

ISECG Lunar Volatiles



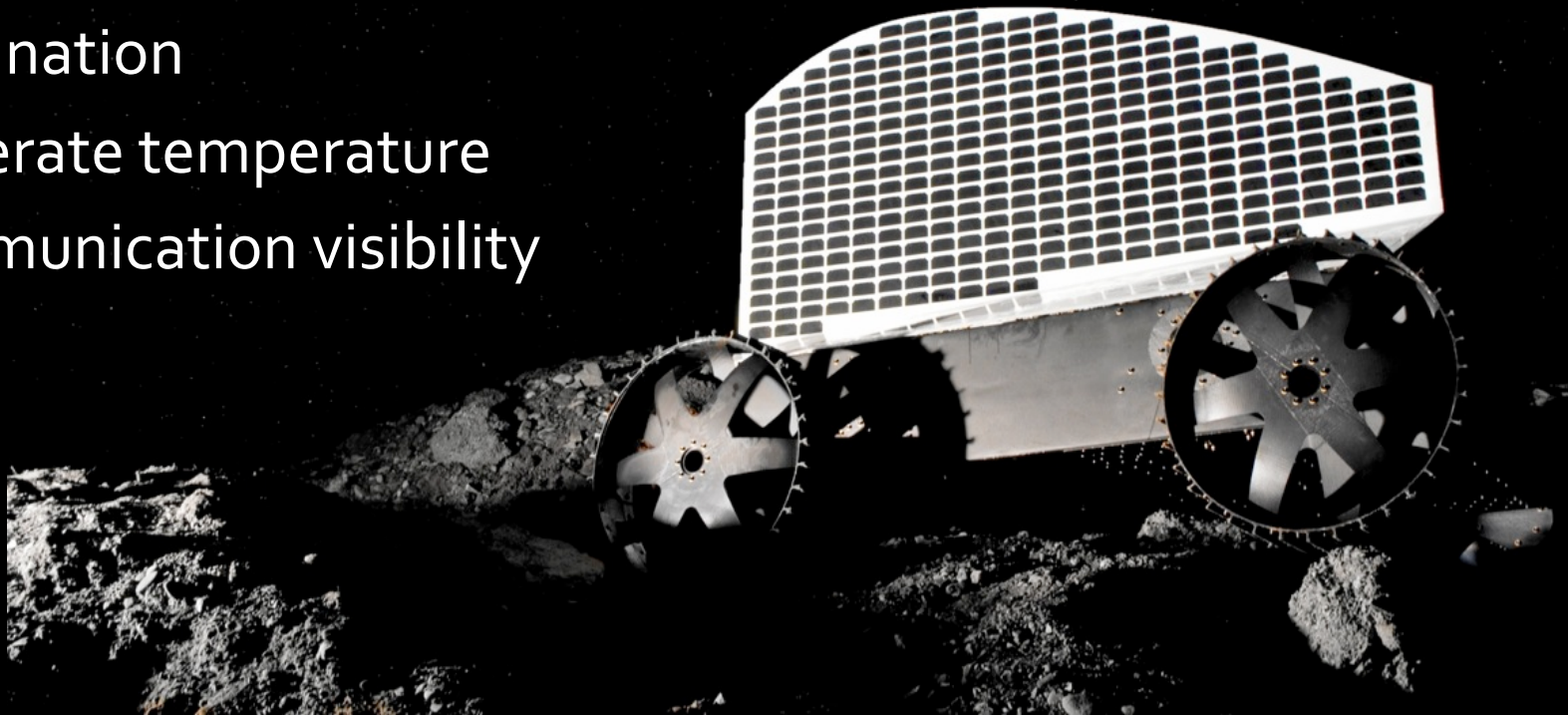
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The Robotics Institute
Carnegie Mellon University



Wide-area Lunar Prospecting



- Navigate long distance (10kms+) to survey and sample many high-potential sites
- Plan routes of
 - Illumination
 - Moderate temperature
 - Communication visibility

