6 Minutes of Terror Landing On Mars Enables Years of Discoveries

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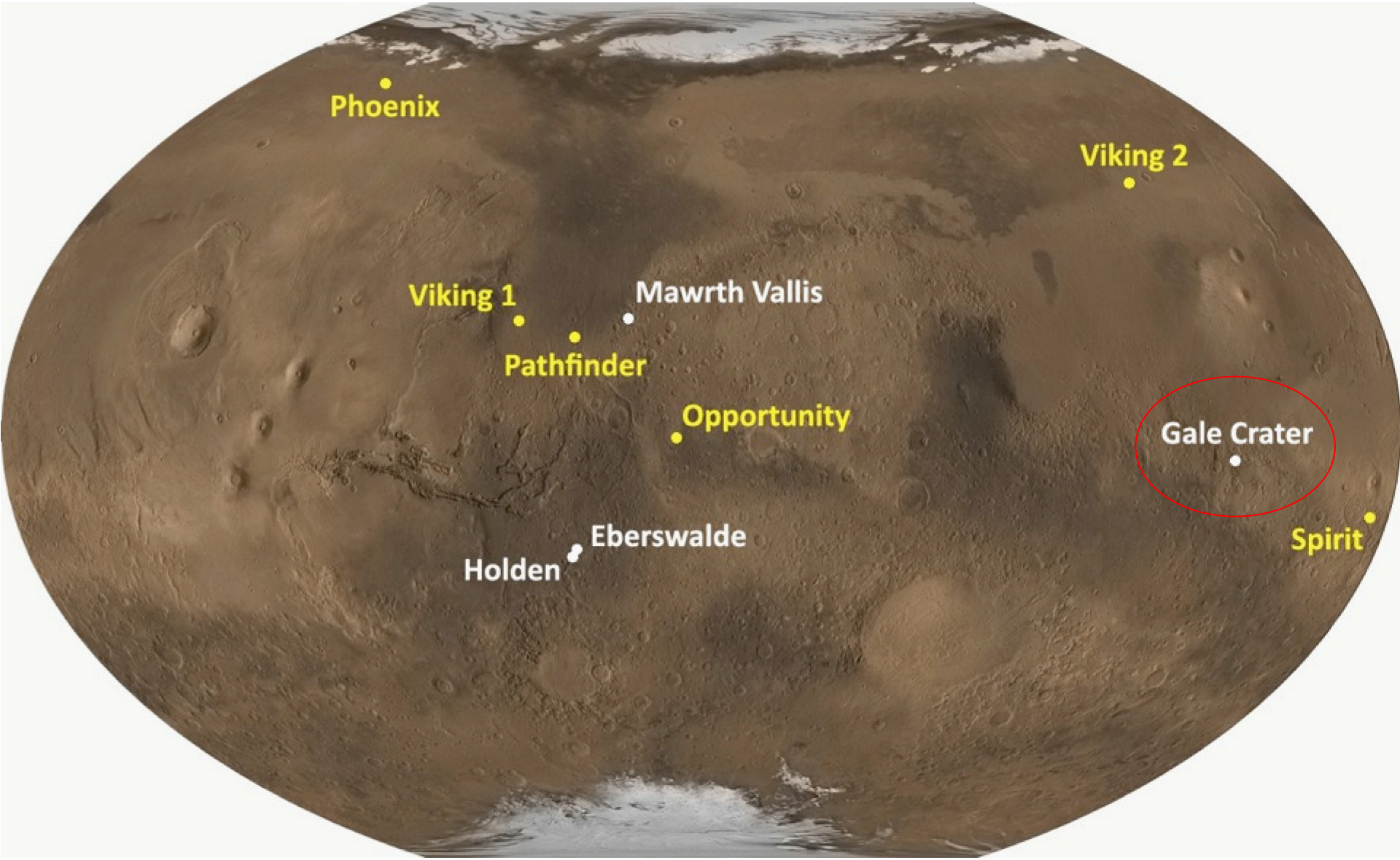
Science Goals

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

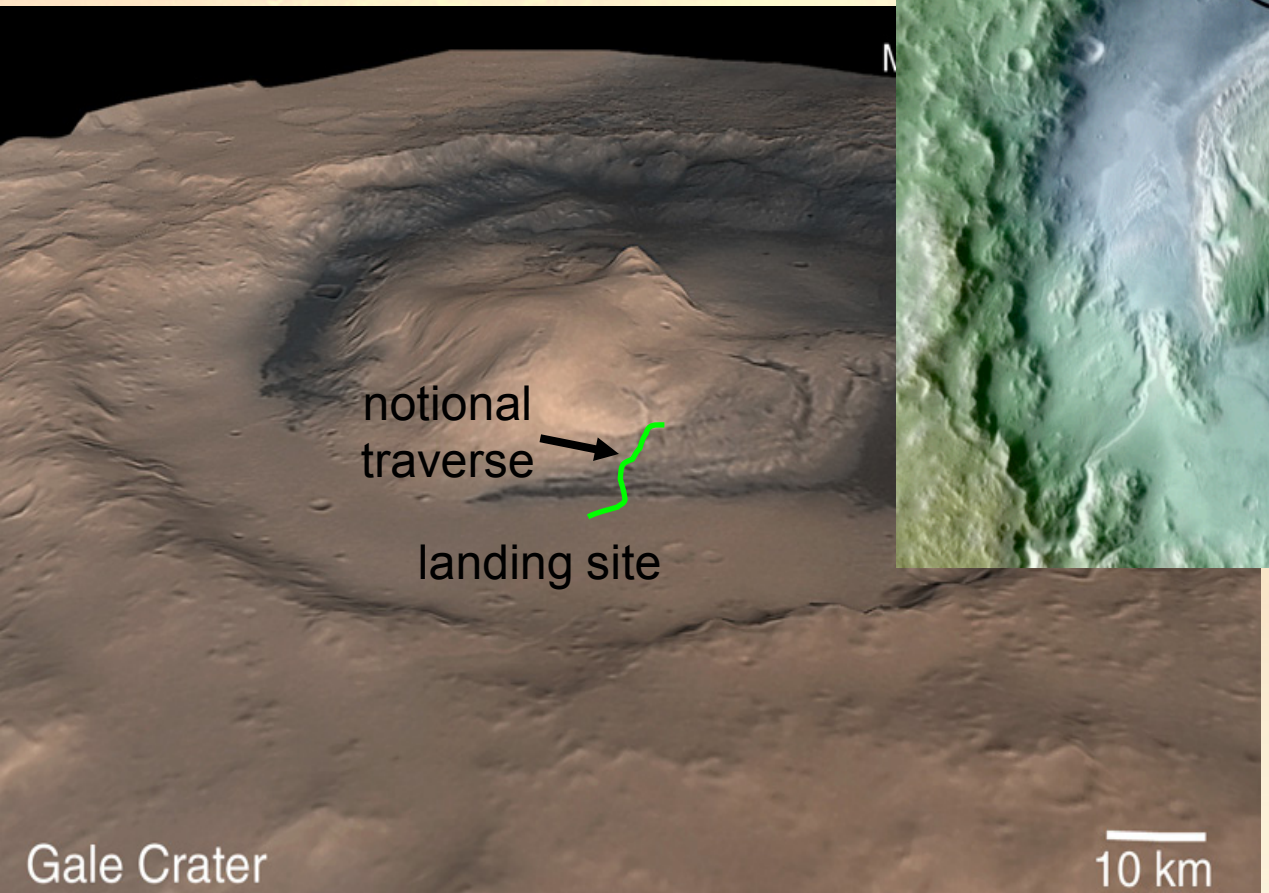
Objectives include:

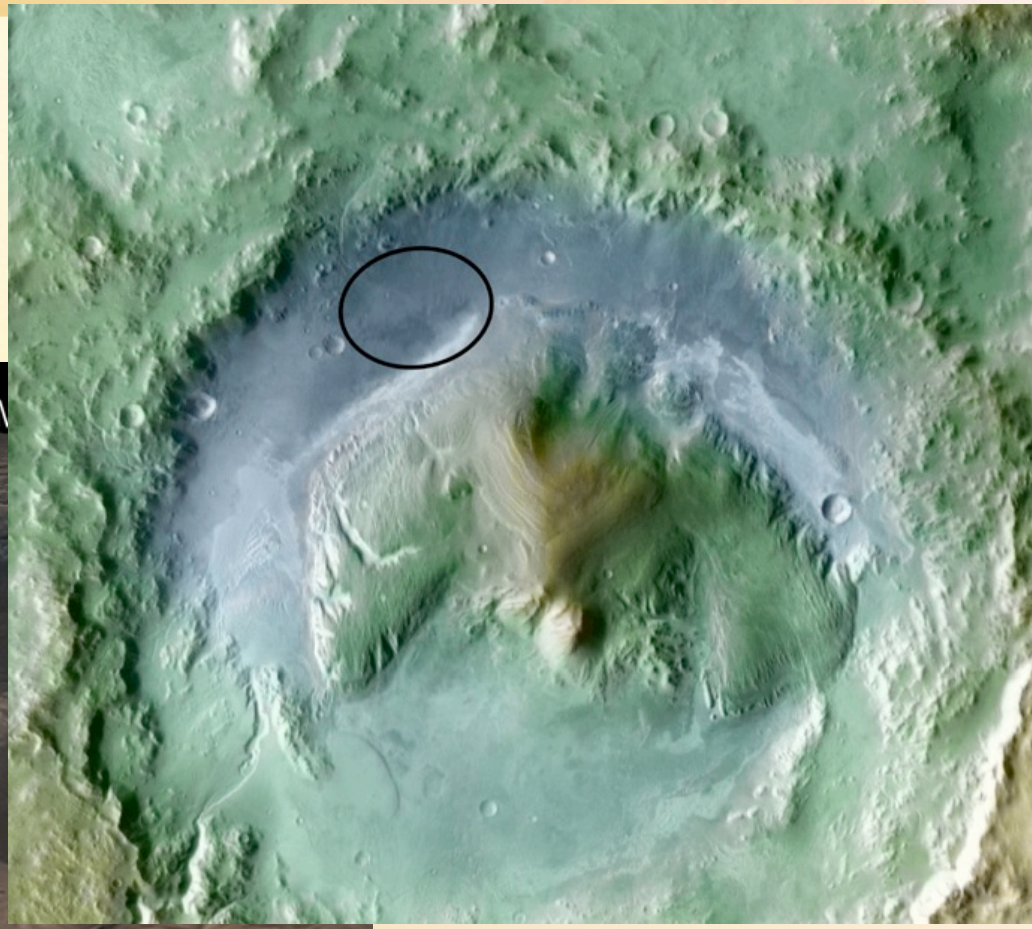
- Assessing the biological potential of the site by investigating organic compounds, other relevant elements, and biomarkers
- Characterizing geology and geochemistry, including chemical, mineralogical, and isotopic composition, and geological processes
- Investigating the role of water, atmospheric evolution, and modern weather/climate
- Characterizing the spectrum of surface radiation

