Mars Science Laboratory

Challenges in Operating the Mars Science Laboratory Curiosity Rover

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California Institute of Technology

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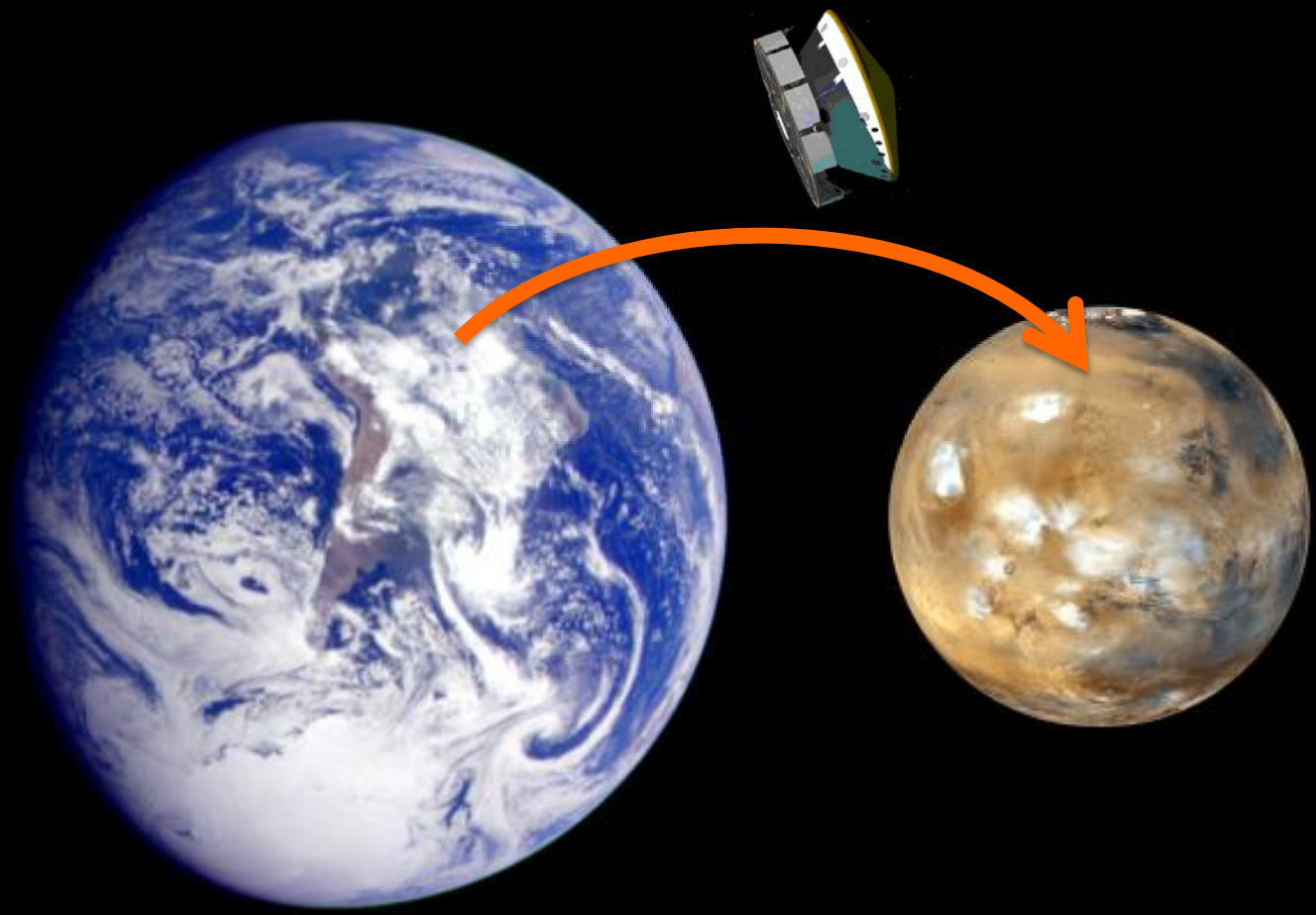
Launch/Cruise View of Mission



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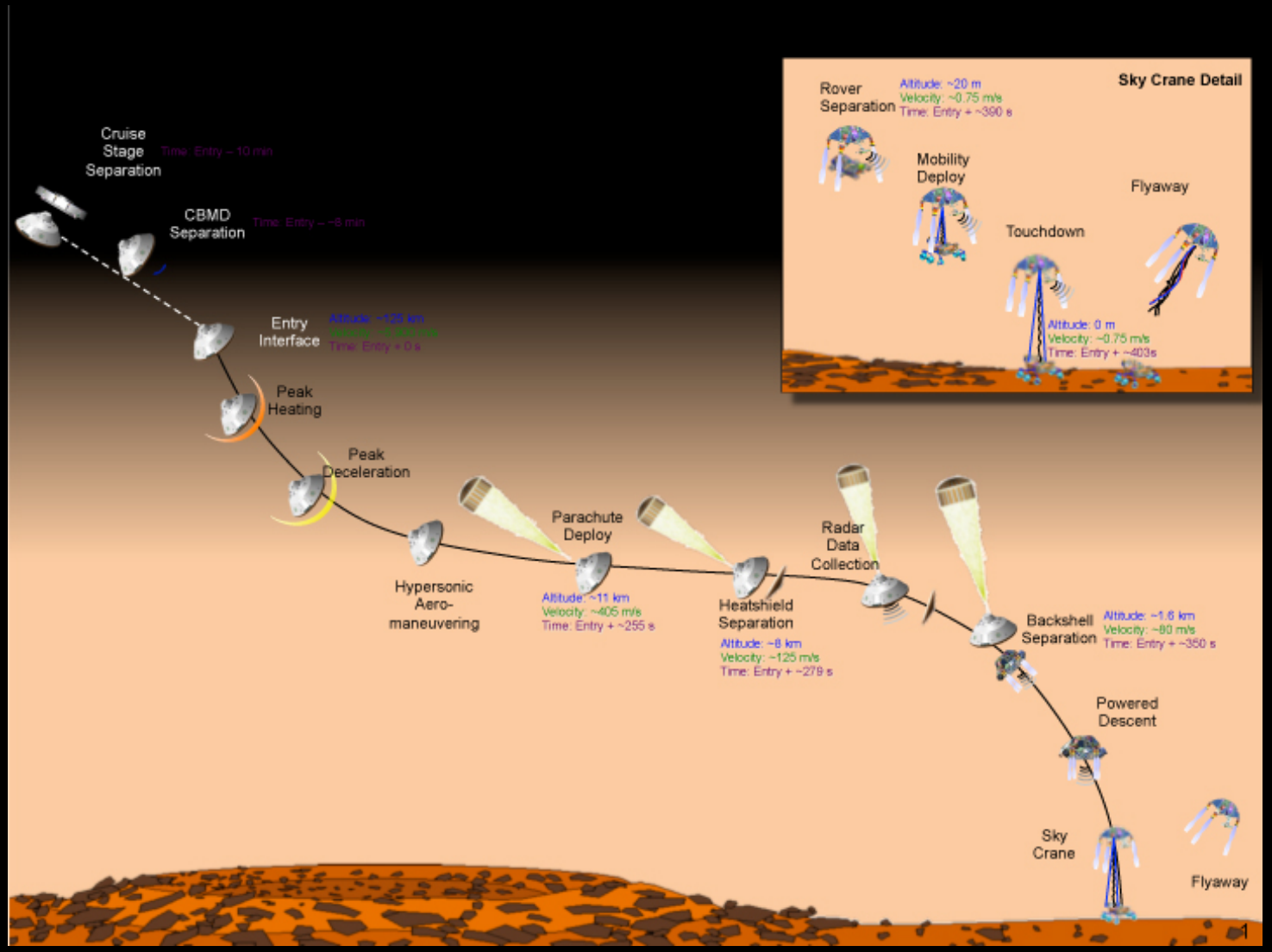
EDL View of Mission



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Surface View of Mission

Image courtesy of Poonsap/FreeDigitalPhotos.ne

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Curiosity Rover: One year on Mars Video (03:59)

- http://mars.jpl.nasa.gov/msl/multimedia/videos/index.cfm?v=137

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Operational Challenages

- **Mars Surface Environment**
- **Mission of Discovery**
- **Operational Approach**

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The Surface of Mars Is A Dynamic Place

- Day/night cycle changes lighting/shadows (Mars solar day or sol ~39 minutes longer than Earth day)
- Daily temperature swing from approximately -80C at night to 0C during the day with seasonal temperature changes over the Martian year (1 Mars Year = ~23 Earth Months)
- Curiosity is interacting with a natural terrain
- Wind
- Dust