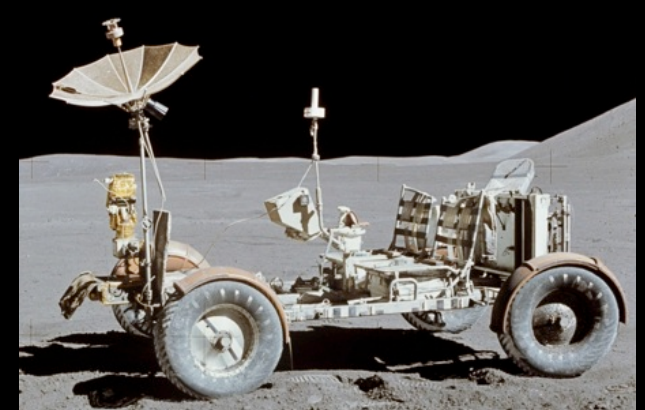
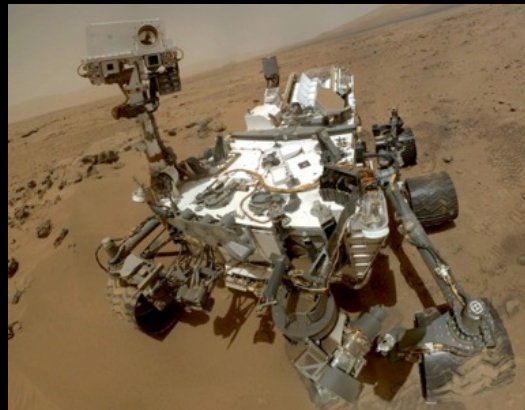


Mission Characteristics

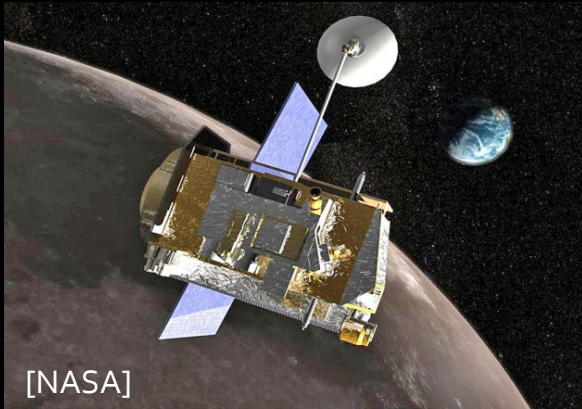


- Solar powered
- Stable temperature
- Long duration/long distance mission
- Moderate speeds
 - Poles: < 1 cm/s

