USING VIRTUAL REALITY FOR SCIENCE MISSIONS AT THE LUNAR SOUTH POLE

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AR/VR PRODUCT DEVELOPMENT LEAD

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AGENDA

- Background
- Lunar South Pole Application Critical Features
- MRET and Lunar South Pole VR
- Future Directions

BACKGROUND

GSFC AR/VR RESEARCH & DEVELOPMENT LAB

THOMAS G. GRUBB, AR/VR PRODUCT DEVELOPMENT LEAD

The Mission Beyond Reality

- Started in 2016 using combination of NASA HQ, GSFC Center, and organizational funds
- Concentration in XR Applications for both NASA engineers and scientists
- Collaboration
  - Center Organizations (SED, ExIS, GMSEC)
  - Missions (OSAM-1 and Roman Space Telescope)
  - Scientists & Engineers
  - Universities (UMBC, UMD, UNT, JHU/APL, BSU)
  - NASA Langley Research Center and Marshall Space Flight Center

PREPARING FOR NASA'S RETURN TO THE LUNAR SURFACE

ARTEMIS (CREWED MISSIONS)

NASA is focused on returning astronaut crews to the Moon beginning in 2024

Image: NASA

COMMERCIAL LUNAR PAYLOAD SERVICES (ROBOTIC MISSIONS)

Multiple missions will land science payloads on the lunar surface beginning in 2021

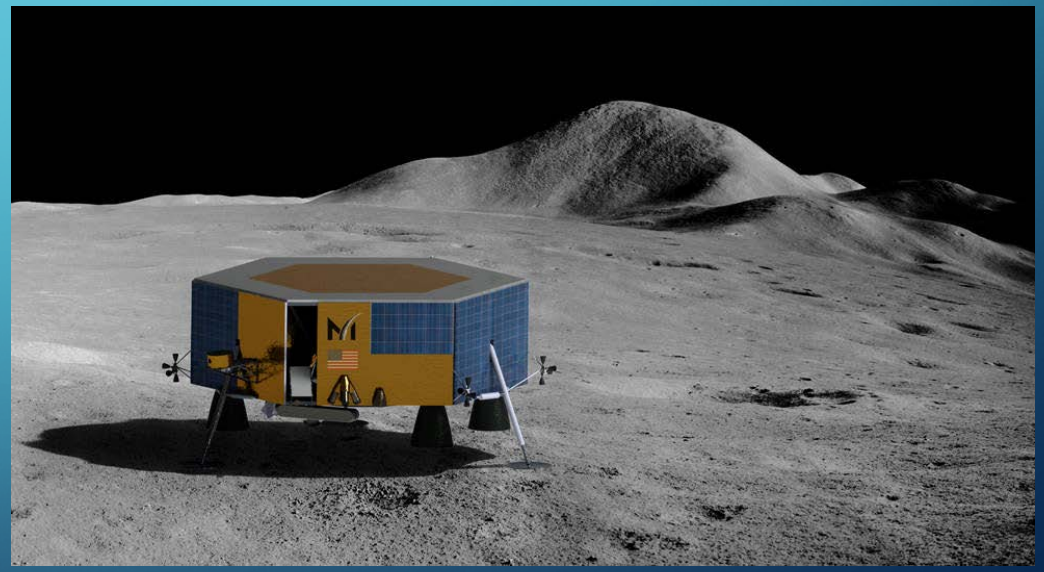


Image: Masten Space Systems

https://www.nasa.gov/specials/artemis/

https://www.nasa.gov/content/commercial-lunar-payload-services

- Artemis 2024
- New Landing Sites
- Extreme Lighting & Terrains

VISUALIZING THE APOLLO LANDING SITES BEFORE VR

- Apollo 15: To understand lighting conditions and visualize the landscape from the lander, a giant model of Hadley Rille was lit from different angles to show the crew what the terrain would look like from the lunar module window
- Traverse team for Apollo 16 rendered several scenes of lunar landscapes and horizons to visualize what the astronauts would see during their mission.