Candidate Landing Sites



Gale Crater





Stratigraphy and Planetary History

Sedimentary rocks are records of environmental change

Curiosity The Rover

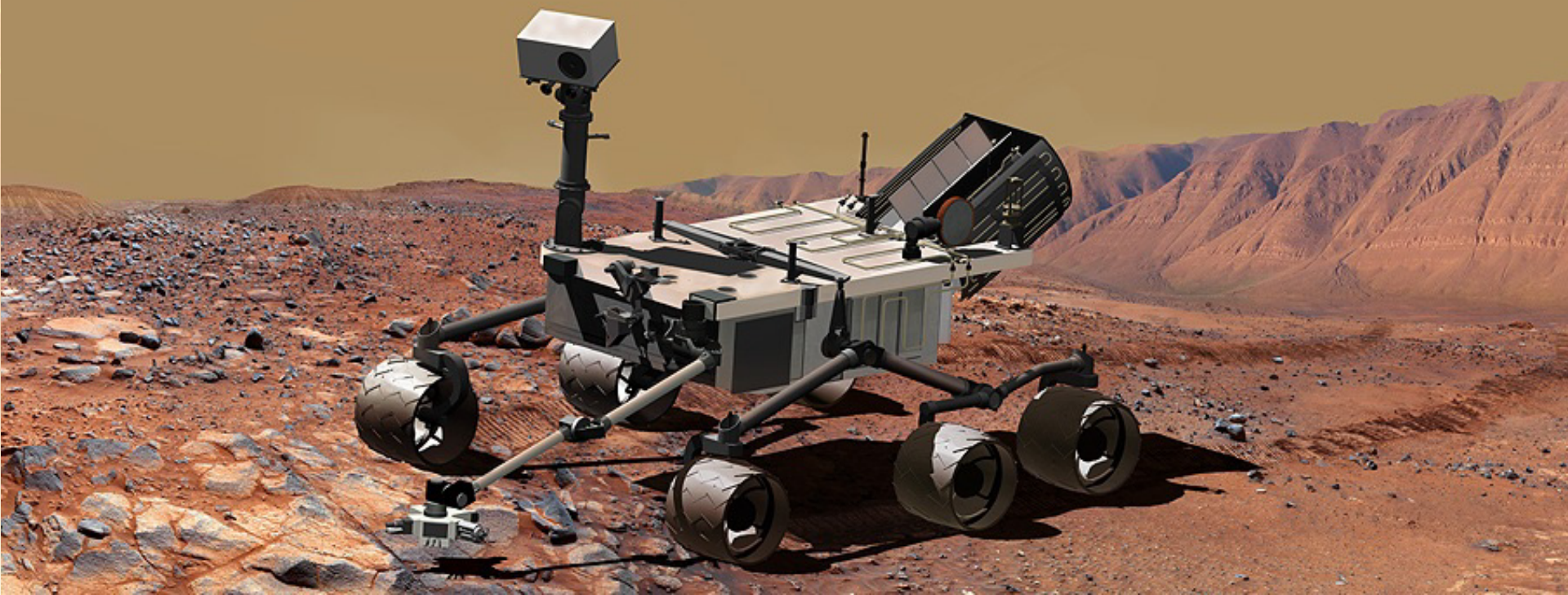
Enabling Capabilities

A Robotic Field Geologist

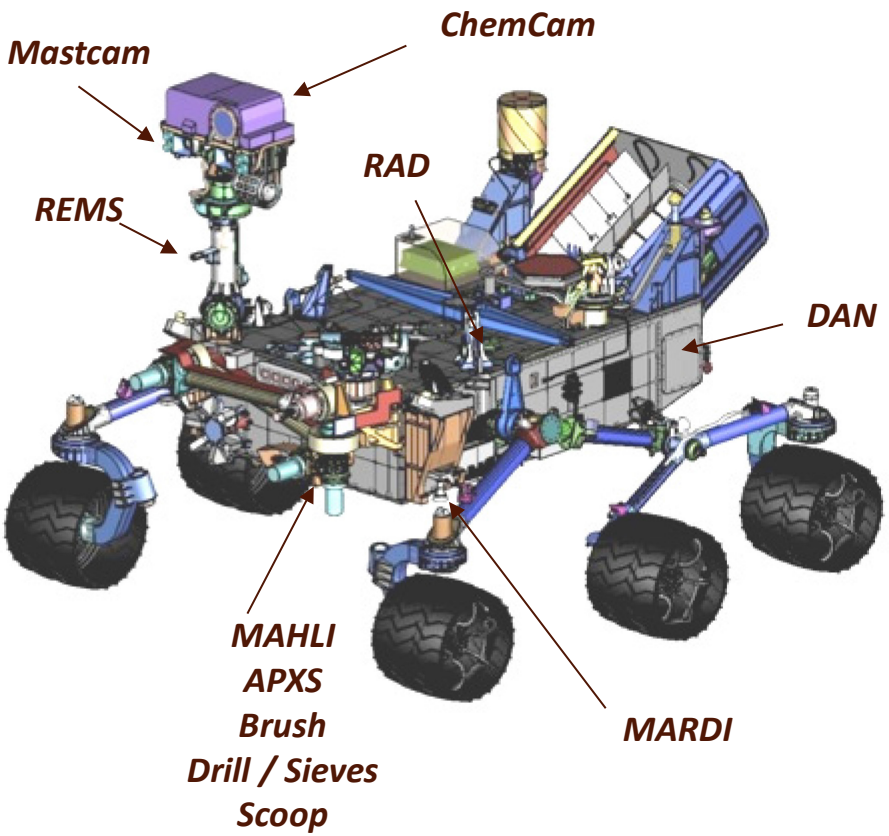
- Access to a site mapped from orbit
- Long life, mobility, capability to explore a local region
- Remote sensing and contact science

A Mobile Geochemical Laboratory

- A broad and flexible payload including analytical laboratory instruments
- Ability to acquire and process dozens of rock and soil samples
- An integrated science team and operations strategy



MSL Science Payload



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

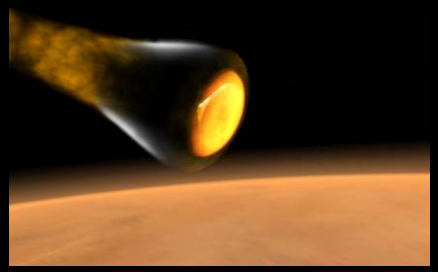
RAD (D. Hassler, SwRI) - High-energy radiation

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

Family Portrait

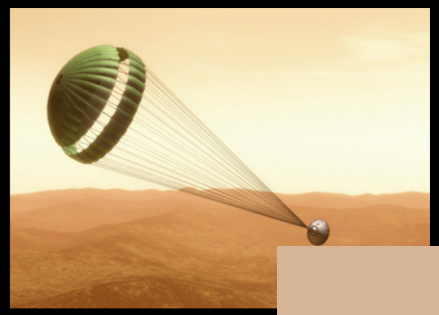
The Challenge of Entry, Descent and Landing

The 6 Minute Challenge



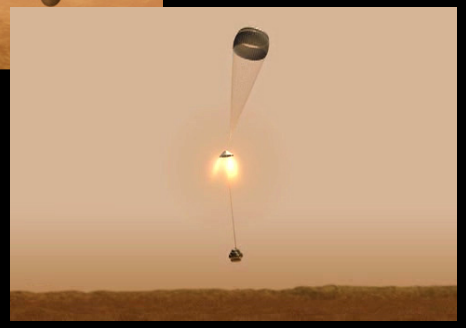
Entry

Energy Dissipation Via: Aerodynamic Drag / Aerothermodynamic heating
Velocity Range: 12,000 mph → 1,000 mph
Peak Temperature : 1447° C
% of Total Energy Dissipated: 99.0 %



Parachute Descent

Energy Dissipation via: Aerodynamic Drag
Velocity Range: 1,000 mph → 200 mph
% of Total Energy Dissipated: 0.98 %

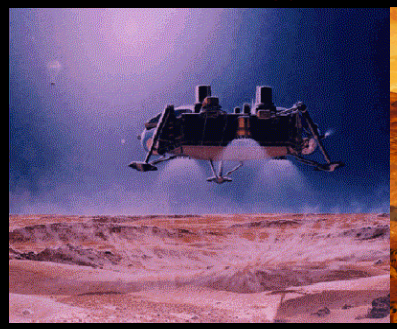


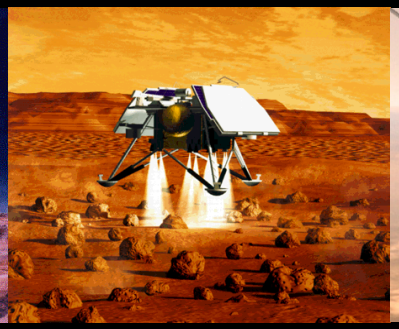
Powered Descent

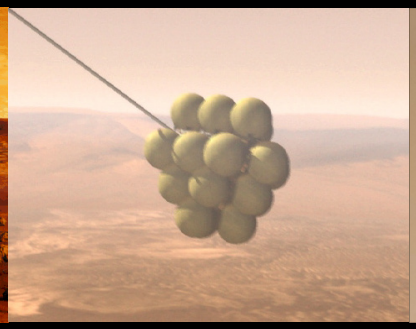
Energy Dissipation Via: Rocket Thrust
Velocity Range: 200 mph→4-40 mph
% of Total Energy Dissipated: 0.002%

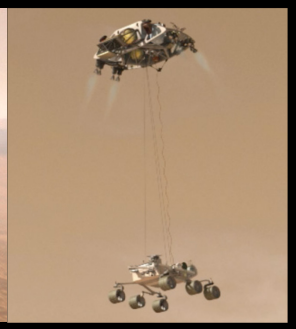
Landing

Energy Dissipation Via: Viscous Damping or Plastically Crushed Material
Velocity Range: 4 – 40 mph → 0.0 mph
% of Total Energy Dissipated: 0.0009%