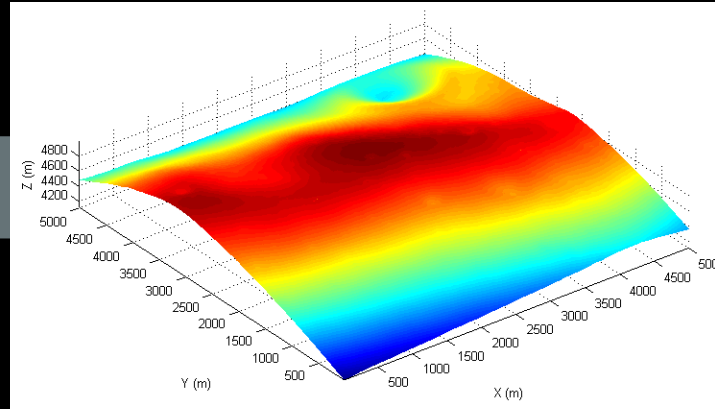
Lunar equator: ~ 16 km/h



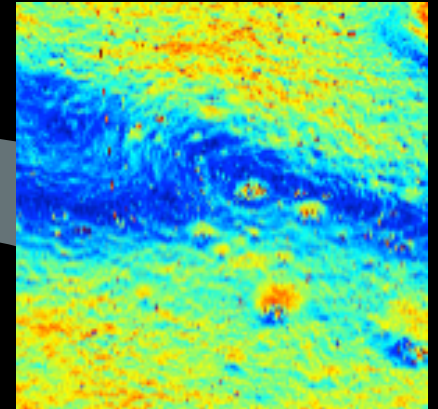
Modeling/Planning Process



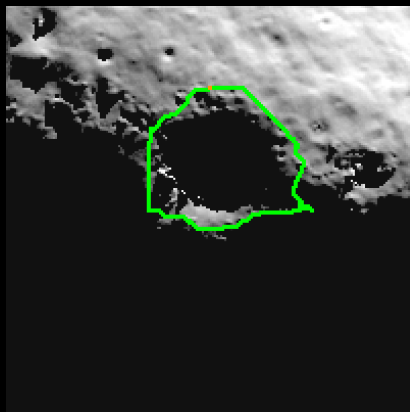
LRO



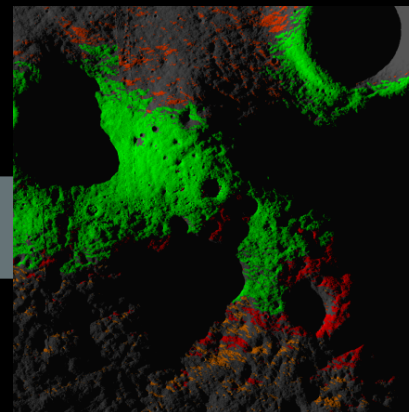
Digital Elevation Model (DEM)



