National Aeronautics and
Space Administration

VIPER

Digital Proving Ground: VIPER Rover Simulator (RSIM)

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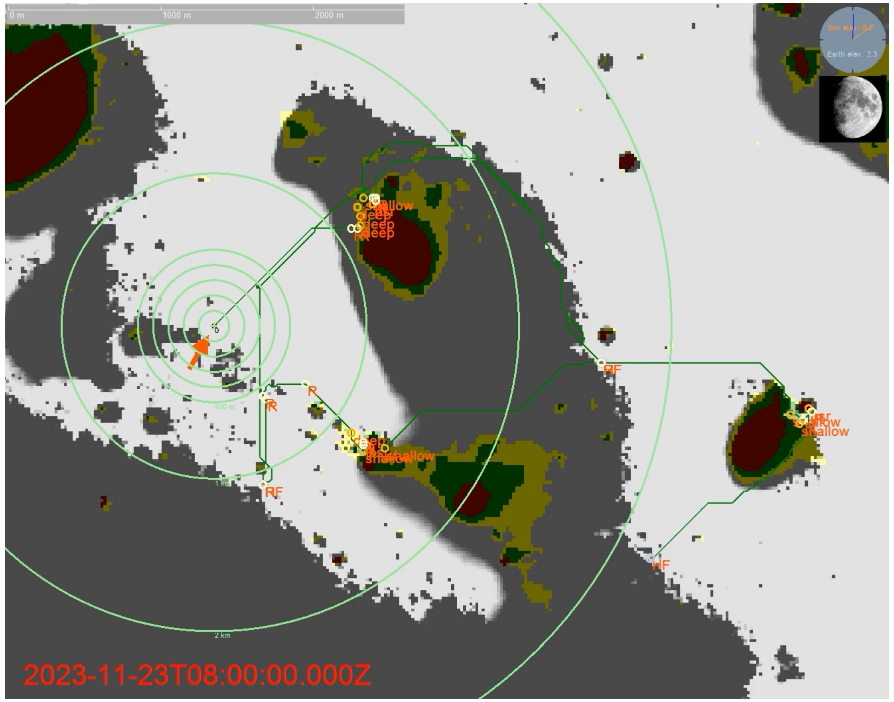
VIPER Mission

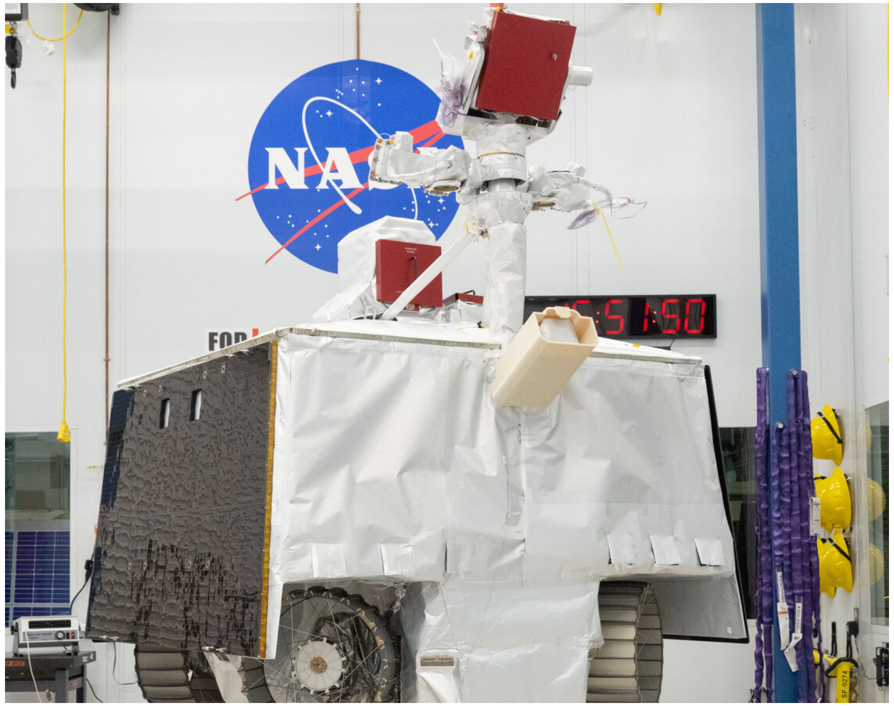
Lunar south pole (84°S, 31°W)

- Characterize distribution and physical state of volatiles (water ice, etc)
- 100+ day mission (multiple lunar nights)
- 20+ km total drive (~1 cm/s avg speed)

Development & training challenges

- How to recreate dynamic lunar polar lighting and shadows?
- How to test terrain relative navigation (stereo vision over large terrain area)?
- How to train for high ops cadence and real-time (interactive) science ops?
- How to facilitate agile software dev (continuous integration / testing)?
- How to perform requirement V&V that needs large data sets and/or many runs?





