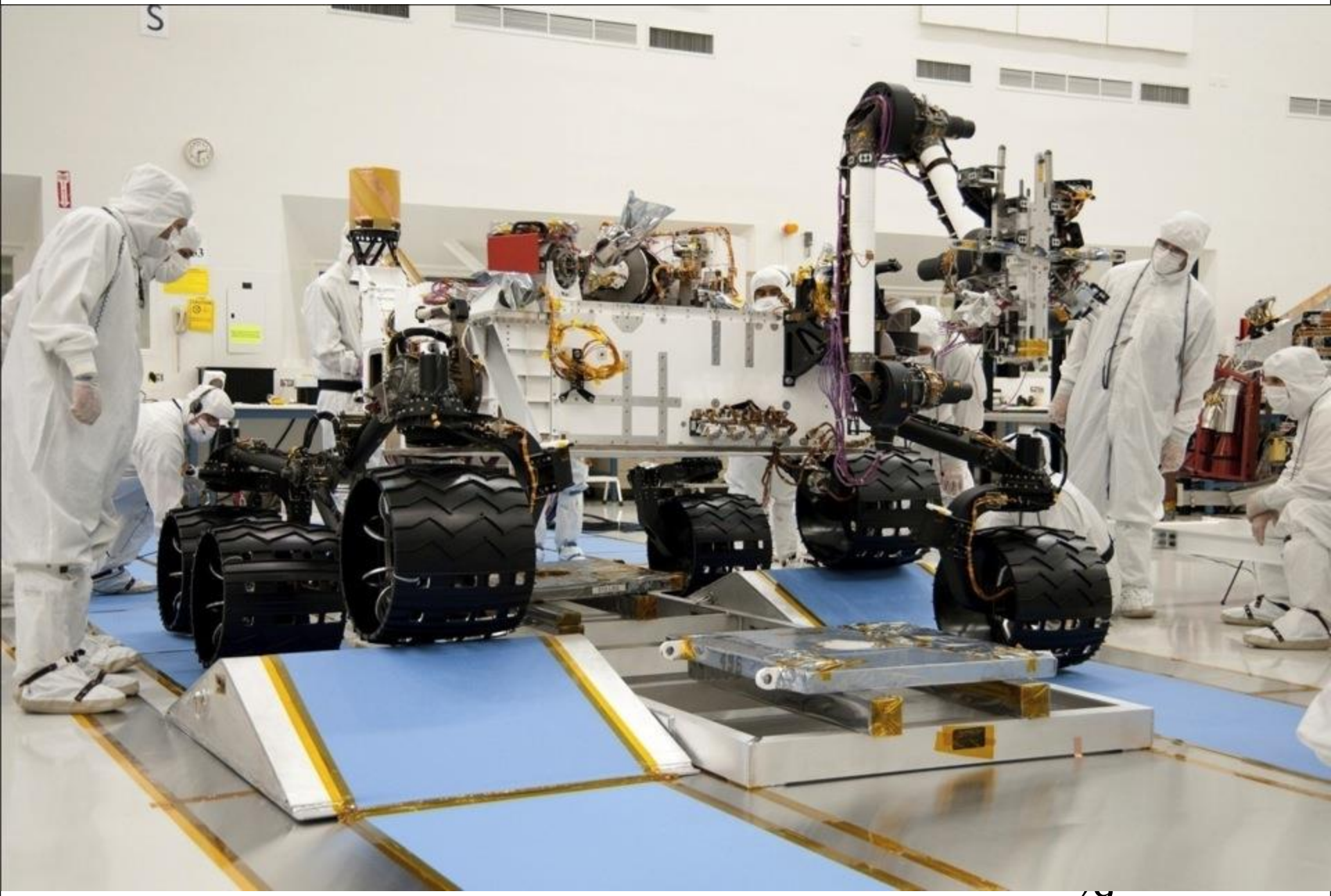
Field Test Venues

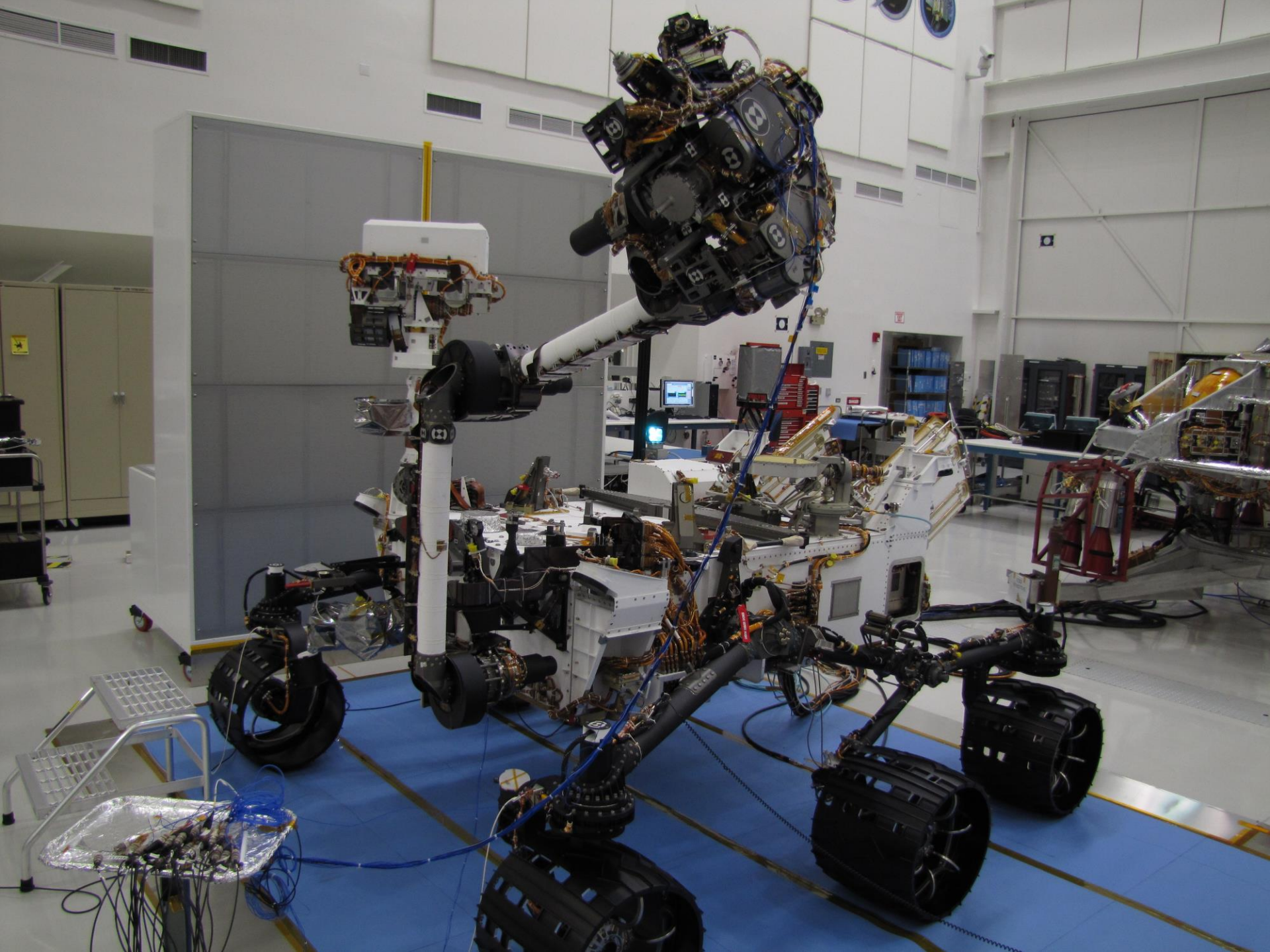