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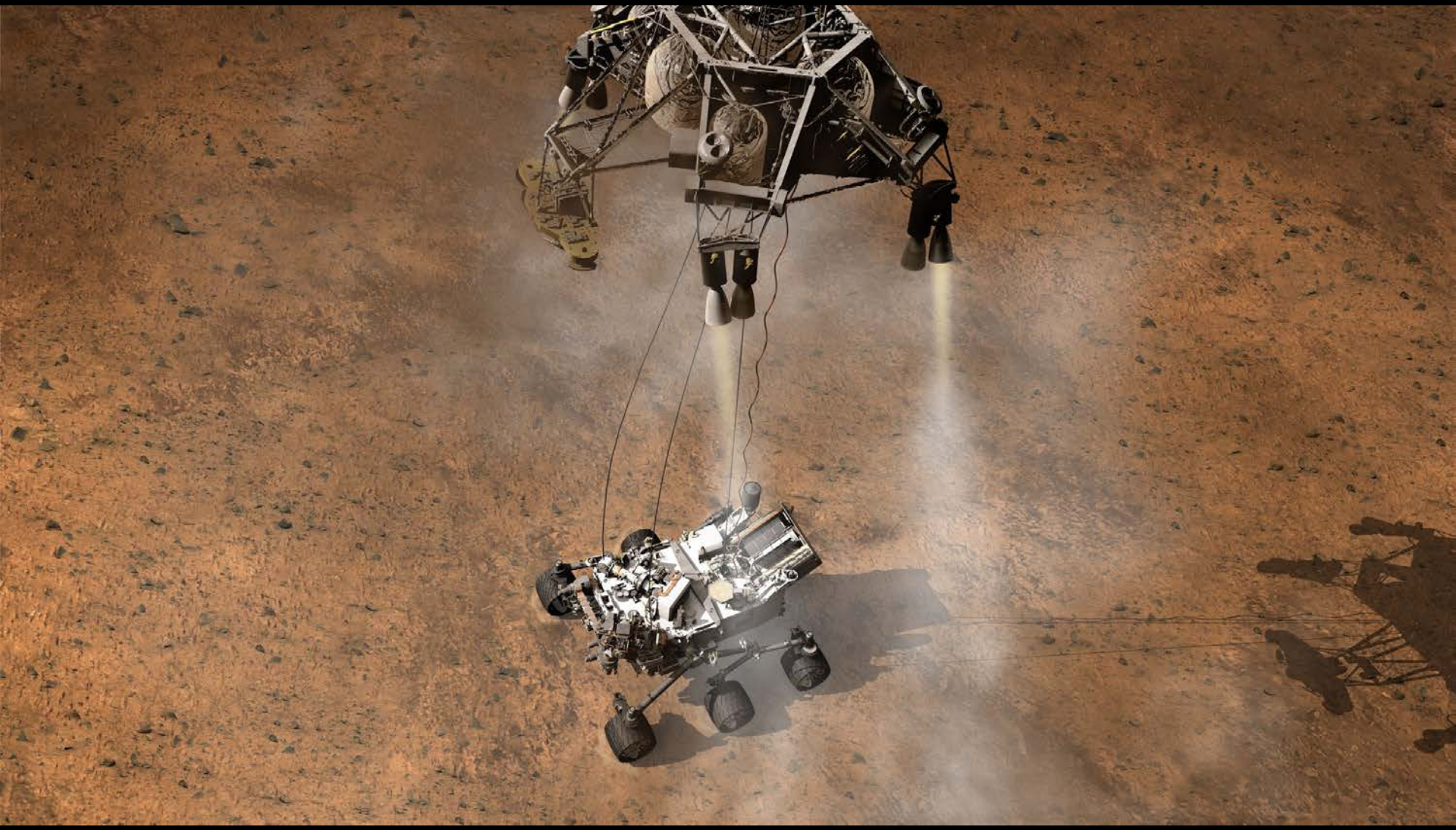
Skycrane & Dust



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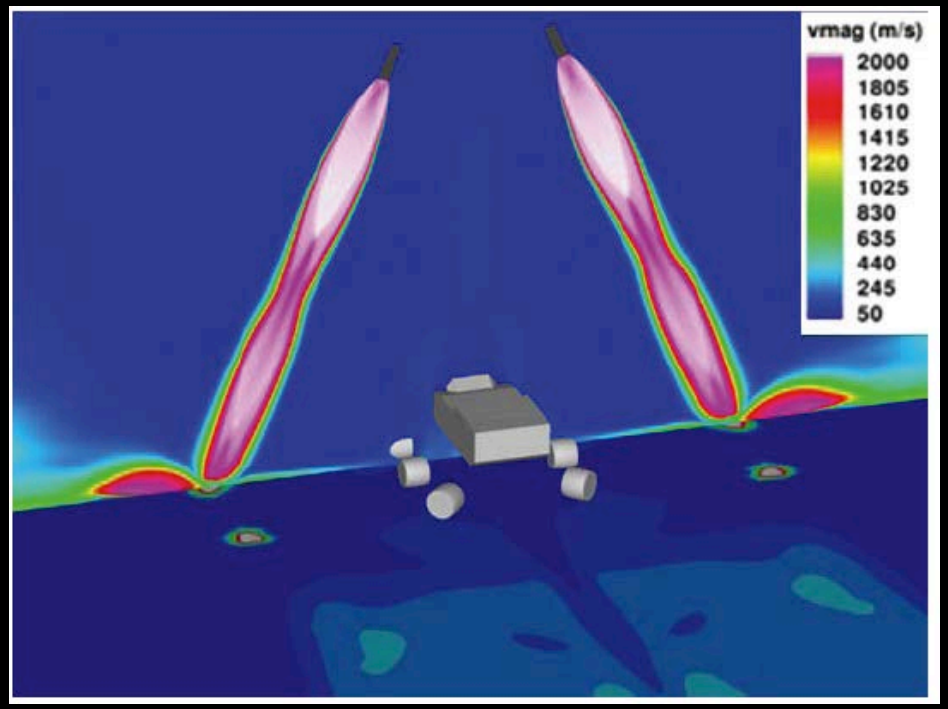
Predict & Reality



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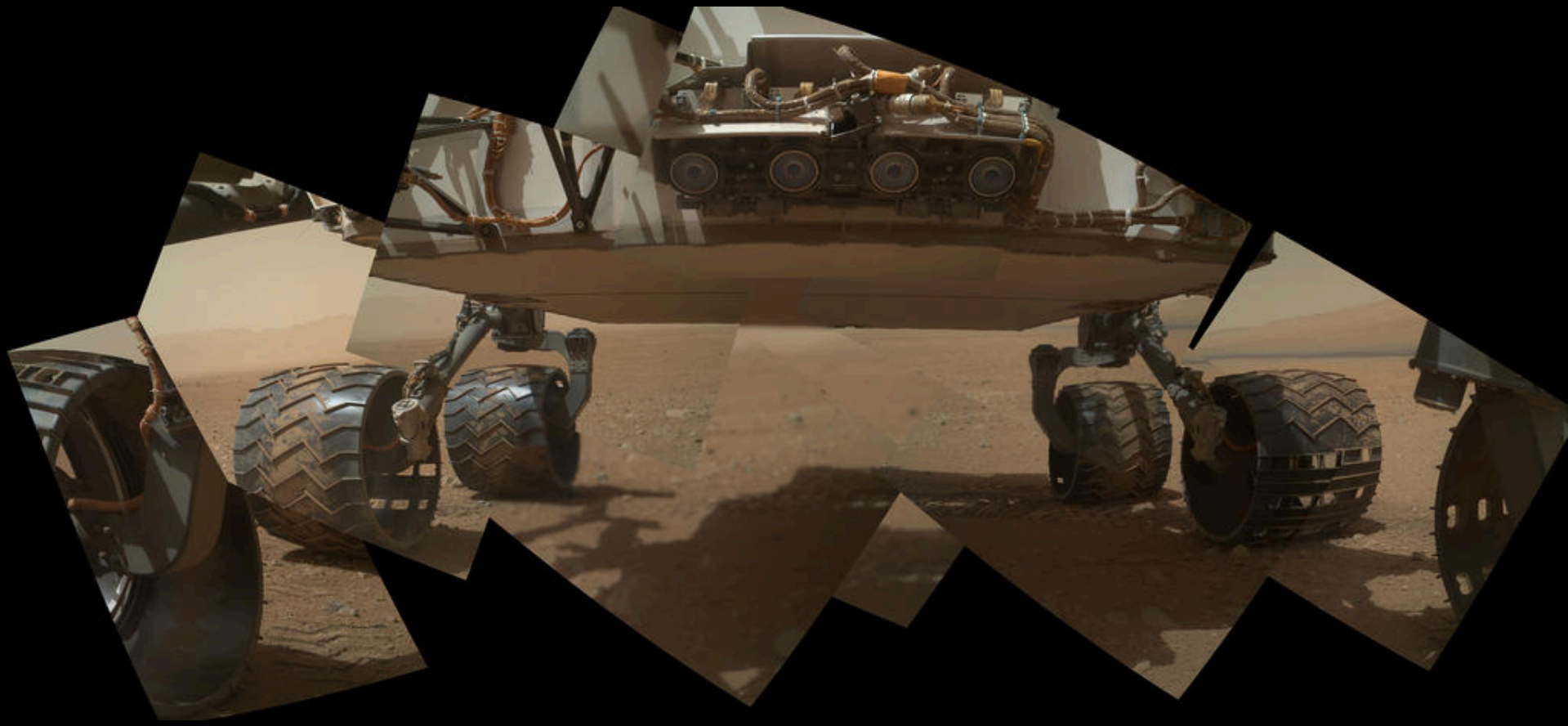
HAZCAM Dust Covers