Perspective Views from an Apollo 16 EVA station

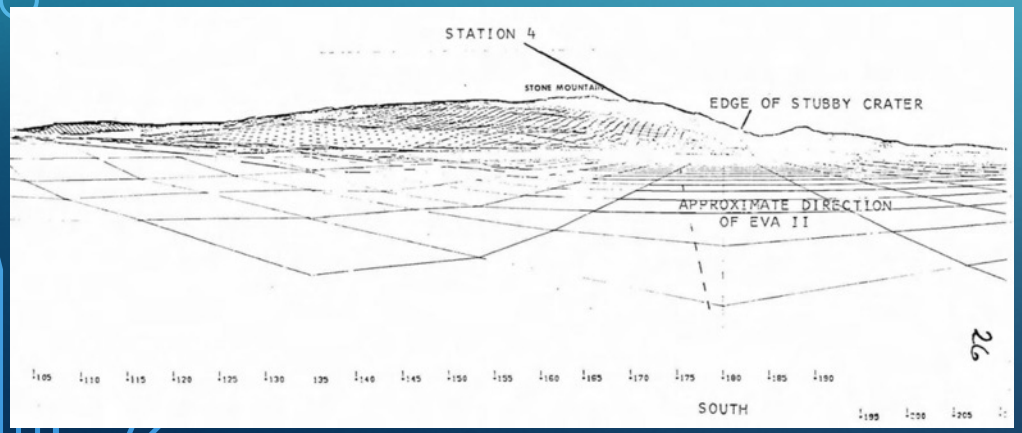
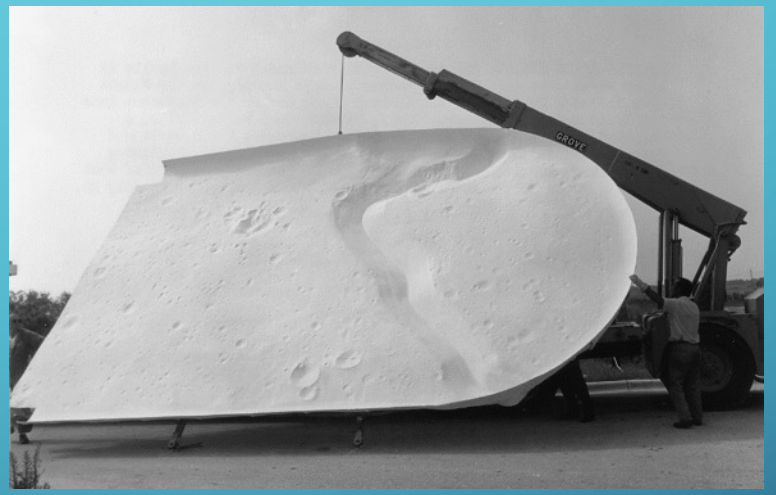
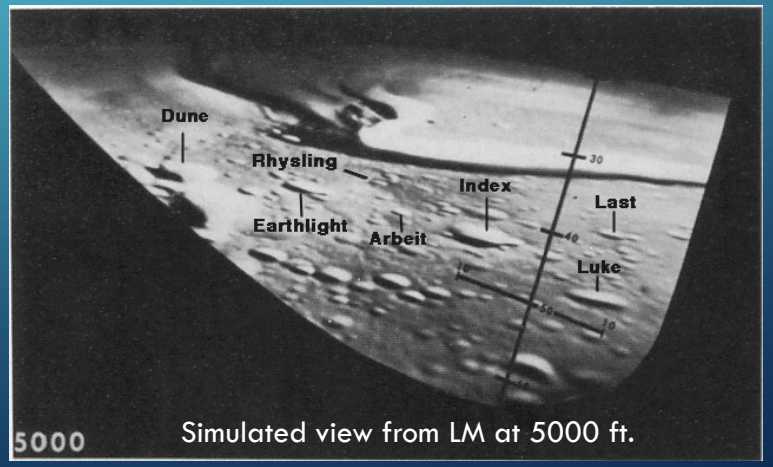


Image: Apollo 16 Traverse Briefing (England et al., 1972)

Physical Model of Apollo 15 Landing Site to Visualize Lighting Conditions





Simulated view from LM at 5000 ft.

Images: Apollo Lunar Surface Journal / Eric M. Jones (2005) (2013)

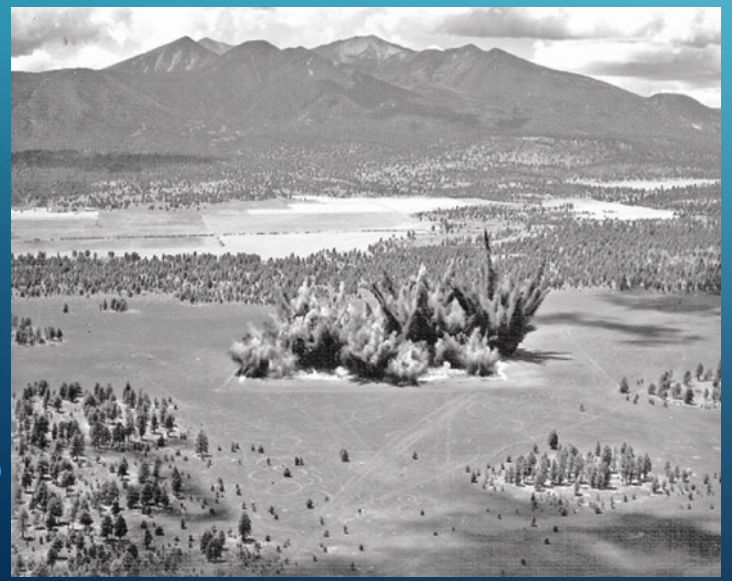
https://www.hq.nasa.gov/alsj/a15/a15SiteModel.html