China Lake Echo Towers

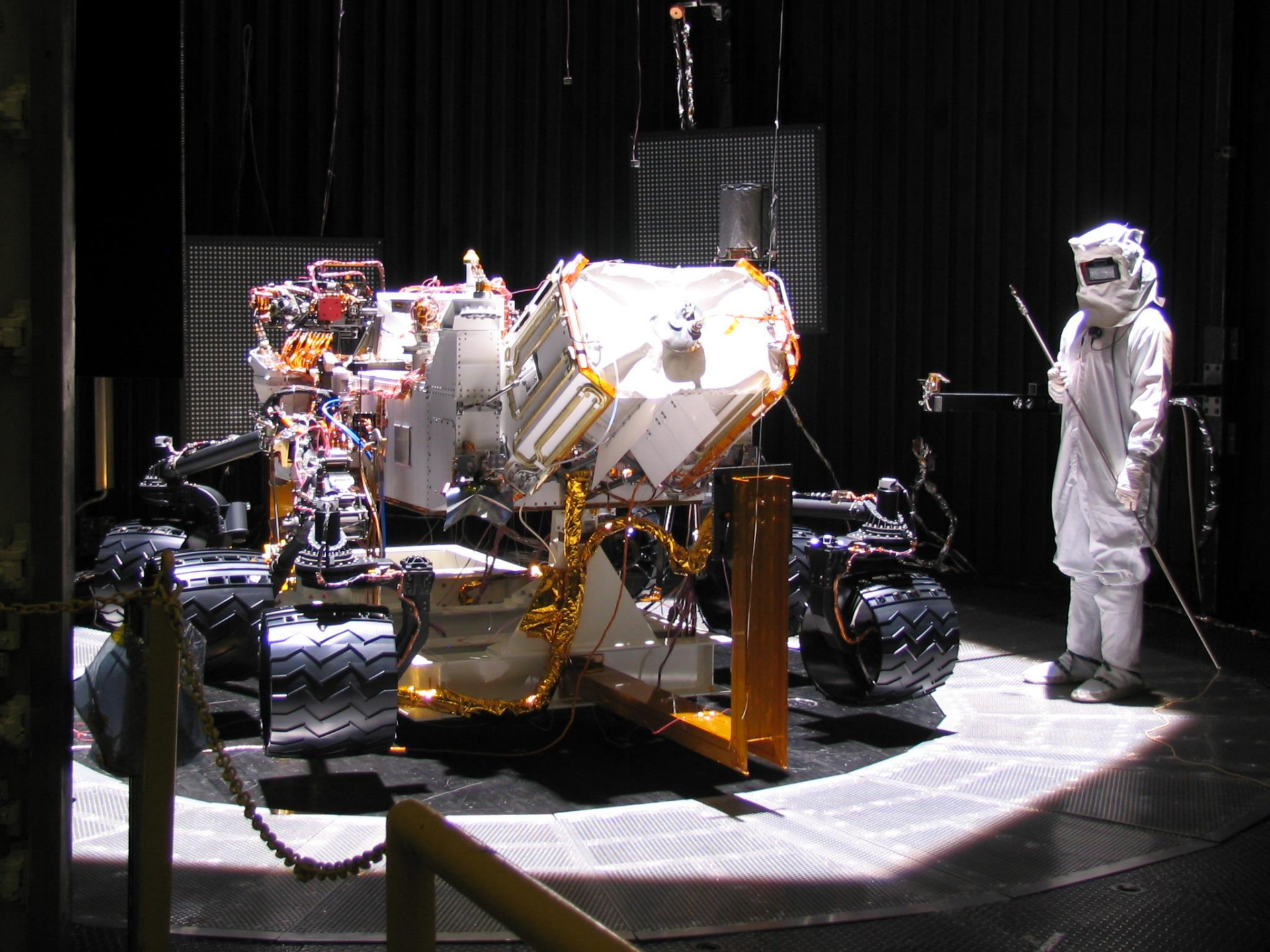
NASA Dryden Flight Research Center F/A-18