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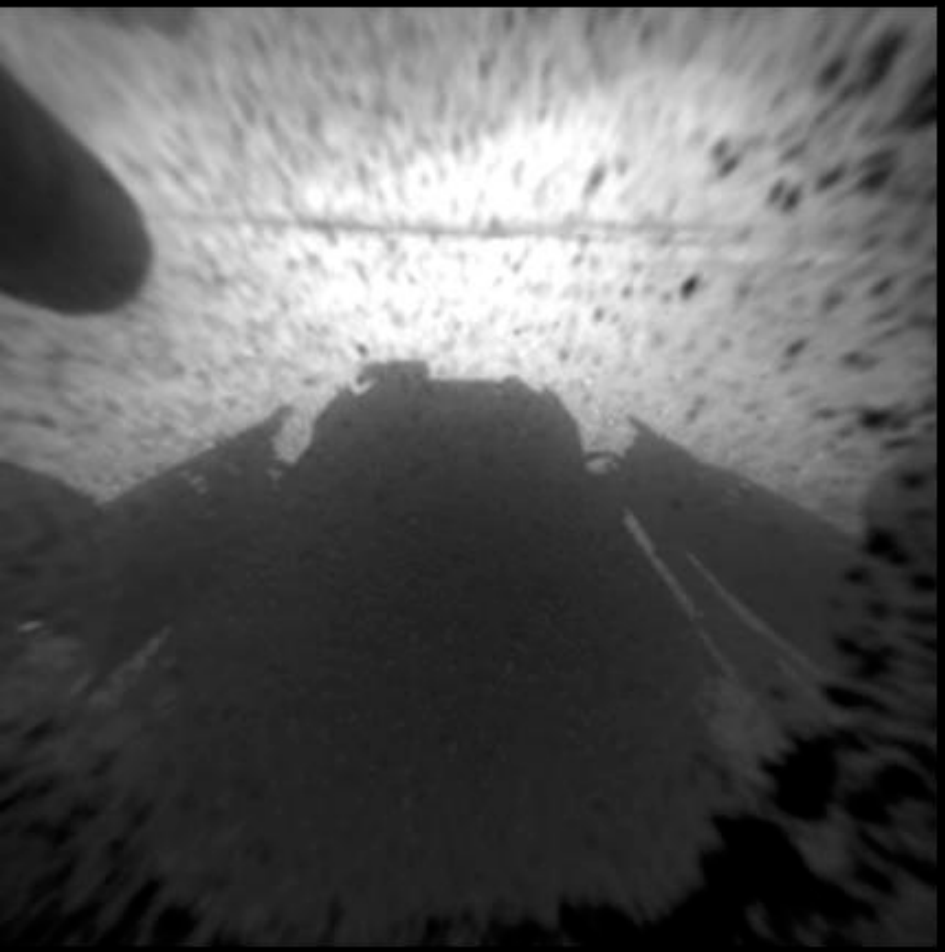
The first thing we saw on Mars was … dust



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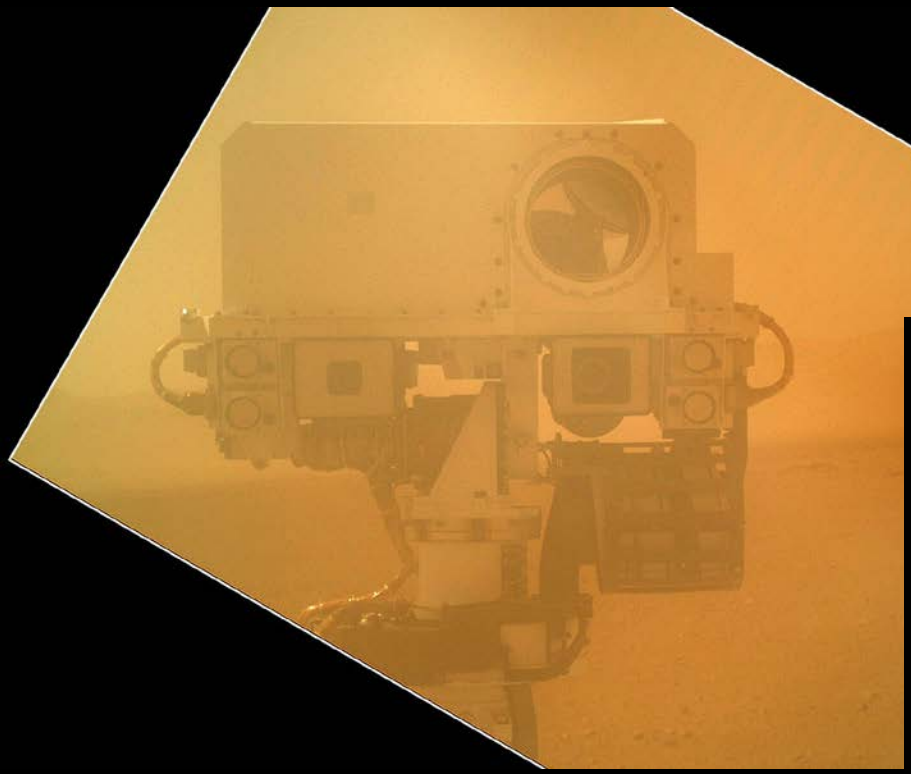
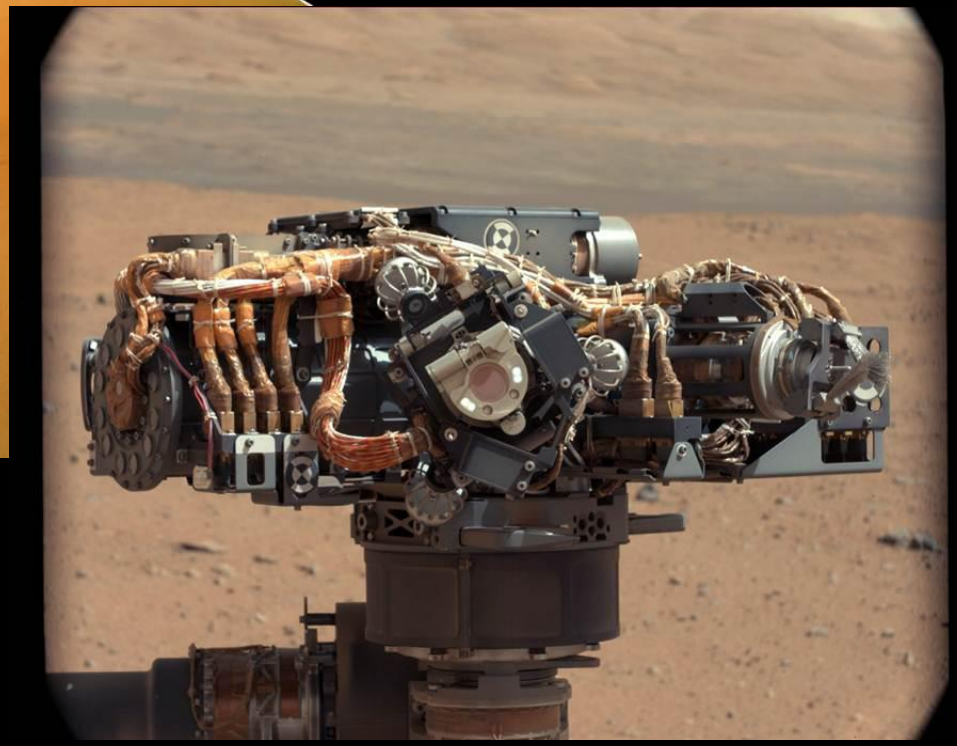
Here's looking at you - MAHLI dust cover