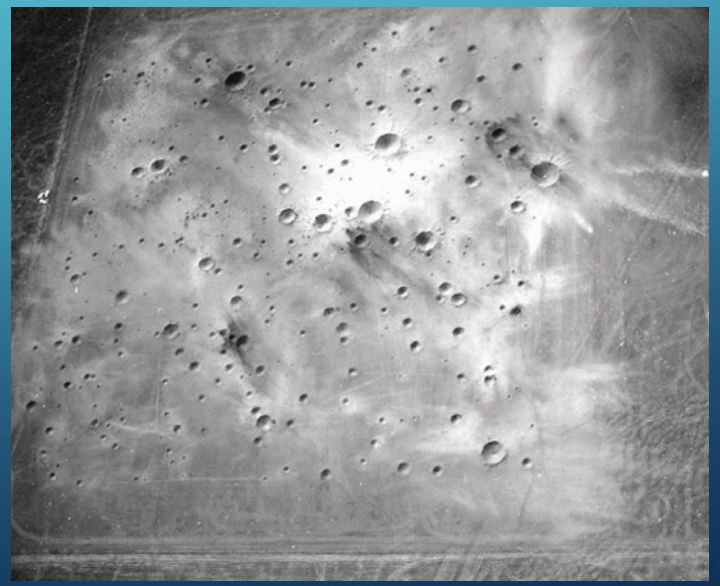
VISUALIZING THE APOLLO LANDING SITES BEFORE VR

- In the 1960's, the USGS created a field of craters to resemble an actual location on the Moon where the Apollo astronauts could train!

Recreating the Sea of Tranquility at Cinder Lake near Flagstaff, AZ

Images: USGS / NASA





WHAT IS MIXED REALITY?

