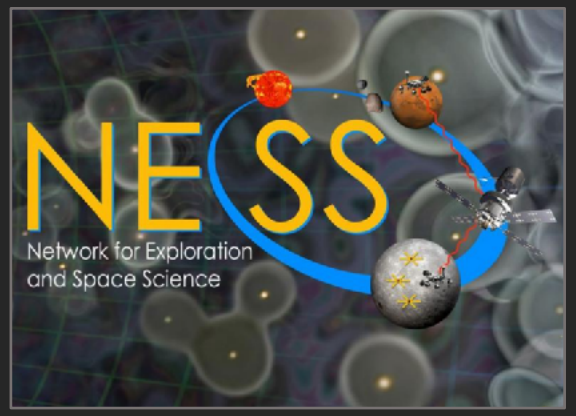
University of Colorado Boulder

# VIRTUAL REALITY SIMULATION TESTBED:
## *IMPROVING SURFACE TELEROBOTICS FOR THE DEEP SPACE GATEWAY*

ATLAS INSTITUTE

IRON LABORATORY

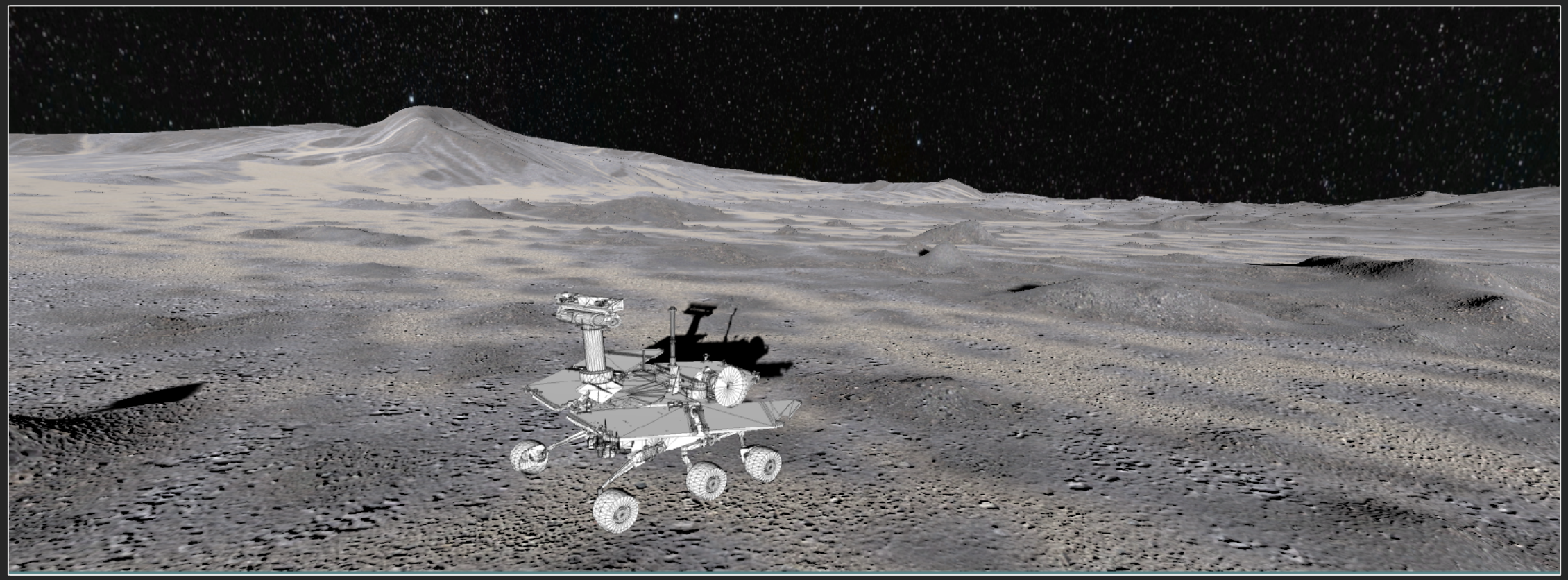



Michael Walker, Jack Burns, & Daniel Szafir

# ROBOT TELEOPERATION METHODS

*Lipton, Jeffrey I., Aidan J. Fay, and Daniela Rus. "Baxter's Homunculus: Virtual Reality Spaces for Teleoperation in Manufacturing." IEEE Robotics and Automation Letters 3.1 (2018): 179-186.*

# VIRTUAL REALITY SIMULATION TESTBED

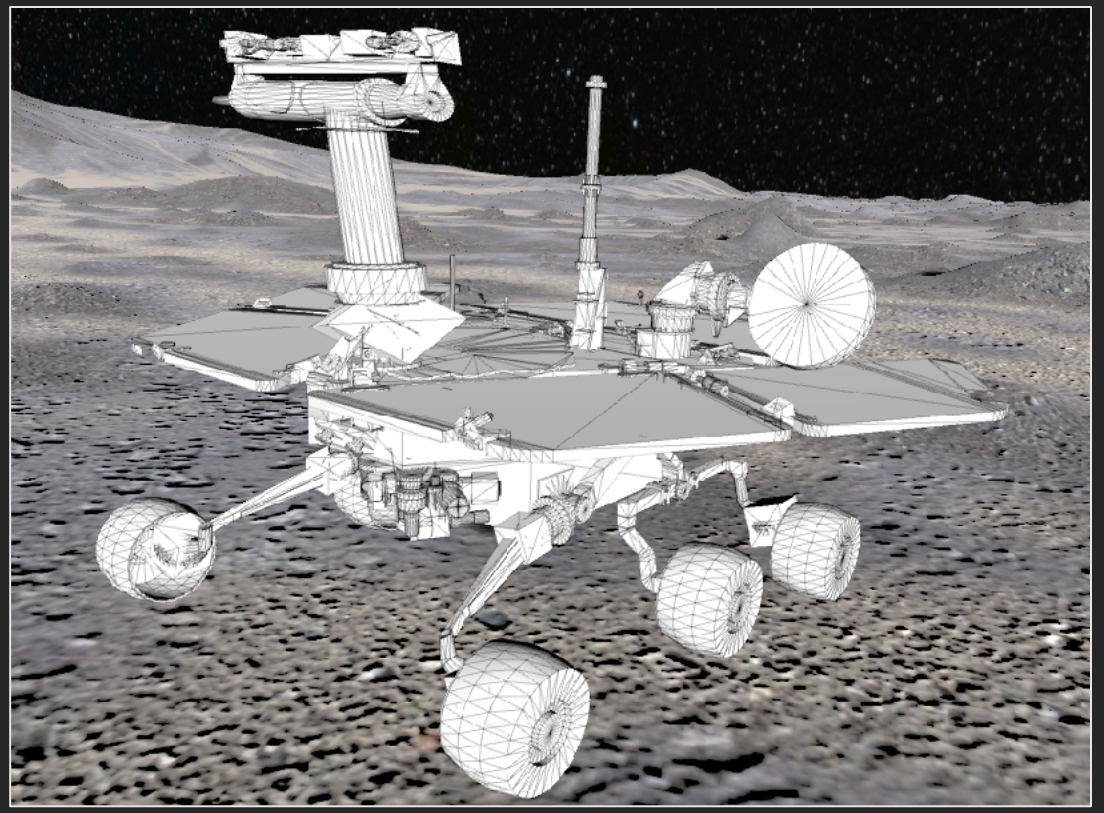


# VIRTUAL REALITY SIMULATION TESTBED

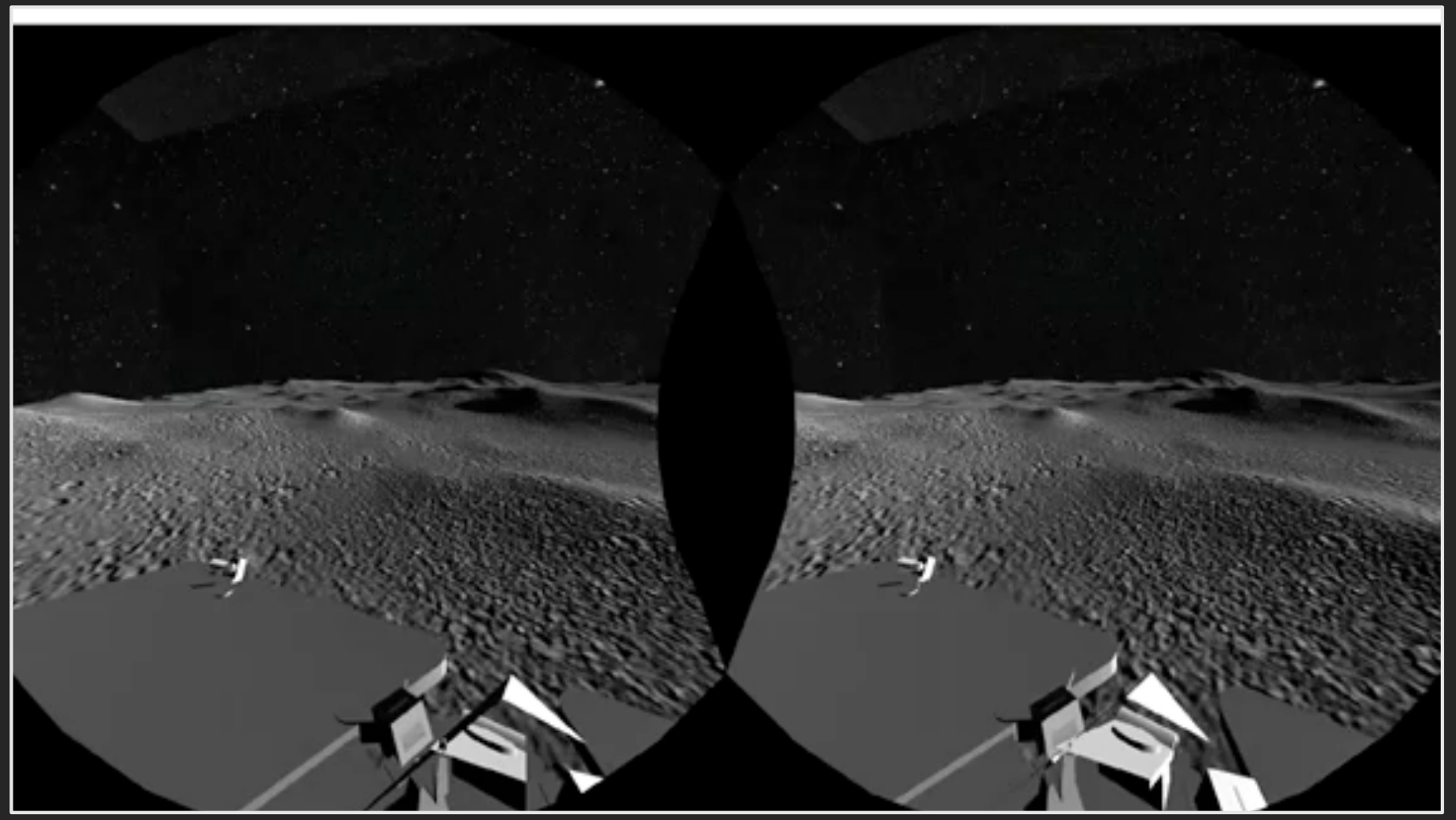
Support Future Virtual Reality (VR) Rover Teleoperation from the DSG