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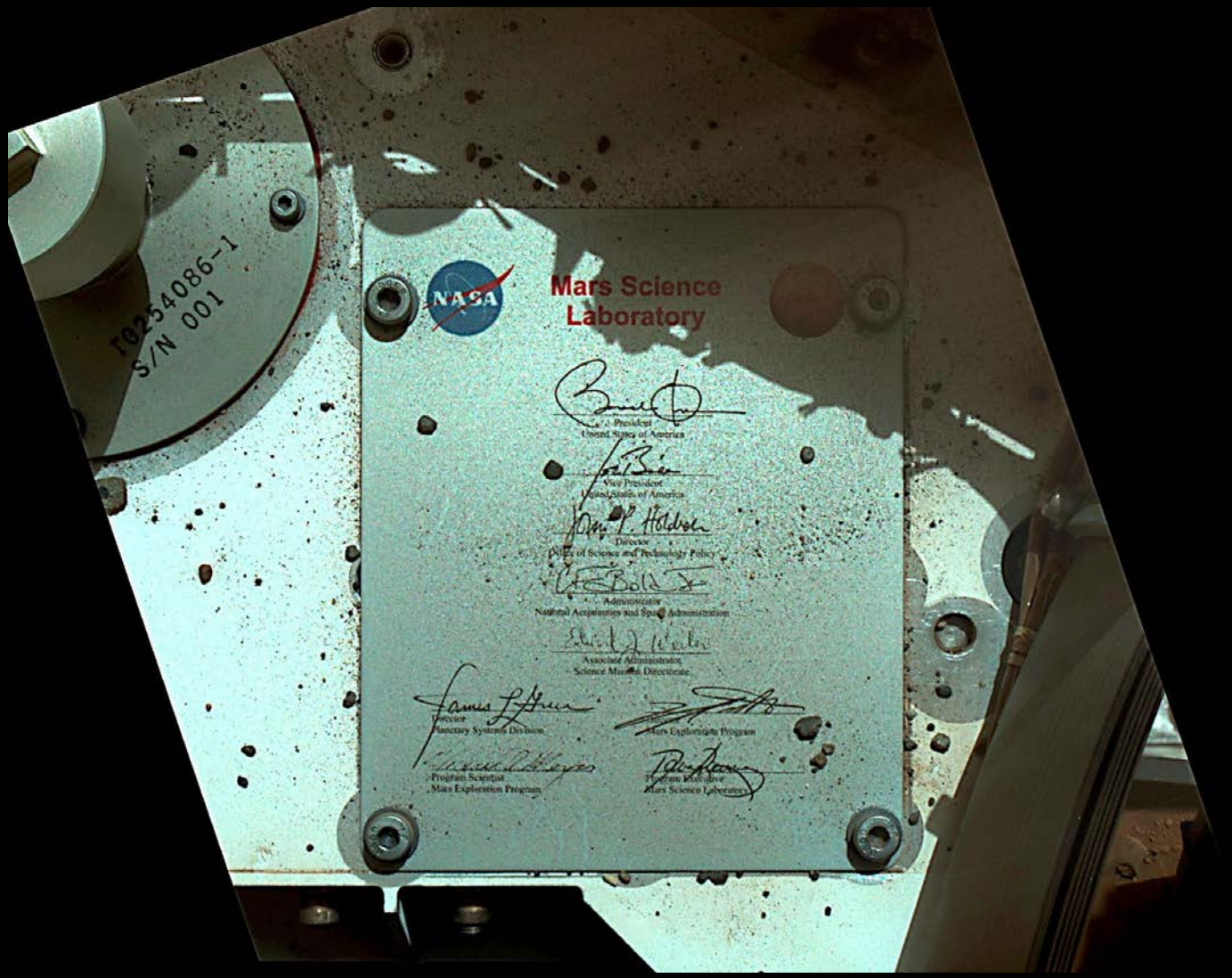
Rover Top Deck & Signature Plate



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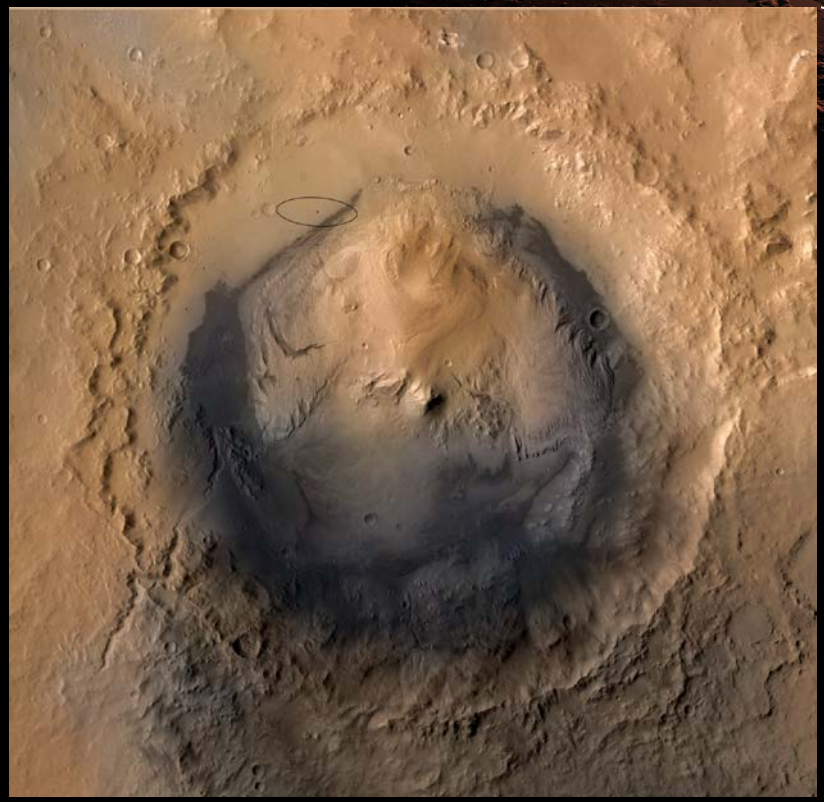
Destination: Gale Crater



- Gale Crater is located near the equator of Mars
- It is about 150 km across and has a large 5 km tall mountain in the middle
- Orbital data showed signs of layered material and clay mineral deposit

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Gale Crater and Mount Sharp

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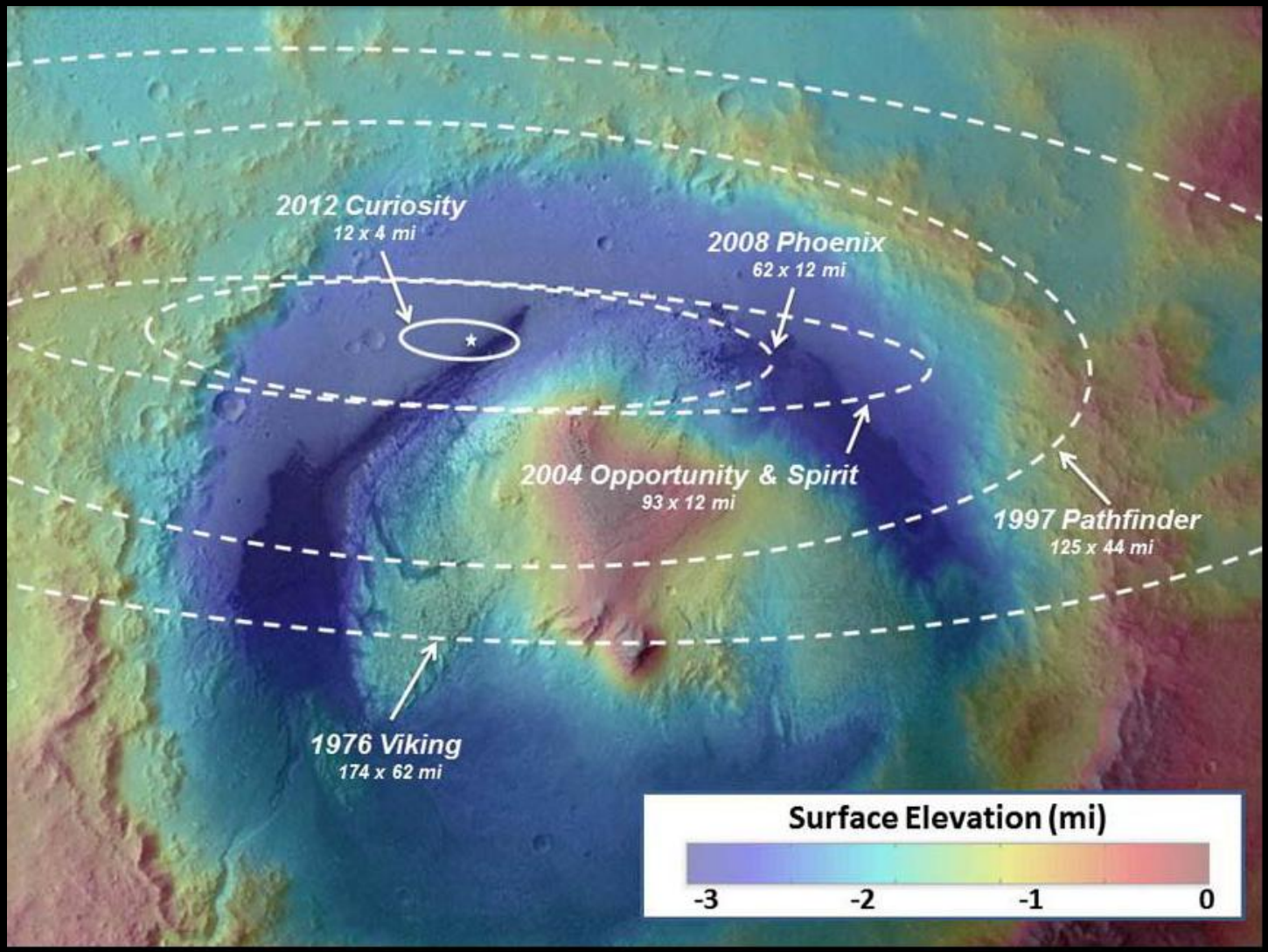
The Landing Site Accessibility