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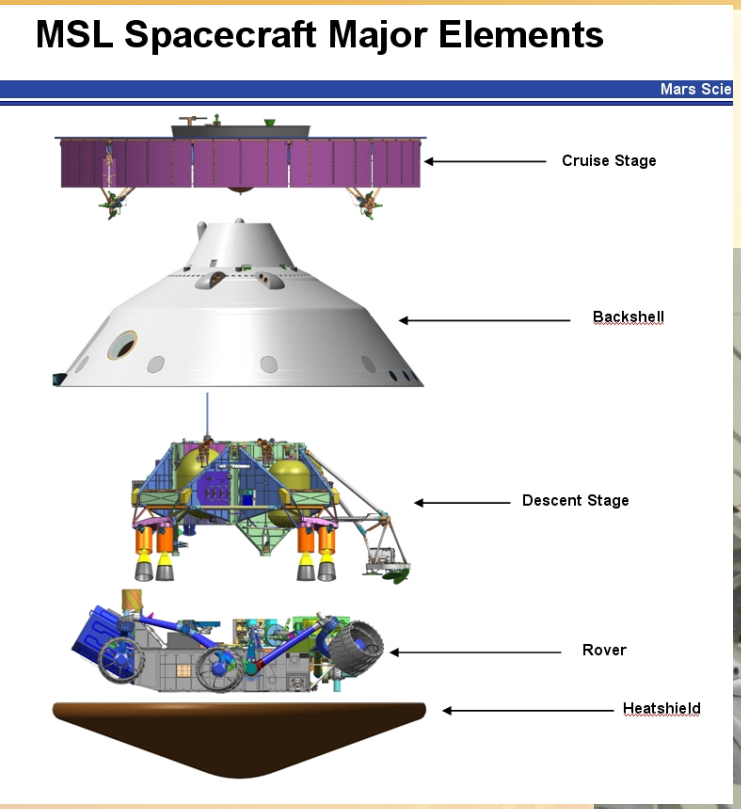
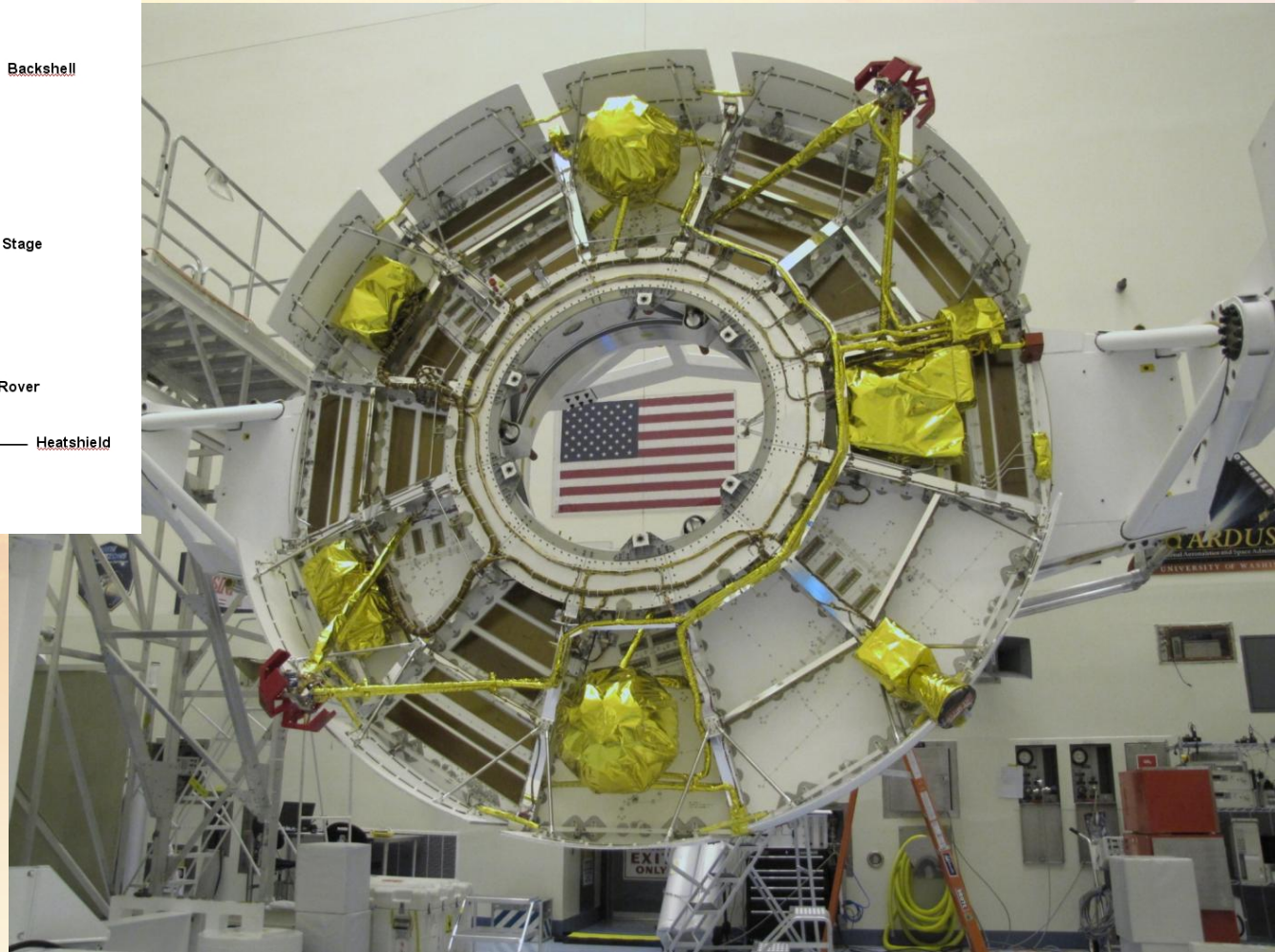
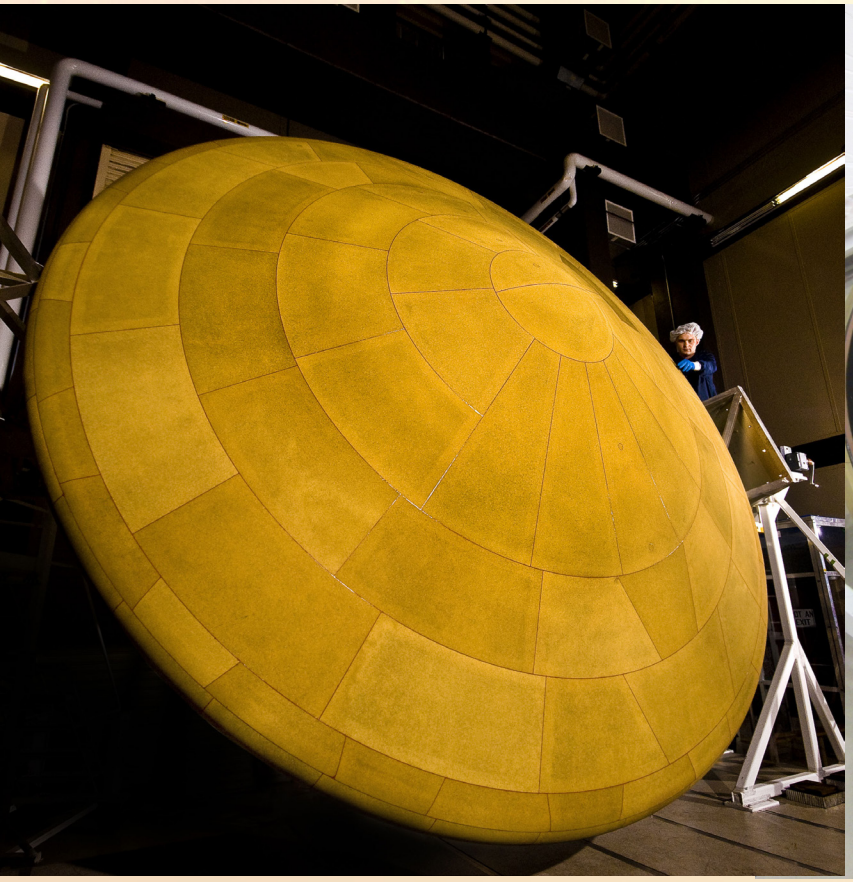
Cruise Stage