Provide Rapid Prototyping of

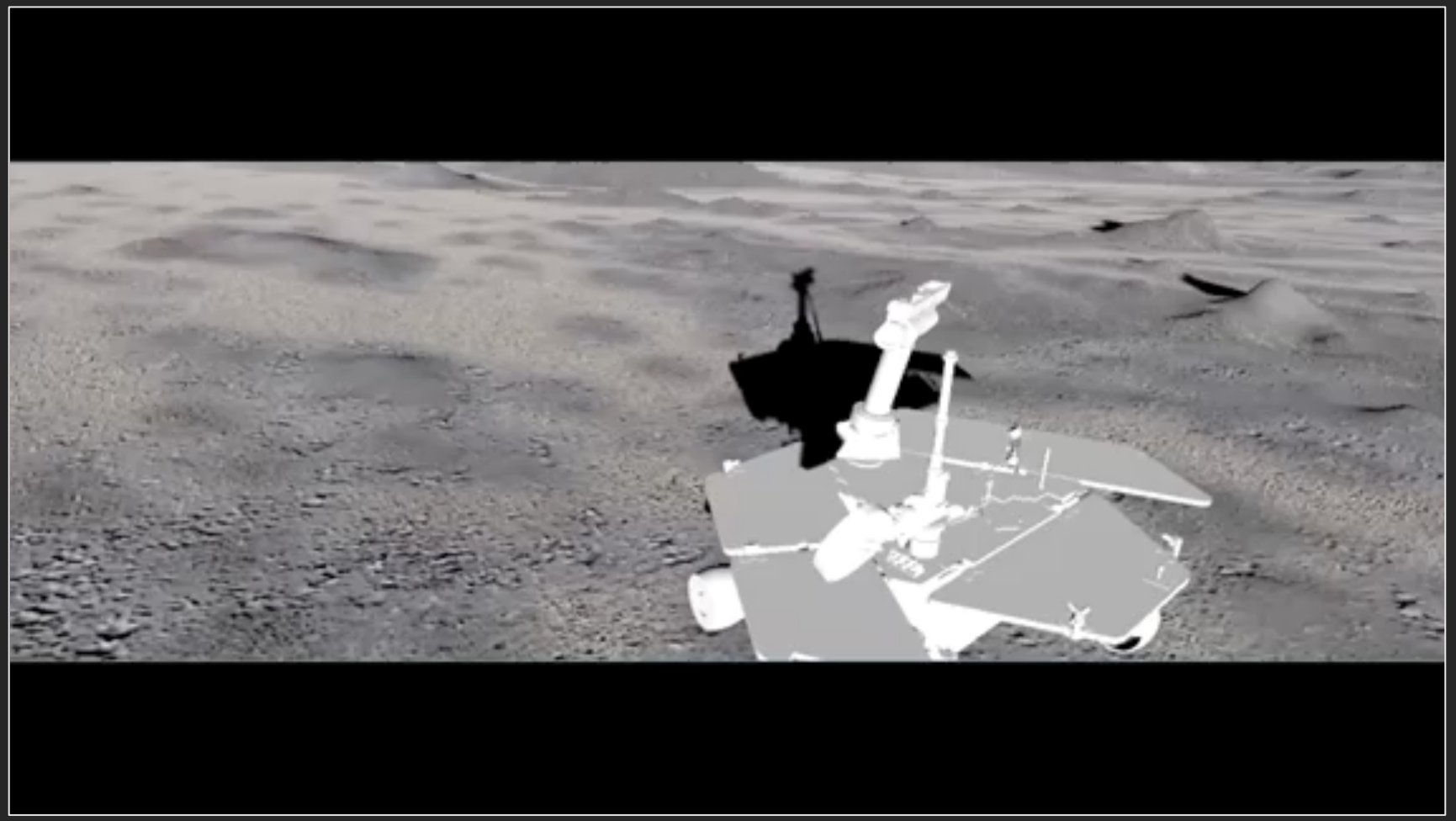
- Rover Designs
- Teleoperation Interfaces



