LESSONS LEARNED WHILE PORTING SIMULATED LUNAR XR UNITY PROJECT TO THE APPLE VISION PRO

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APL XR SYMPOSIUM, JULY 09

AGENDA

- Mixed Reality Exploration Toolkit (MRET)
- Augmented Reality Data Visualization Analog Research Campaign (ARDVARC) and Lunar XR ConOps
- Porting MRET to AVP

MIXED REALITY EXPLORATION TOOLKIT (MRET)

NASA OPEN SOURCE TOOL FOR XR

GSFC AR/VR RESEARCH & DEVELOPMENT LAB

THOMAS G. GRUBB, AR/VR PRODUCT DEVELOPMENT LEAD

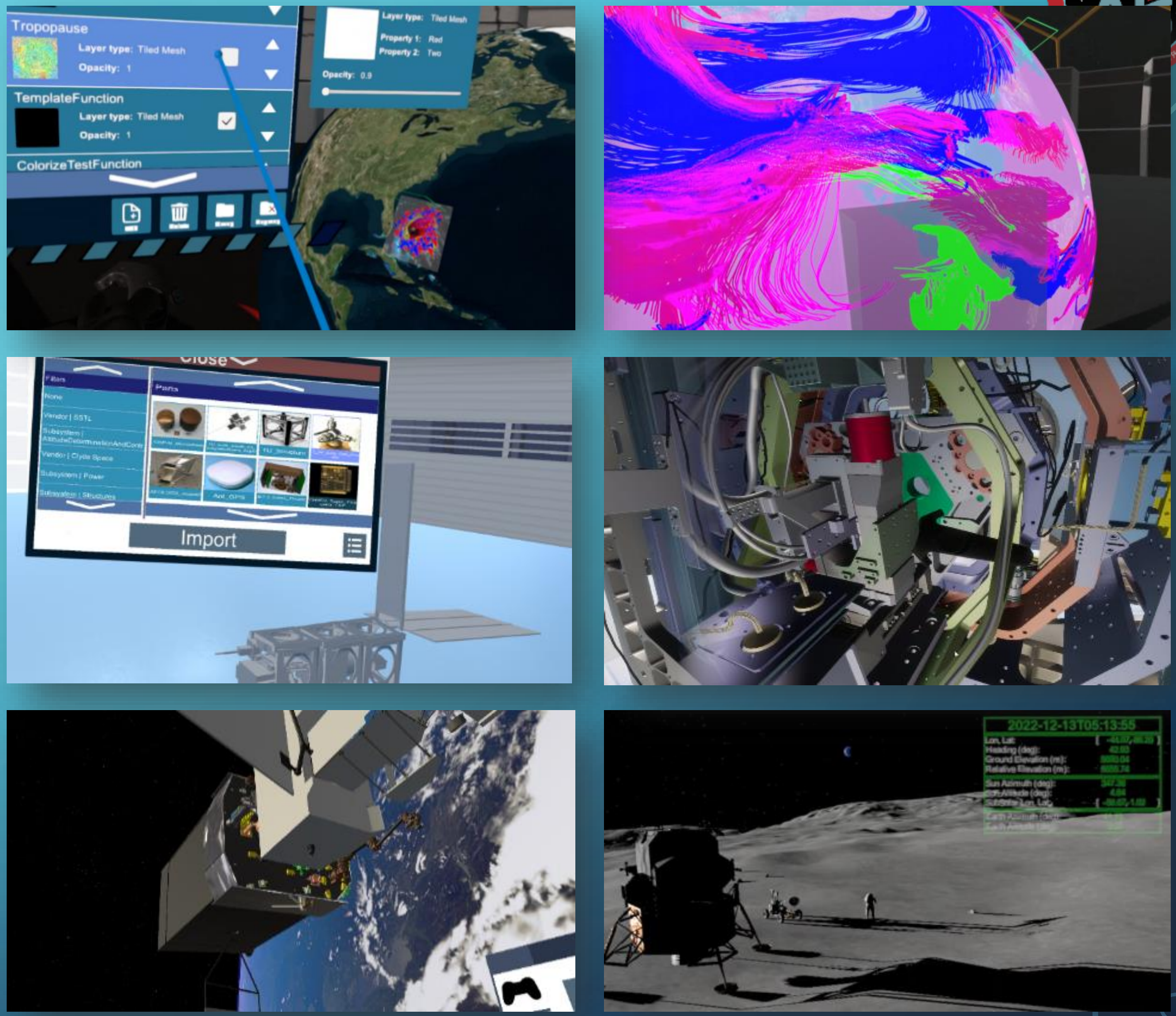
The Mission Beyond Reality

- Started in 2016 using combination of IRAD, CIF, and organizational funds
- Initial survey of XR Use Cases across center
- Collaboration
  - GSFC Center Organizations (SED, ExIS, GMSEC)
  - Missions (Roman Space Telescope)
  - Scientists & Engineers
  - Universities (UMBC, UMD, UNT, JHU/APL)
  - Other NASA Centers