Slope Map



Route



Connected Components



Lighting Map

Mission Metrics



Nobile Crater

74 Earth days

63.5 km total

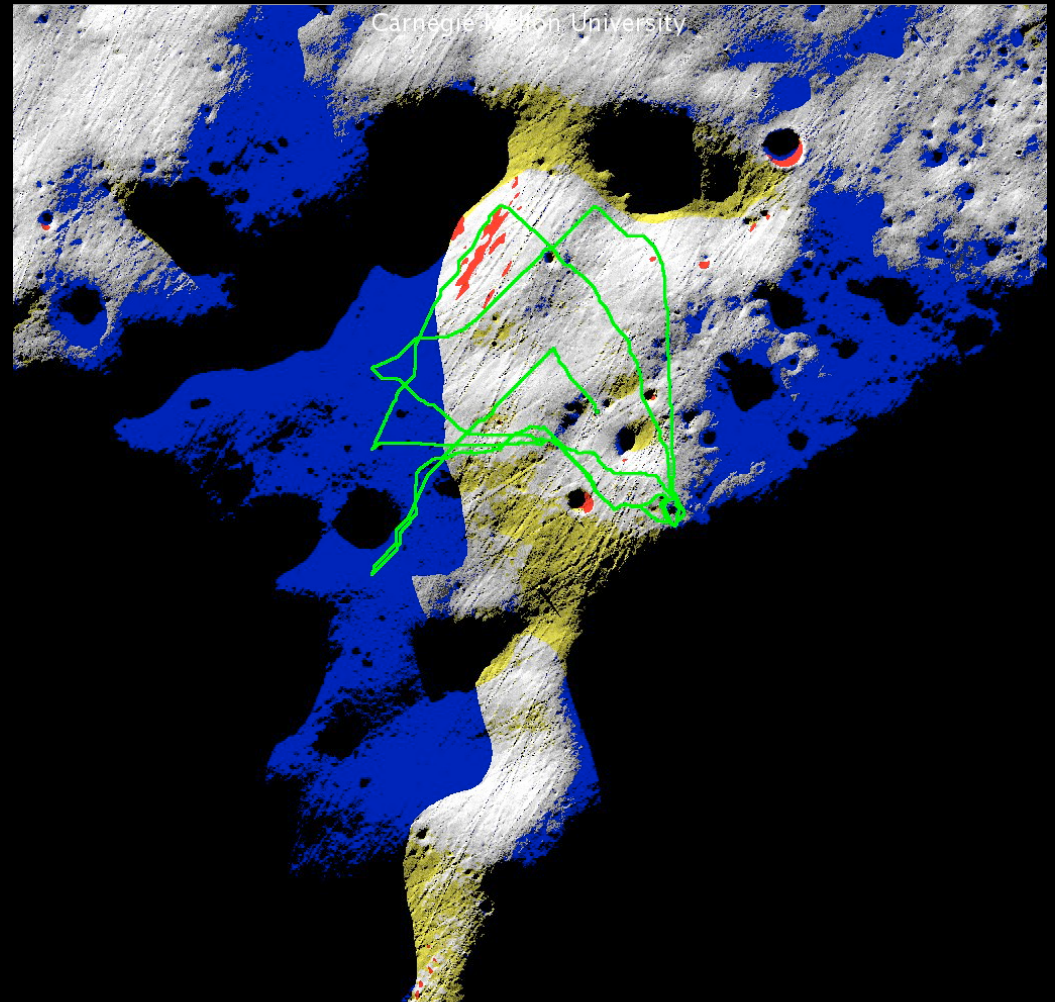
35.8 m/h average

= 1.0 cm/s

345.2 m/h max

= 9.6 cm/s

Dwell (hrs): 63, 58, 43, ...



STATUS: **COMM** SPEED: 345.2 m/h DISTANCE: 59381 m DD:hh 66:01

Legend (Color Map)



