Example of Robotic Technology for Accessing and Sampling High-Risk Terrain

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Keck Institute for Space Studies workshop on
2009 Mission Concepts for Accessing and Sampling High Risk Terrains

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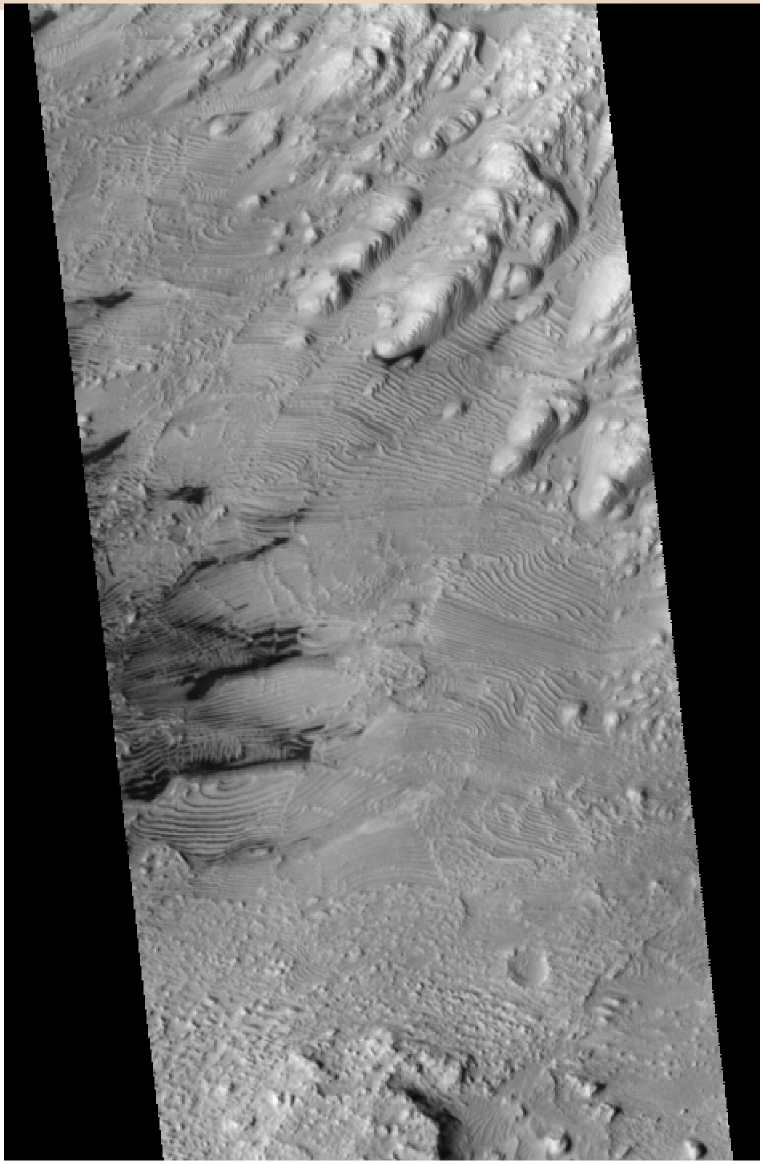
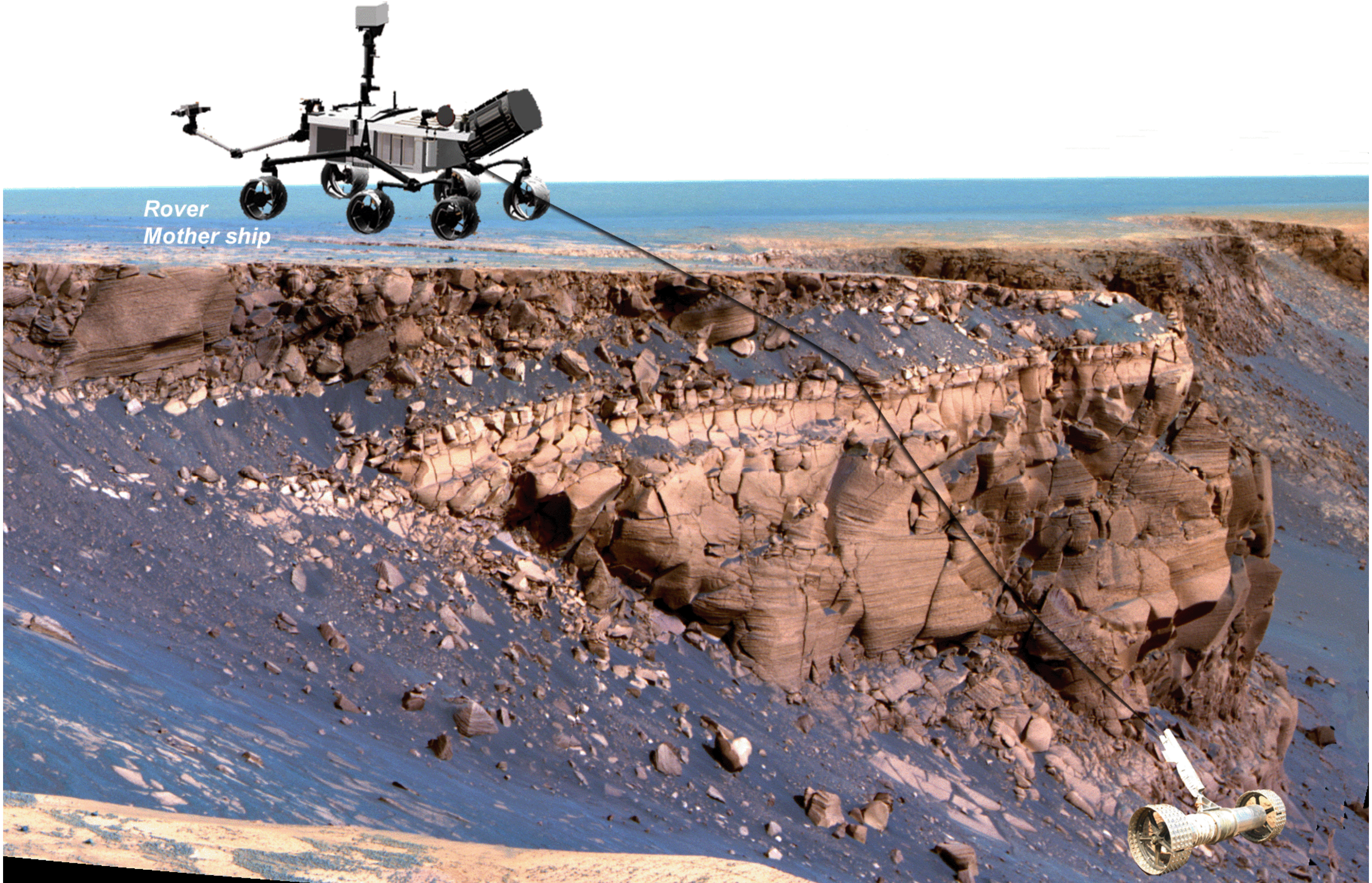
Minimalist Robotic Platform to Deliver Instruments and/or Acquire Samples on High-Risk Terrains