Physical World

Digital World

Augmented Reality

Virtual Reality

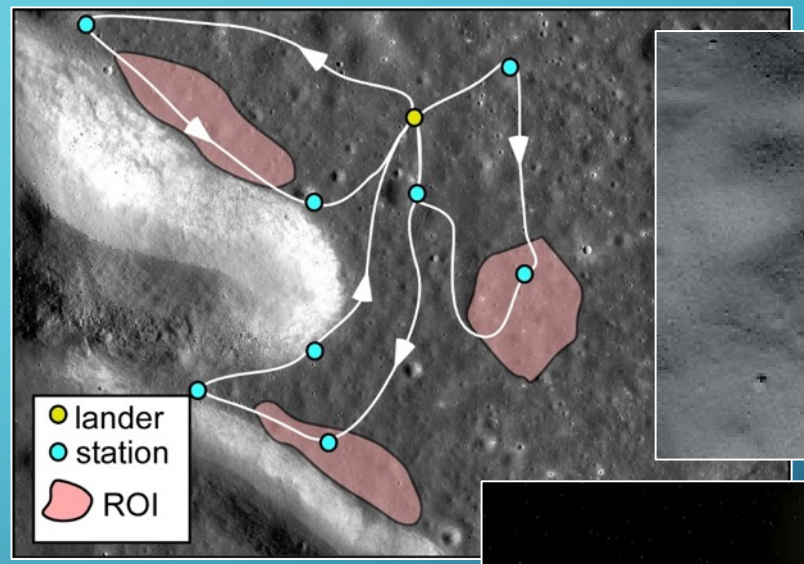
Mixed Reality
Spectrum

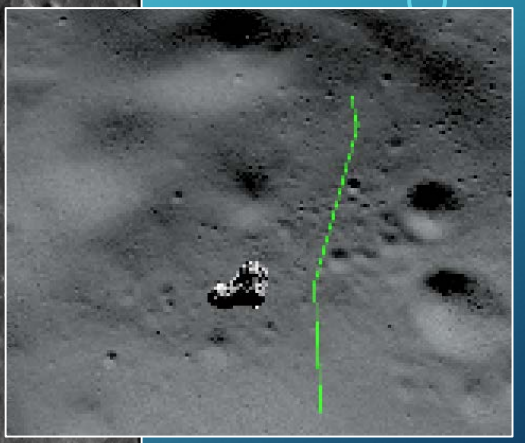
CRITICAL FEATURES IN VR – SUPPORT FOR SCIENCE MISSION PLANNING

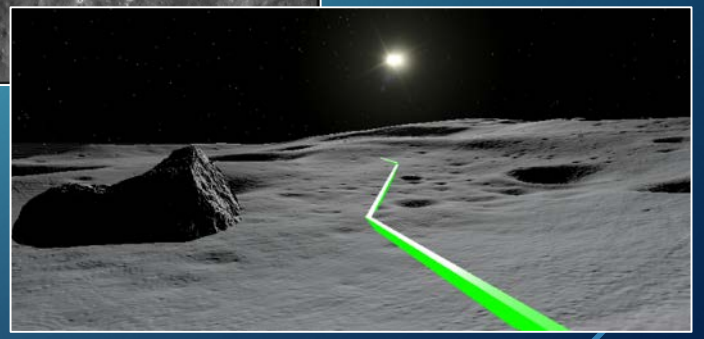
HOW CAN SCIENTISTS AND ENGINEERS USE VR?

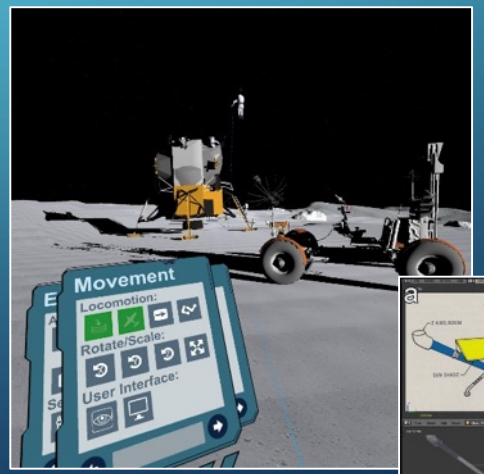
- **Science use case:** (1) Scientists identify science locations for an EVA with LRO data. (2) Draw EVA route in VR with map planning tool. (3) Virtually "walk" the traverse route to visualize lighting conditions during different mission dates (primary, backup) to see if sites have sufficient light. (4) Use virtual geologic tools and instruments to practice science operations.

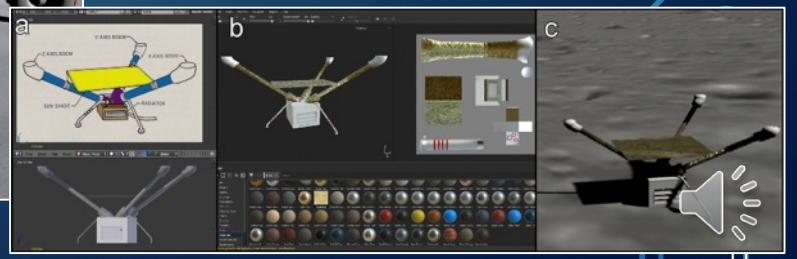
- **Engineer use case:** (1) Upload interactive vehicles and instruments to VR. (2) Users can hold a physical model of instrument and view 'virtual' version in VR. (3) Practice science operation and order of EVA tasks. (4) Visualize lighting conditions for instruments, lander, habitat, & vehicles (When will object be in shadow, sunlight? When will crew be driving towards or away from the sun?)





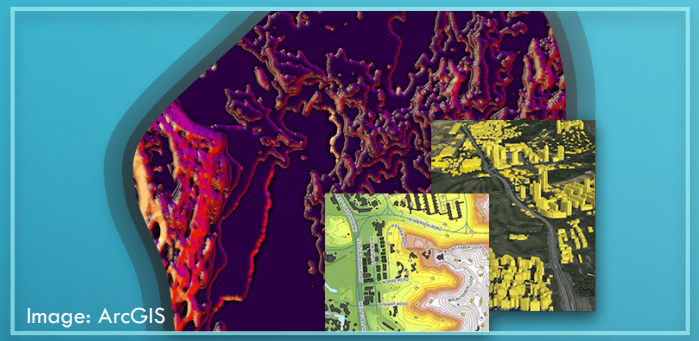


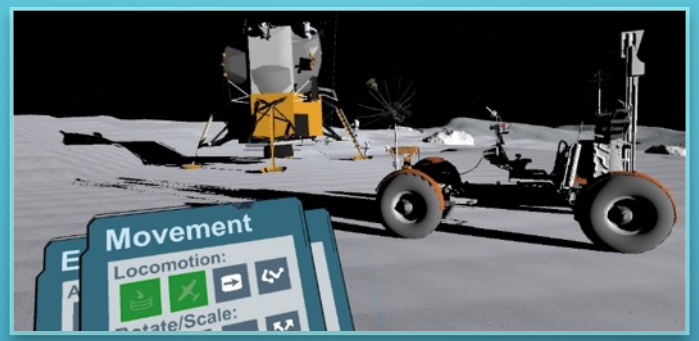




CRITICAL FEATURES

Enable users to view, analyze, and make science observations and exploration plans in a 2D and immersive 3D environment of the Moon





GIS TOOLS

Mapping, Layering, Planning, Drawing and measuring tools. Analysis of elevation, slopes, and hazards.