VIPER "RSIM"

1. High-quality lunar lighting

- Direct/indirect sun, "Earth-shine", rover lights
- Coherent backscatter ("opposition effect")

2. High-fidelity camera models

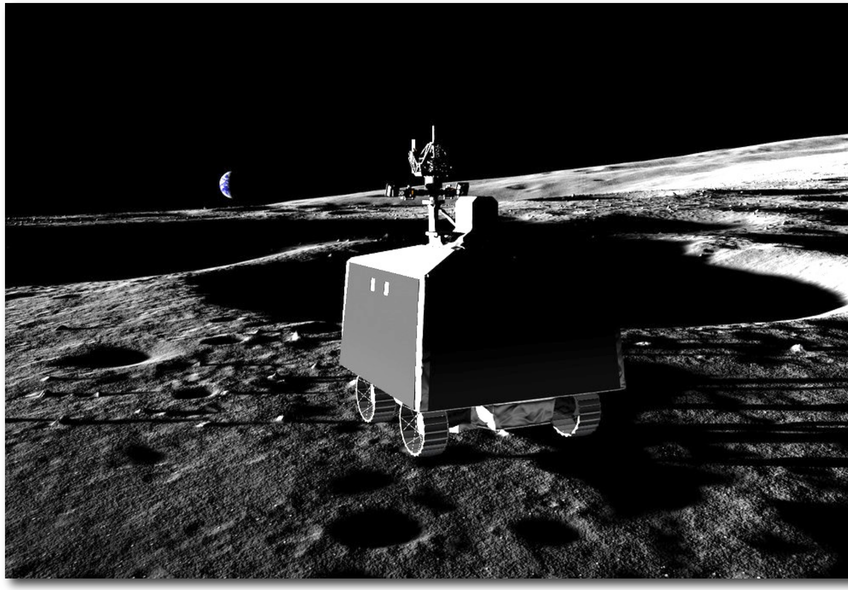
- Exposure, distortion, flare, fixed pattern noise, pixel defects, bit depth, read noise, etc.
- Tuned using NASA Ames "Lunar Lab" tests with camera/light EDUs

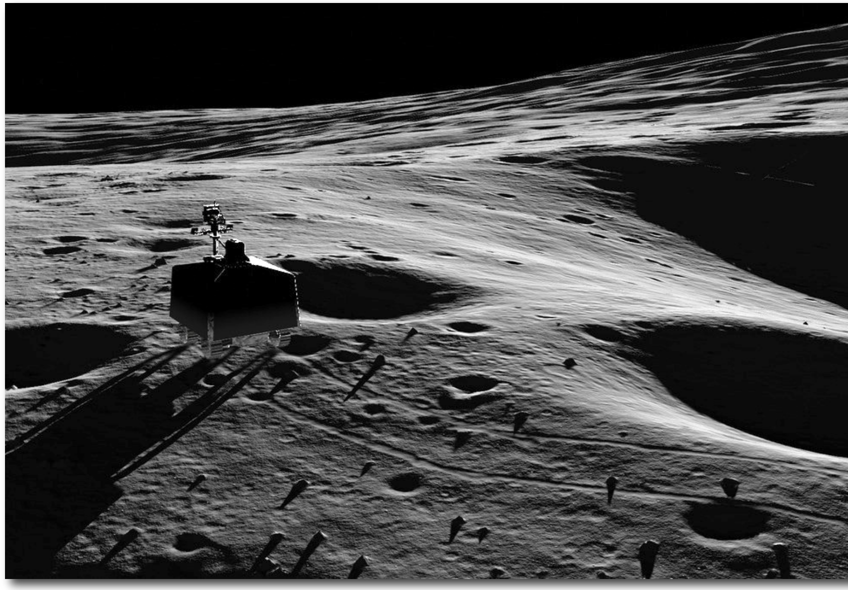
3. Real-time slip modeling

- Driving on unconsolidated soil
- Tuned using NASA Glenn "SLOPE" tests with mobility EDU

4. High-resolution lunar terrain models

- 1 m/pix DEM (photoclinometry, many images)
- 4 cm/pix synthetic DEM (science-based)





1. High-Quality Lunar Lighting

NASA Ames "Lunar Lab"

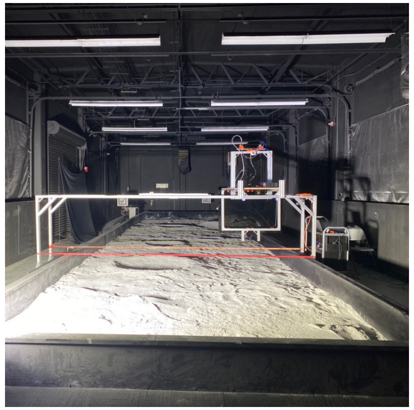
- High-fidelity surface appearance testbed
- Highlands: 12 tons of LHS-1 simulant in a 4x20 meter sandbox
- Mare: 8 tons of JSC-1A simulant in a 4x4 meter sandbox
- Terrain can be shaped and dusted to mimic micro-meteorite surface texture

Experimental setup

- Sun simulators for lunar polar lighting
- Sliding gantry provides non-contact data collection for optical sensors
- High accuracy (survey grade) lidar and positioning system for ground truthing