- Objective:
  - Provide a **low-cost low-mass** platforms to deliver science instruments to terrains that would otherwise be inaccessible to state-of-the-art mobility platforms
  - Provide capability to collect samples and return to a host platform for in-depth analysis
  - Confine risk for accessing high-risk terrain to delivery platform



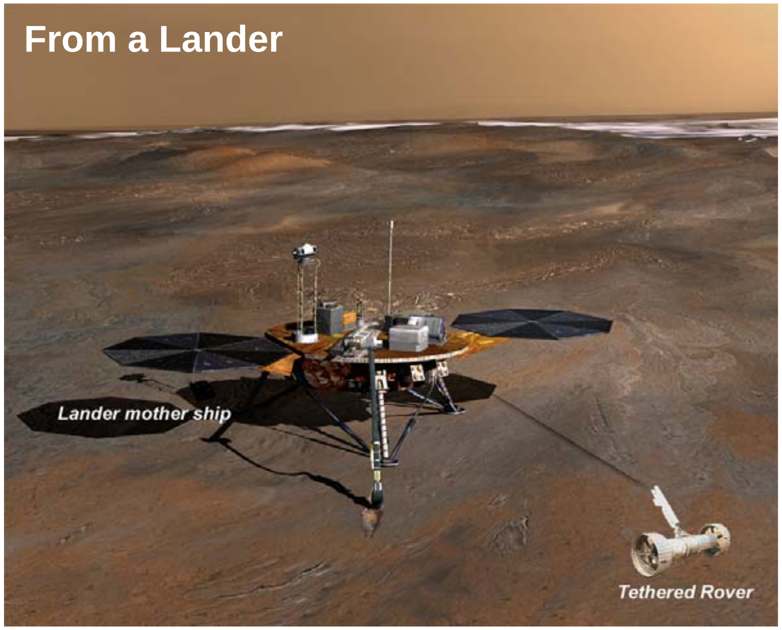
Supports mission concepts that may include multiple such assets