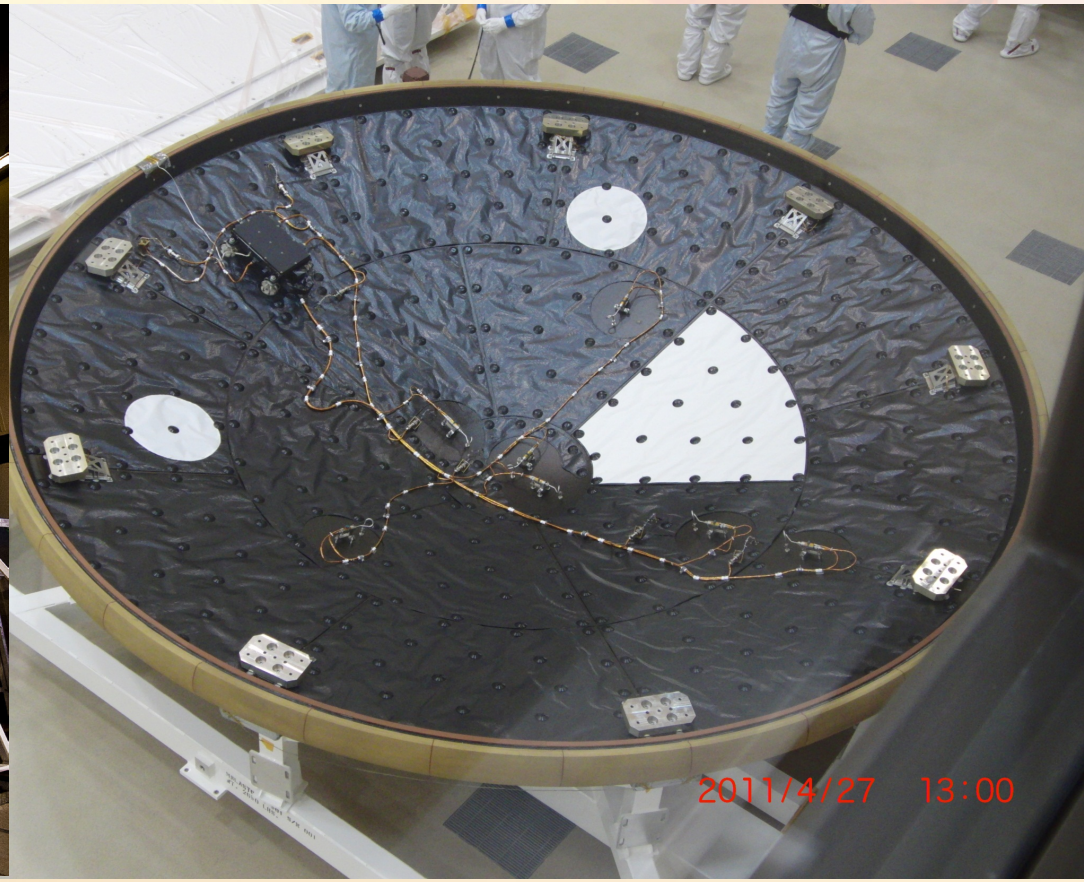




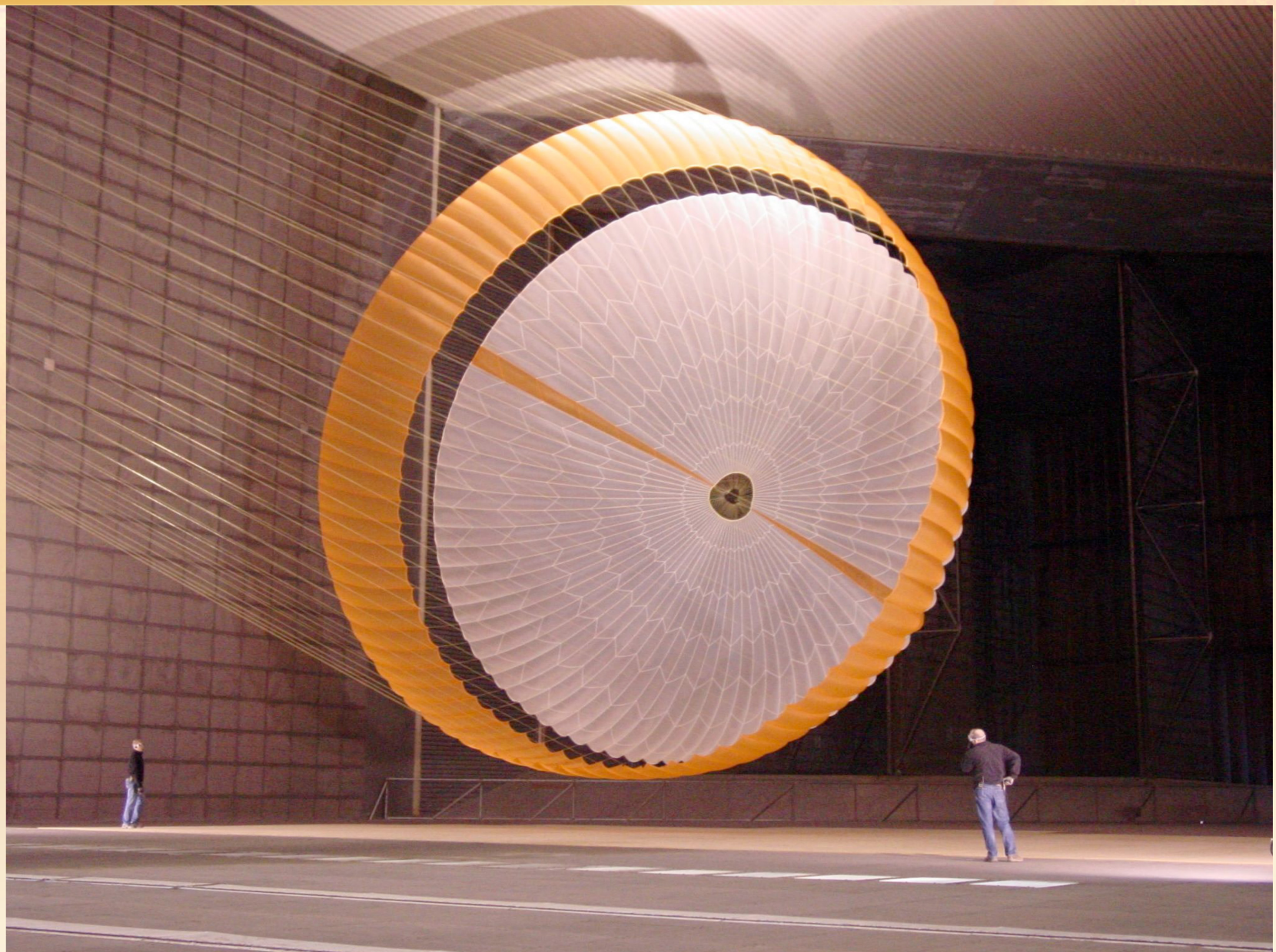
Aeroshell Test

Heatshield



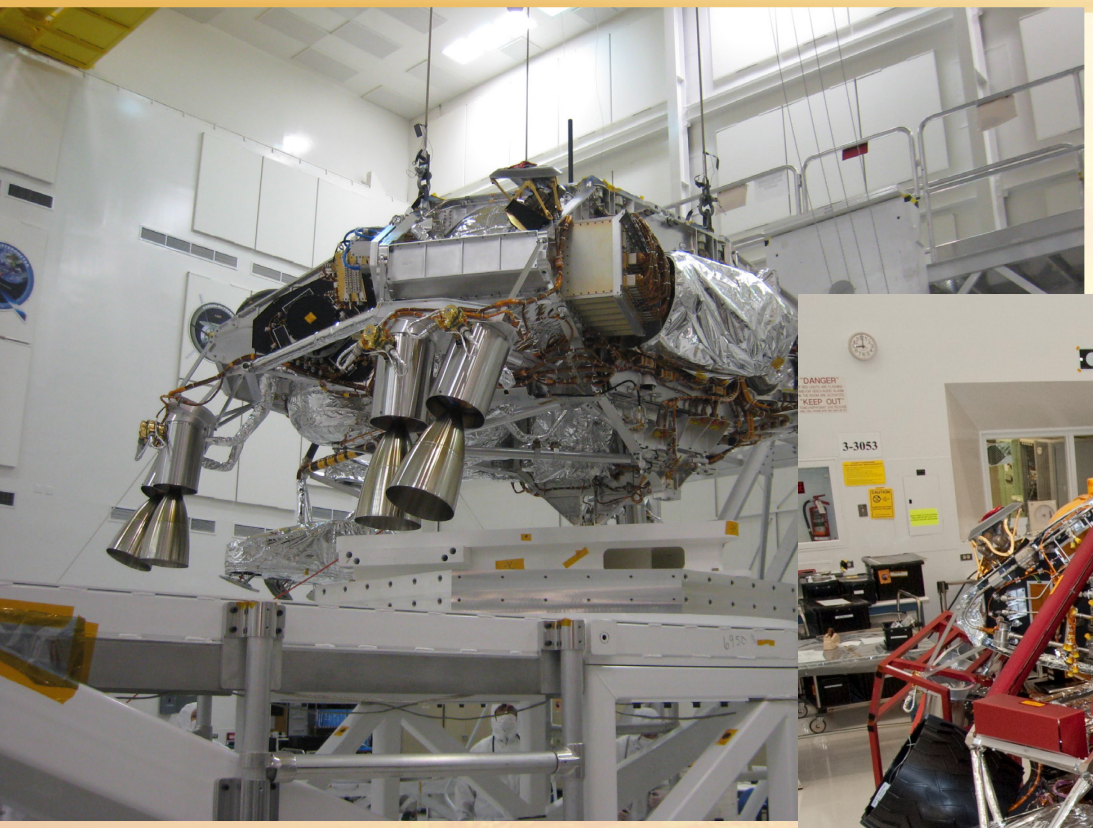


Parachute Test



Landing Radar Test in California Desert

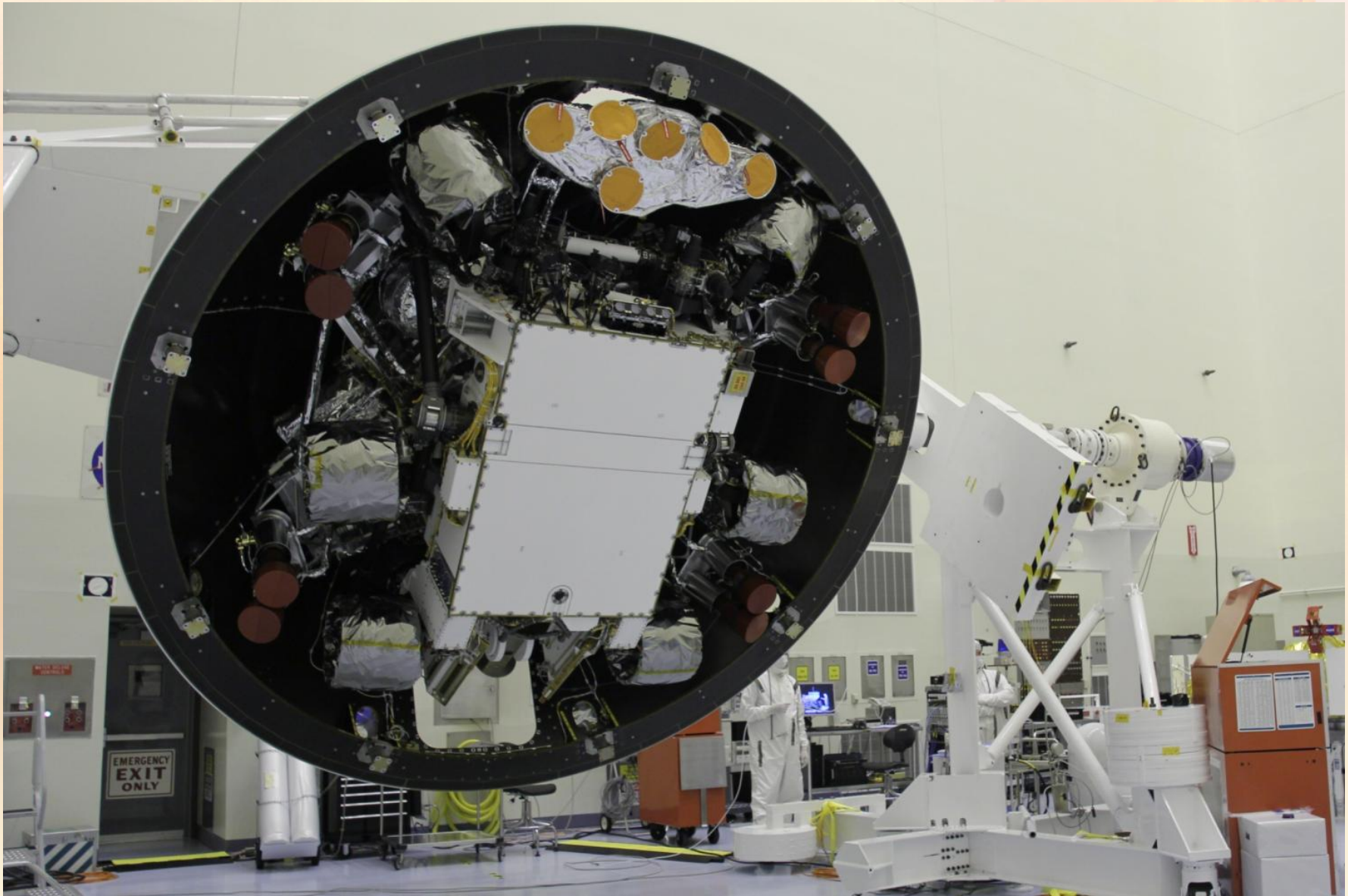
Descent Stage



Descent Stage

Powered Descent Vehicle
(Descent Stage + Rover)