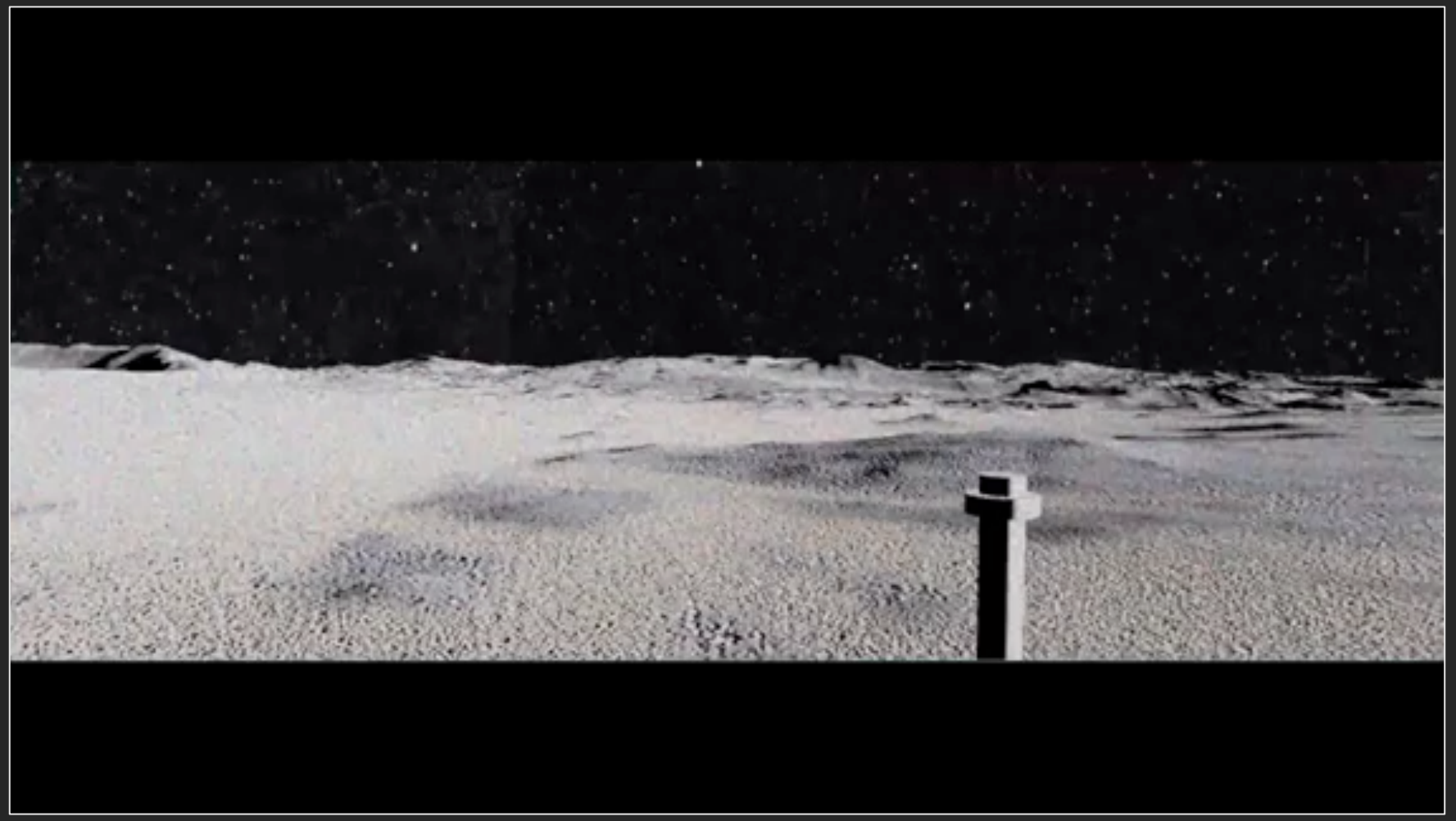
# DEPTH & IMMERSION IN VIRTUAL REALITY



# 3rd PERSON ROVER TELEOPERATION



# 1st PERSON ROVER TELEOPERATION



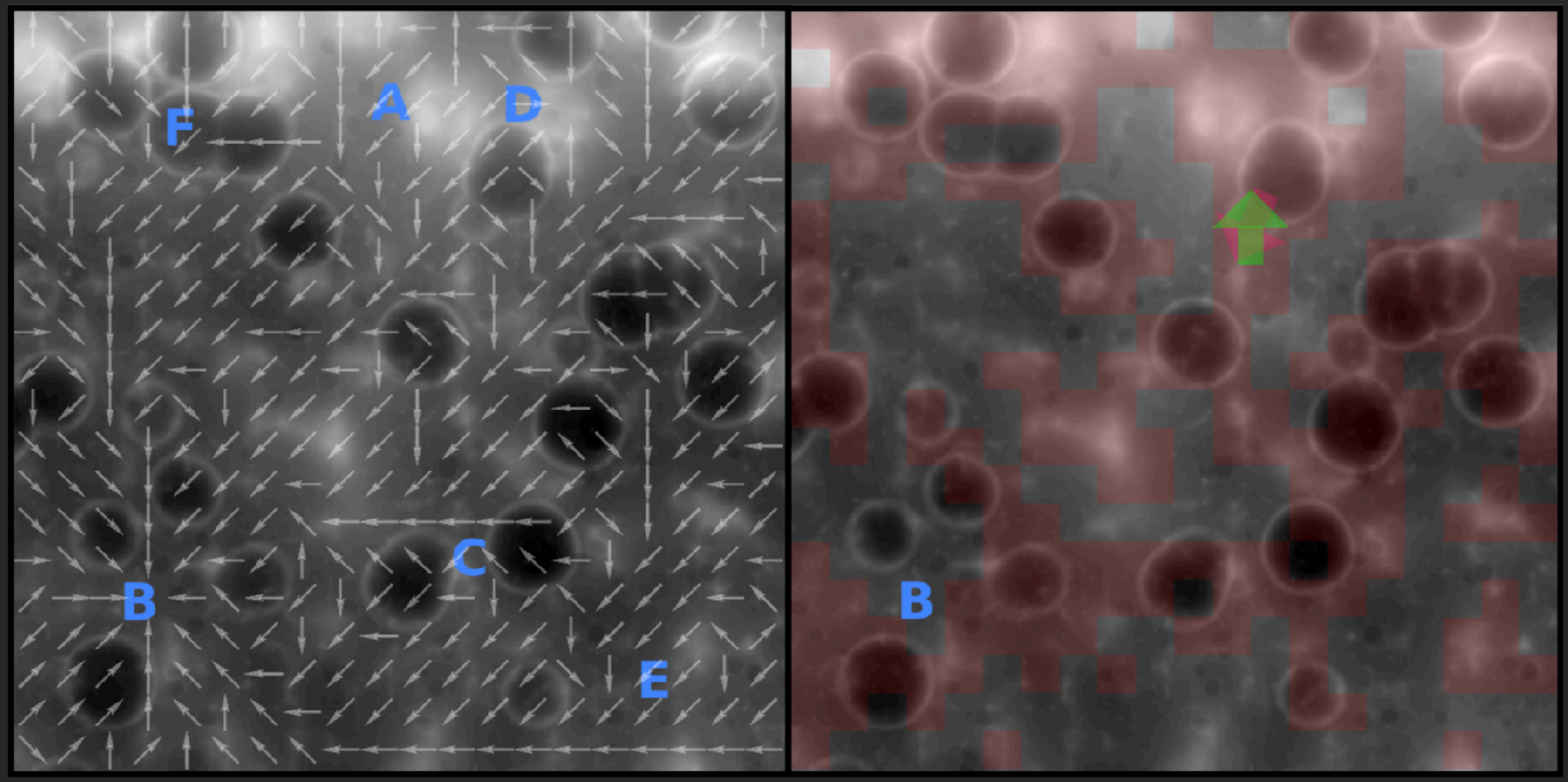
# IN-SIMULATION RESEARCH STUDIES

# AUTONOMOUS ADVISOR TRUST FOR ROVER TELEOPERATION

**Scenario**: Lunar surface exploratory telerobotics is a complex problem largely due to communication delays that limit traditional ground control effectiveness.

**Problem Statement**: Surface models of distant planetary bodies inherently contain imperfect data (e.g., hazard mapping). What factors influence user's trust in autonomous assistants operating under uncertainty while teleoperating exploratory surface robotics?

# AUTONOMOUS ADVISOR TRUST FOR ROVER TELEOPERATION



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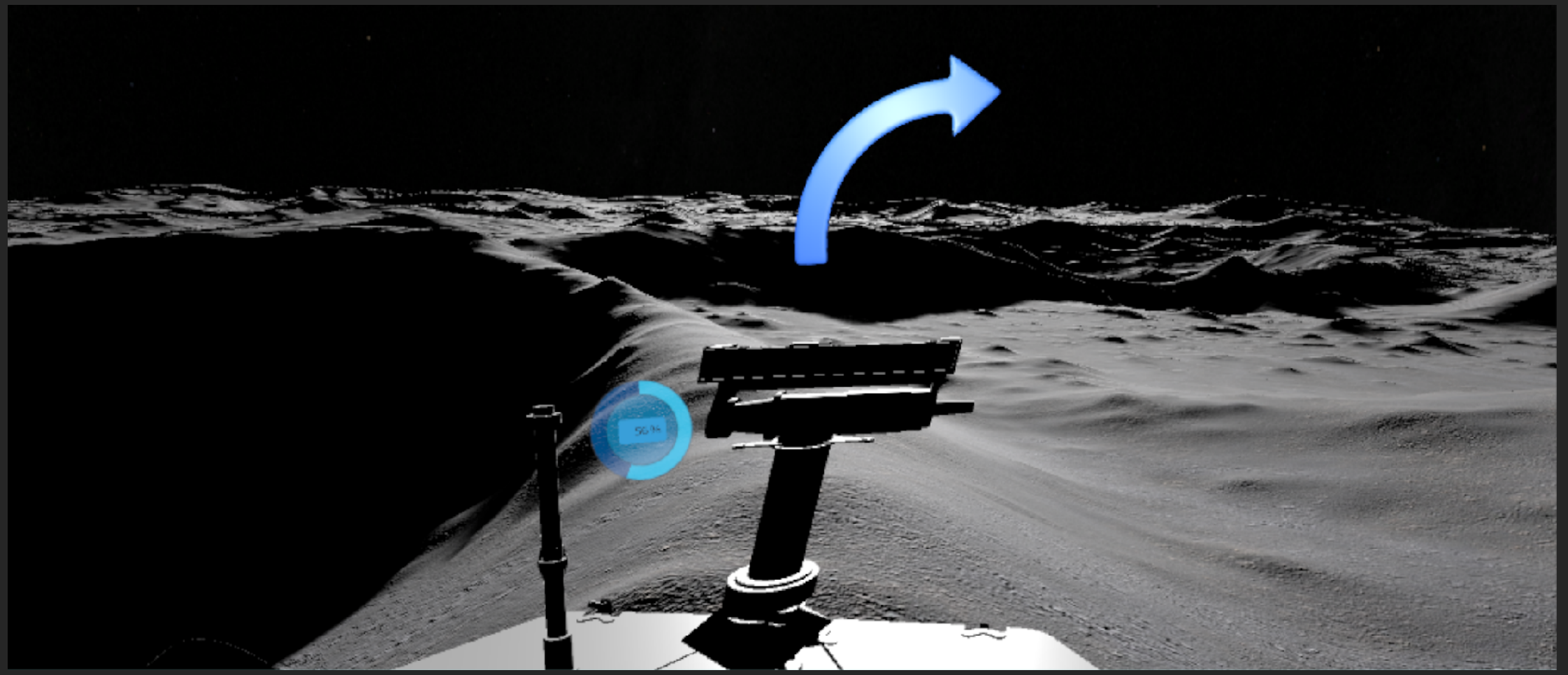

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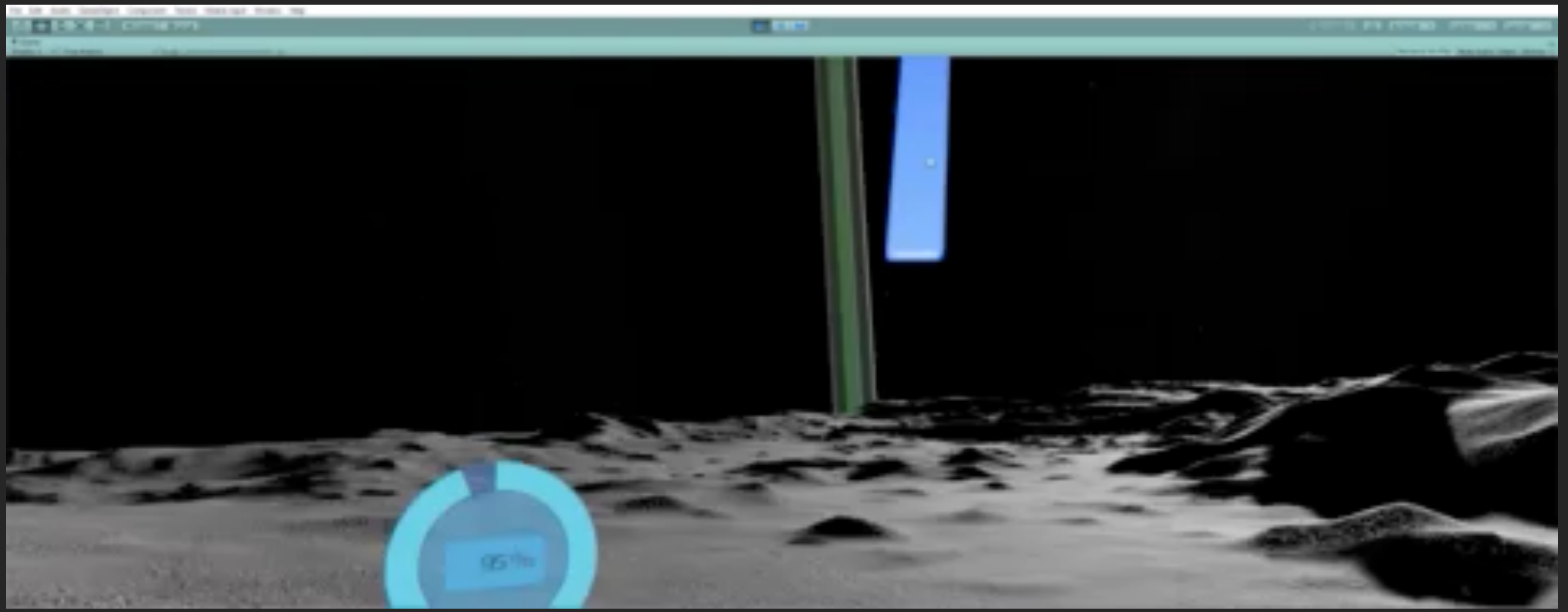

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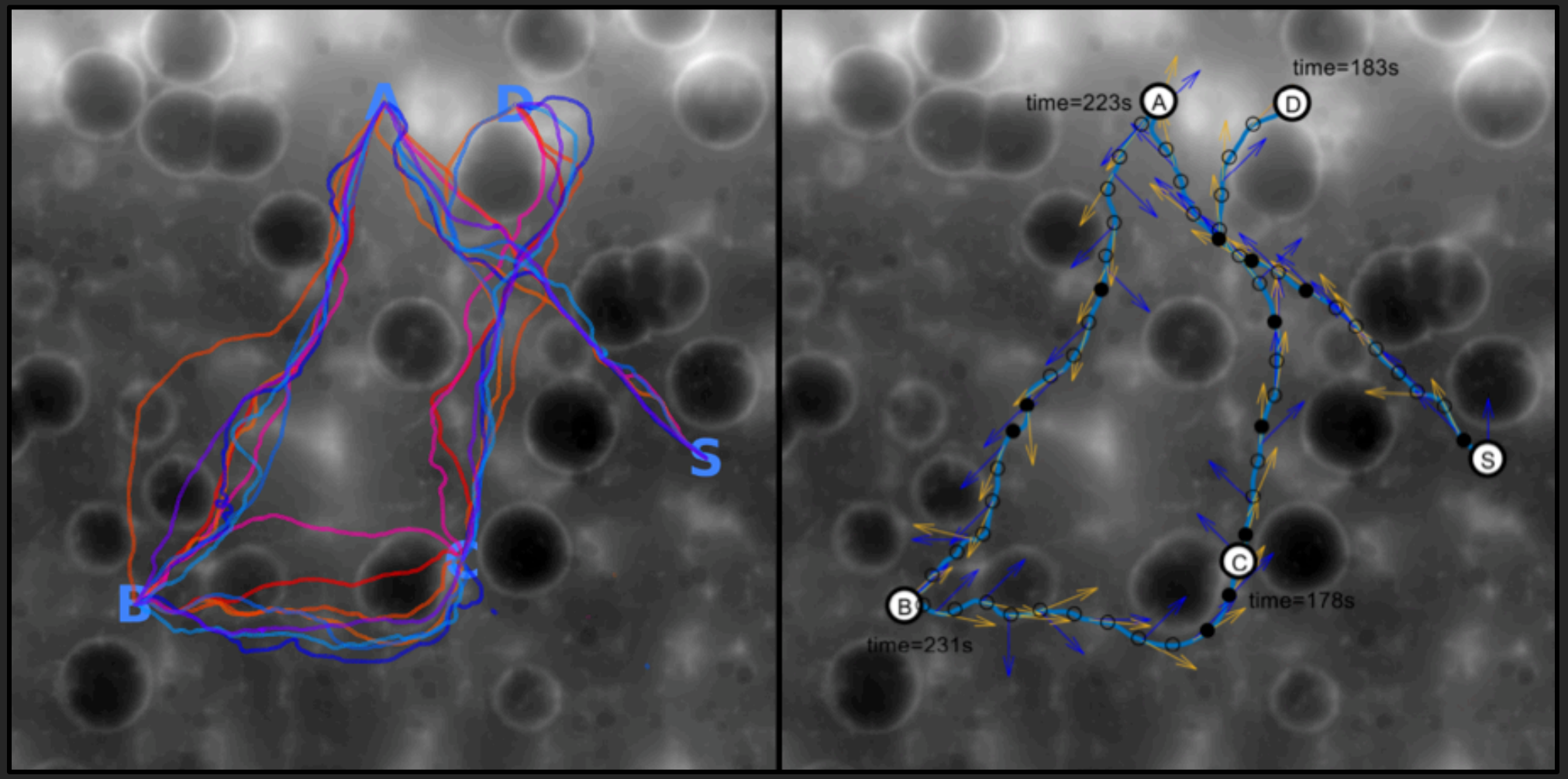