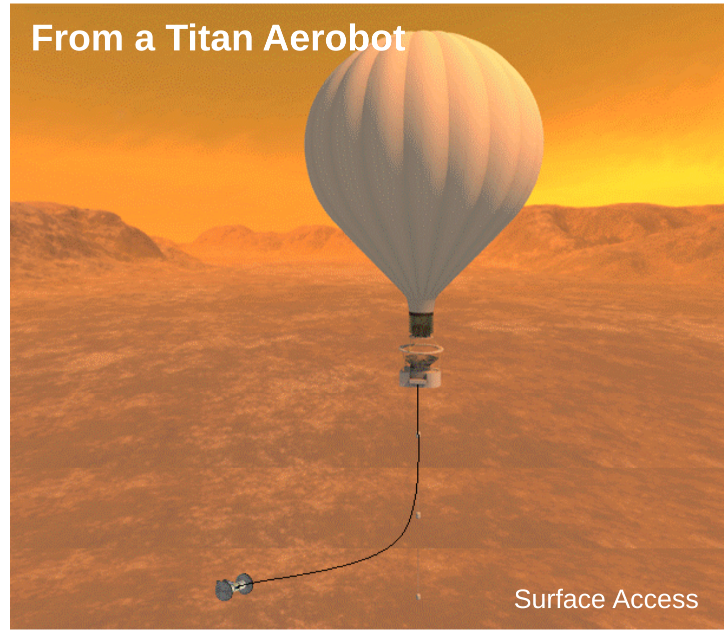
One Possible Mission Concept for Mars:
Mobile Science Payload Tethered to a Larger Rover