3D/VIRTUAL REALITY

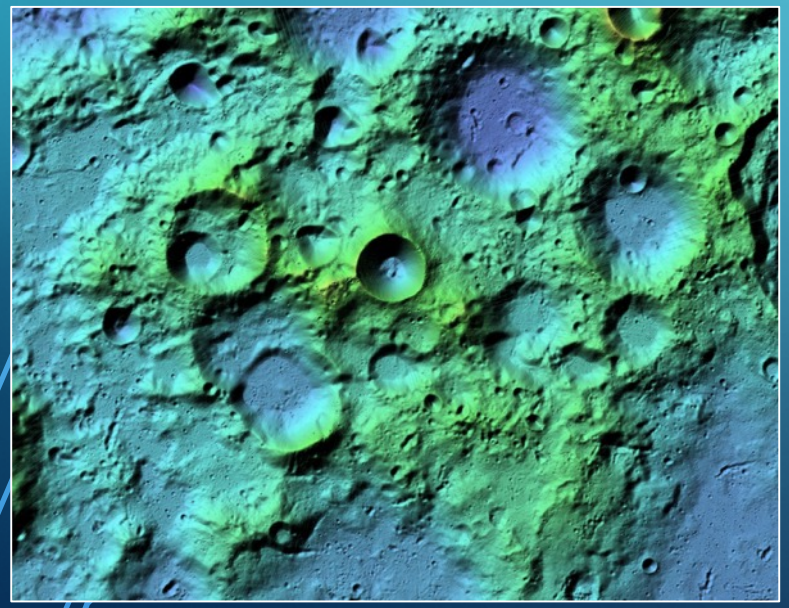
Visualize lunar science data in an immersive 360° world and get a 'boots-on-the-ground' view of Artemis landing sites.

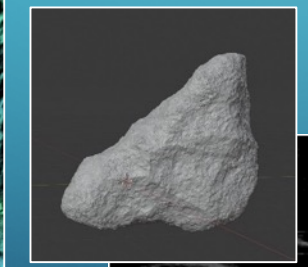
COLLABORATIVE

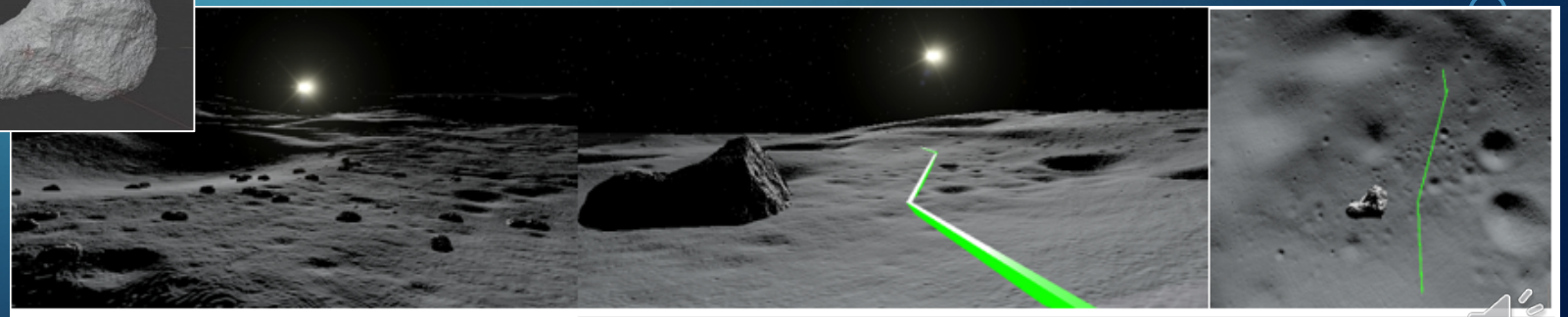
Crews and mission teams can work in the same VR environment while remotely located to walk through different science tasks and traverse plans.