Eurocopter AS350 AStar Helicopter

EMERGENCY
EXIT
ONLY
DANGER
STARDU

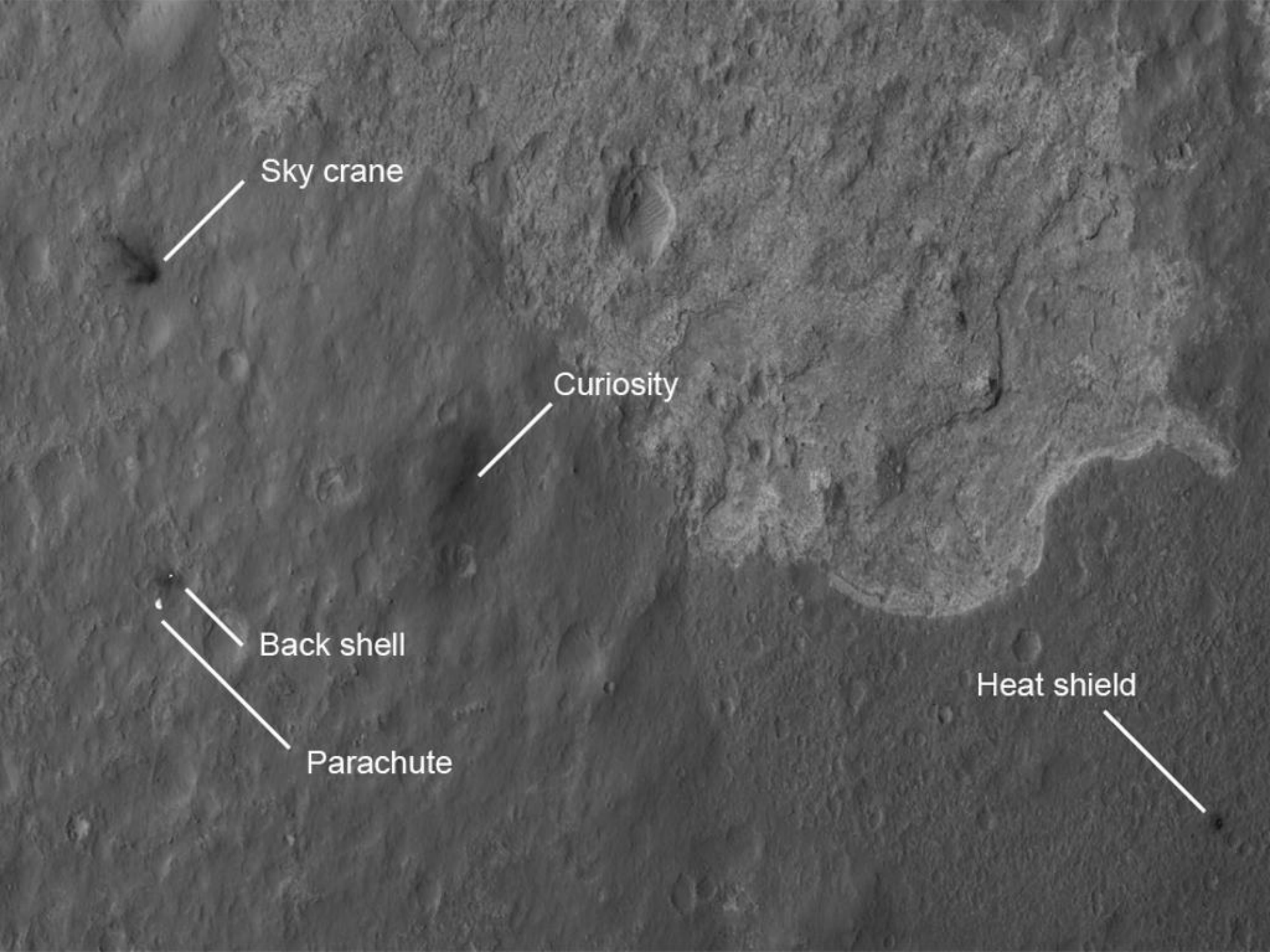