Powered Descent Vehicle Stowed in Backshell



Curiosity Suspended Below the Descent Stage

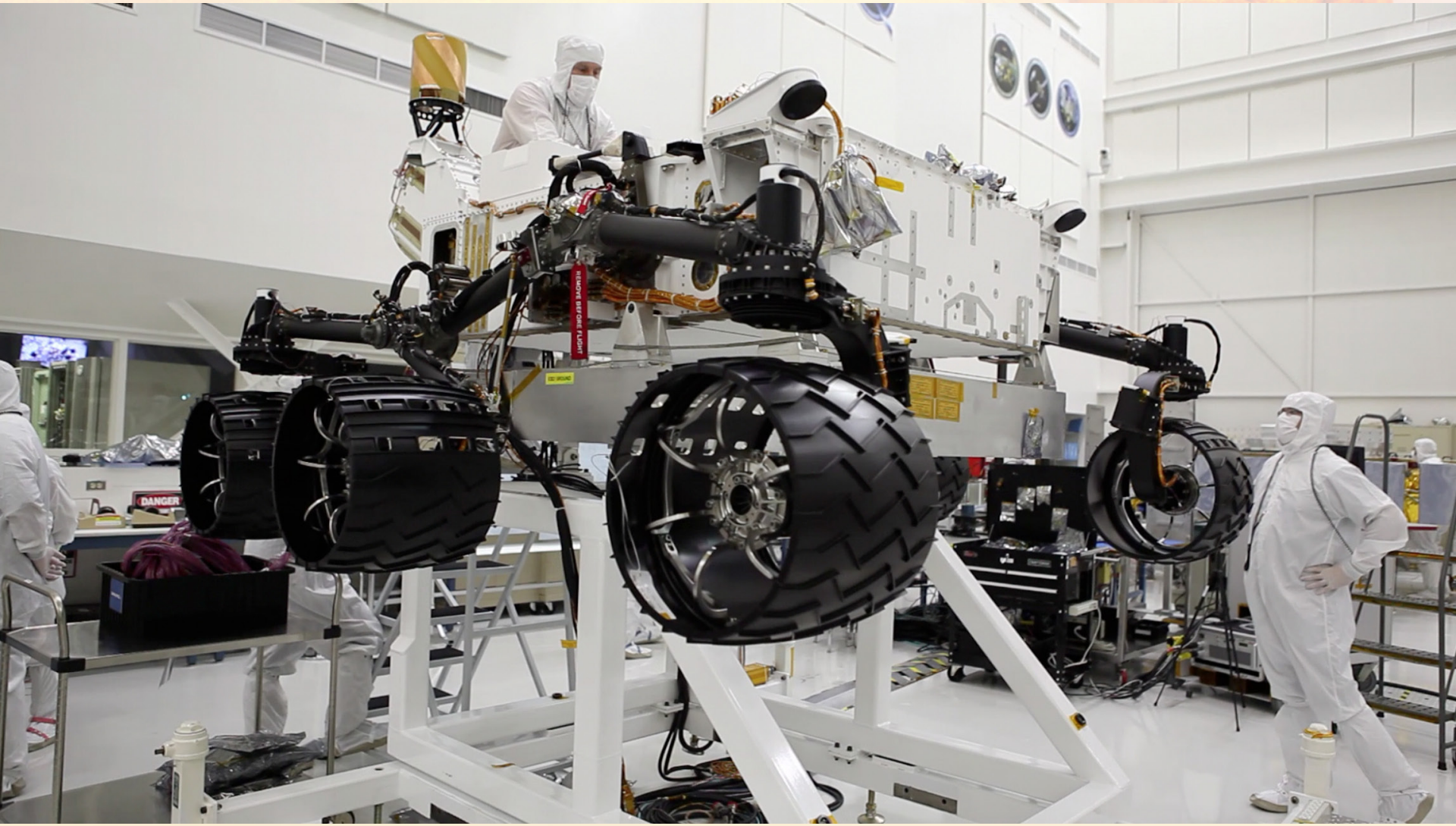
“Building Curiosity” Video – YouTube
Full Motion Drop Test

http://mars.jpl.nasa.gov/msl/multimedia/videos/movies/msl20110119/msl20110119-640.mov

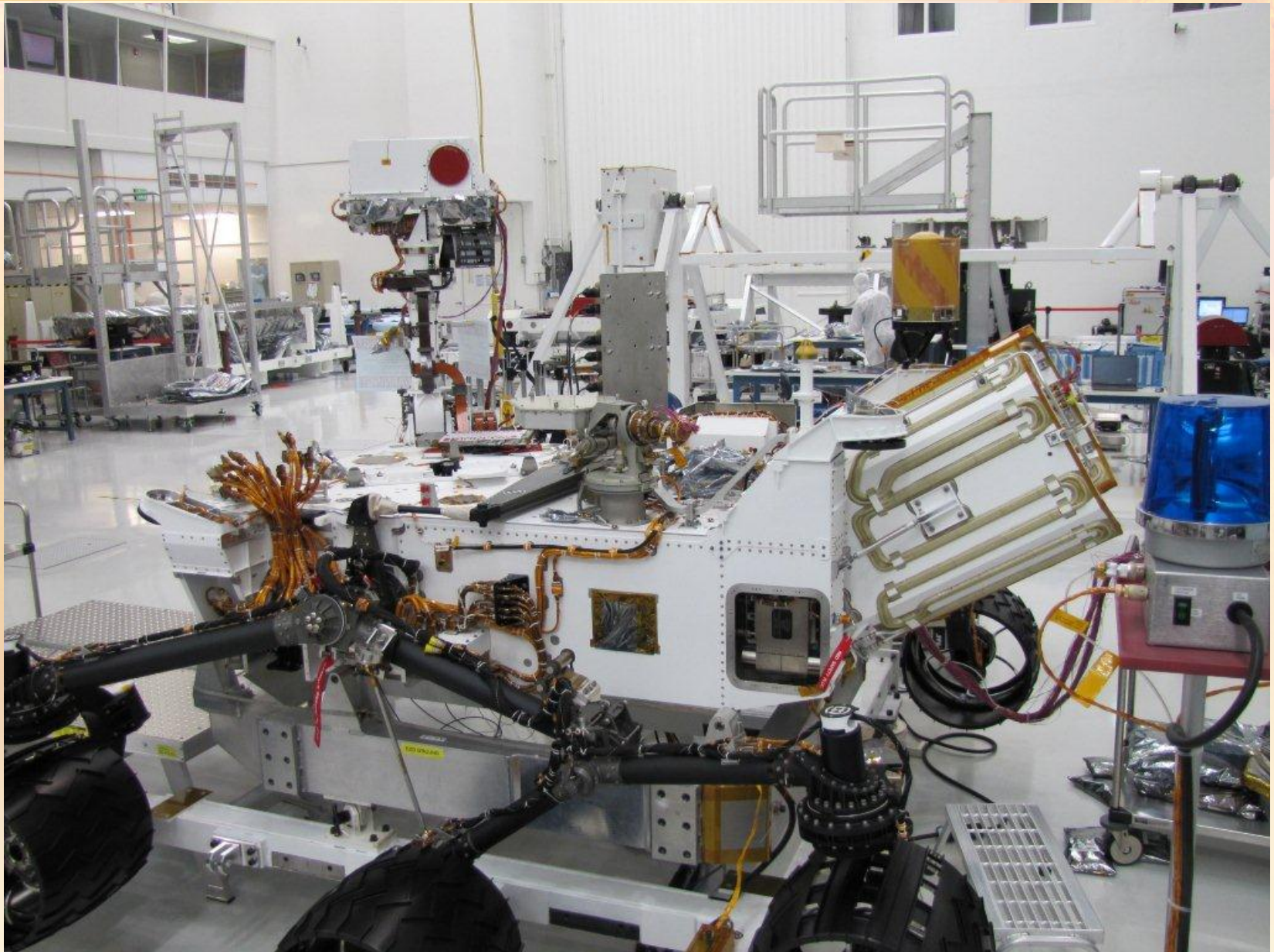
Curiosity

Our Mobile Field Geologist/Analytical Laboratory

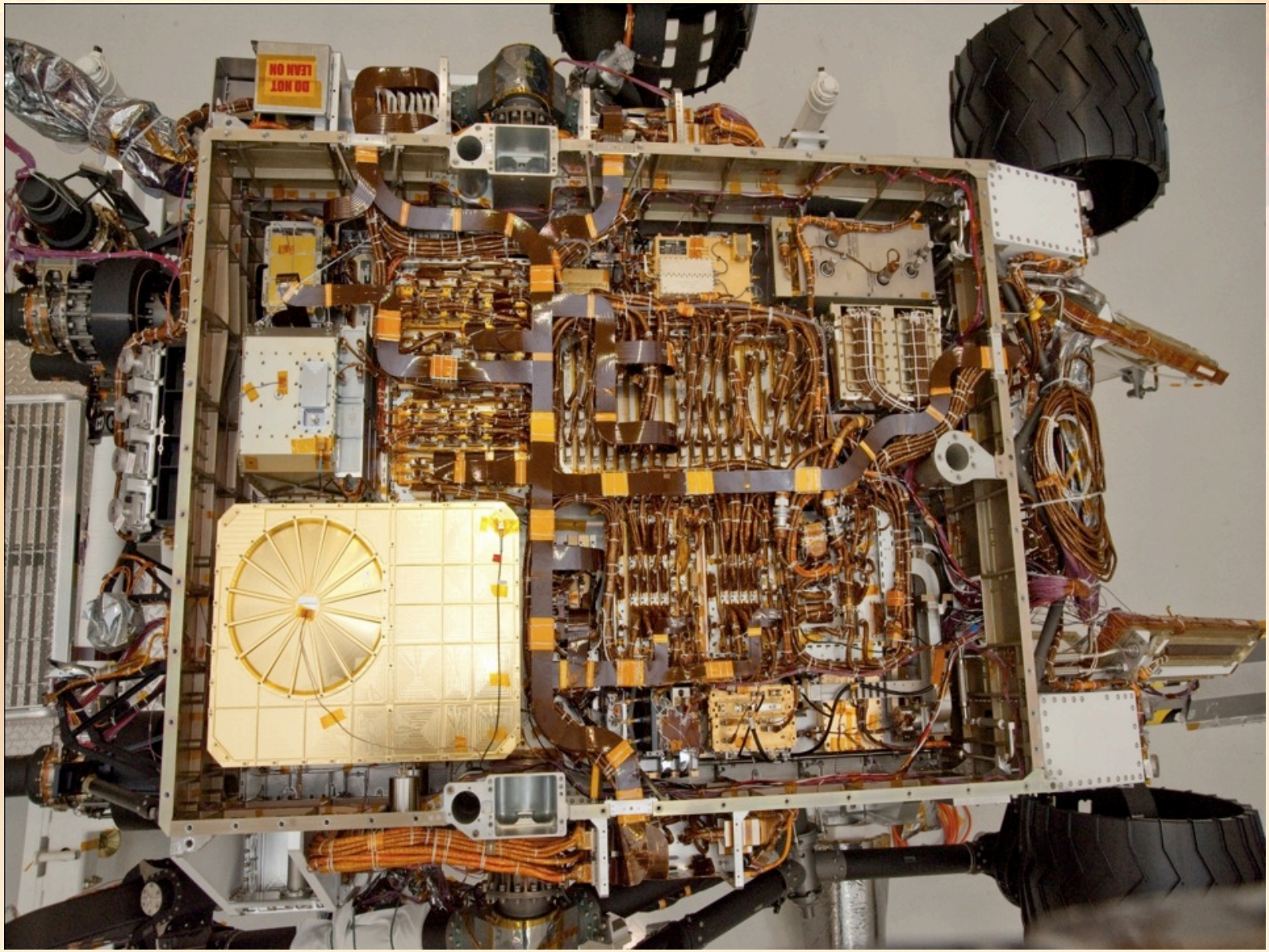
Curiosity Gets Her Wheels!