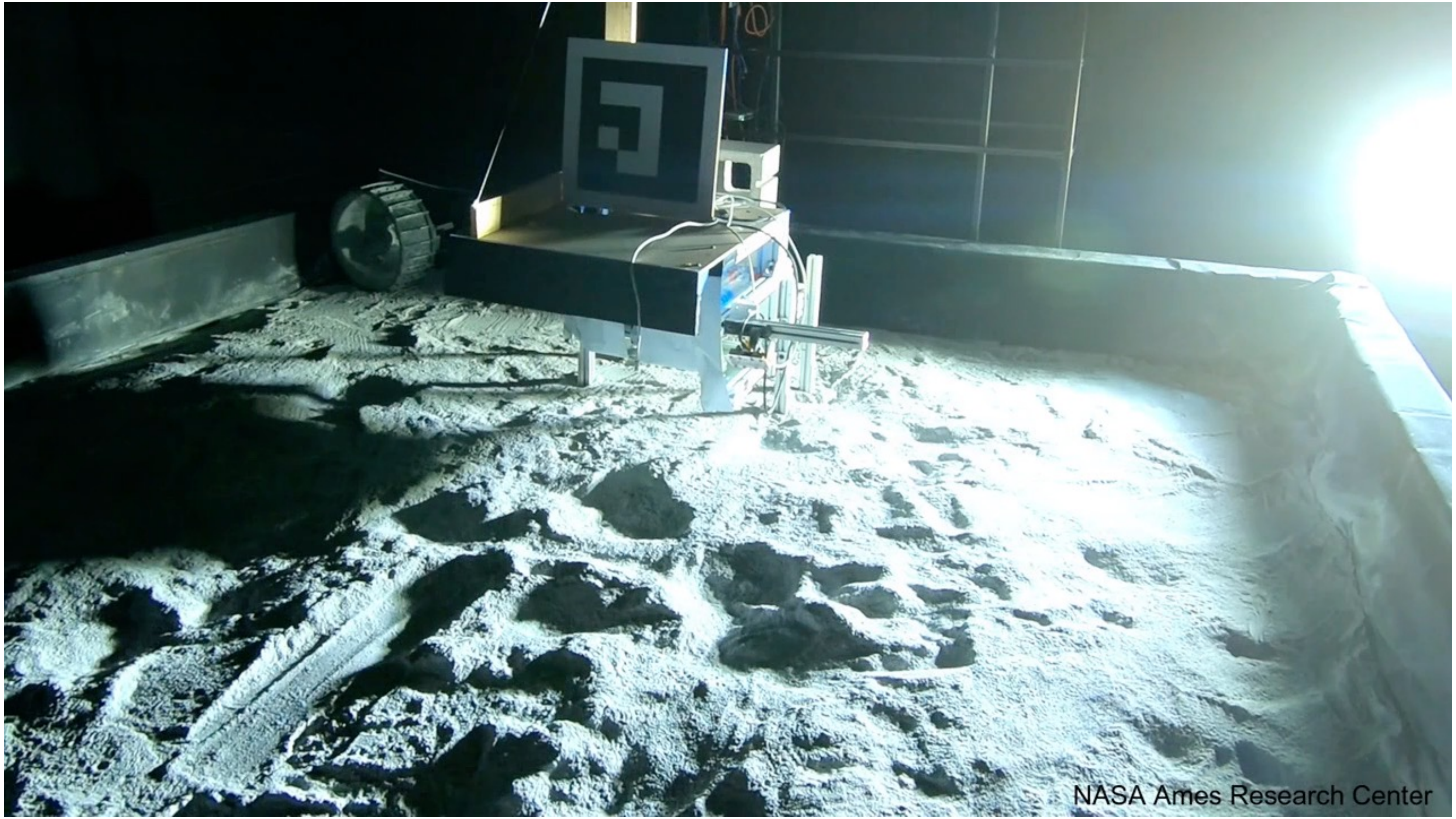
Simulated polar lighting on LHS-1 terrain