MRET
MIXED REALITY EXPLORATION TOOLKIT

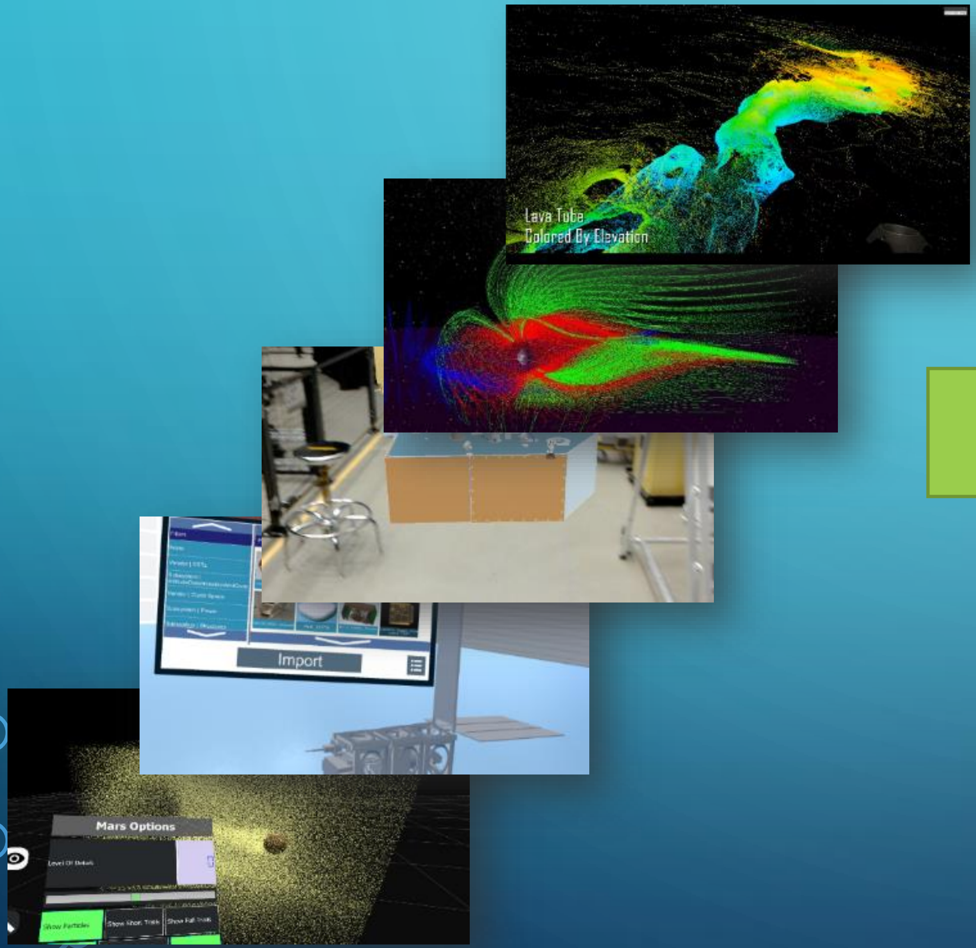
- Cross-domain, mission lifecycle support tool in Science and Engineering for rapidly building XR environments for NASA domain problems, e.g., pulling in CAD models of thermal vac chamber and Roman Space Telescope to do fit checks
  - NASA Open Source
  - Integration with NASA data
  - Secure Collaboration

- VR/Desktop/AR* (Hololens 2)
- Developed in Unity/C#



MRET is NASA Open Source and available at https://github.com/nasa/Mixed-Reality-Exploration-Toolkit

MRET – COMMON PLATFORM FOR NASA XR



MRET

MIXED REALITY EXPLORATION TOOLKIT

INTEGRATION WITH NASA SOFTWARE AND DATA SOURCES IS CRUCIAL

GMSEC

Integration with the General Mission Services Evolution Center (GMSEC) to get spacecraft/instrument telemetry and secure XR collaboration

ROS

Integration with the Robot Operating System to get robotic telemetry

NASA IOT PLATFORM

Integration with NASA Internet of Things (IoT) Platform to get industry standard telemetry and control/interact with systems

RAPID MODEL IMPORT TOOL

Integration with NASA Open Source tool to convert on-demand CAD models to GLTF (XR Ready file format)

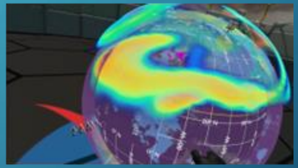
*Other Toolkits

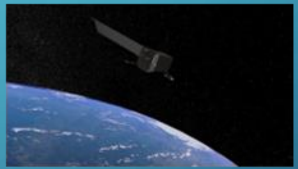
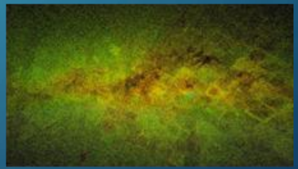
- MATLAB
- SPICE
- Virtual Data Explorer (VDE)