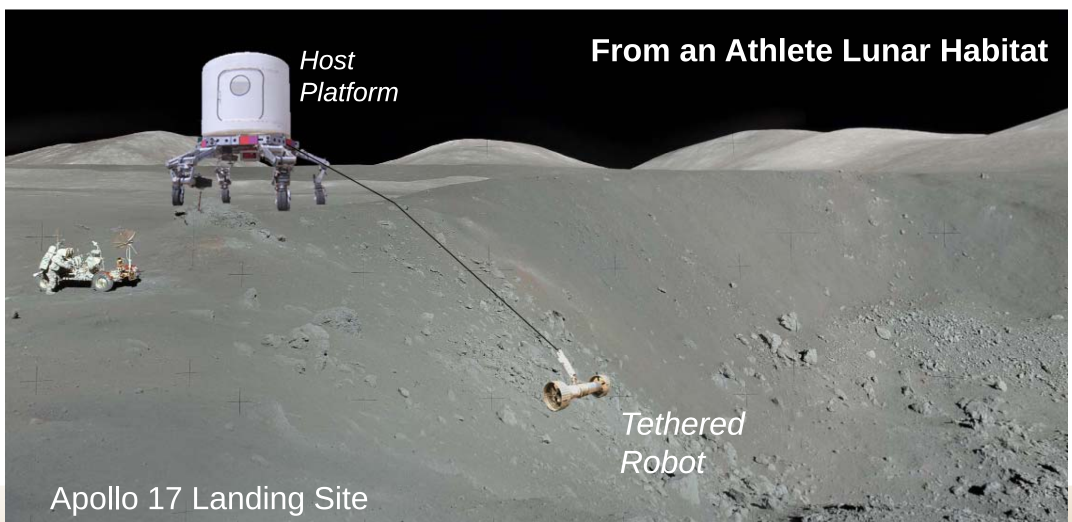


Cape Saint Vincent, Victoria Crater, Mars
False Color, Graphics not to scale

Other Mission Concepts for Terrain Access and Sampling







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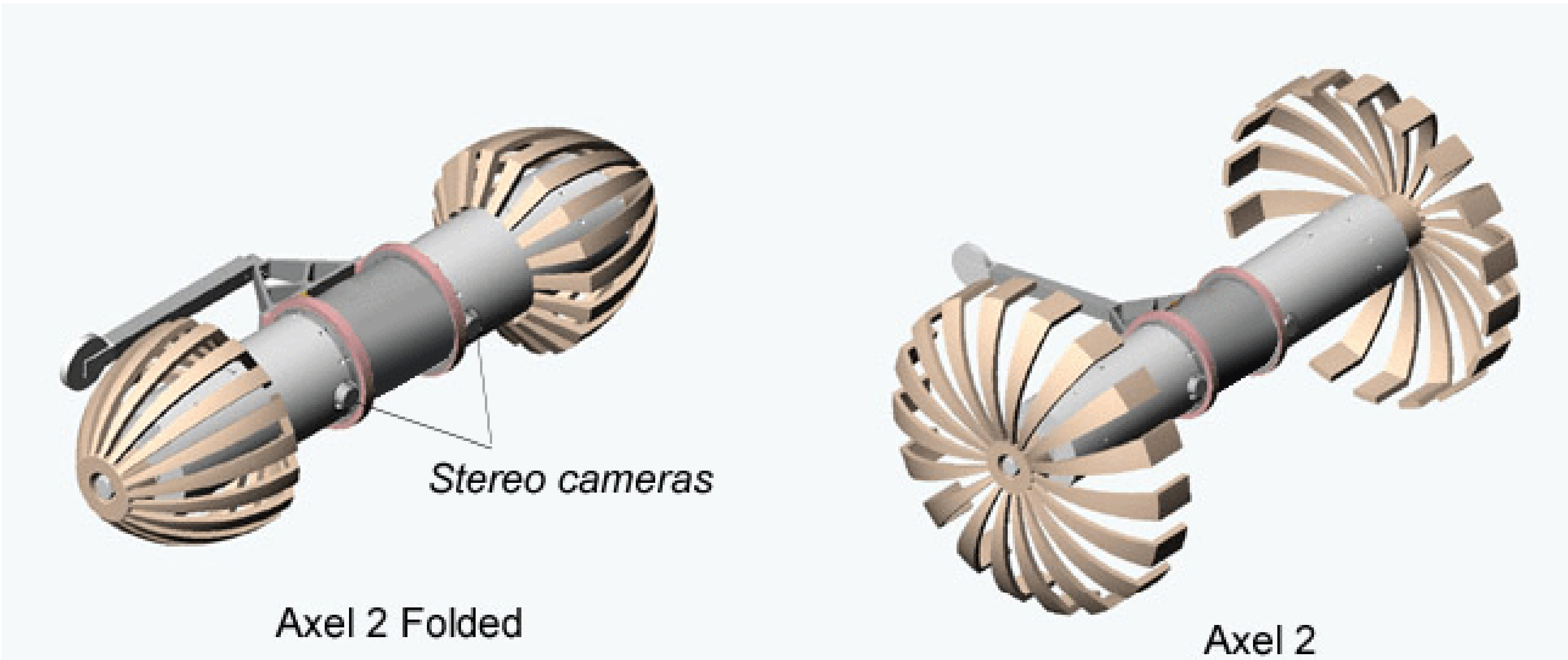
Mobility Platform Example: Axel



A yoyo-like rover

- **Simple**
- **Low mass** and **low cost**
- Can carry and **point multiple science instruments**
- Operable from any state using **symmetric design**
- **Robust** to sudden drops and hazardous terrain
- **Scalable** design
- **Compact** for flight packaging

Handles large obstacles

Inside the Robot

Avionics stack
with flash storage

Color Stereo cameras

Science Payload

Rechargeable Battery

Inertial Measurement Unit

Capabilities

- **Mission Capabilities**
  - Can be hosted on larger rover, lander, or possibly self-anchor
  - Potential accommodations of multiple science instruments
  - Confines risk of steep terrain excursions to mobile payload
  - Multiple such mobility platforms in a single mission can reduce mission risk
- **System Capabilities**
  - Mobility, pointing and sampling using only three motors
    - Full motion range on moderately sloped terrain, vertical on higher slopes
    - Points its instruments using wheels and boom on moderately sloped terrain
    - Uses a tether to pull itself out of sand traps
  - Host requirements minimized (e.g. fixed mount, power, communication)
  - Light tether carried and managed by rover (e.g. polyethylene fiber)
  - On-board computing with data storage and autonomy capabilities
  - Stereo vision sensing and inertial sensing
  - Wireless communication