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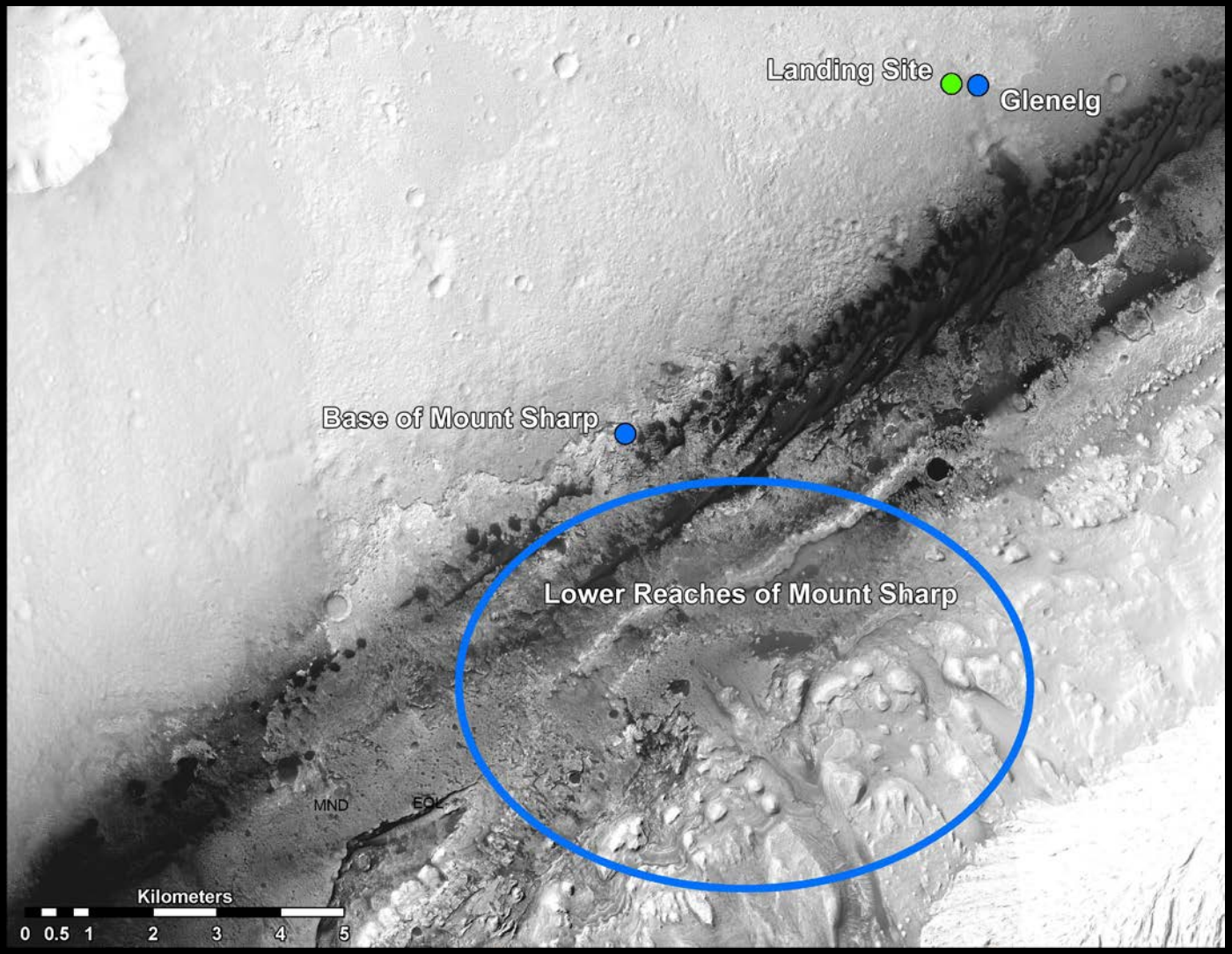
Where we landed



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Layers, Canyons and Buttes of Mount Sharp

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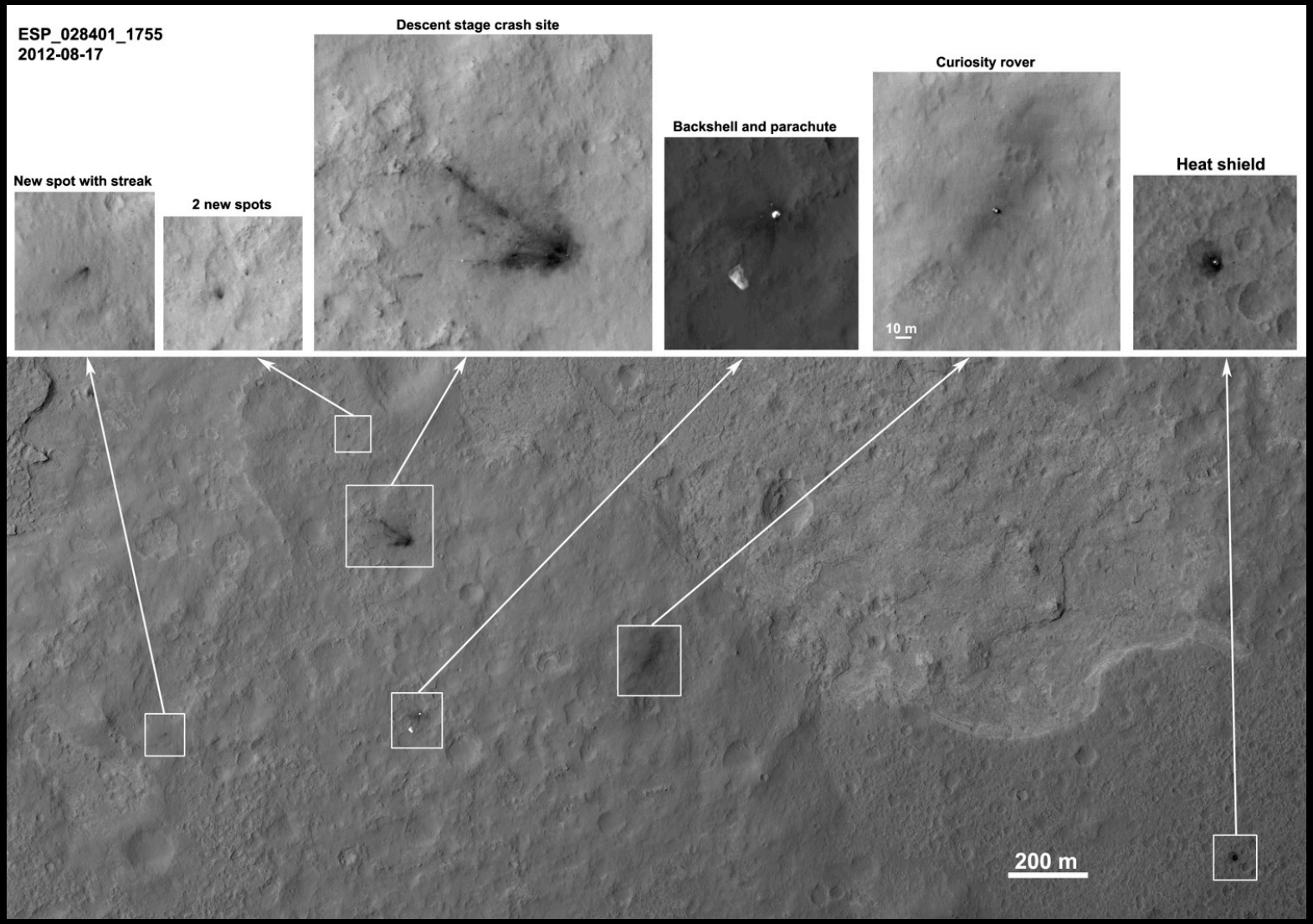
More than just a rover “landed” on Mars