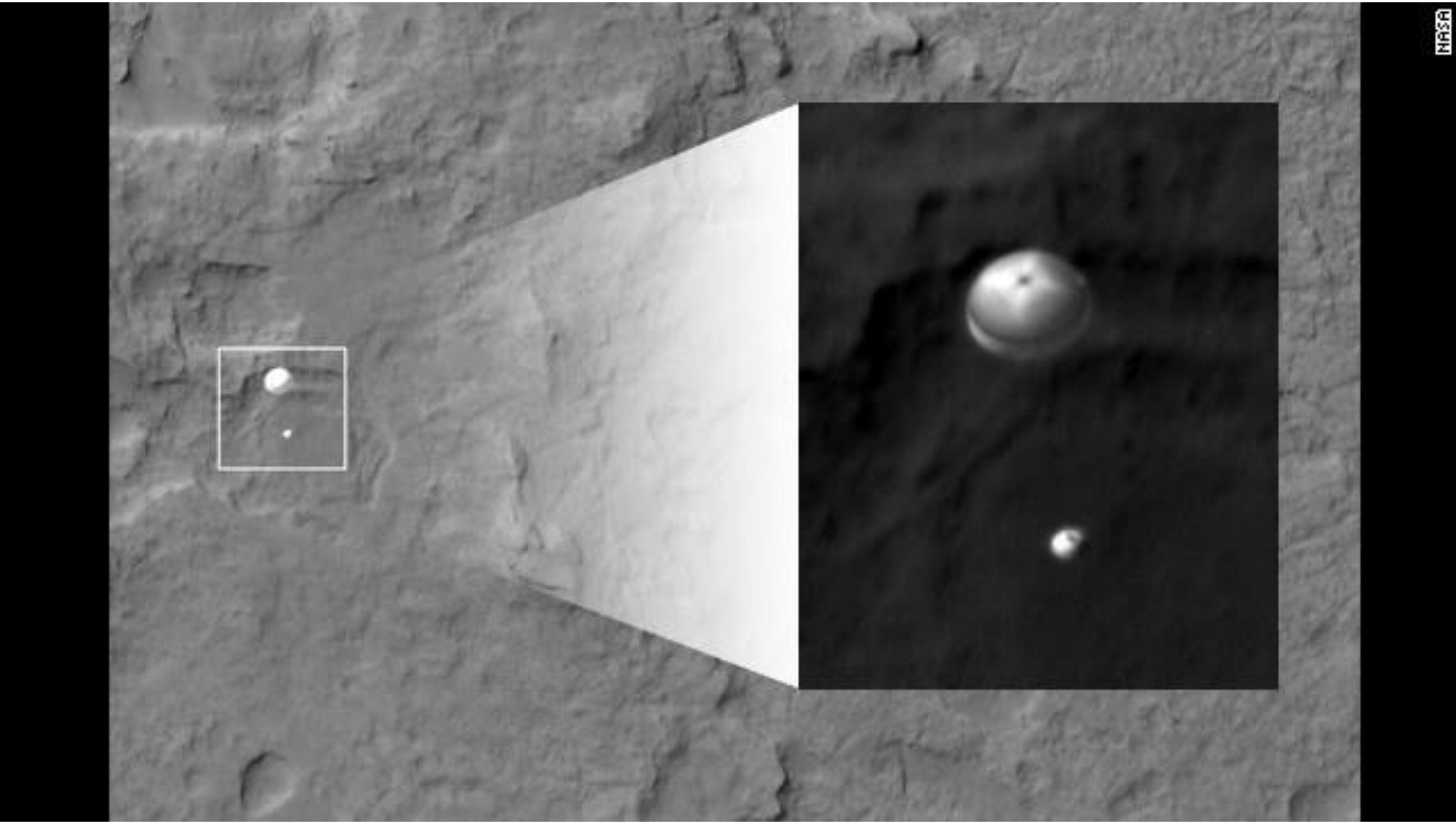


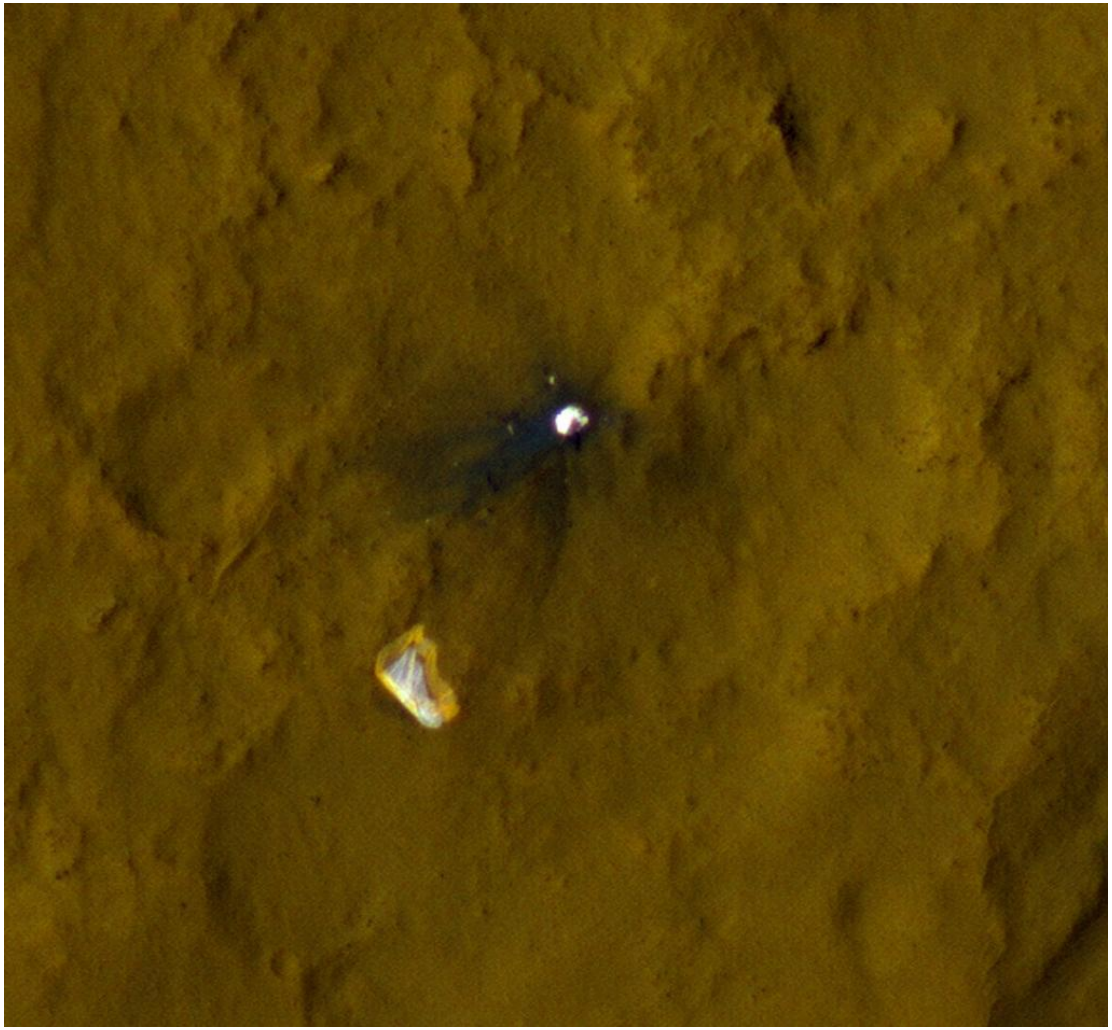