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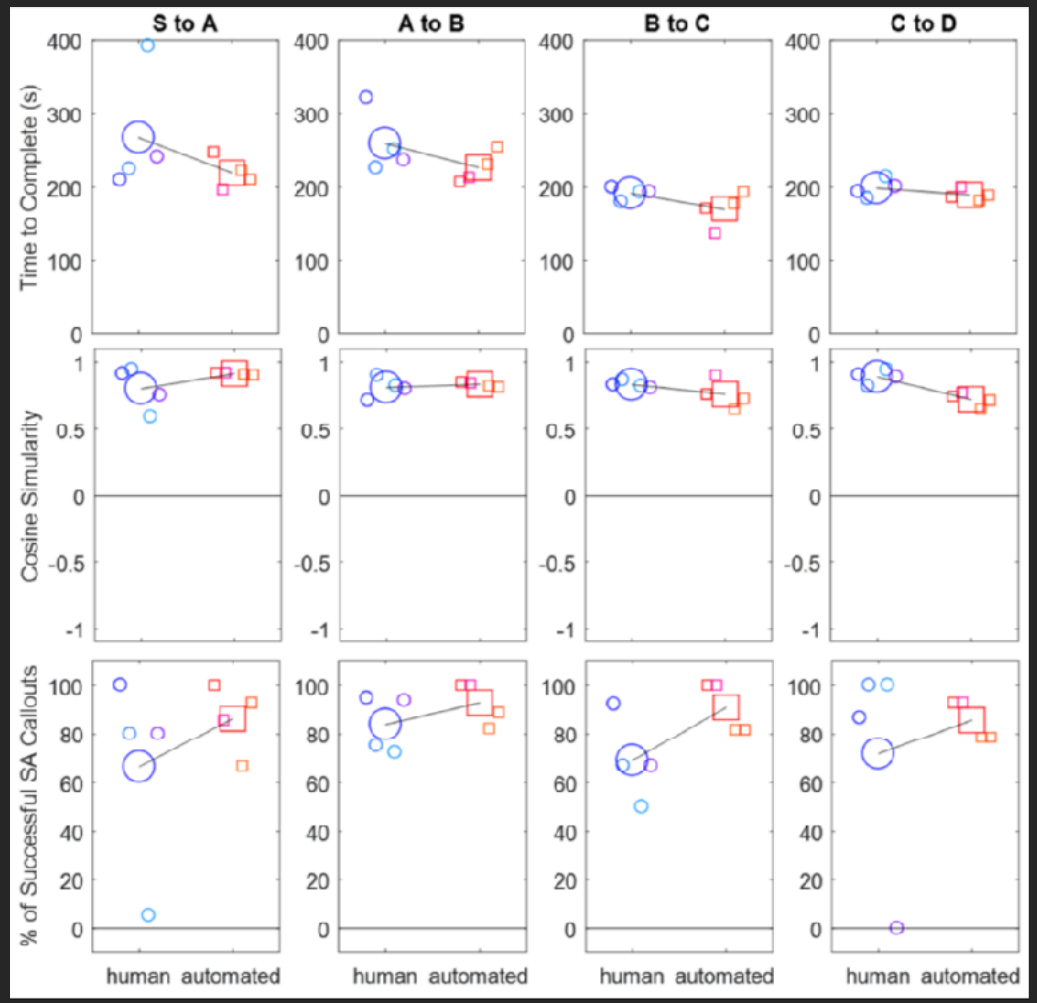

# LUNAR TERRAIN

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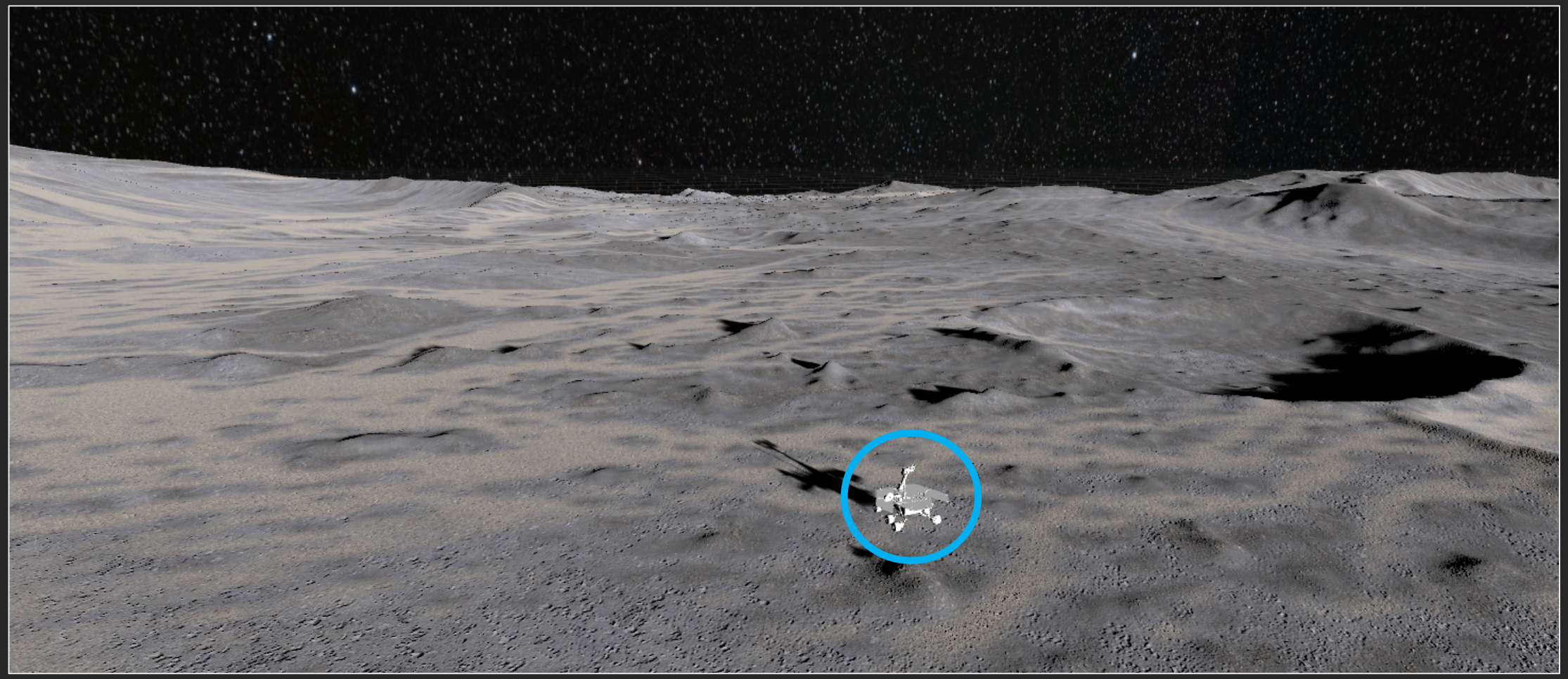

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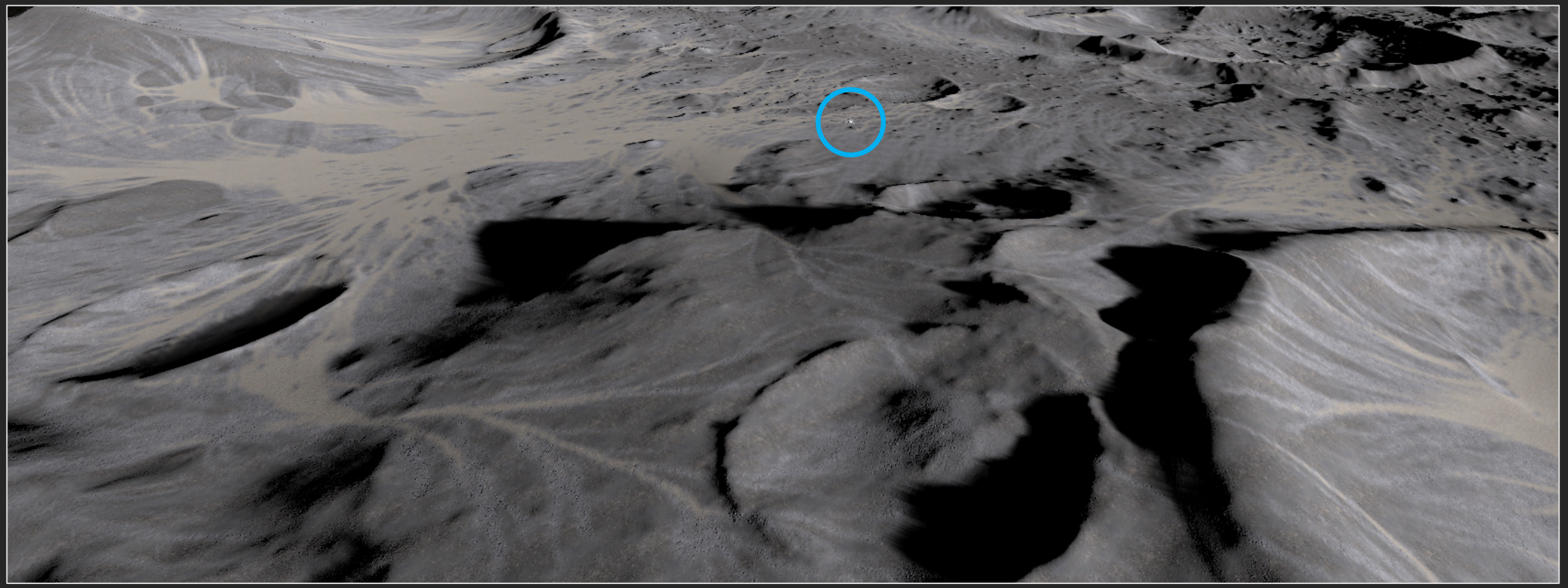