GEOLOGIC AND ENVIRONMENTAL FEATURES IN VR

- Realistic Terrain
- High fidelity lunar terrains based on actual lunar topographic from **LOLA (5 m/pixel) DEM**
- Simulate 'boots-on-the-ground' view to understand geologic context and access to sites of scientific interest







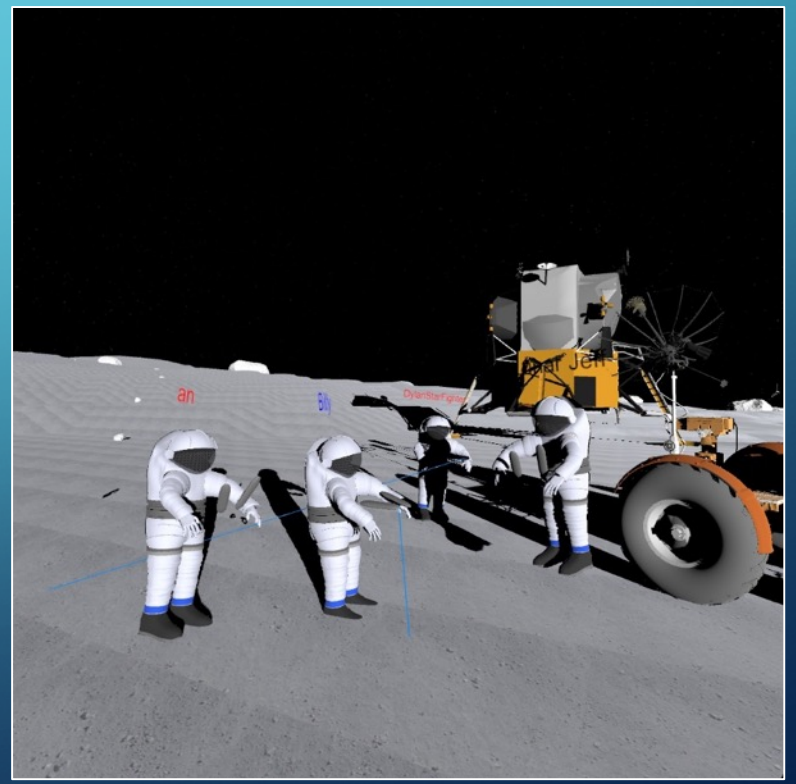
Procedural rocks on the lunar surface | Lightweight path terrain visualization | "MiniMap" view with path

- Realistic Lighting Conditions
- Accurate lighting models for specified dates and times to simulate changes in the relative position of the sun and shadows during the timeframe of a robotic or crewed surface mission
- Geologic Features, Surface Textures, & Planning Tools
- Catalog of virtual lunar rocks randomly distributed across the surface, plus ground textures that resemble the lunar regolith. Capability to draw paths for EVA traverses.

LUNAR SOUTH POLE VR

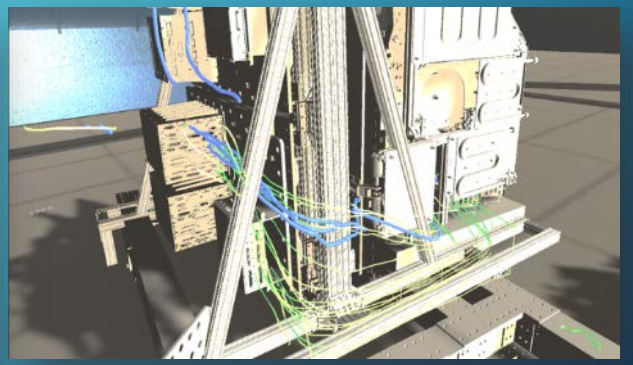
LUNAR SOUTH POLE VR PROTOTYPE

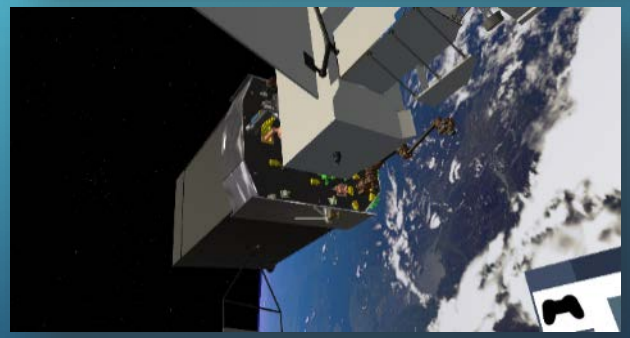
- Leverages the Goddard-developed Mixed Reality Exploration Toolkit (MRET)
- Goal is to create VR environment of the Lunar South Pole for scientific evaluation of dynamic surface conditions (sunlight, geology, topography) to plan & visualize activities on future missions
- Tailored for the Lunar South Pole
  - LRO terrain data that covers latitudes 87.5° to 90° South
    - (LOLA 5m/pixel digital terrain model)
  - Lunar lighting tool to show sun position for any date/time
  - Rocks, geologic surface textures, and mission vehicles
  - Path planning tool to create and follow EVA routes
  - Collaboration capability for a group working remotely to
    - explore the same VR space in real-time together