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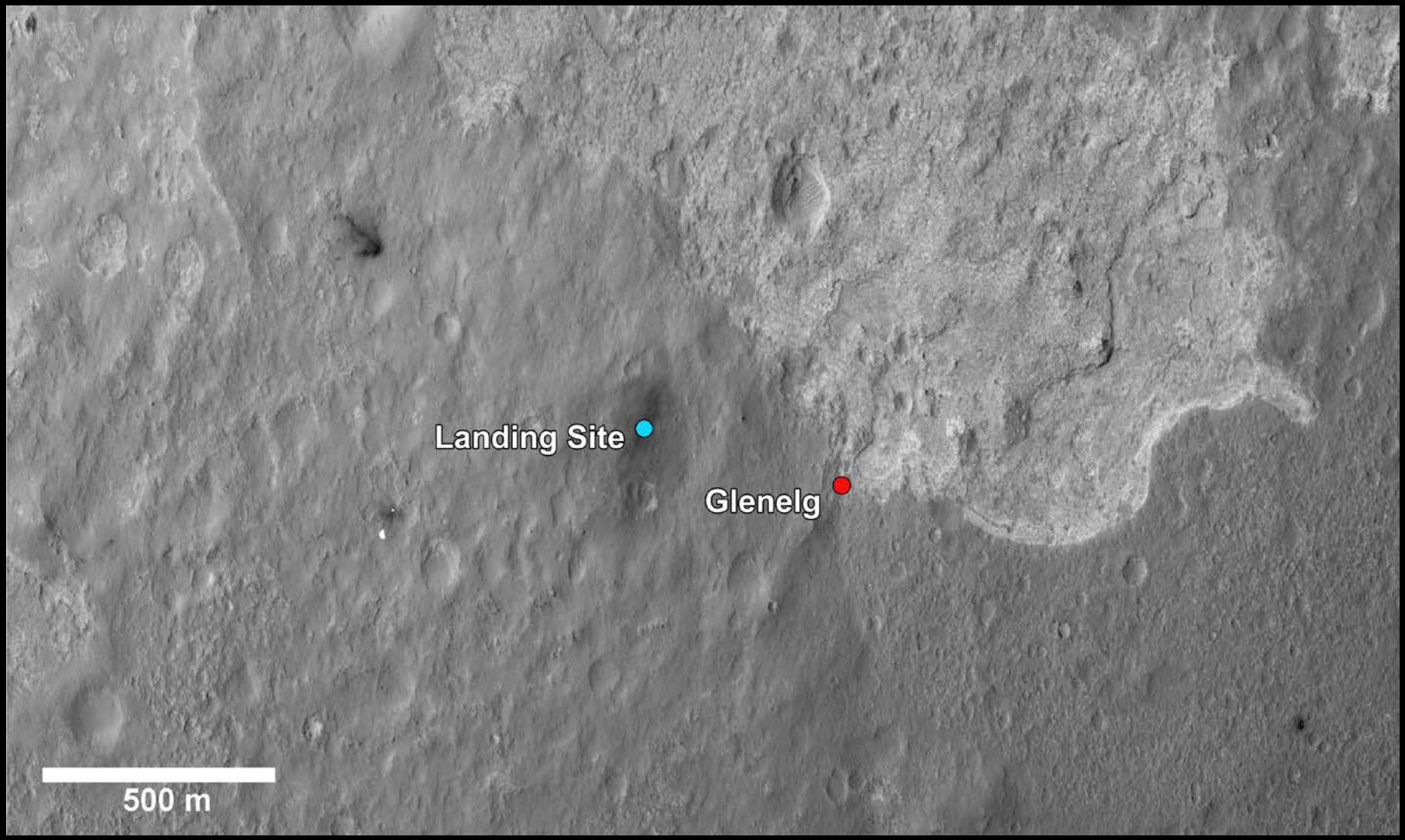
Nearby terrain was intreging



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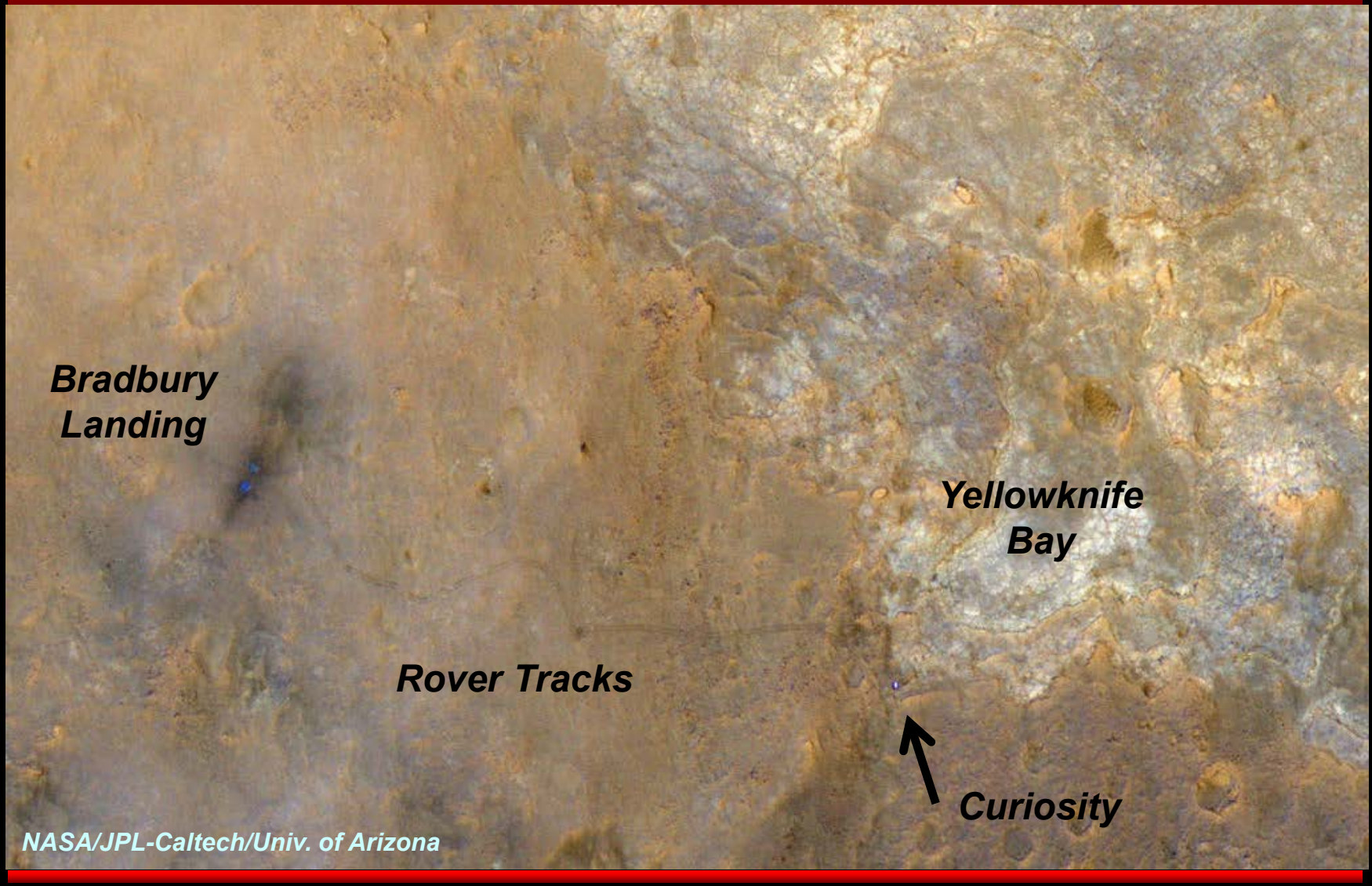
Tracks on Mars as seen from Orbit