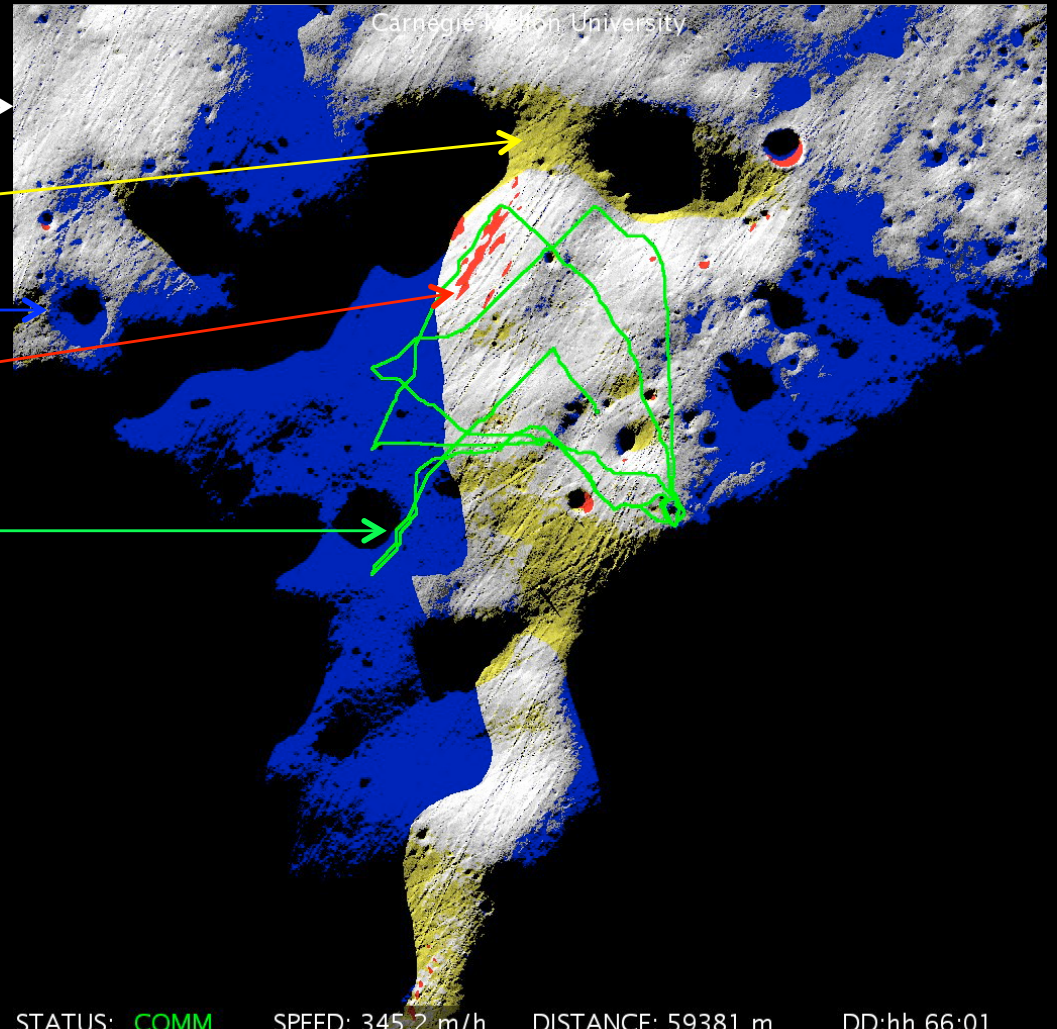
Illuminated —————→

Sunlight, no comm —————→

Comm, no light —————→

Slope > 15° —————→

Route, 74 days, 64km —————→



STATUS: **COMM** SPEED: 345.2 m/h DISTANCE: 59381 m DD:hh 66:01

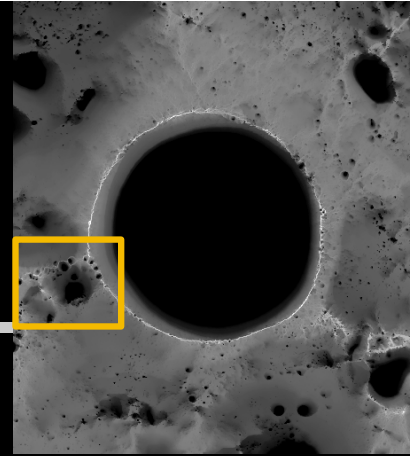
Play Video



Extra Material



Mission Metrics



Shackleton Crater

59 Earth days for 1 loop