Next Steps

- Integration of three instrument payload and field-test
- Power management
- Tether management
- Various levels of autonomy for operations
- Optimize science operational scenarios

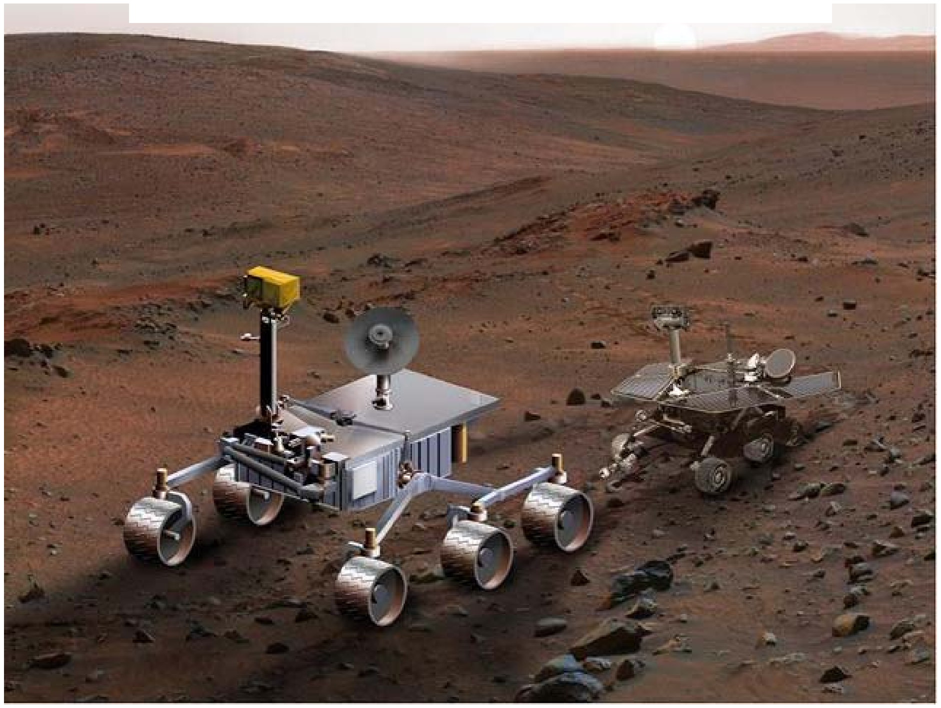
Summary

- Low-mass and low-cost mobility platform that delivers science payload to high-risk terrains
- Can extend access to previously inaccessibly terrains
- Preliminary investigations demonstrate potential for accessing, measuring and sampling highly sloped terrain
- Potential to host multiple science instruments for assessing geochronology and chemostratigraphy

Backup Slides

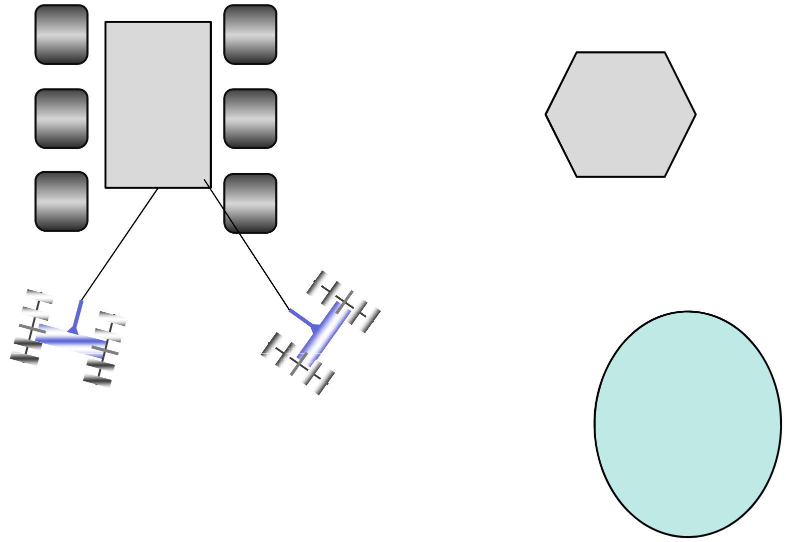
Surface Explorers: Today's vs. Tomorrow's