Appearance of VIPER rover wheel and tracks



Sliding gantry over LHS-1 terrain

1. High-Quality Lunar Lighting

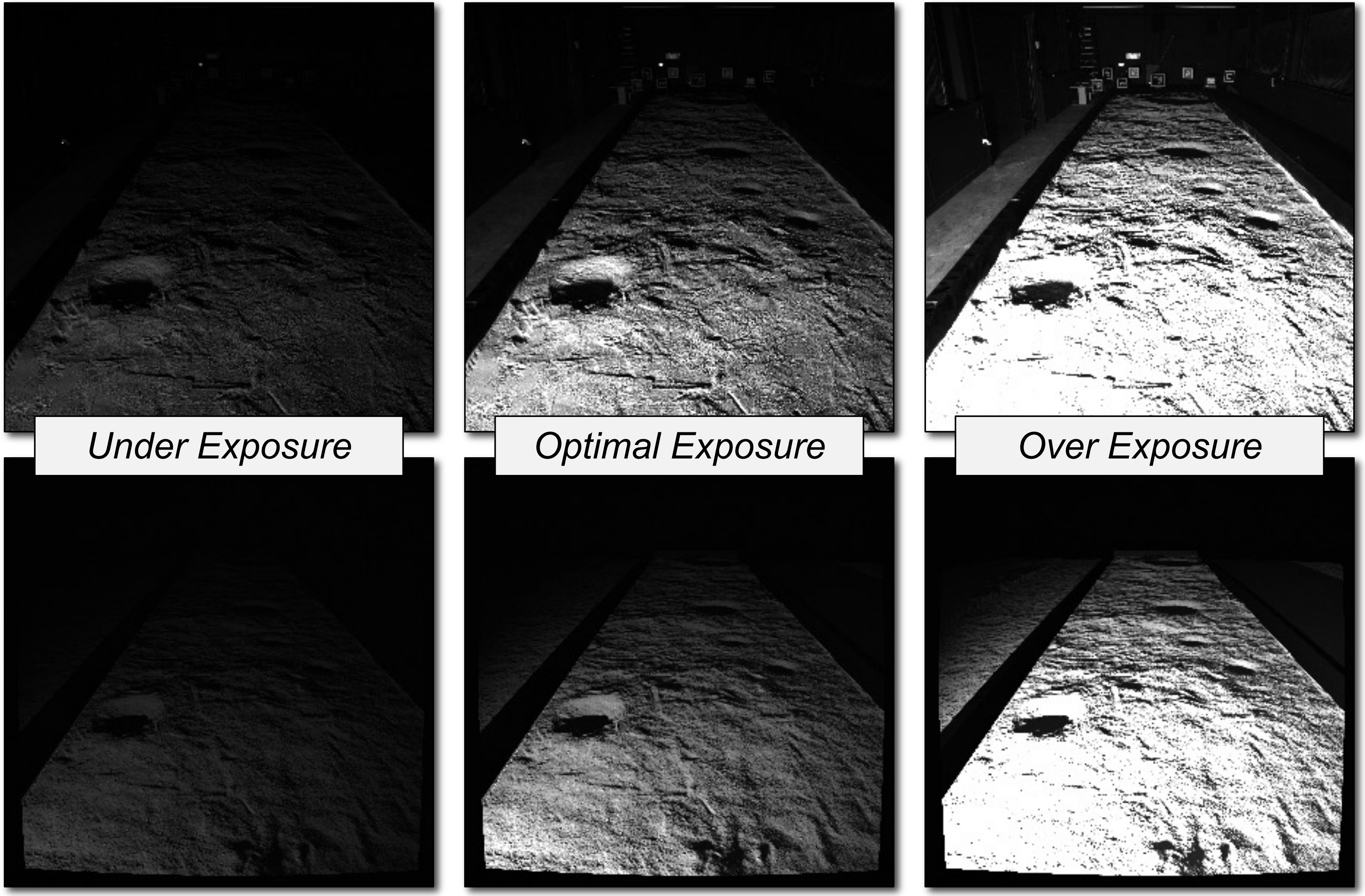


4m x 19m sandbox with 19 tons of LHS-1 lunar regolith simulant

2. High-fidelity Camera Models

Lunar Lab

RSIM



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Lunar Lab

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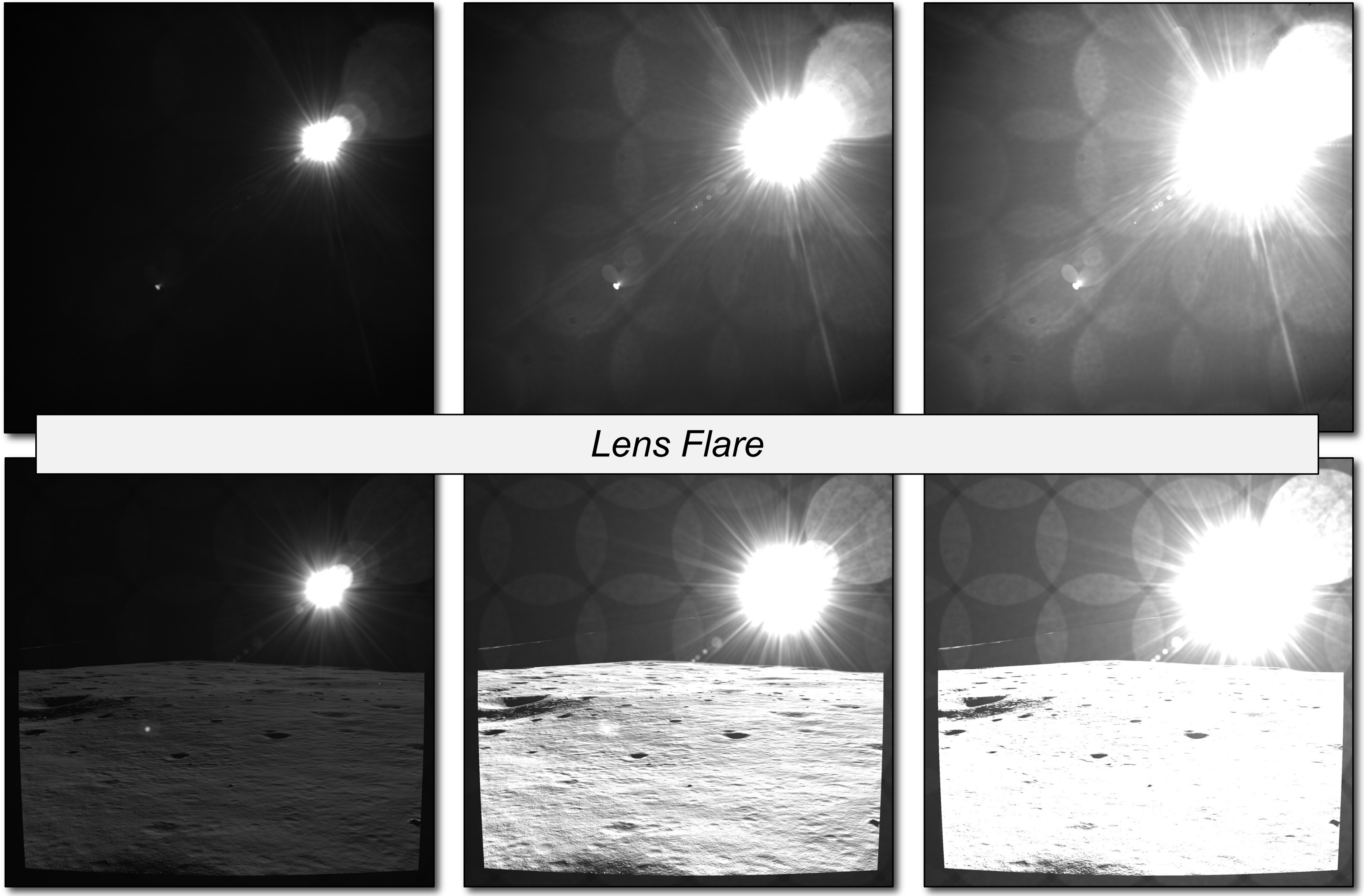