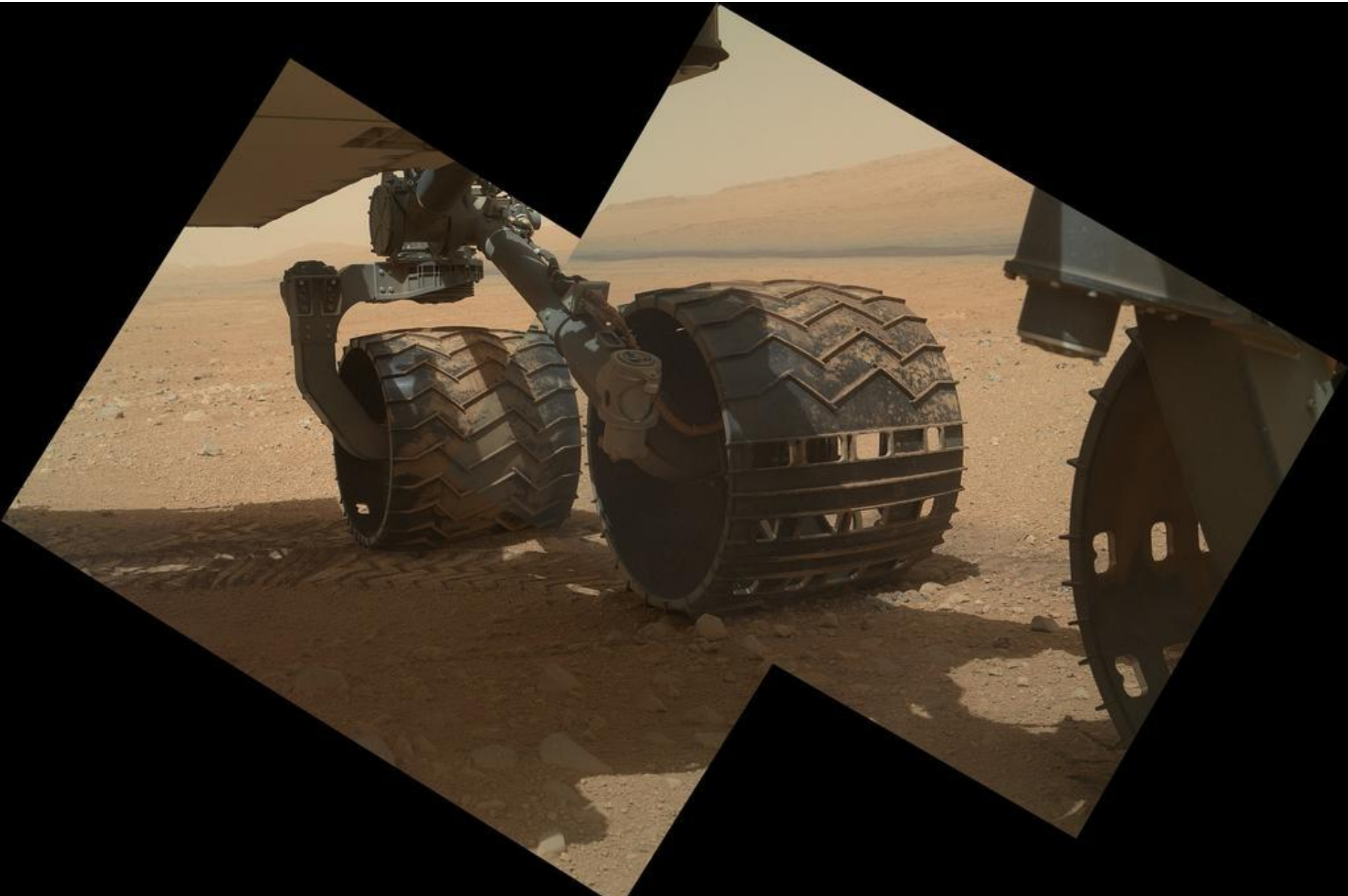
Assembled Spacecraft

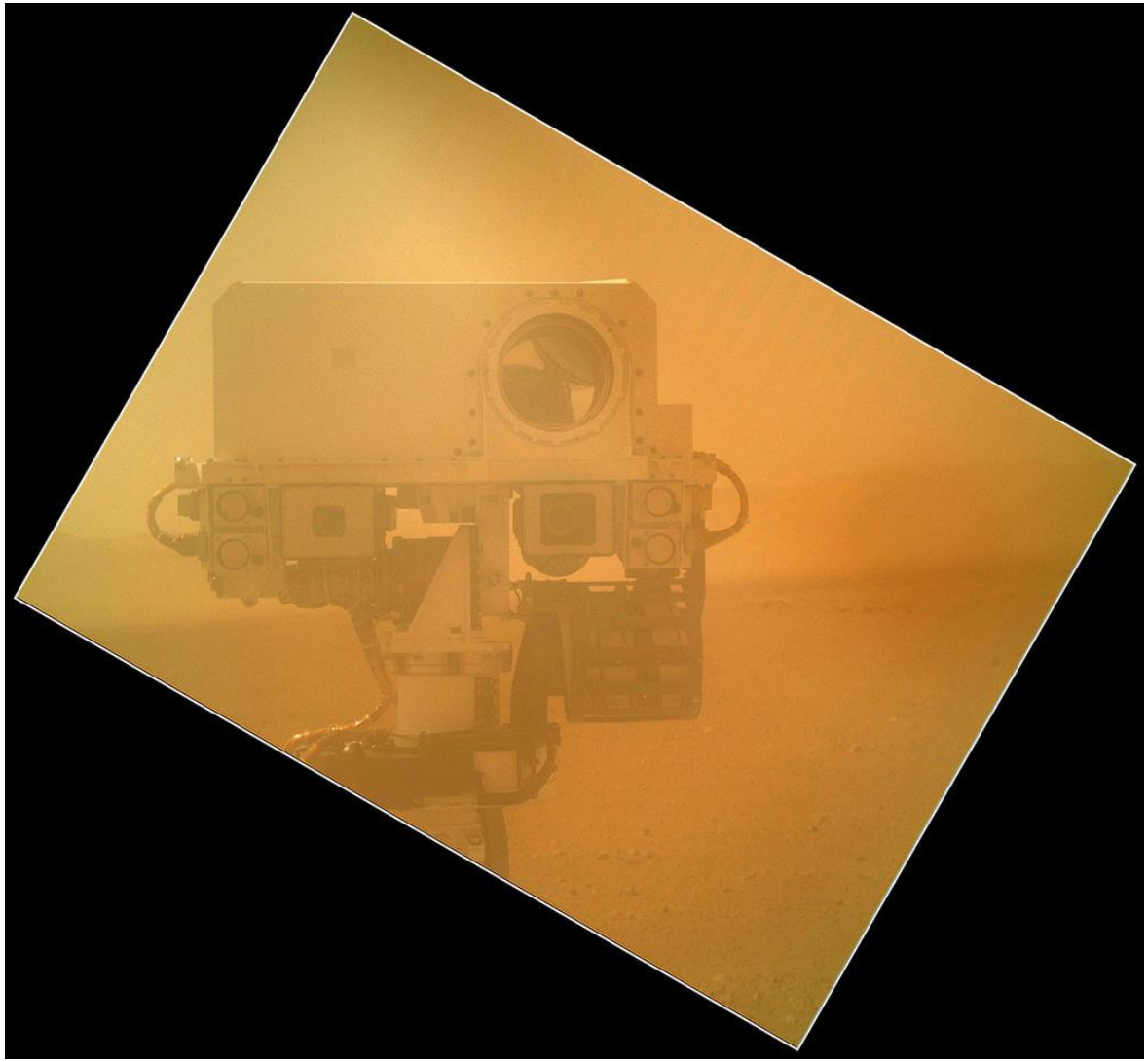
CAUTION !