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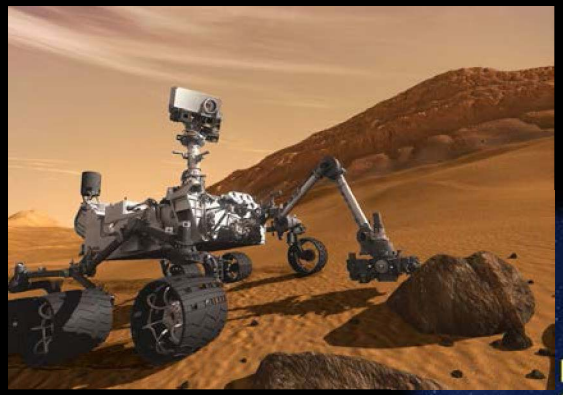
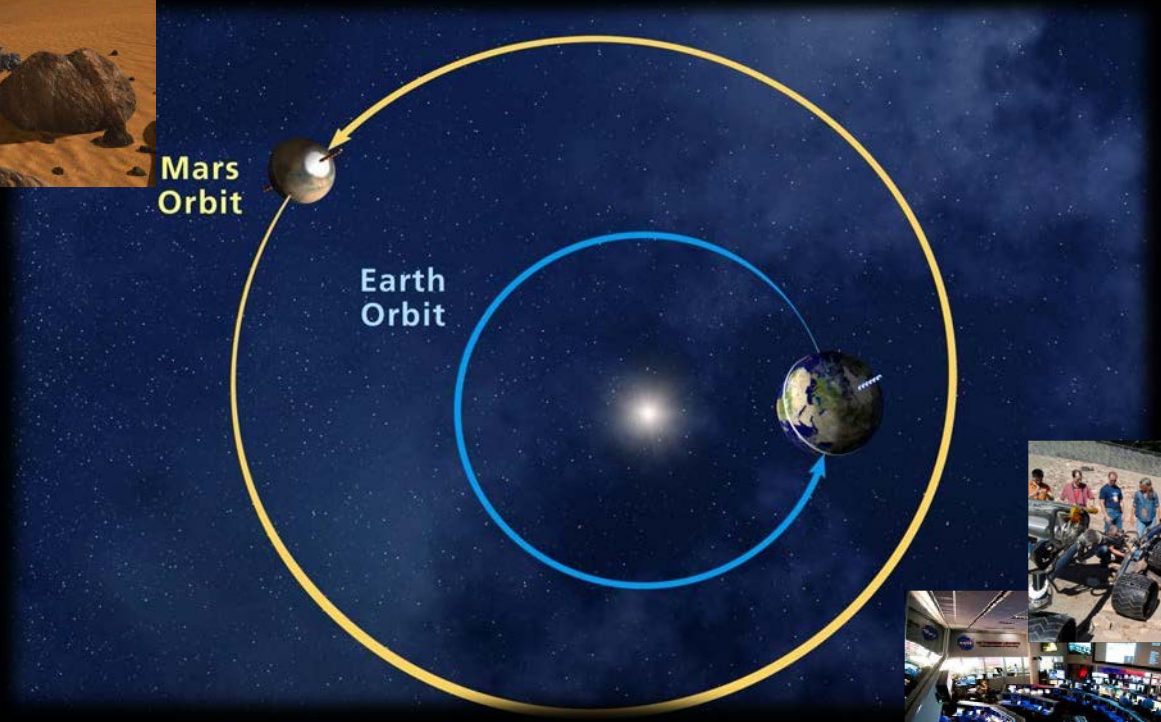
Operations - How to close-the-loop?





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Operational Challenges

- **Rover Resource limitations**
  - Power/energy - Curiosity spends most of each day sleeping to recharge batteries
  - Data Volume/latency - radio signal time delay, visibility (orbiter over-flights, earth in view) and energy limit communications to a few narrow windows per sol
- **Rover Activity Constraints**
  - Different activities want to be at different times of day for light or thermal reasons
- **Human intensive process**
  - 100s of scientist and engineers are involved in evaluating what happened, deciding on what to do next, and developing a safe set of commands for next activities
- **Discovery driven nature of mission**
  - In order to maximize mission return want to as quickly as possible close the loop between Mars and Earth
- **Alignment of Mars-time and Earth-time**

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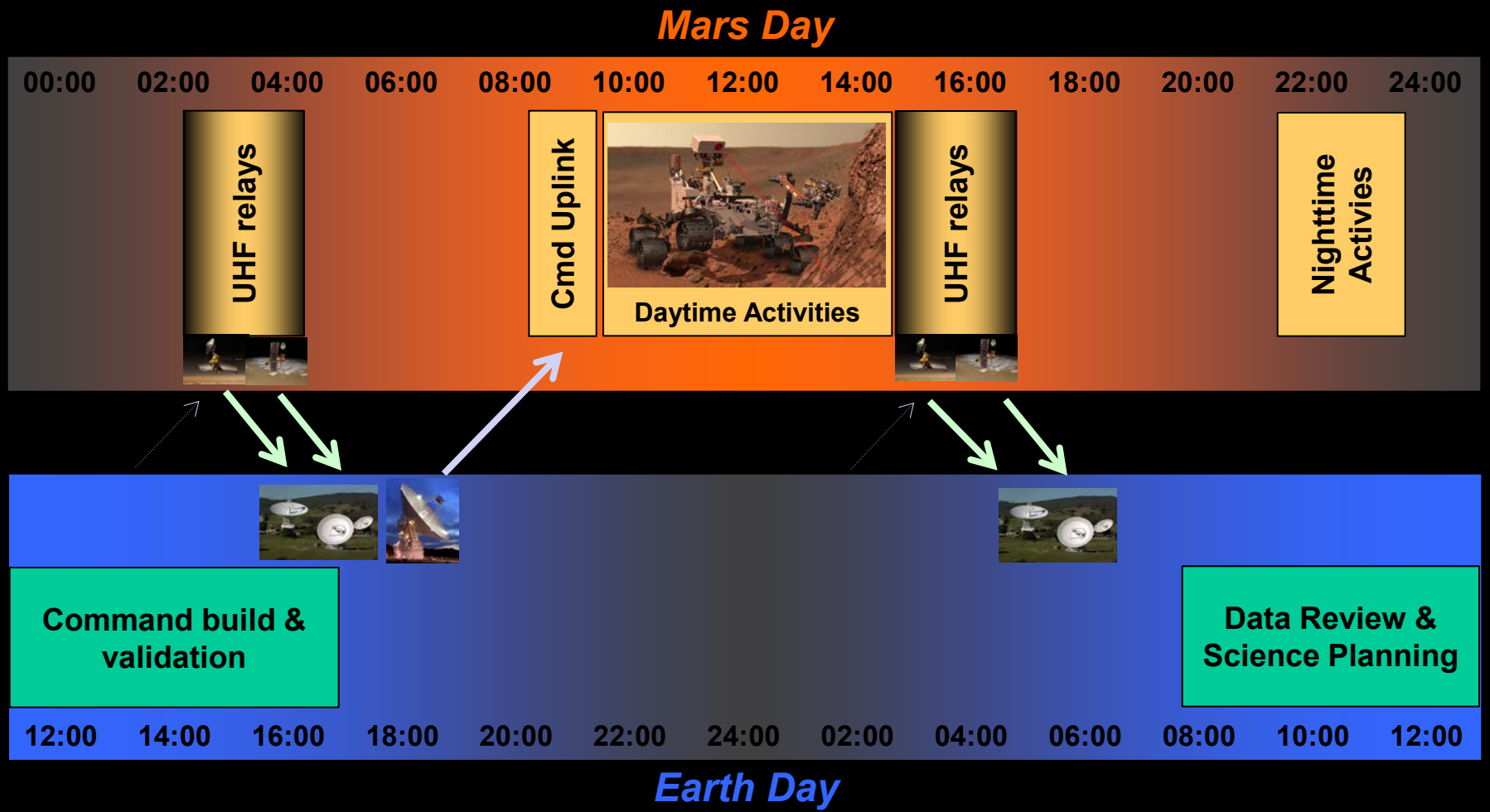
Tactical Operations Approach



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Mars-time Versus Earth-time Work Schedule

- **The alignment between Mars and Earth time shifts ~39 minutes everyday so how to align the schedule between Curiosity on Mars and operators here on Earth?**
  - People work on Mars-time

    - Earth Operations works during Martian night and therefore your work schedule shifts 39 minutes later every day
    - Gives us the most time to review data and develop next command load
    - What we did for first 90 sols of mission but not sustainable
  - People work on Earth-time
    - Earth Operations works regular Earth day schedule
    - Approximately half the days become “restricted”; that is you don’t have data back from Mars yet and can only plan activities that aren’t dependent on outcome of previous sol.
    - What we do today