State-of-the-art



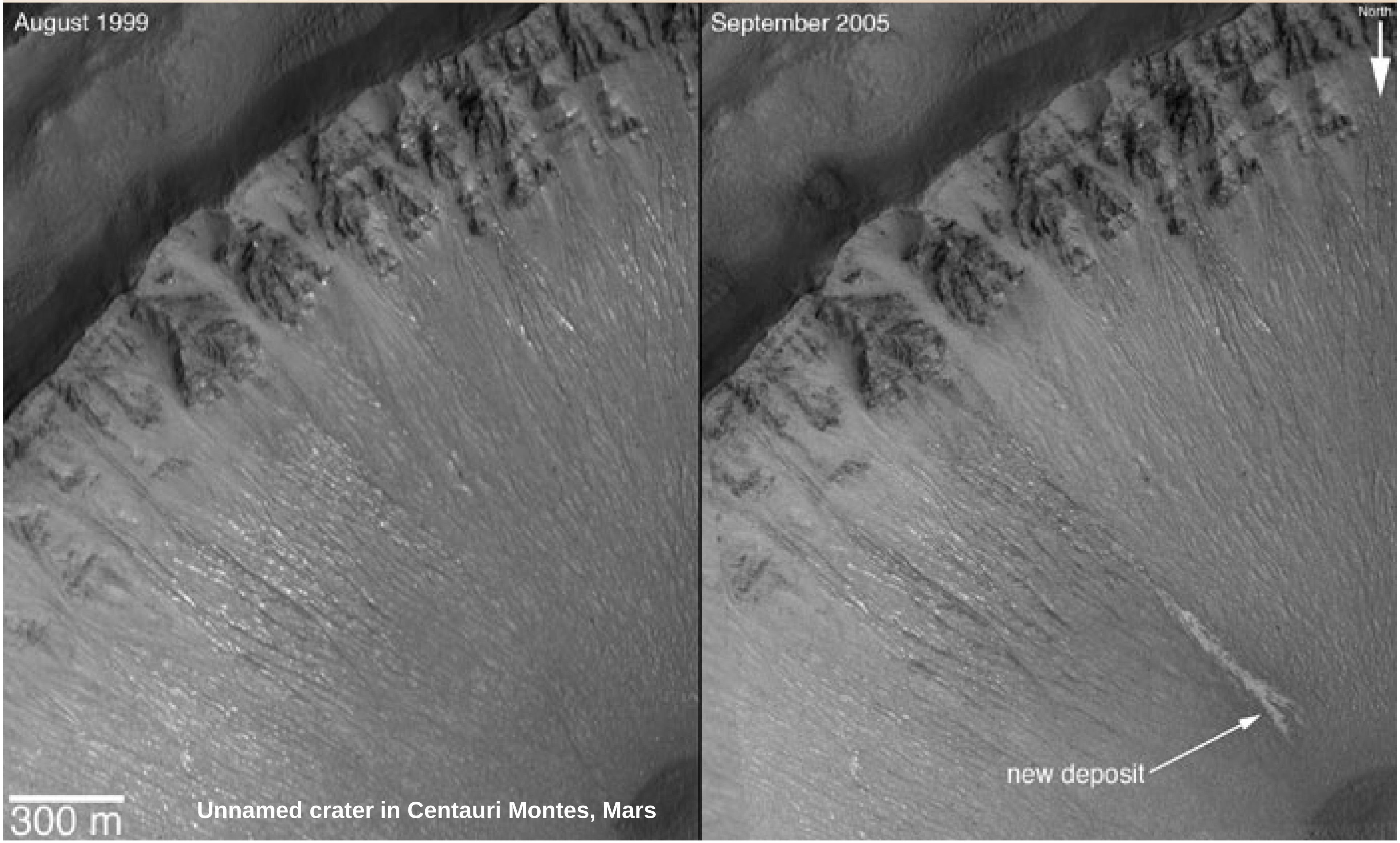
Architecture: single rover
Terrain: low-risk
moderately sloped (0 – 30º)
Range: 15- 20 km
Risk: single level