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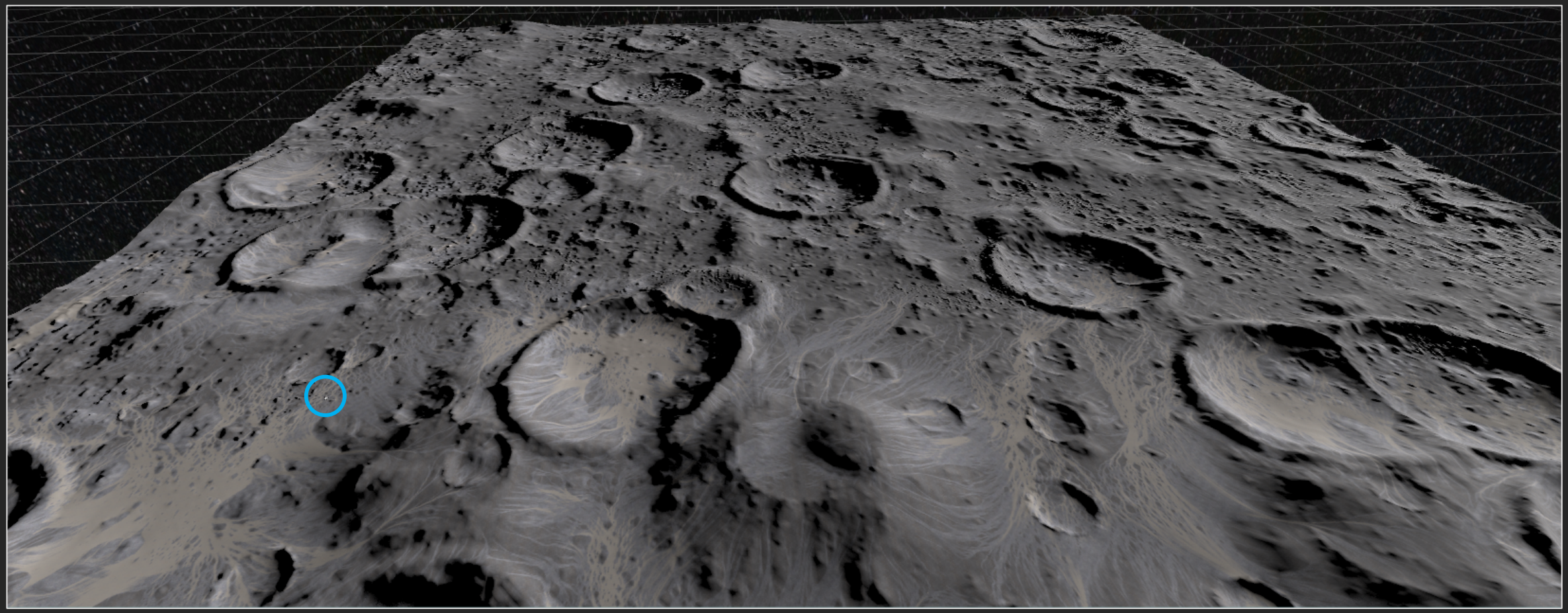
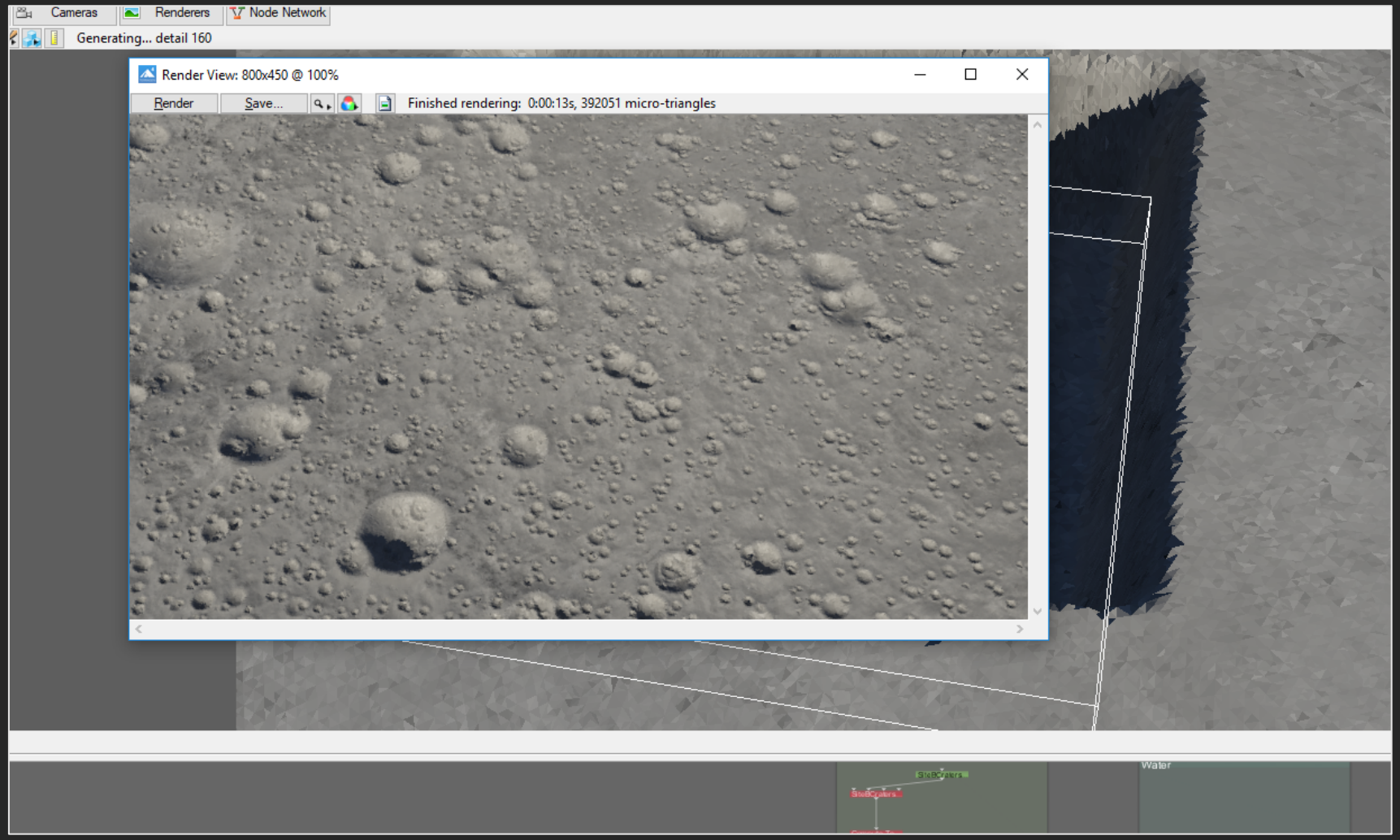
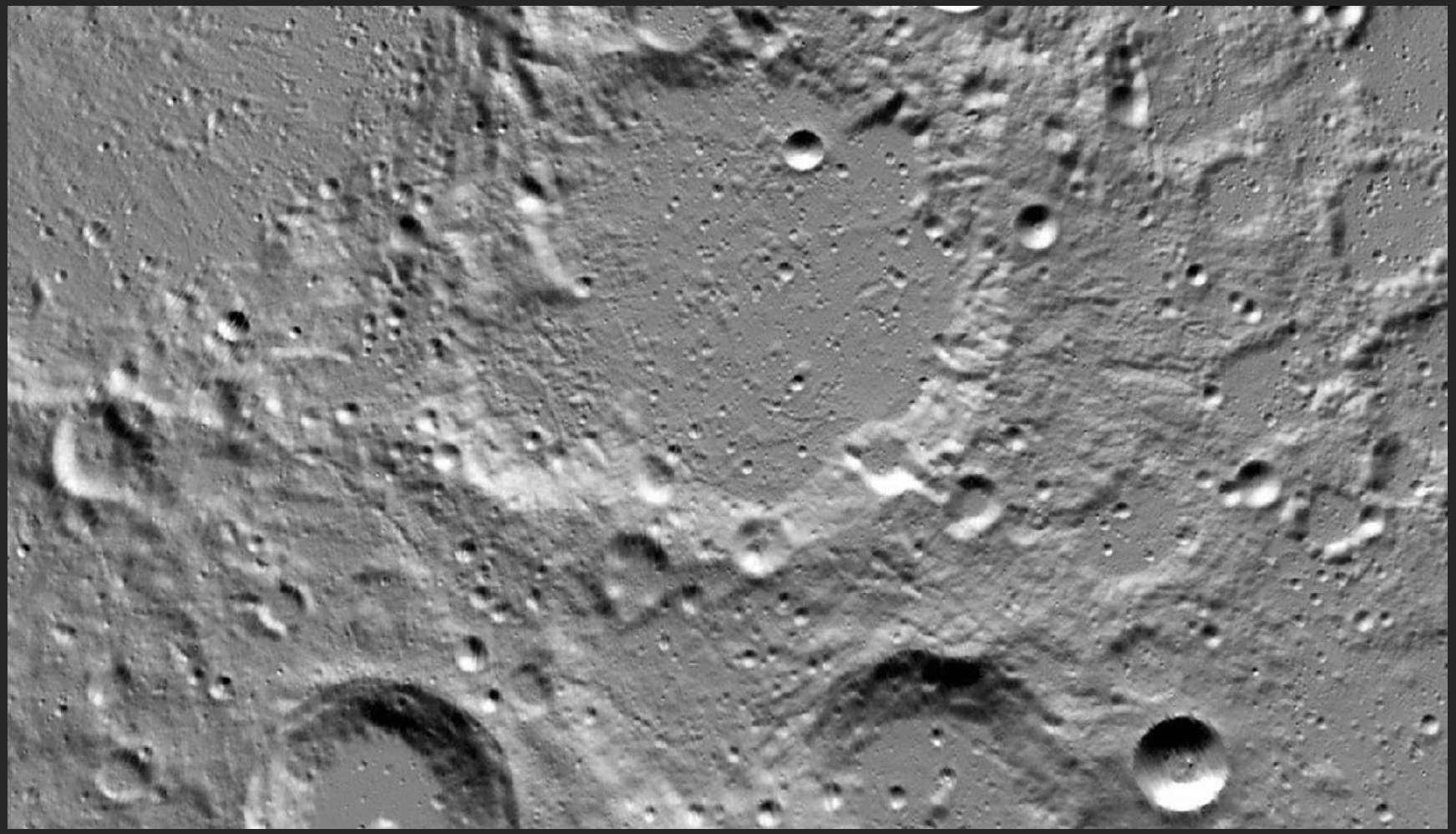