34.7 km total

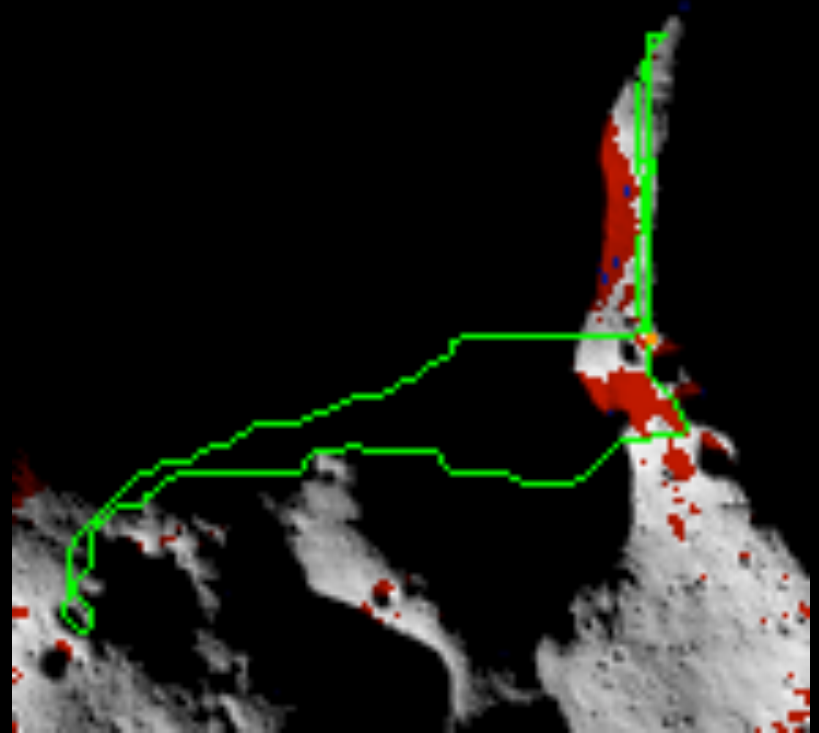
25 m/h average

= 0.7 cm/s

58 m/h max

= 1.6 cm/s

Dwell times: 226, 104, 53, 45, 43, 29, hours



Mission Metrics



Malapert Peak

59 Earth days for 2 circuits

2.13 km total

~1 km/loop

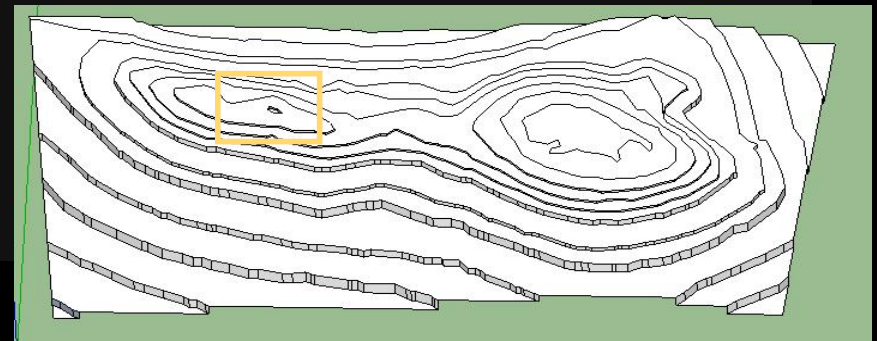
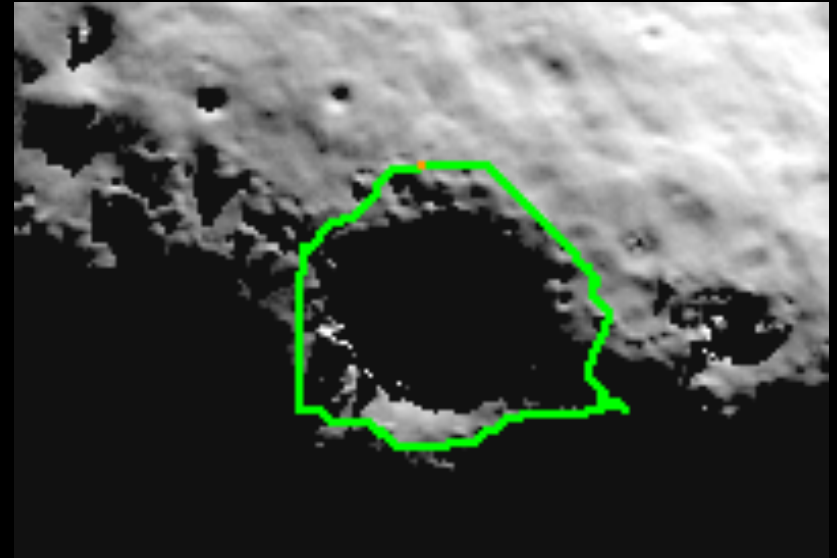
1.5 m/h average