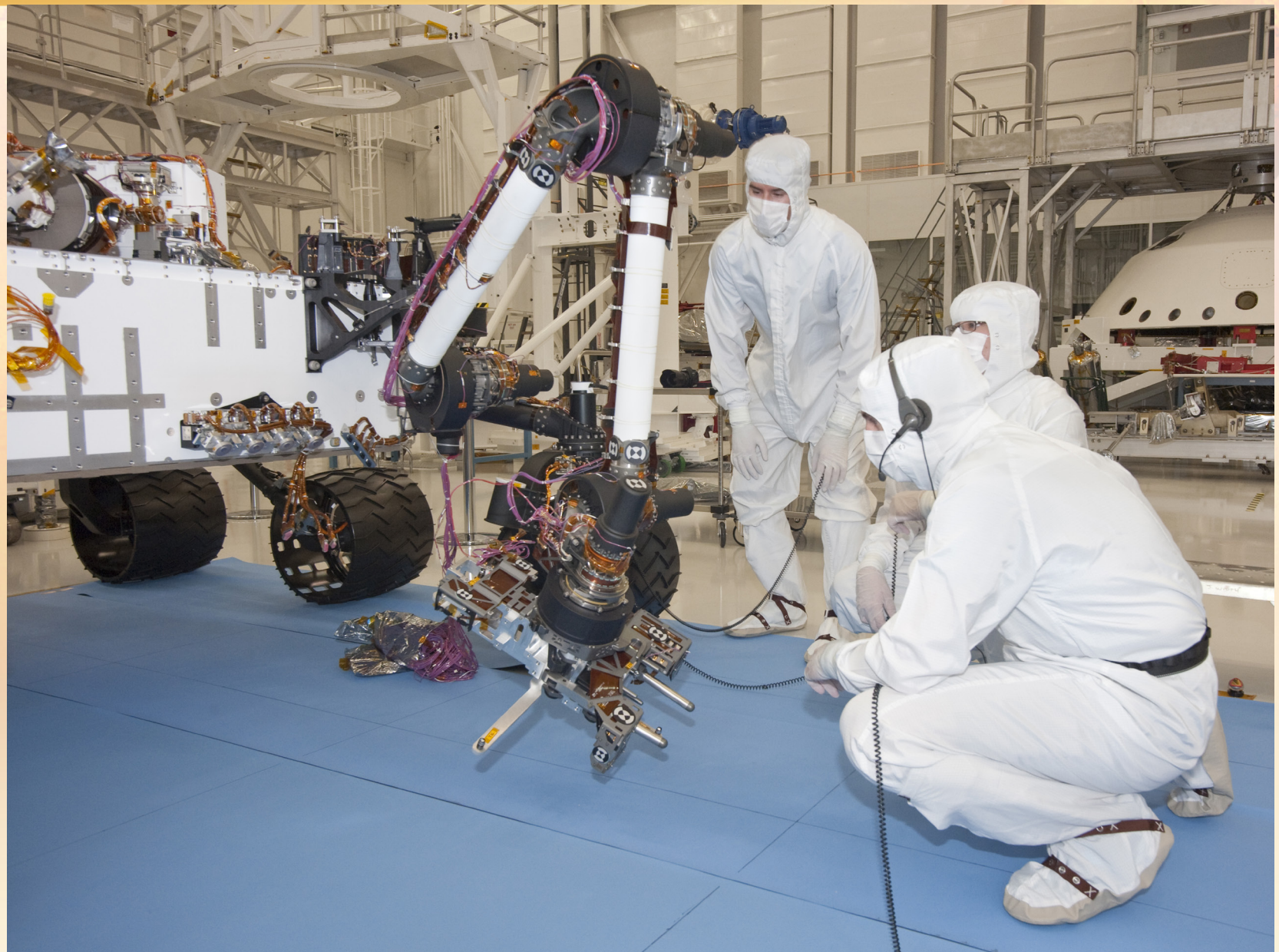
Remote Sensing Mast Deployed



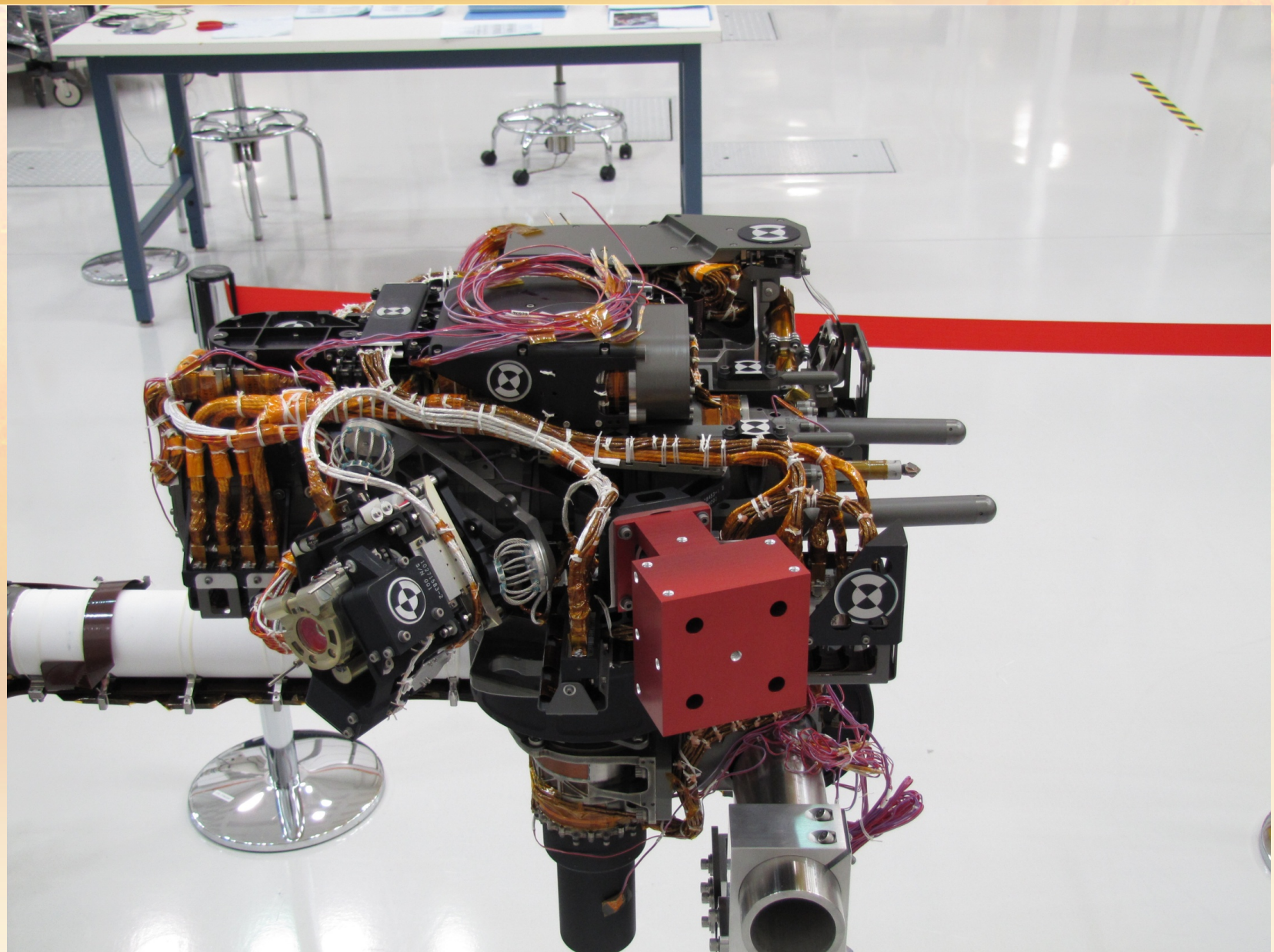
Spaghetti Everywhere!



Flexing Her Muscles!



Turret – Sample Collection and Portioning



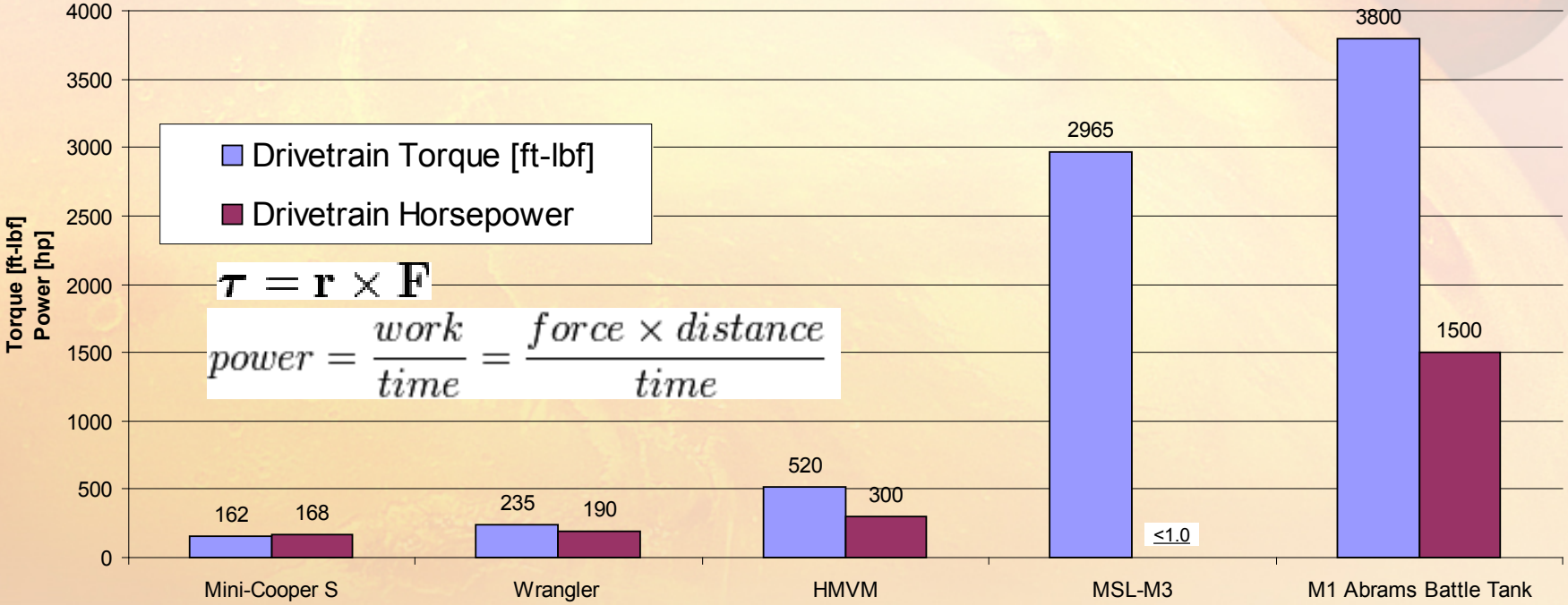
Drill/Sample Collection

System Test Bed Drills

Flight Unit Traverse Tests

Torque: A Perspective

- *Current torque capability*
  - *~80% the torque output of an M1 Abrams Main Battle Tank*