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Layers of Operations

- **Strategic**
  - Big picture mission goals, long term science plan
  - Long term capability development (e.g. drilling at high tilt)

- **Supra-tactical**
  - 1 week plan working towards strategic goals
  - Develop outline for each sol and balance constraints between sols
  - Develop activities too complicated to be done tactically

- **Tactical**
  - Evaluate spacecraft performance/state, outcome of activities
  - Detailed planning of sols activities to ensure they fit within available resources (time, power, data volume)
  - “Coding” of activities into commands/sequences and validation of commands

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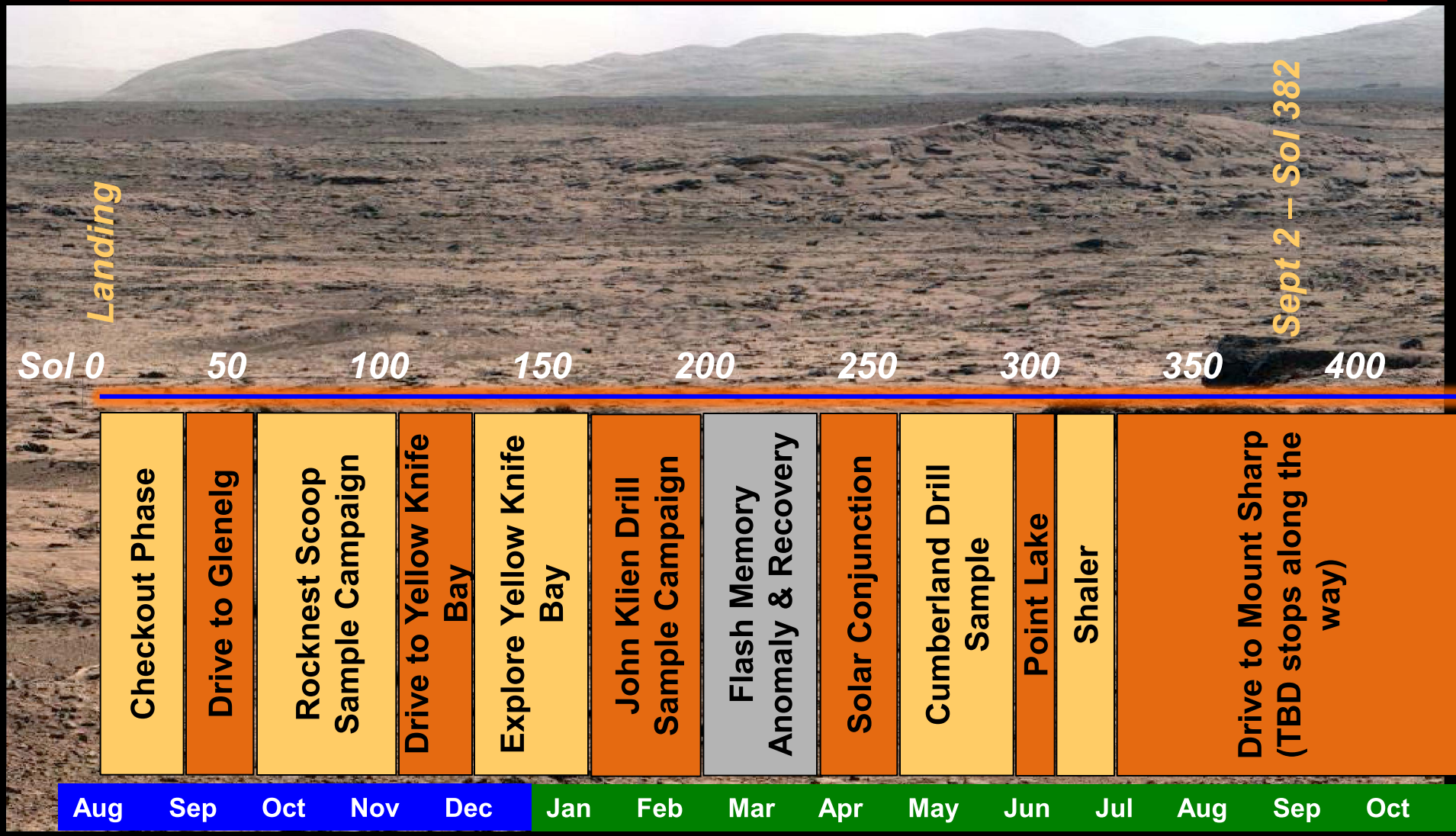
Surface Mission Timeline So Far…



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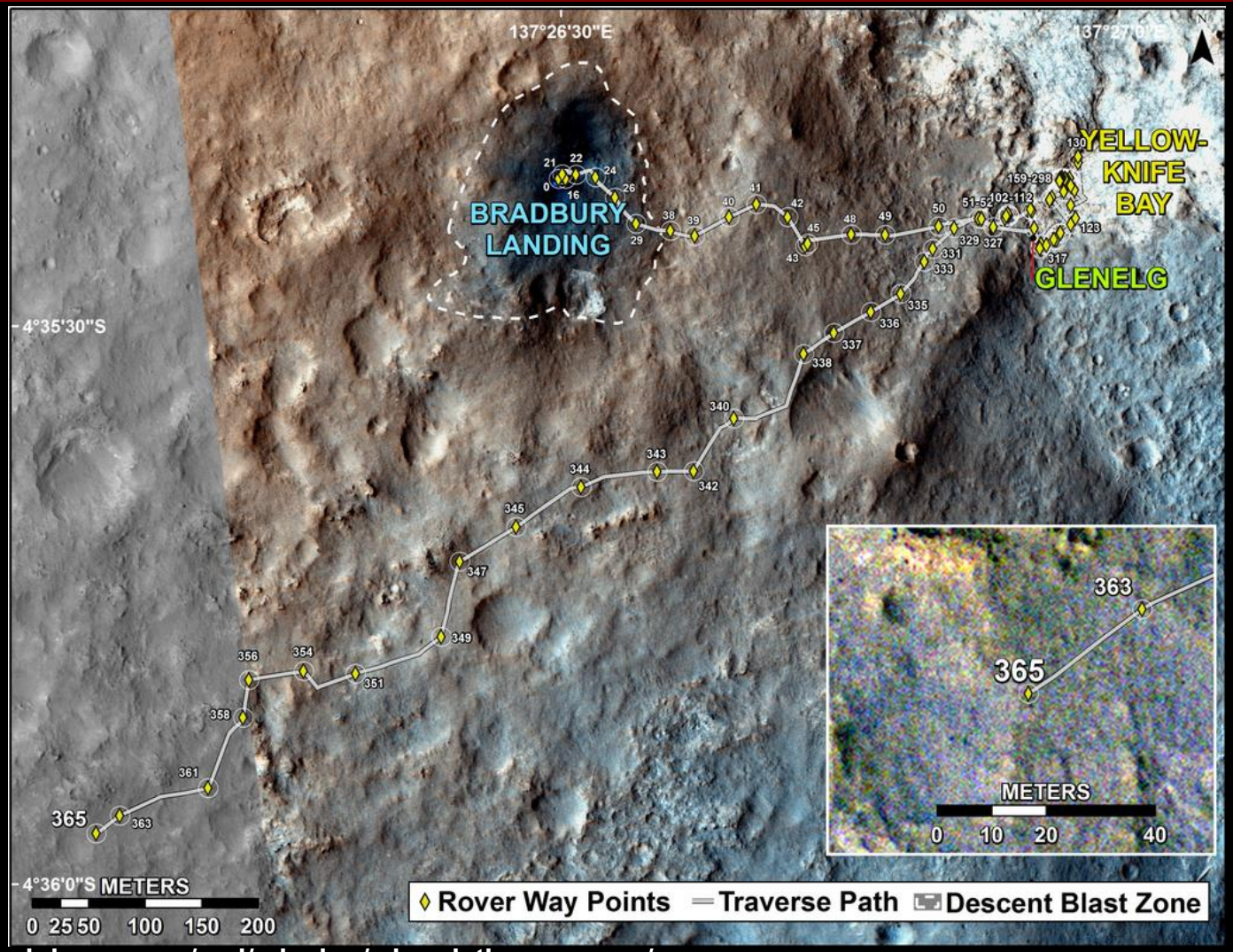
Are we there yet…



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

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Twelve Months in Two Minutes; Curiosity's First Year on Mars (02:12)

- http://mars.jpl.nasa.gov/msl/multimedia/videos/index.cfm?v=136

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Did you ever have that feeling…

User: wrighteous5280

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