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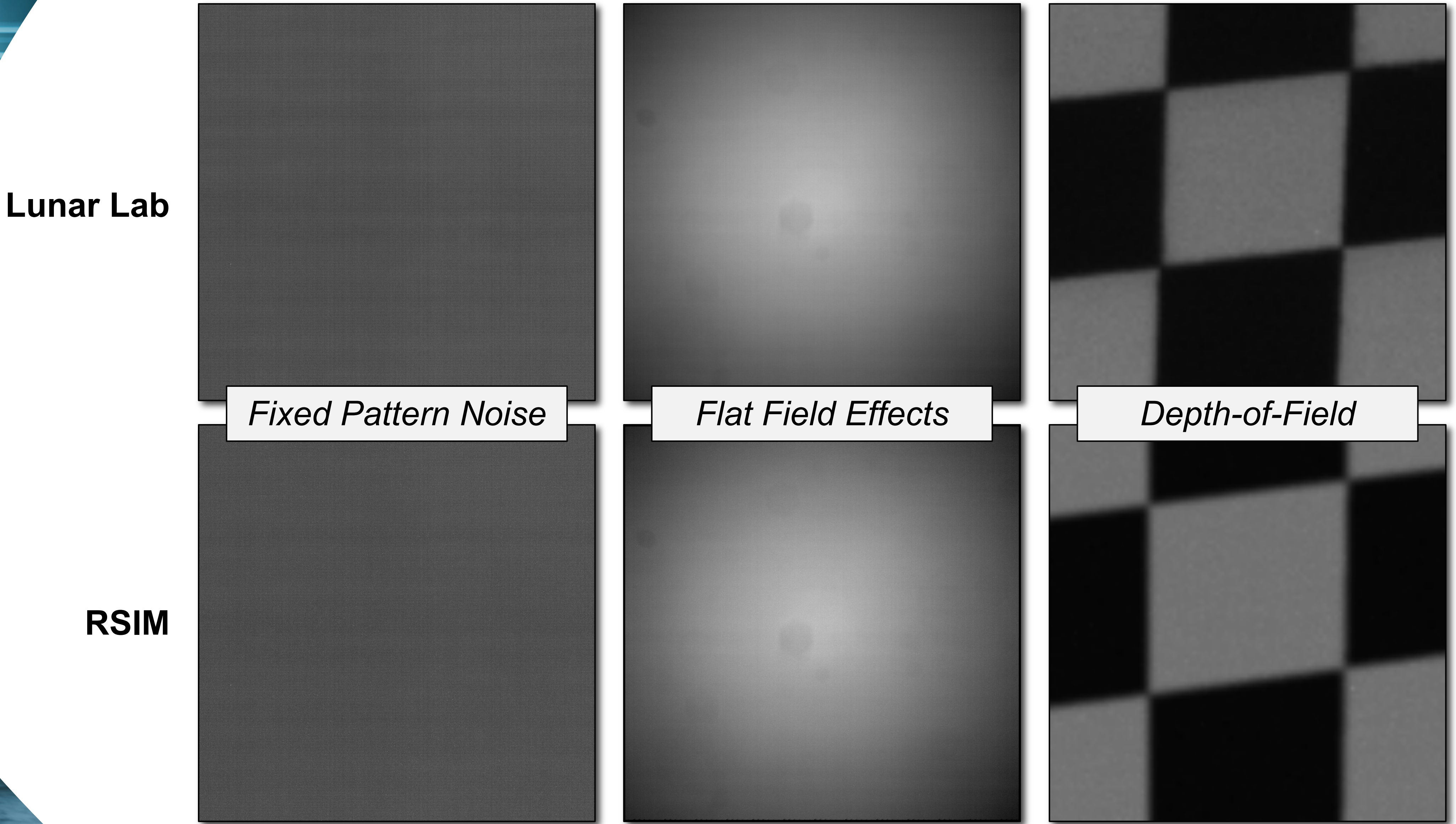
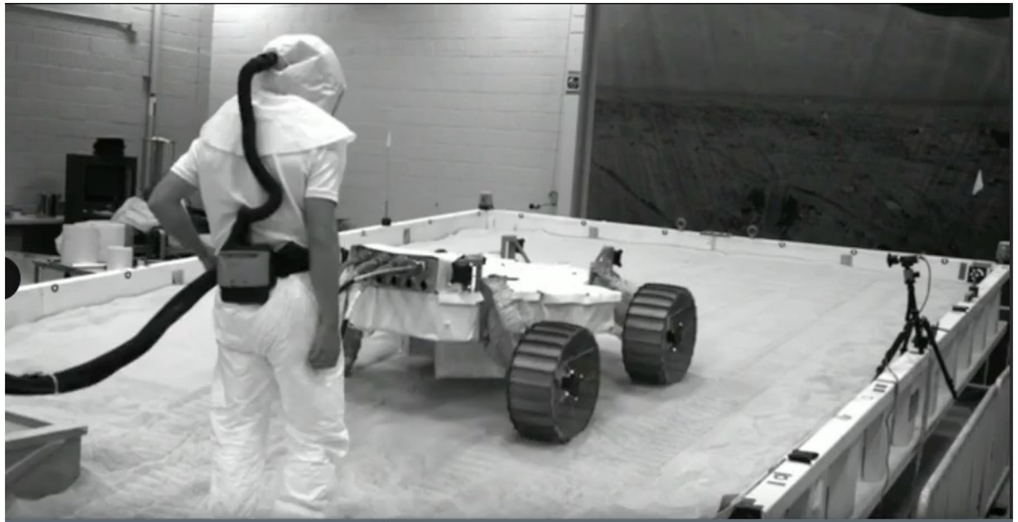