= 0.04 cm/s

2.9 m/h max

= 0.08 cm/s

Dwell times: 45, 41, 37, 31, 31, 27, 25, 23 hours



Mission Metrics



Peary Crater

80 Earth days

49.2 km total

26 m/h average

= 0.7 cm/s

58 m/h max

= 1.6 cm/s

Dwell times: 240, 237, 136, 58, 37, 29, 29 hours



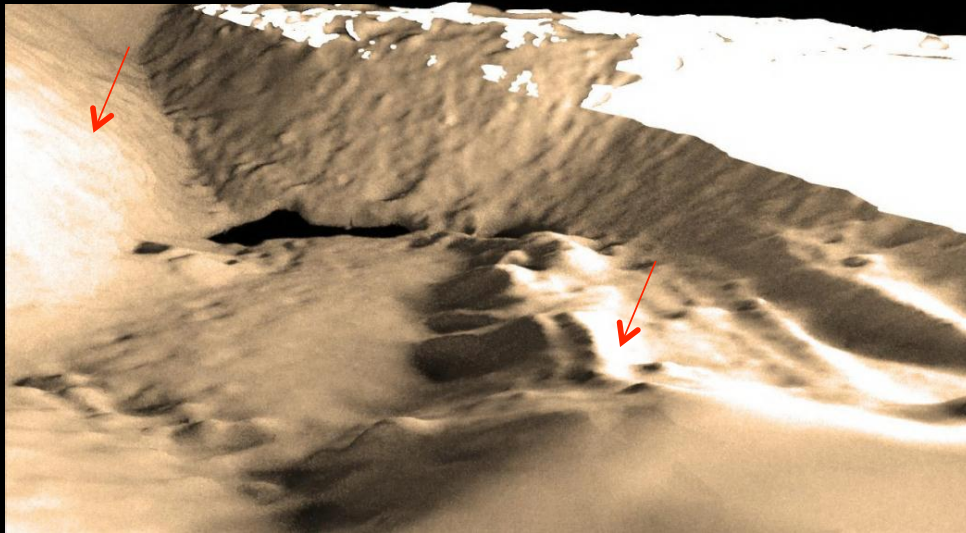
Static Shadow Model



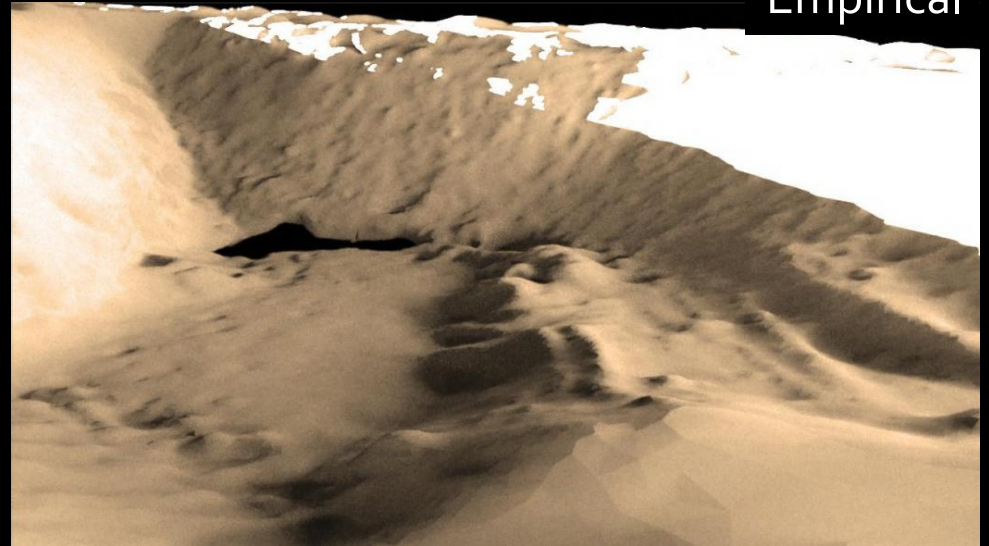