Future Possibilities

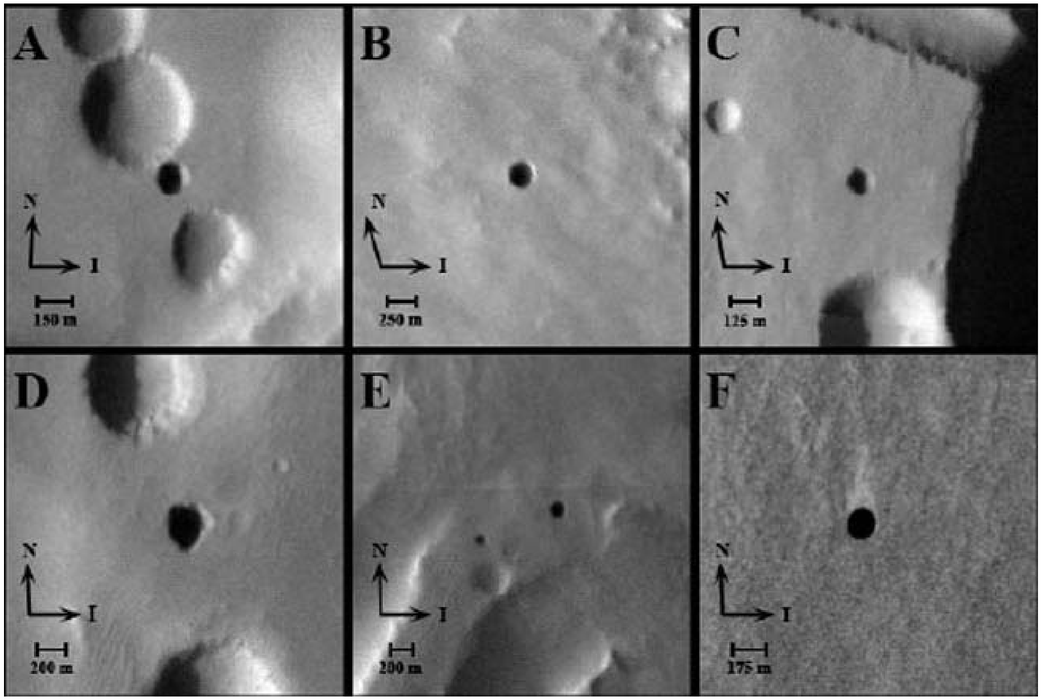


Architecture(s): marsupial
lander + tethered rover(s)
rover + tethered rover(s)
Terrain: high-risk for tethered robots
vertical strata (90º slopes)
Range: 100 m – possibly kms
Risk: multi-level

Technology Relevant to Other Challenging Terrains



Including possible caves



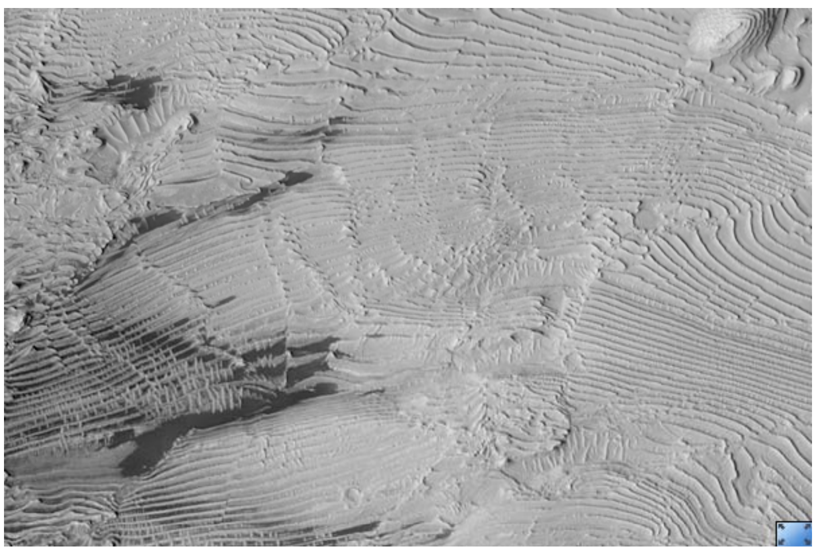
Dark spots believed to be caves observed by the Thermal Emission Imaging System (THEMIS) on the Mars Odyssey spacecraft