3. Real-time Slip Modeling

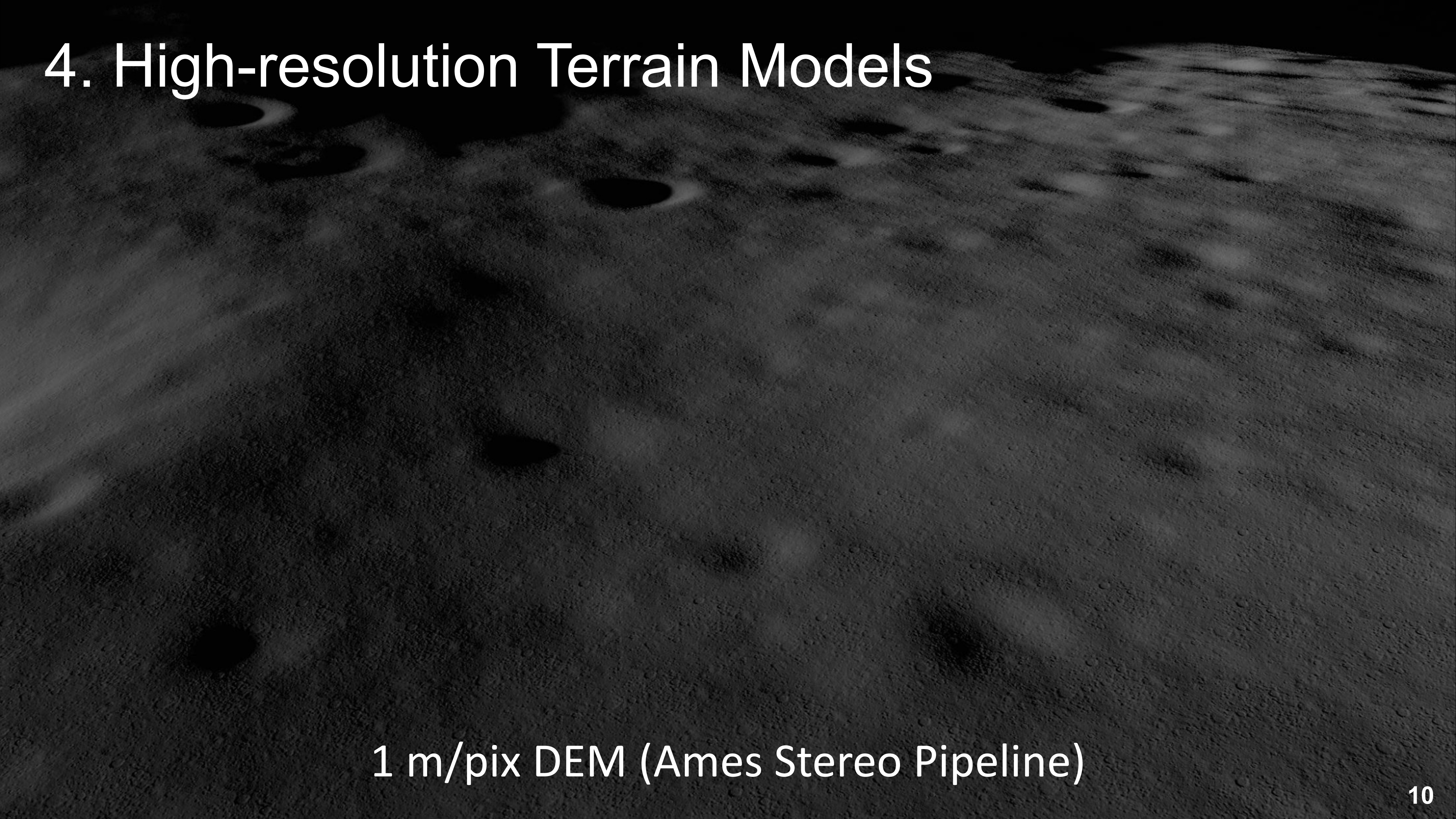
RSIM Rover Physics

- Approximate terramechanics of driving on unconsolidated soil
- Slip compliance and friction modulated on a per-wheel basis to account for compaction and rocks