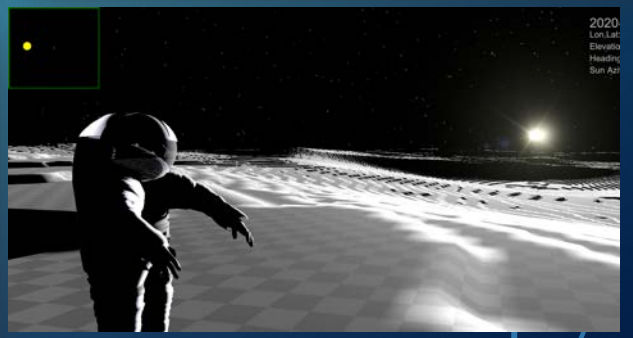


MRET SUPPORTS VR CAPABILITIES FOR NASA MISSIONS AND RESEARCH

- Collaborative, cross-domain, mission lifecycle support tool for Science and Engineering
  - Integrates NASA "models" (scientific models, point clouds and LIDAR data, and engineering, CAD-based models)
  - Common tool set available in AR*/VR/Desktop (e.g., measurement tools, voice commands, notes, animations, lunar and planetary lighting models, etc)
  - Access to NASA data sources. Easy to use and powerful communications infrastructure for all VR NASA applications using the Goddard Mission Services Evolution Center (GMSEC) architecture
- Stakeholders and Partners: Roman Space Telescope (Roman, formerly WFIRST), Exploration & In-Space Services (ExIS)/On-Orbit Servicing, Assembly and Manufacturing (OSAM-1), GMSEC project, LaRC, MSFC and Universities (UMBC, UMD, JHU/APL, BSU, UNT)





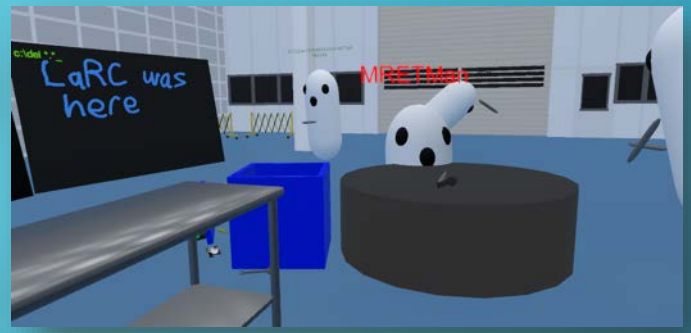


MRET has been officially released for Government Purposes Only and is available through https://software.nasa.gov A NASA Open Source Agreement (NOSA) is planned this year.

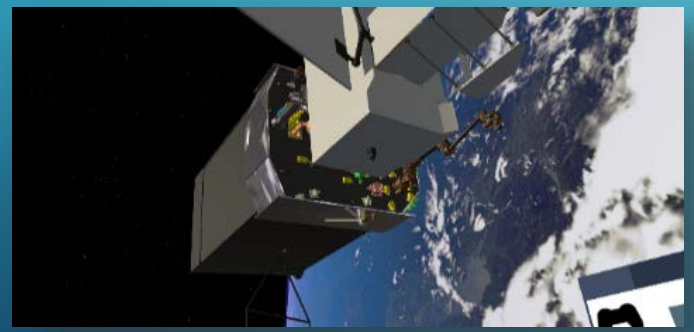
MRET HIGHLIGHTS

COMBINE 3D MODELS, POINT CLOUDS, AND TERRAINS

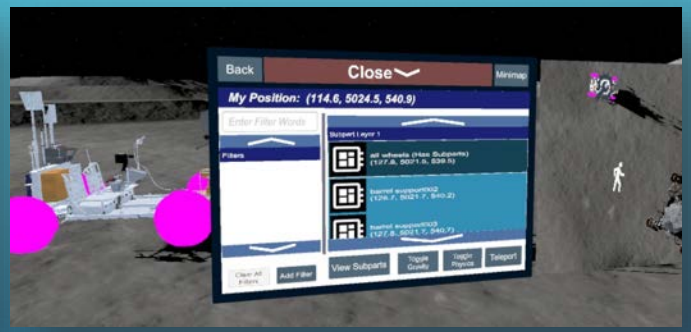
FOR VR AND PC DESKTOP (AND AR FY21)



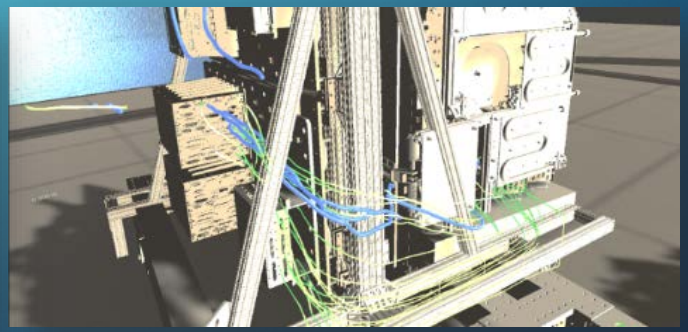
COLLABORATE ON SECURE NETWORKS AND OVER VPN