# REALISTIC HIGH-RESOLUTION SYNTHETIC LUNAR TERRAIN



# HERMITE CRATER (NASA LRO)



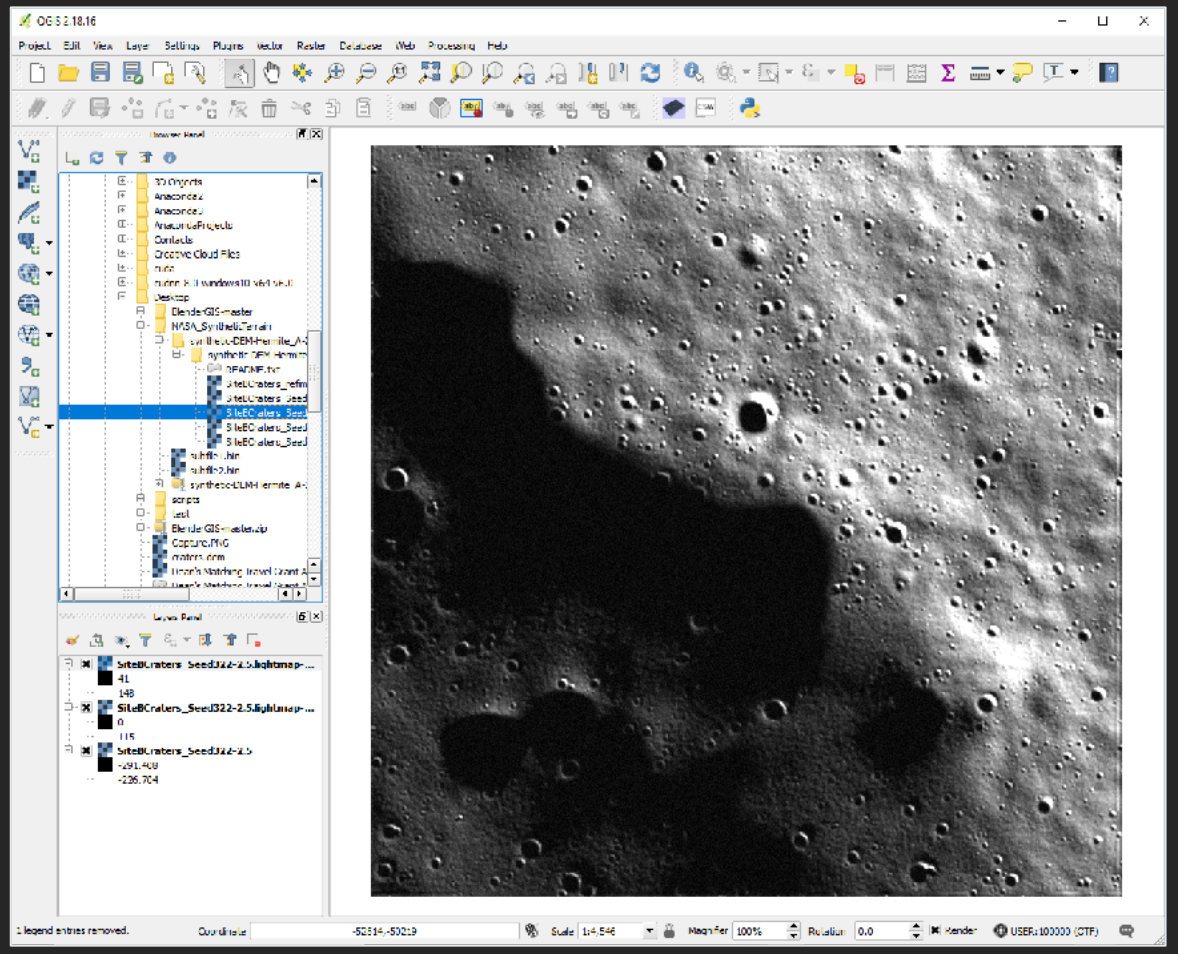
# SYNTHETIC DIGITAL ELEVATION MODEL (DEM)

1 km x 1 km area near the Hermite A crater near the north pole of the Moon

Source data compiled from:

- Publicly available images
- Laser altimetry of the Hermite A region (acquired by the Lunar Reconnaissance Orbiter)

This source data was used to generate an initial Digital Elevation Model (DEM) with 1 m resolution

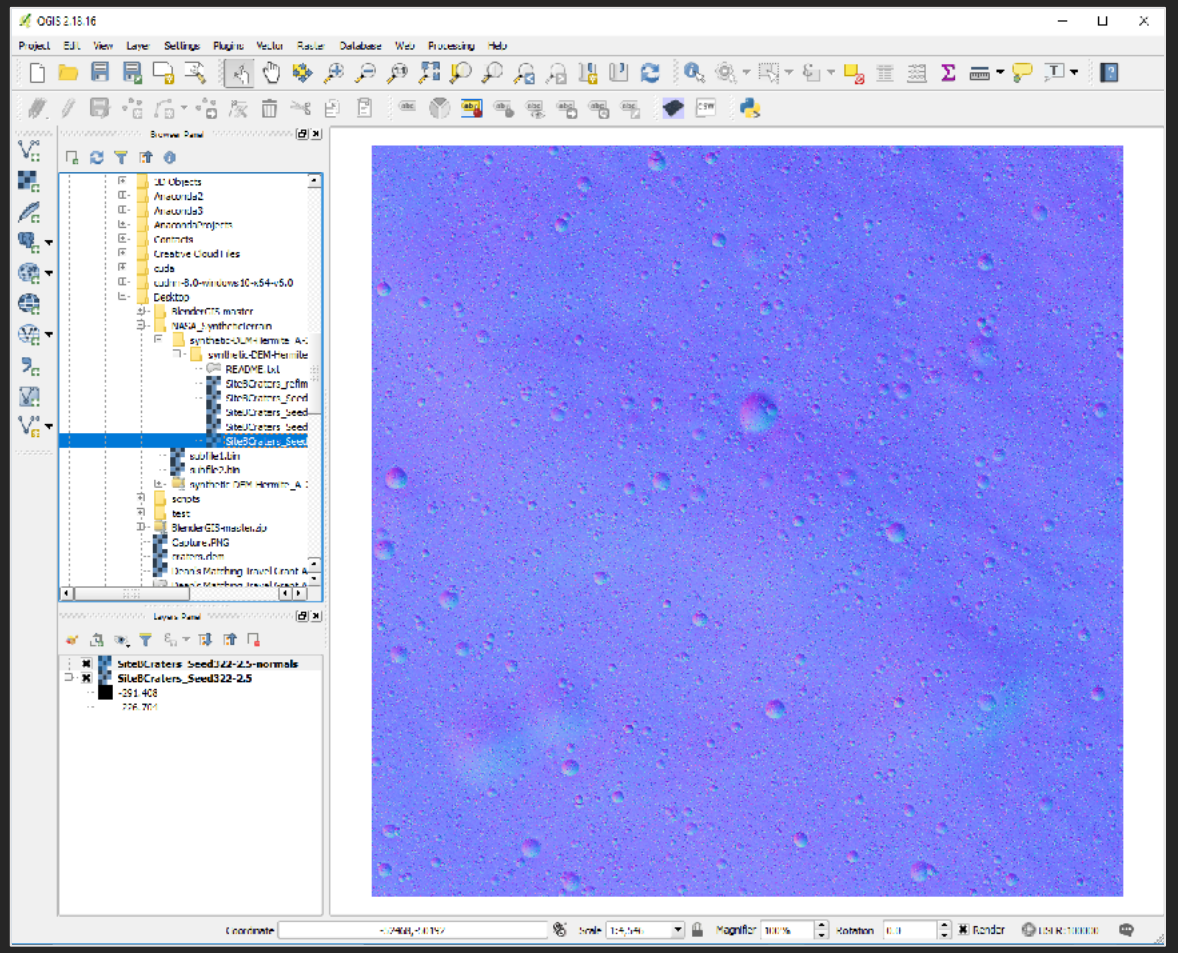


# SYNTHETIC DIGITAL ELEVATION MODEL (DEM)

DEM is synthetically enhanced to create terrain consistent with lunar morphology

Synthetic rocks and craters are inserted into the DEM

Synthetic DEM is approximately 4 cm per pixel



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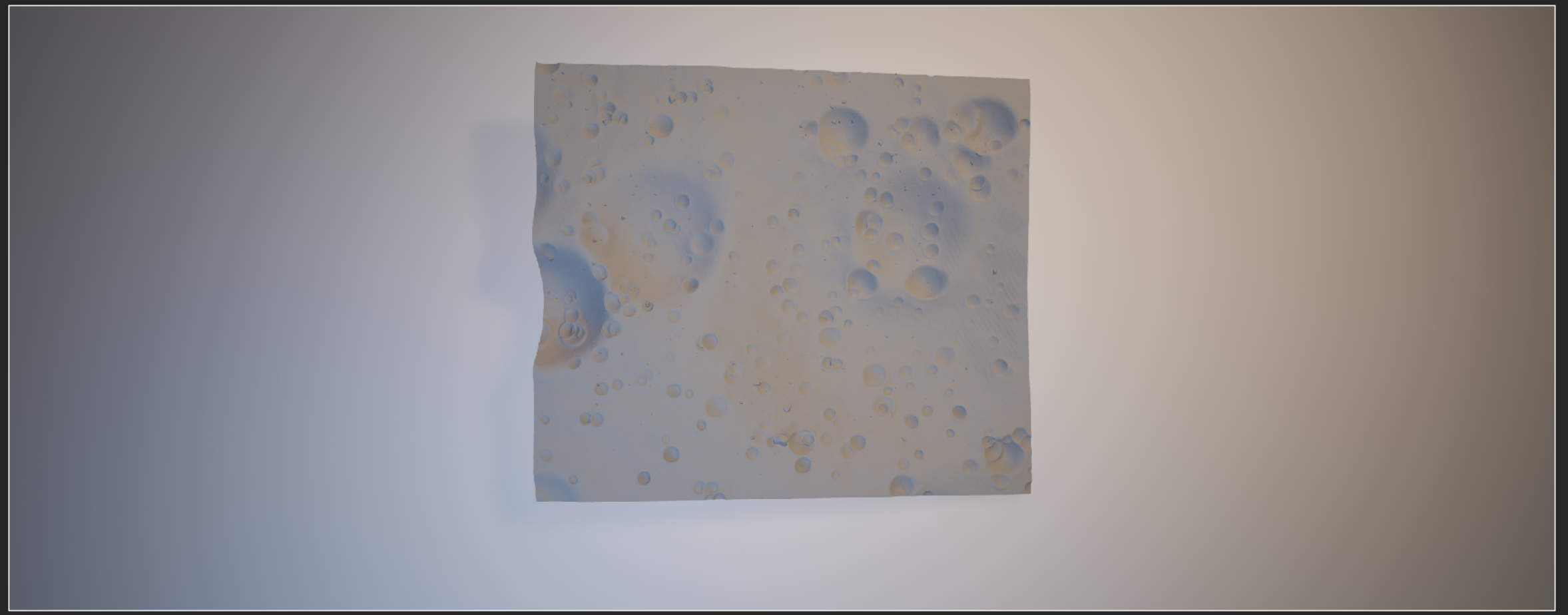