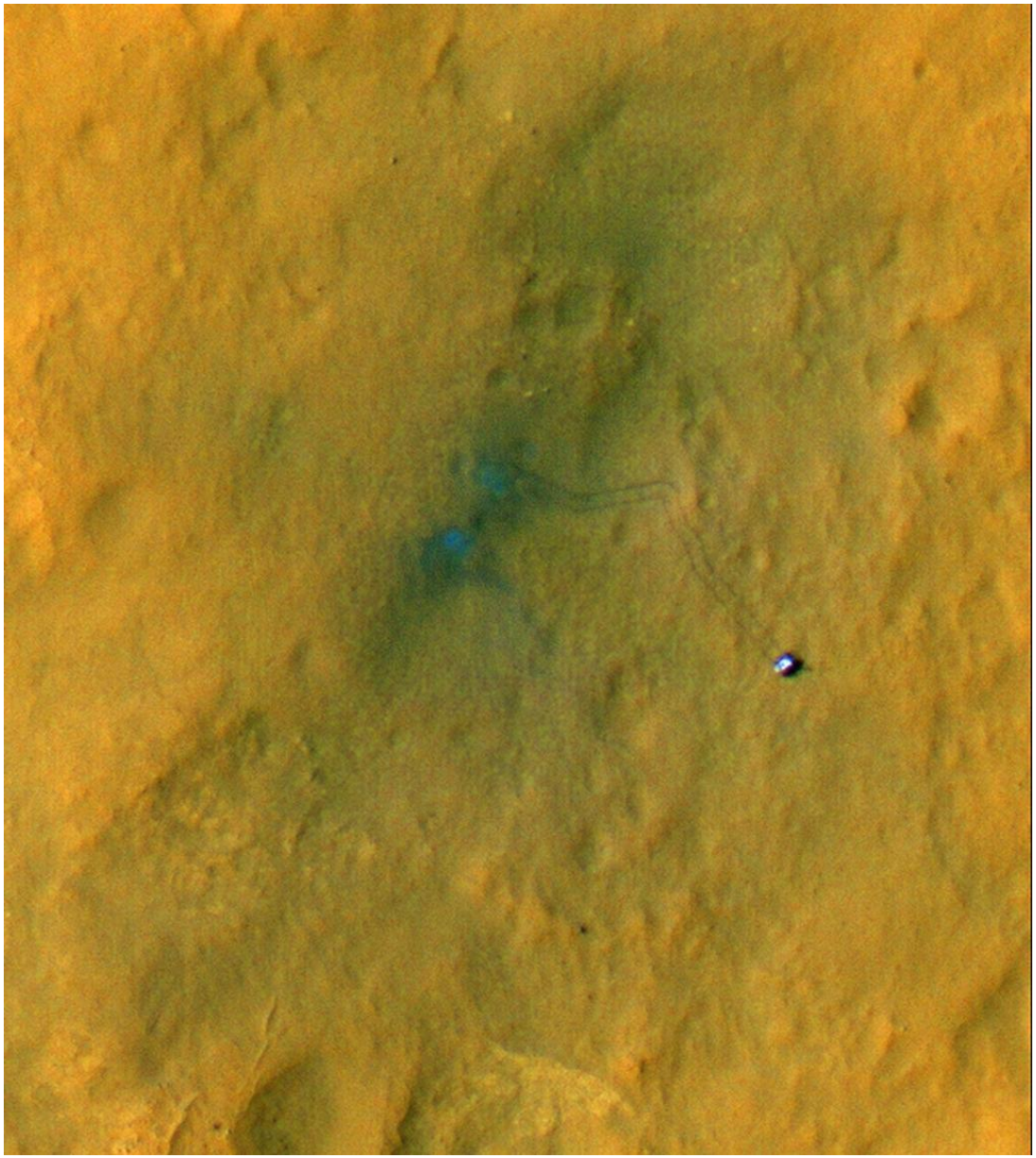

Sky crane
Curiosity
Back shell
Parachute
Heat shield

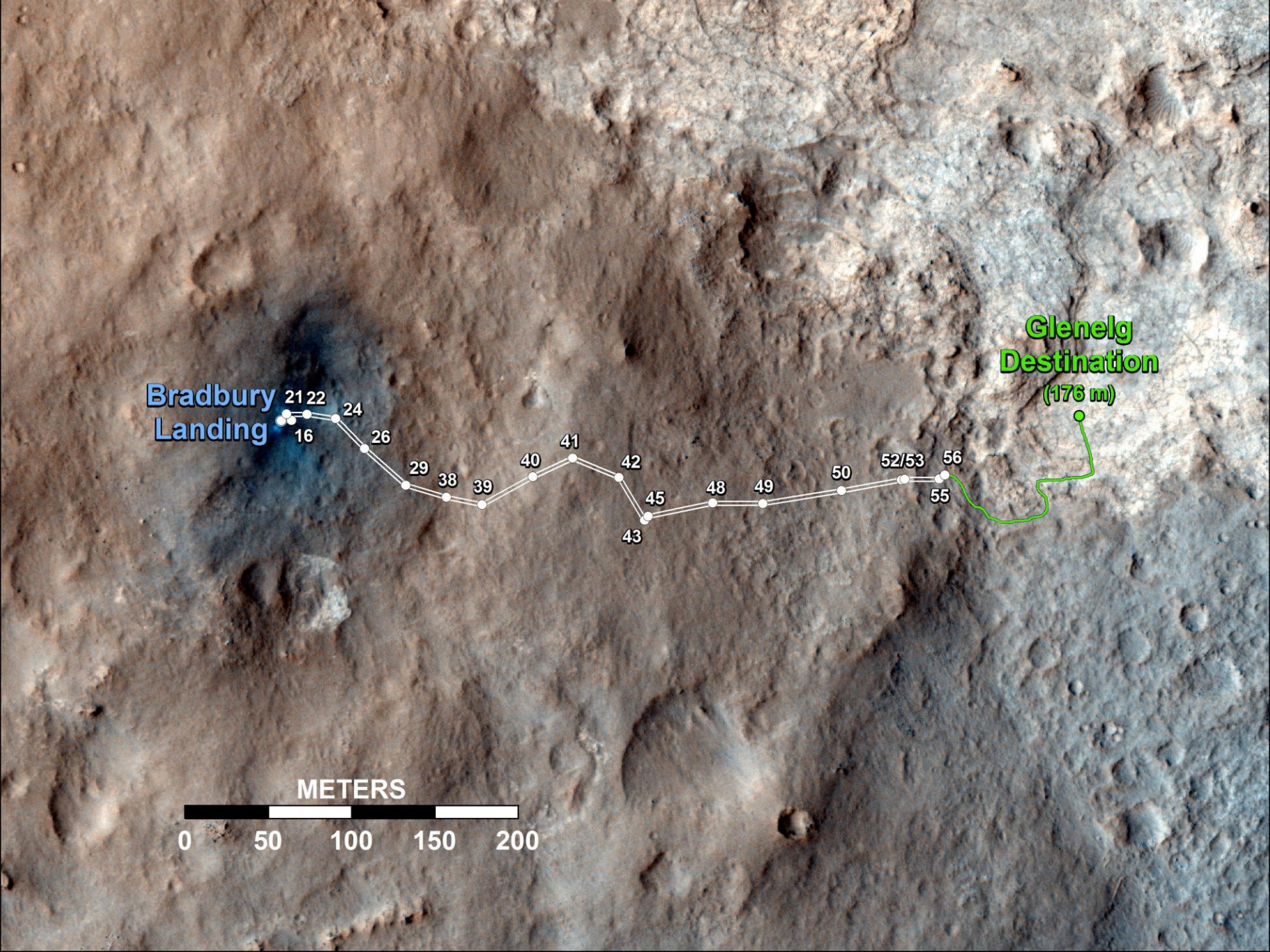