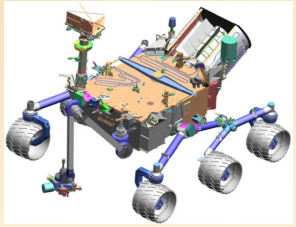
$$\tau = \mathbf{r} \times \mathbf{F}$$

$$power = \frac{work}{time} = \frac{force \times distance}{time}$$

Curb Weight 2,700 lbs

3,500 lbs

6,820 lbs

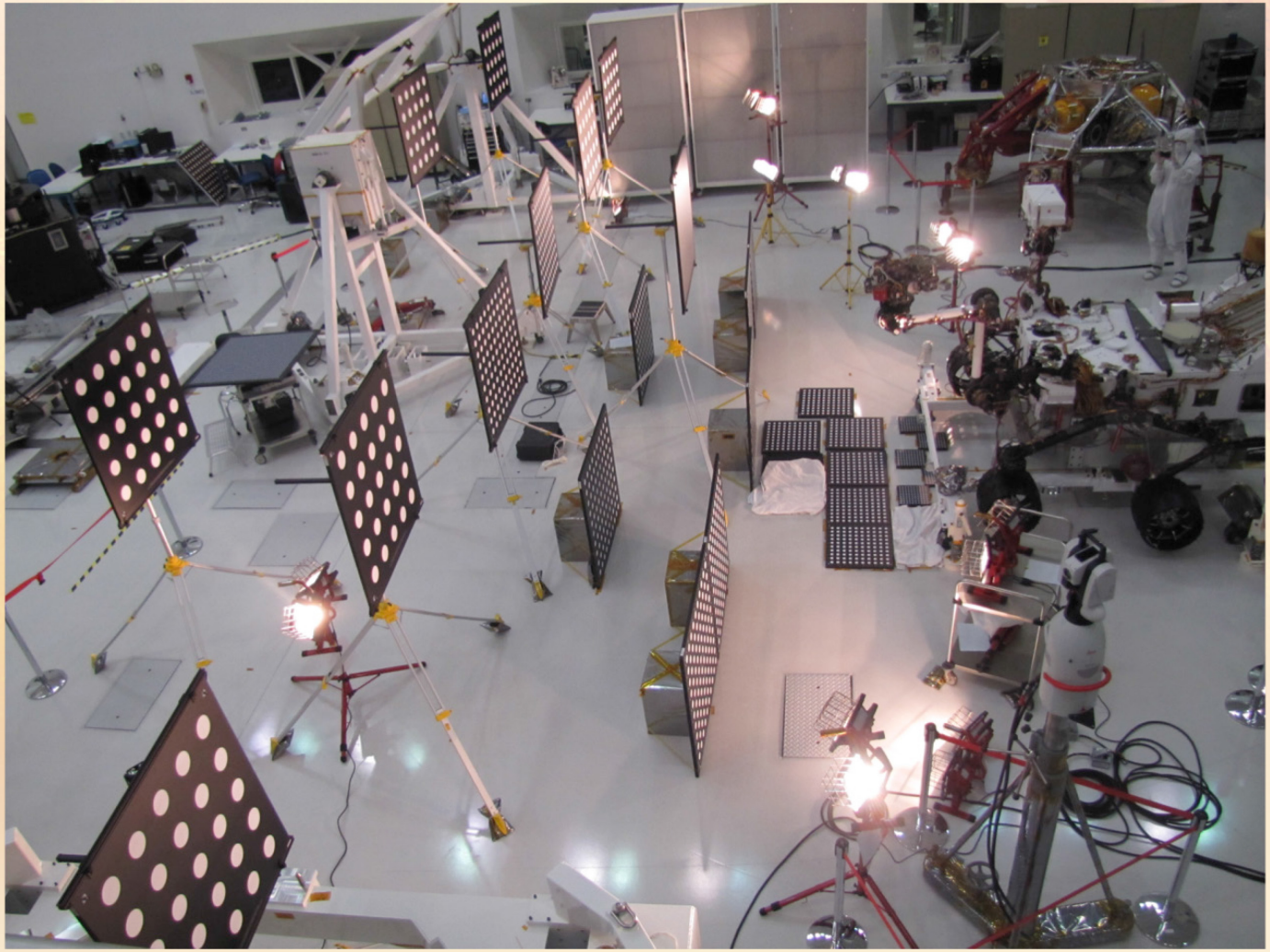


~2,000 lbs

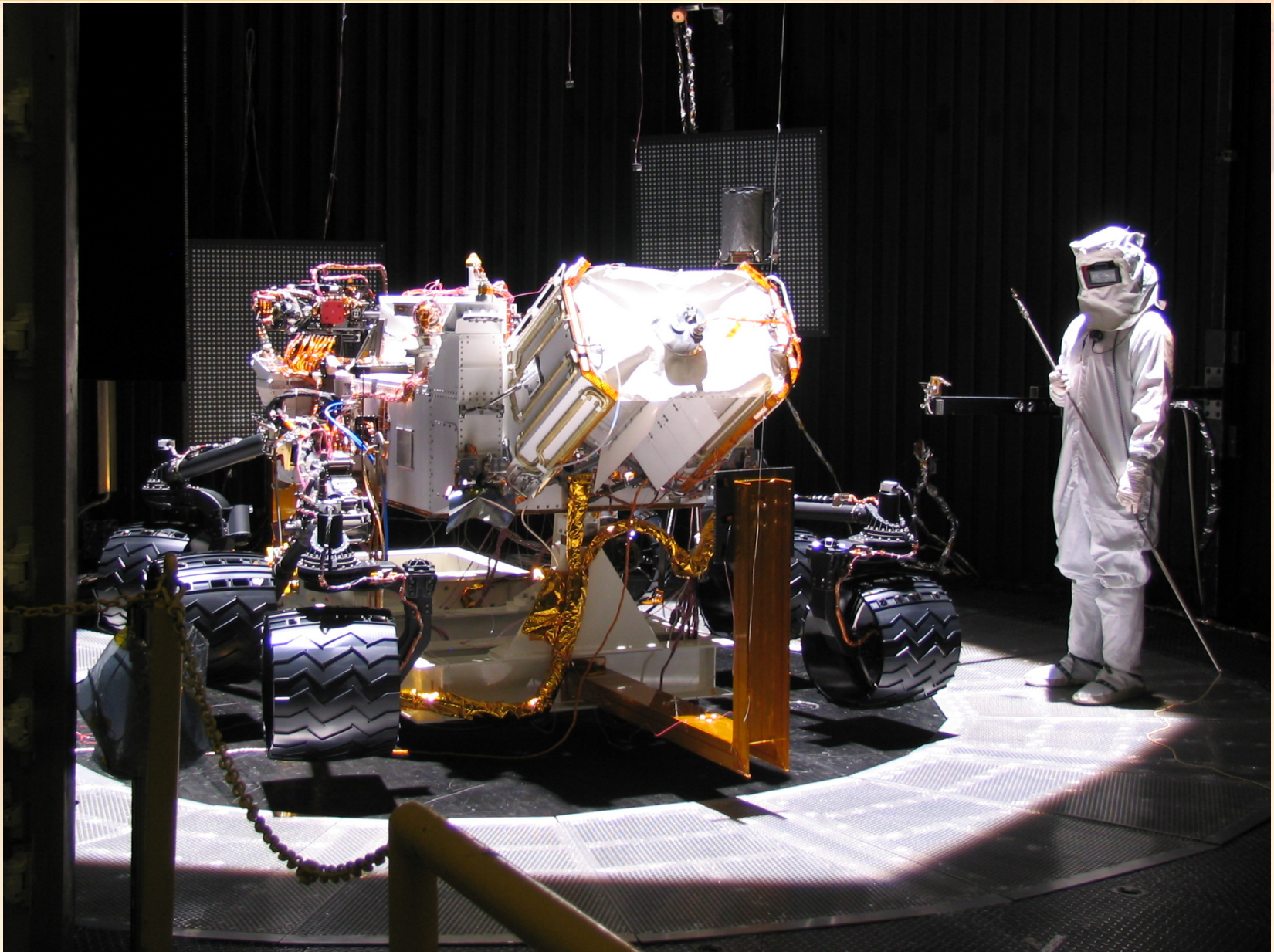
120,000 lbs

Verification of Operations on Slope

Rover Camera Testing



Surface System Environmental Test

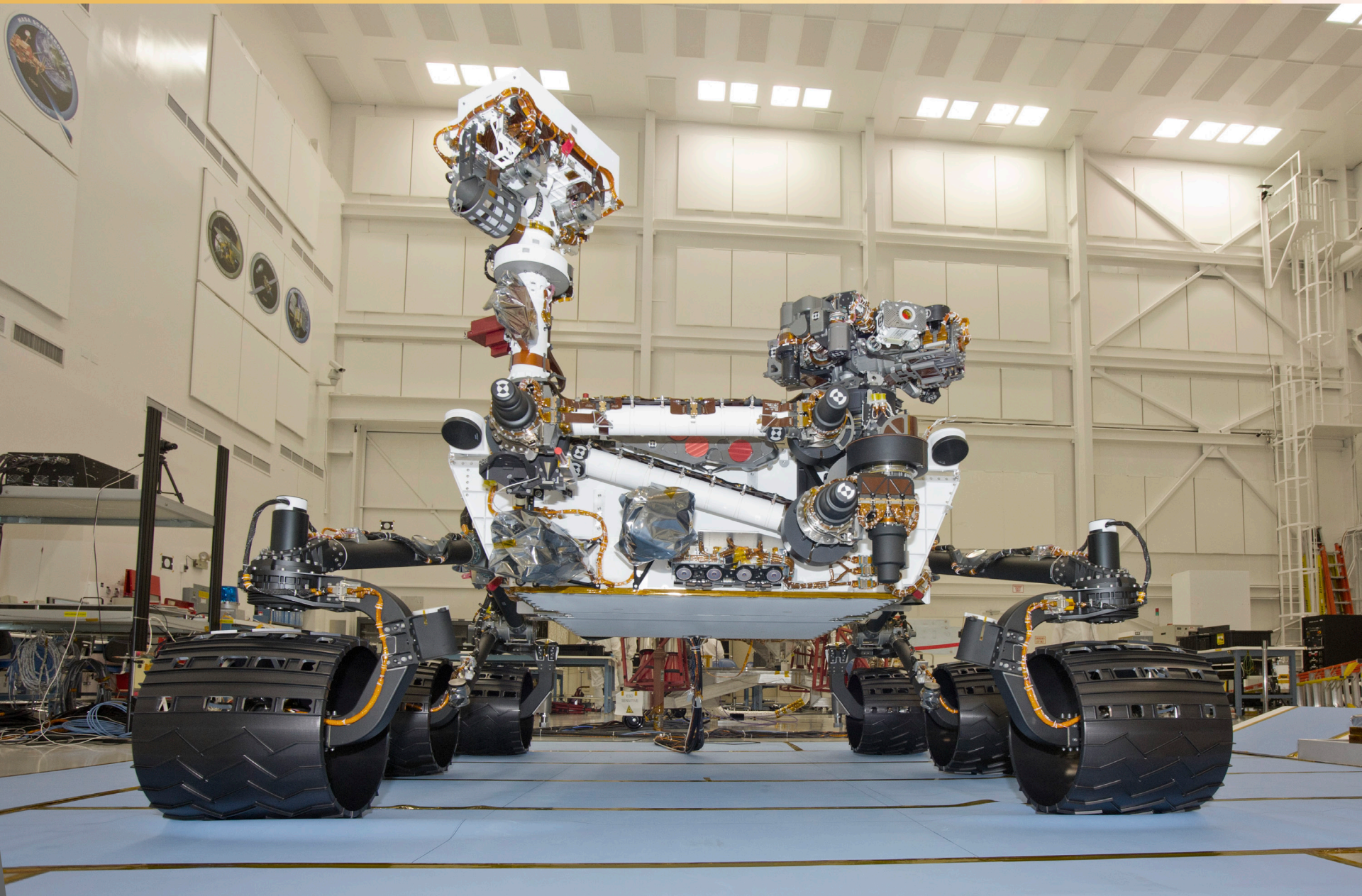


Aeroshell "Fit Check"