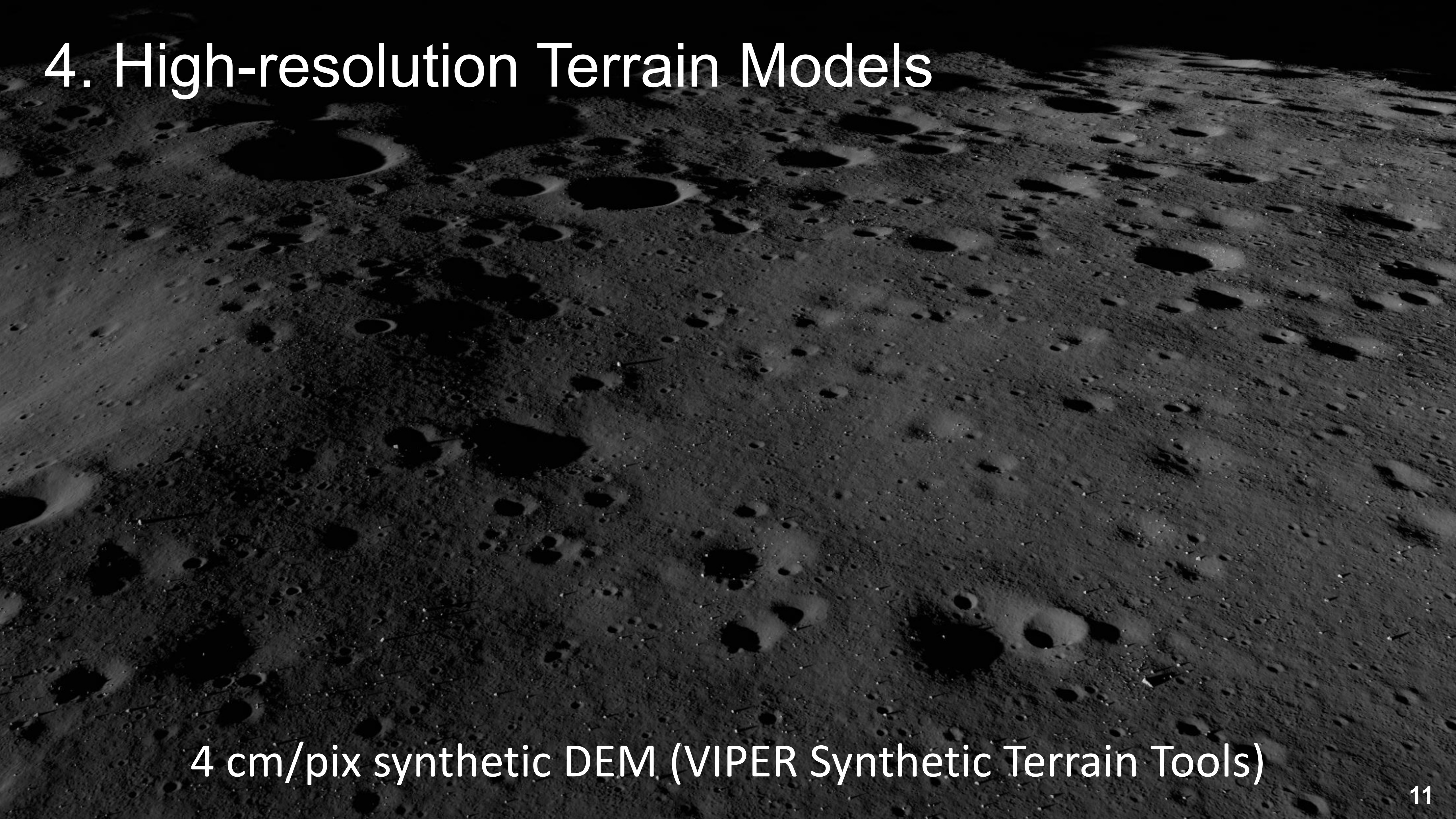
SLOPE Lab (GRC)