DRIVE MODELS FROM REAL-TIME TELEMETRY VIA GMSEC

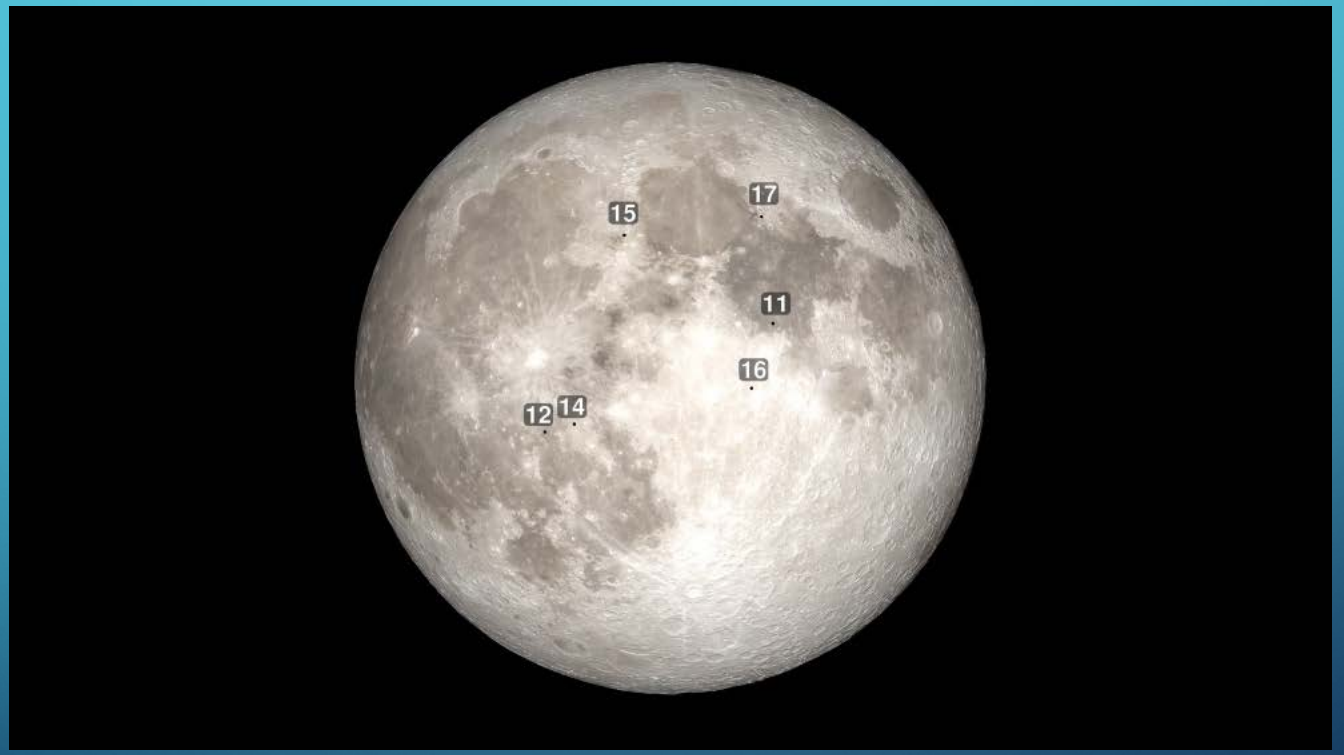


PROJECT BASED TOOL (ENVIRONMENT, PARTS AND HIERARCHIES, KIOSK MODE...



COMMON TOOLSET, E.G., MOVE, MEASURE, DRAW, VOICE, NOTES, ANIMATION...

LUNAR SOUTH POLE VR IN ACTION – SHACKLETON CRATER



LUNAR SOUTH POLE VR IN ACTION – APOLLO 15

FUTURE DIRECTIONS

LUNAR SOUTH POLE VR 2.0: A VIRTUAL REALITY TOOLKIT AND INTERFACE FOR LUNAR SCIENCE AND EXPLORATION

- More locations: User-ready landscapes at the lunar south pole, north pole, and other high-priority and historical sites (e.g., Apollo sites).
- Improved Lighting: Optional Real-Time Raytracing
- More Mapping and Planning Tools: Integrate GIS-like drawing tools and timeline tools for traverse and operations planning
- More Lunar Geologic Materials and Assets: library of high-resolution lunar surface, catalog of interactive geologic features (e.g., rocks) and science instruments and tools.
- Leverage MRET infrastructure
  - AR and Desktop in addition to VR
  - Integration with Mission Operations