YouTube Video

http://mars.jpl.nasa.gov/msl/multimedia/videos/movies/CuriosityUpdate_20110318/CuriosityUpdate_20110318-640.mov

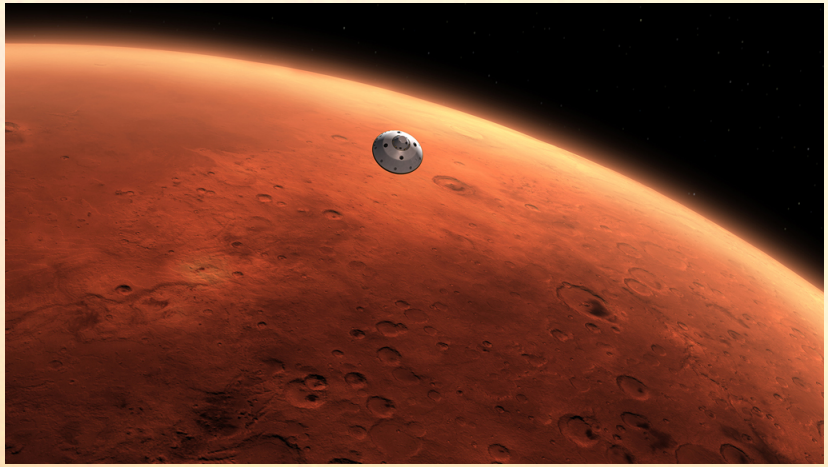
“Ready For Mars!”

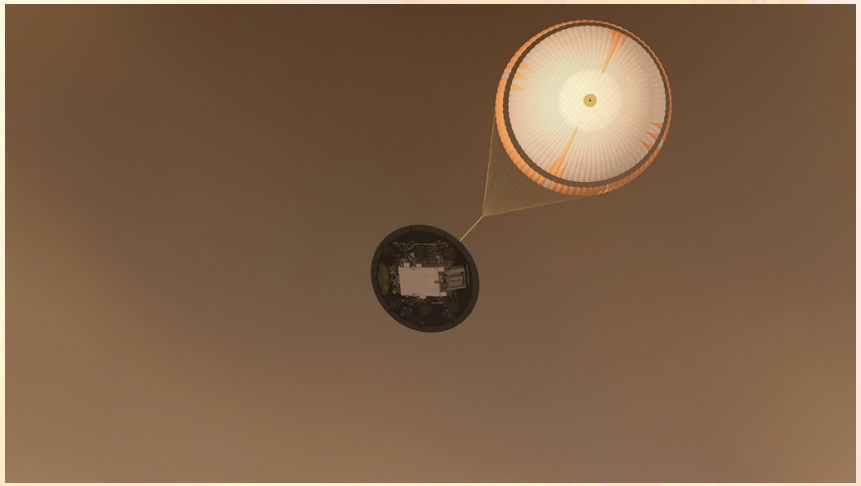


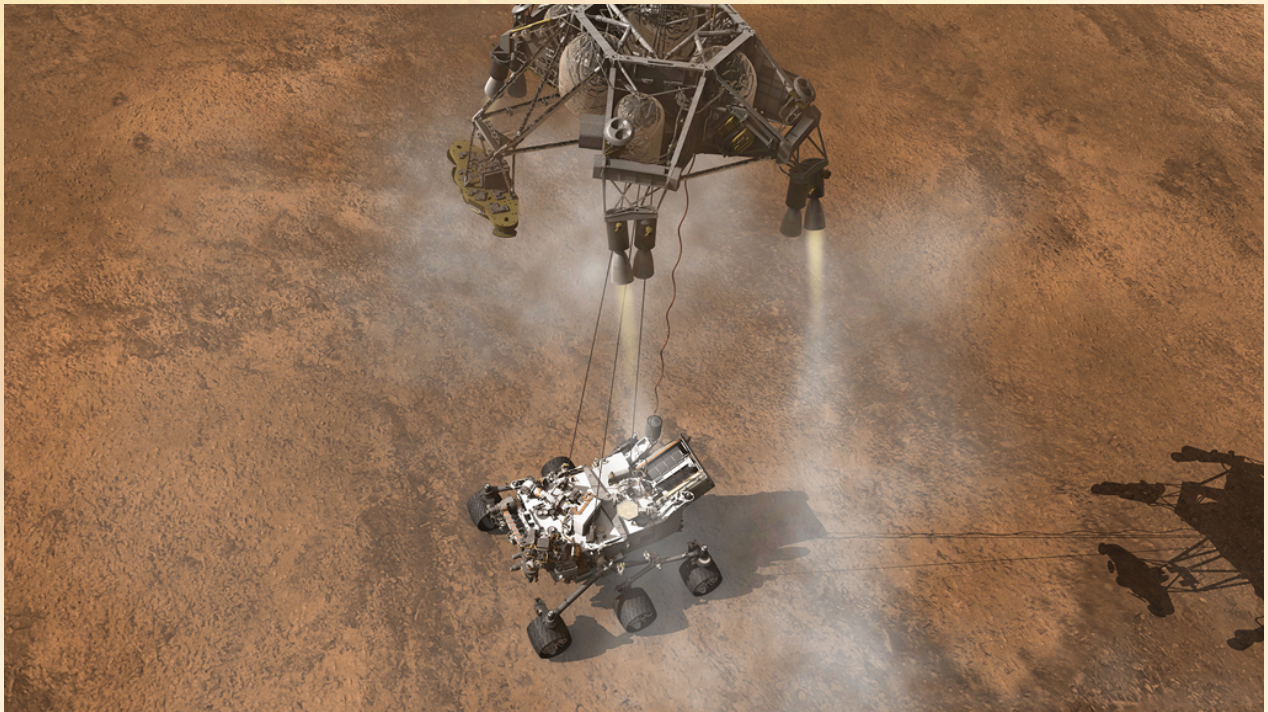
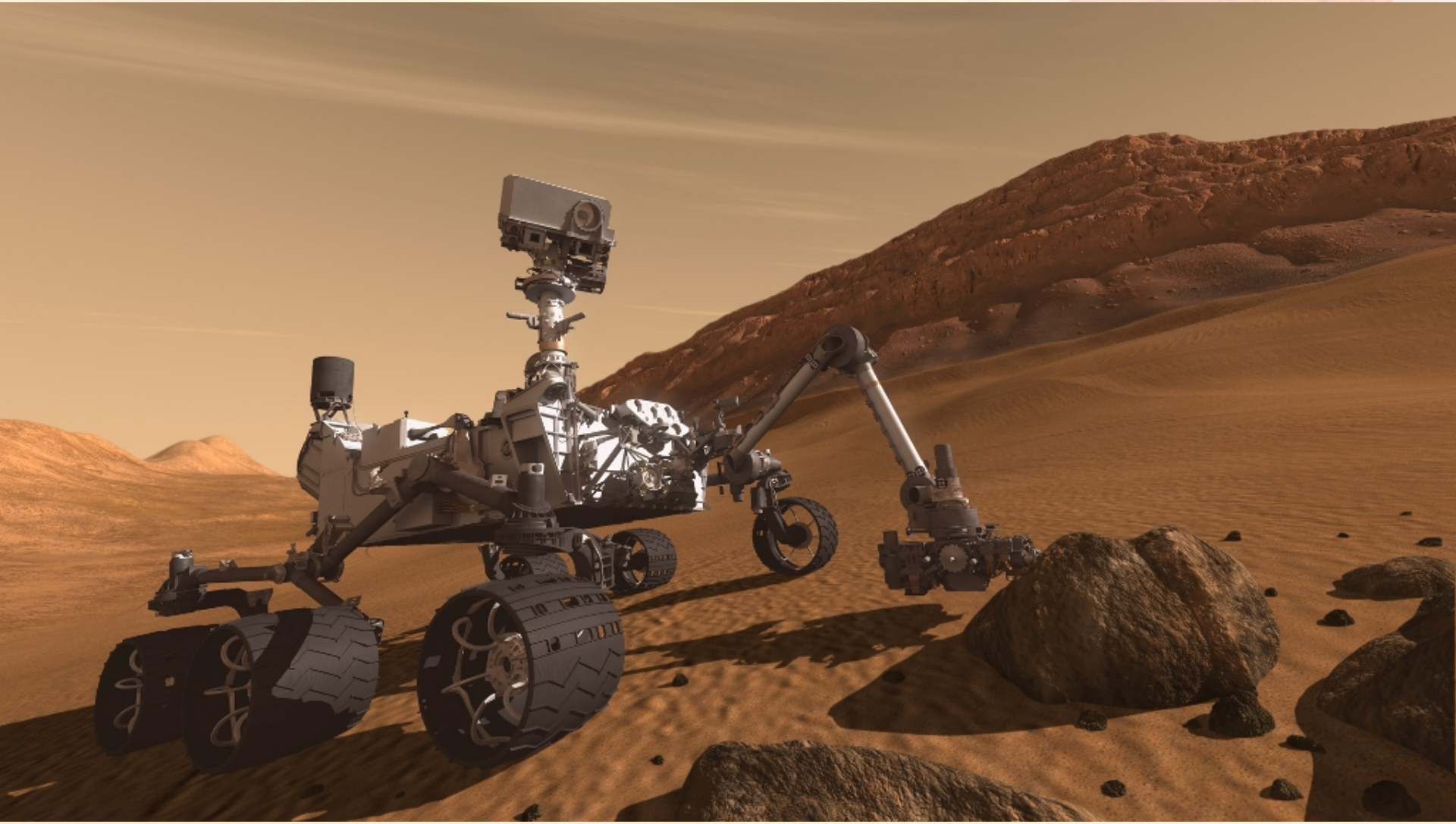
Liftoff In 7 Days!

http://mars.jpl.nasa.gov/msl/

August 5, 2012







and Beyond!