4. High-resolution Terrain Models

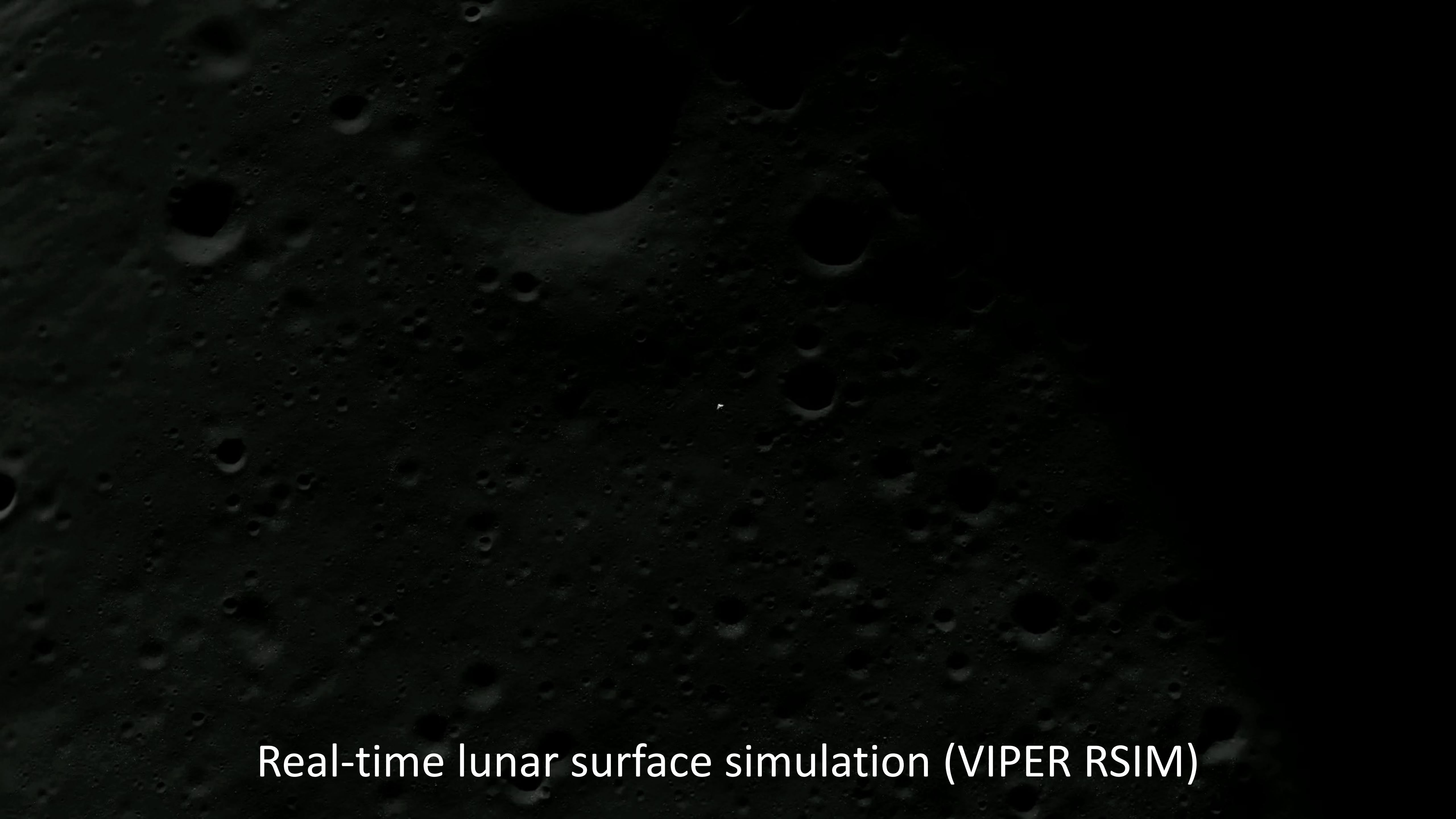


1 m/pix DEM (Ames Stereo Pipeline)

4. High-resolution Terrain Models



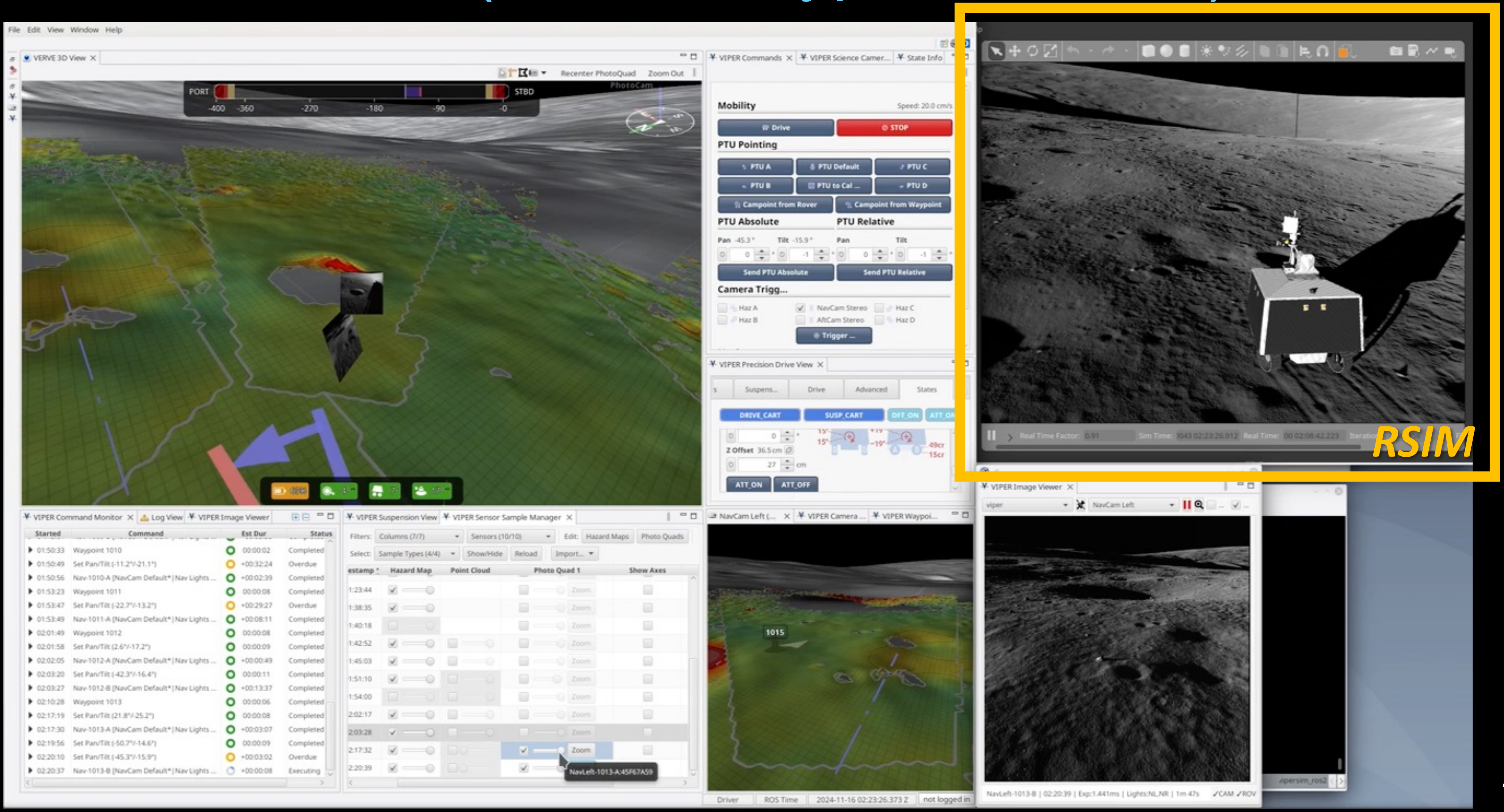
4 cm/pix synthetic DEM (VIPER Synthetic Terrain Tools)



Real-time lunar surface simulation (VIPER RSIM)

Mission Operations Training

VERVE + RSIM (Refine waypoint + drive)



For additional information:

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