# REALISTIC HIGH-RESOLUTION SYNTHETIC LUNAR TERRAIN

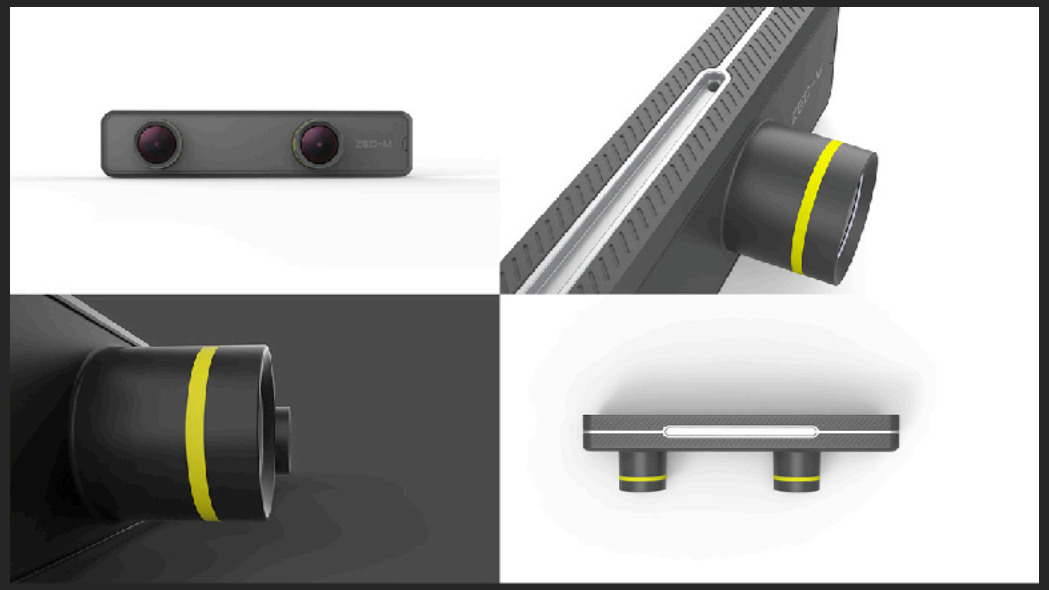
# COMMUNITY OUTREACH

# GAME ENGINE CAMERA FILTERS

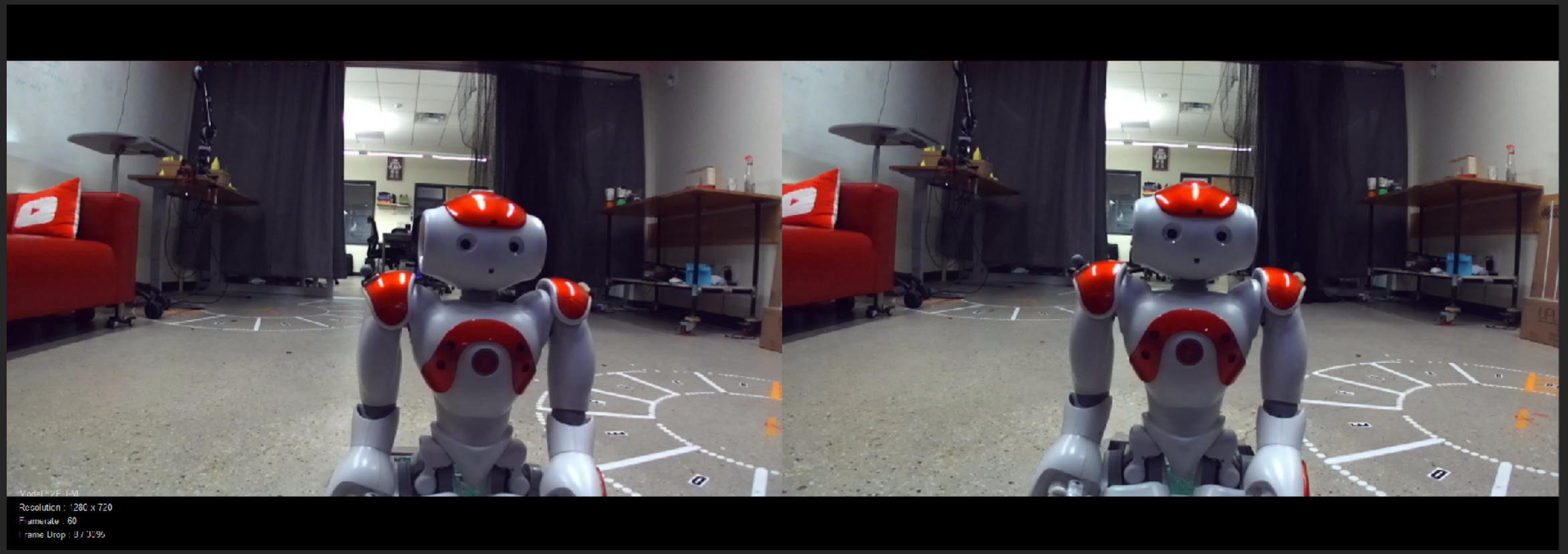
# FISKE PLANETARIUM

# PHYSICAL ROVER VR TELEOPERATION

# VR STEREO PASS-THROUGH

# VR STEREO PASS-THROUGH



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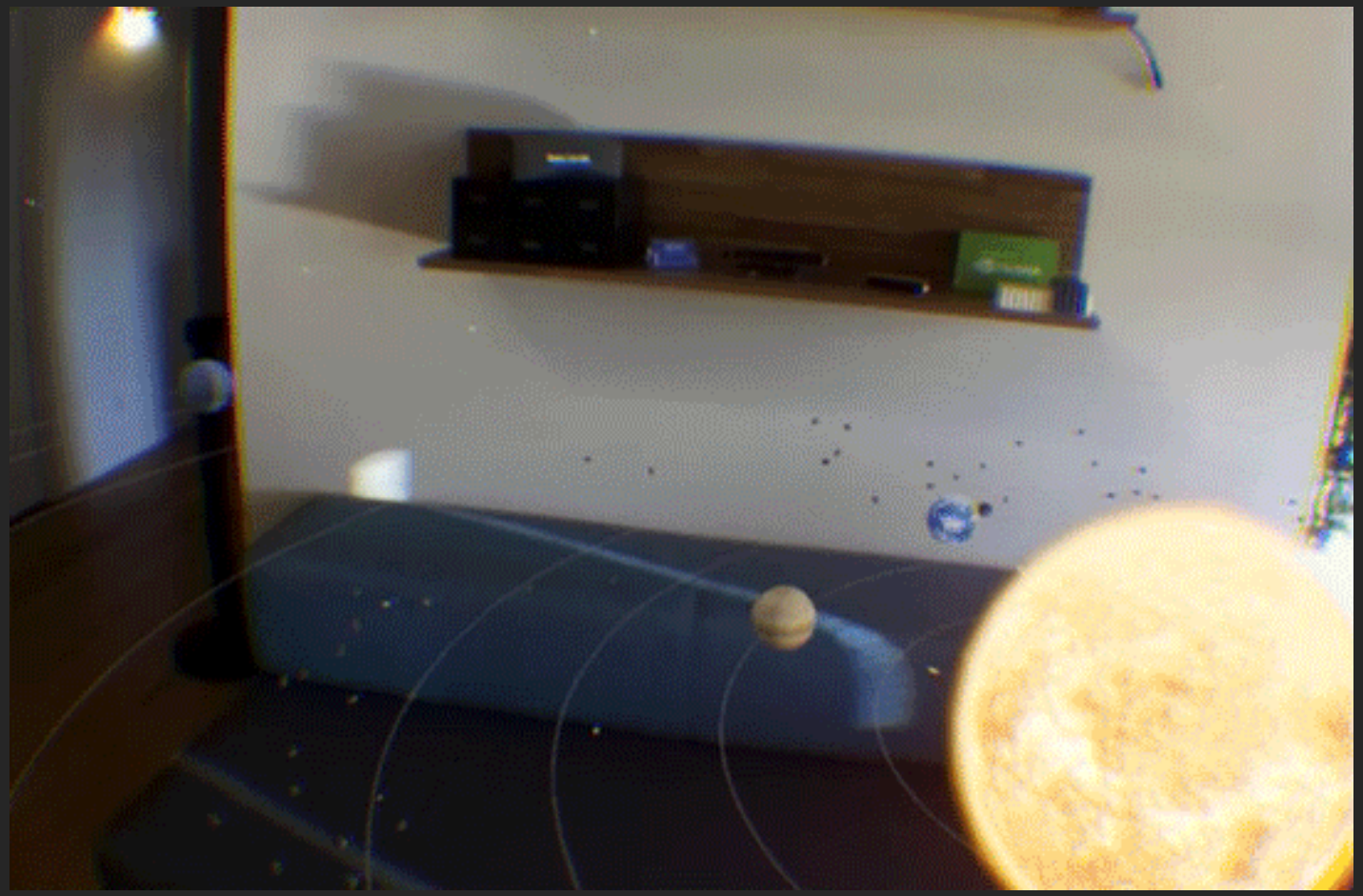