NASA

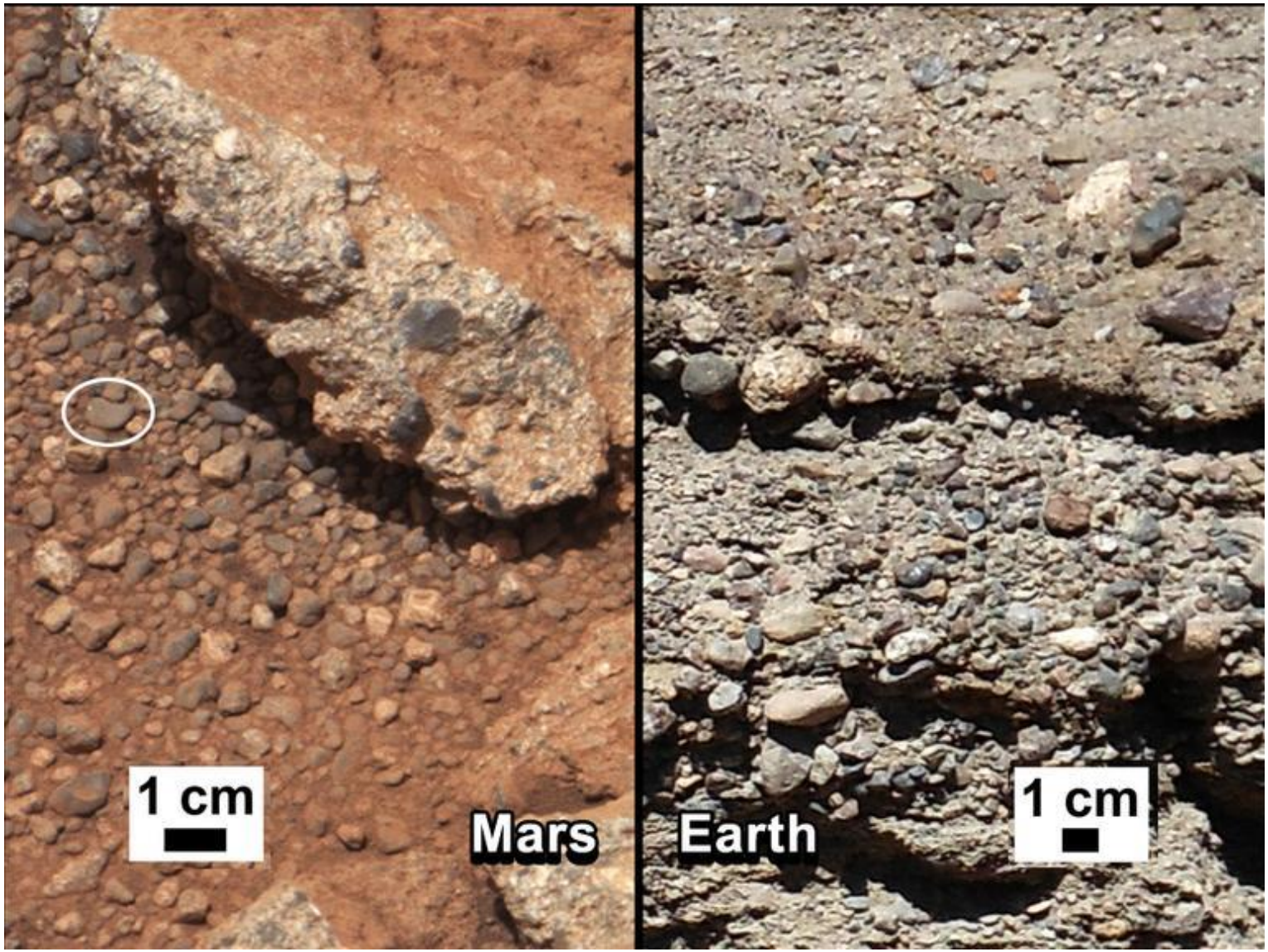


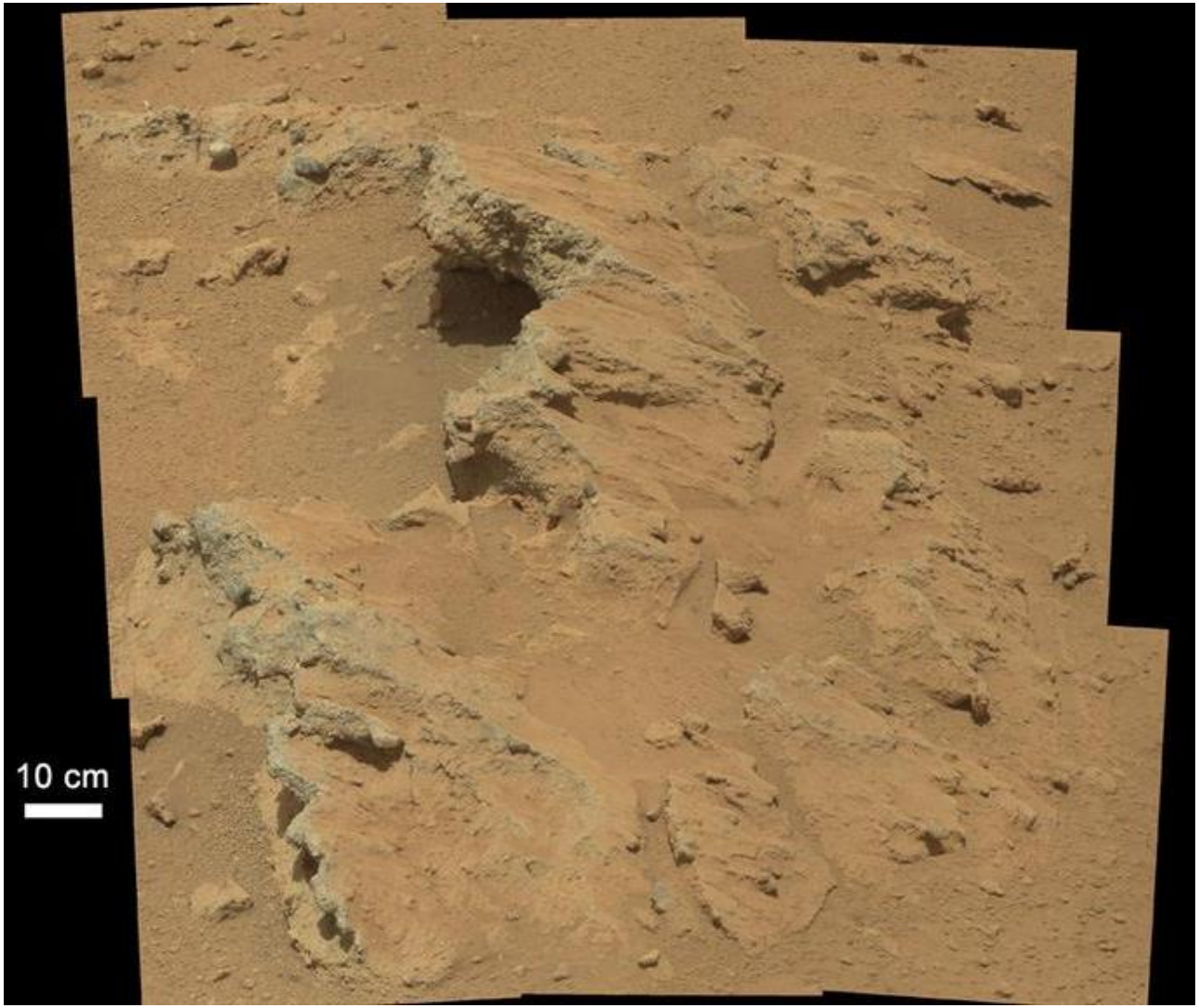







Bradbury Landing
21
22
16
24
26
29
38
39
40
41
42
43
45
48
49
50
52/53
55
56
Glenelg Destination
(176 m)
METERS
0
50
100
150
200


1 cm
Mars
Earth
1 cm


10 cm

Mount Sharp