Verifying Illumination



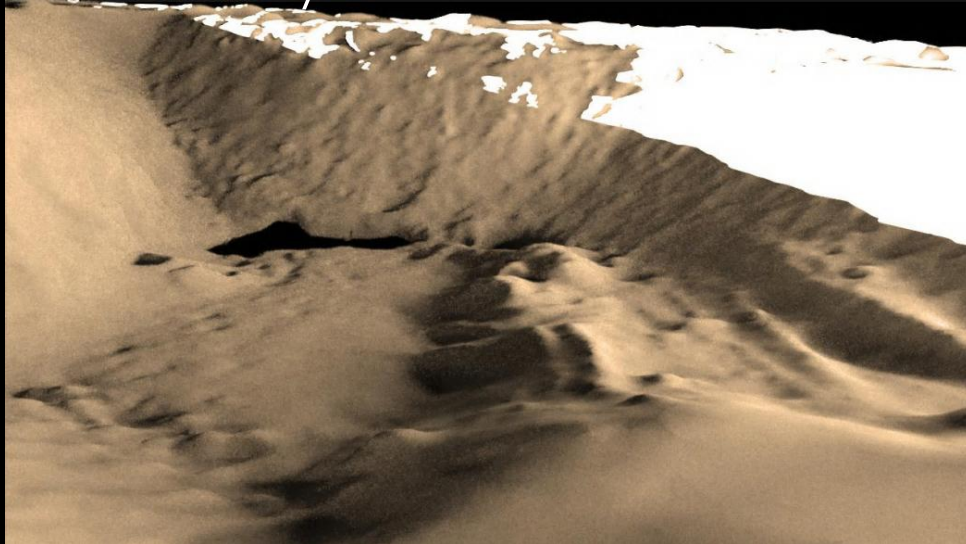
Pure Lambertian



Empirical



Pure Oren-Nayar



- Correctness of lighting models is critical to plan feasibility

LRO M124020663M



LRO
WAC



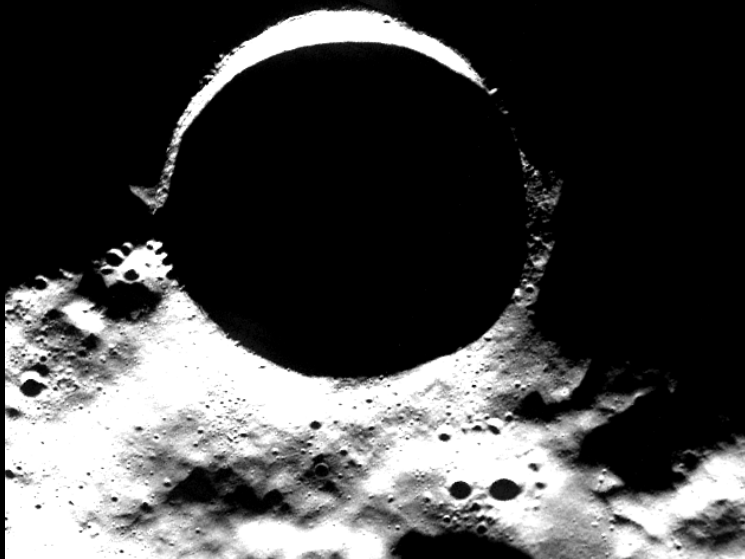
CMU
Render



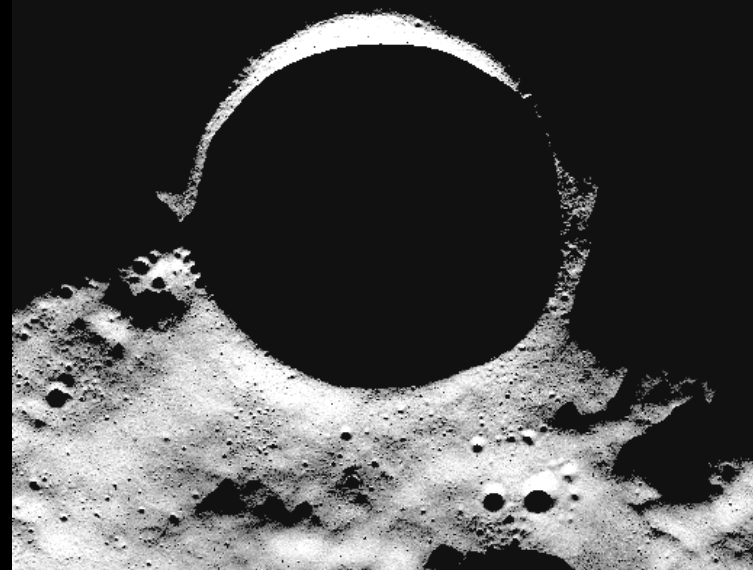
LRO M138582948M



LRO
WAC



CMU
Render



LRO M147761957M