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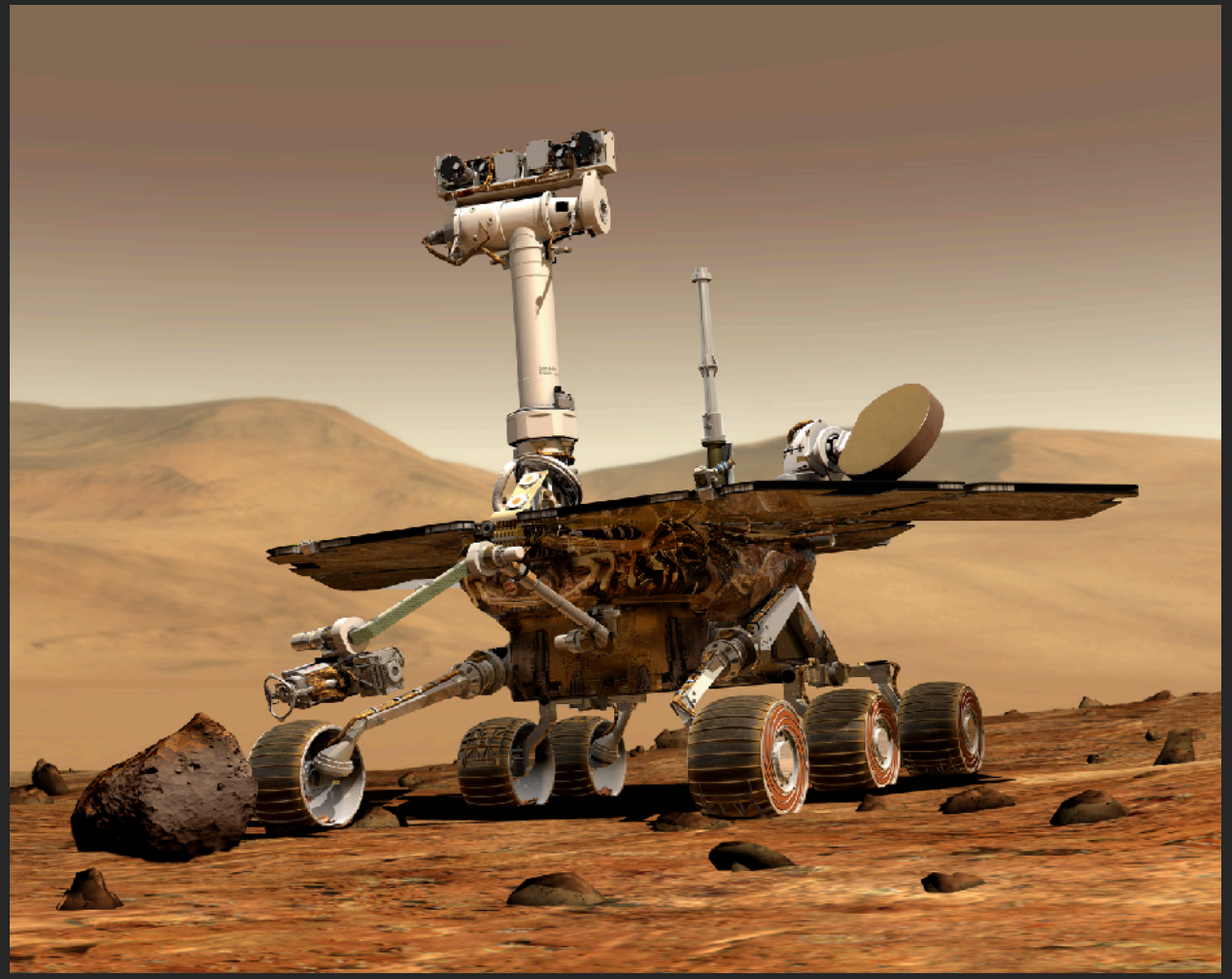

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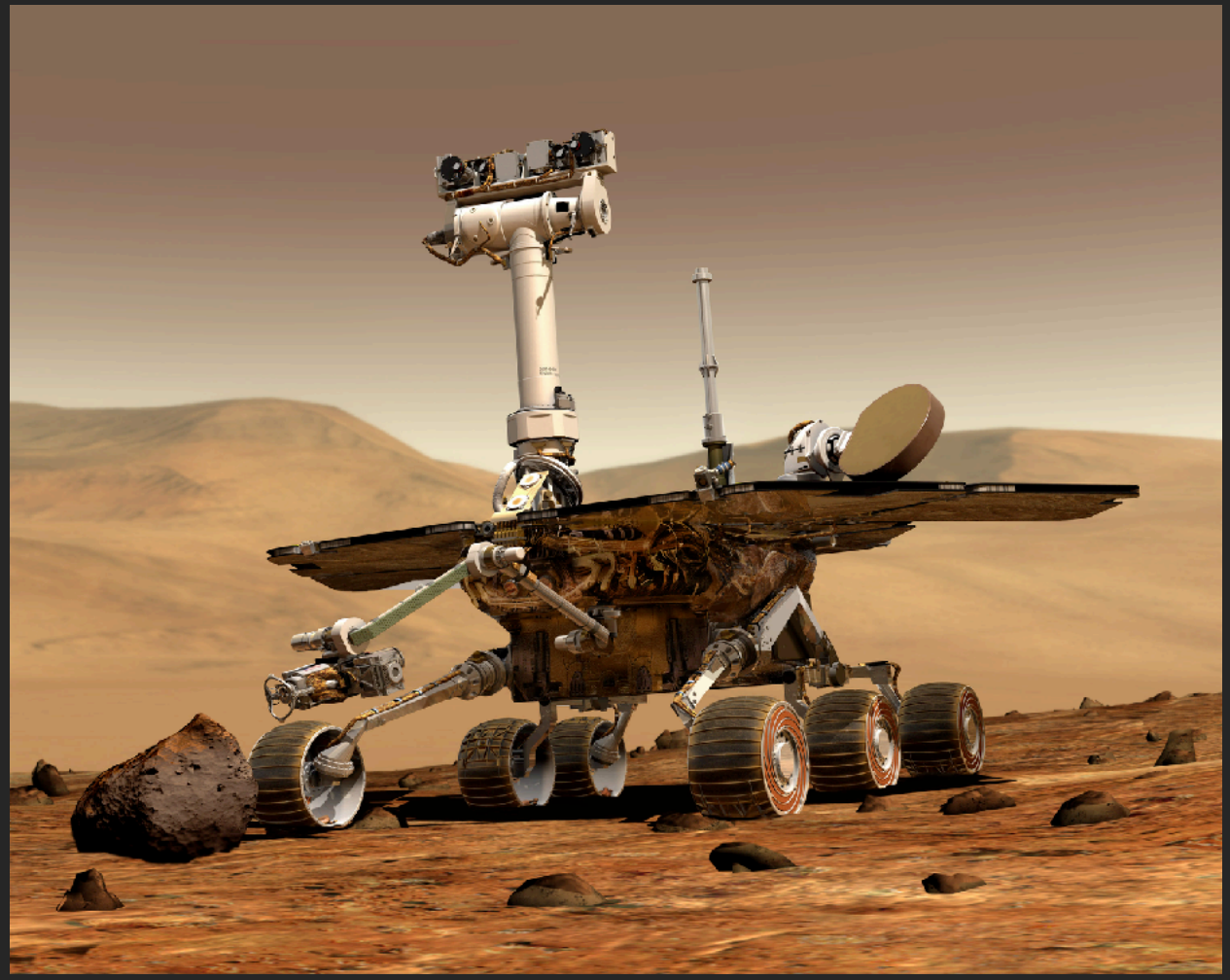

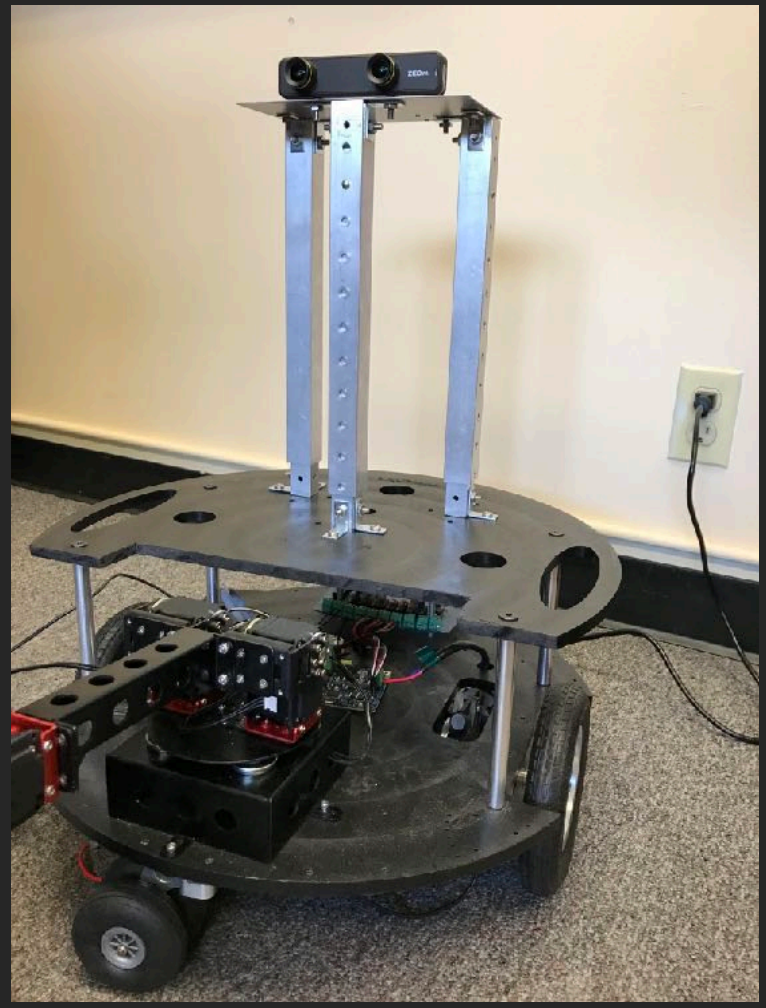

# FUTURE WORK

# ADDITIONAL FUTURE WORK

Explore:

- Dynamic Bandwidths
- Environmental Conditions (Albedo, Sun Azimuth, etc)
- Rover Designs
- Control Interfaces
- Planning Interfaces

# ADDITIONAL FUTURE WORK

Enable rapid prototyping of user interfaces

From the DSG we can support astronaut mission…

- Trainings
- Rehearsals
- Real-time rover teleoperation

# THANK YOU

Questions?

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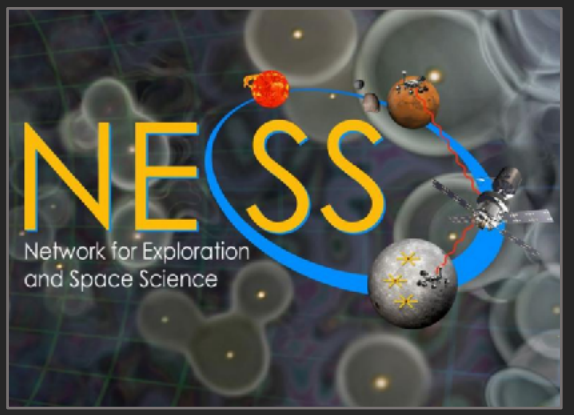


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