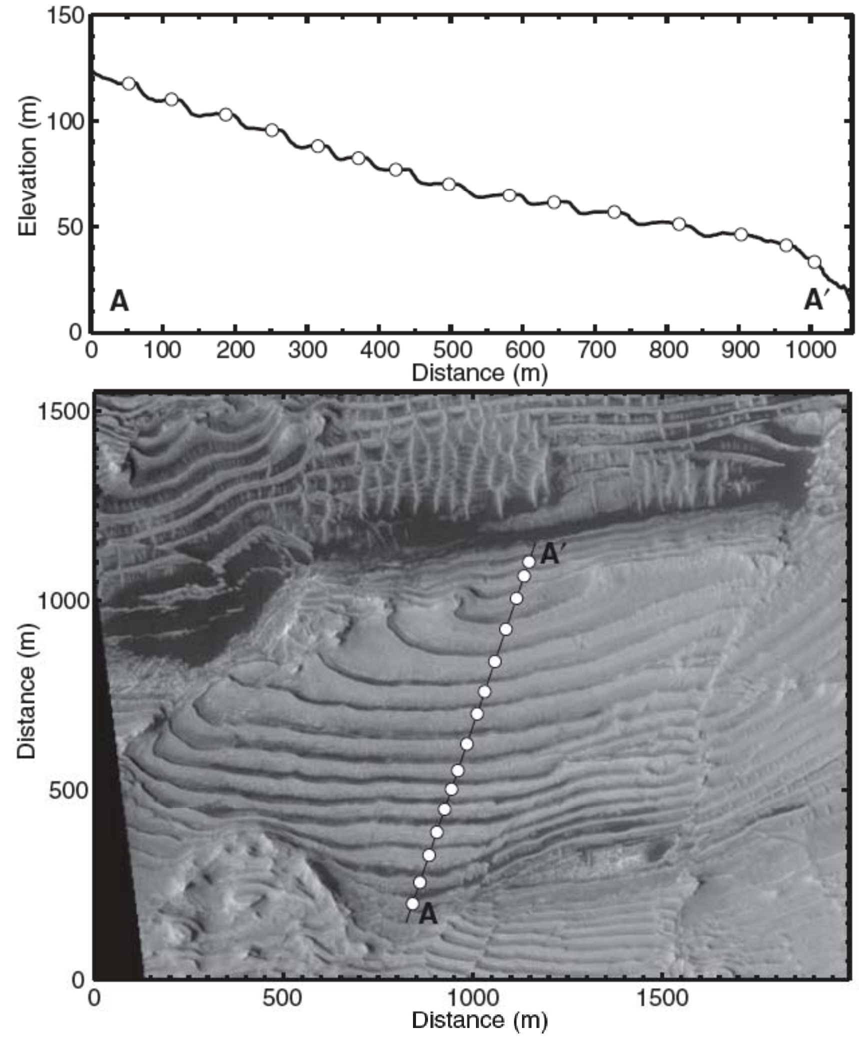
Credit: Cushing, G. E., T. N. Titus, J. J. Wynne, and P. R. Christensen (2007), THEMIS observes possible cave skylights on Mars, Geophys. Res. Lett., 34, L17201, doi:10.1029/2007GL030709.

Challenges of Terrain Topography for Mobility Platforms

Credit: Kevin W. Lewis, Oded Aharonson, John P. Grotzinger, Randolph L. Kirk, Alfred S. McEwen, Terry-Ann Suer, "Quasi-Periodic Bedding in the Sedimentary Rock Record of Mars," Science 5 December 2008

Crater	Location	Number of beds measured	Mean thickness ± SD (m)
Becquerel (beds)	22°N, 352°E	66	3.6 ± 1.0
Becquerel (bundles)	22°N, 352°E	10	35.5 ± 9.2
Crommelin	5°N, 350°E	8	19.6 ± 4.0
Unnamed	8°N, 353°E	14	9.7 ± 1.5
Unnamed	9°N, 359°E	10	12.6 ± 2.6





Faulted Layers in Impact Crater in Meridiani Planum of HiRISE image PSP_002733_1880