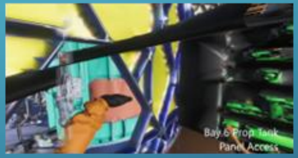
XR ENHANCES BEST PRACTICES THROUGHOUT THE MISSION LIFECYCLE

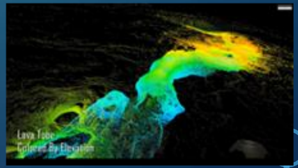








Pre-Phase A
Conceptual Studies

→

Phase A
Preliminary Analysis

→

Phase B
Definition

→

Phase C/D
Design & Development

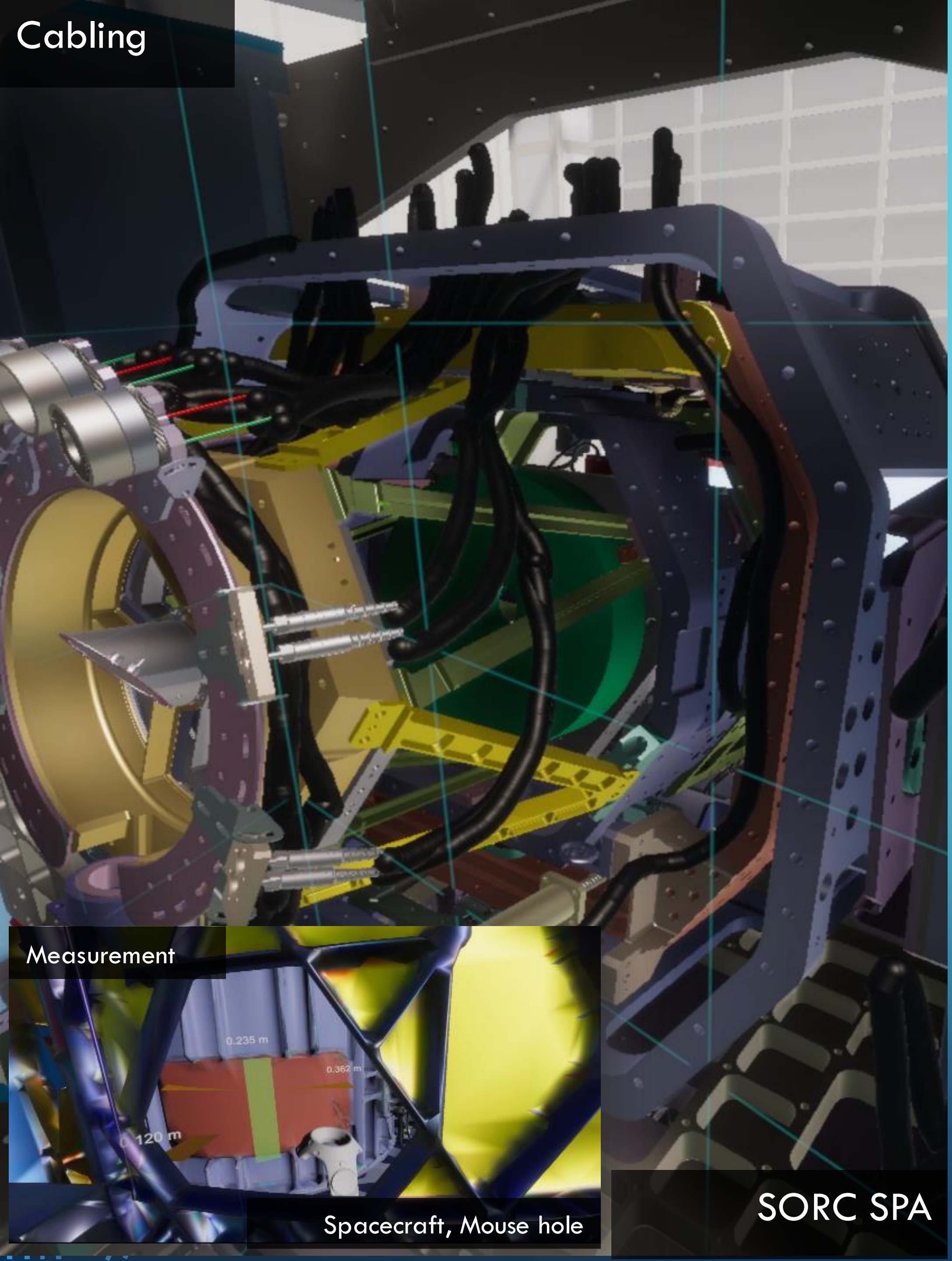
→

Operations Phase
Mission Ops & Data Analysis

→

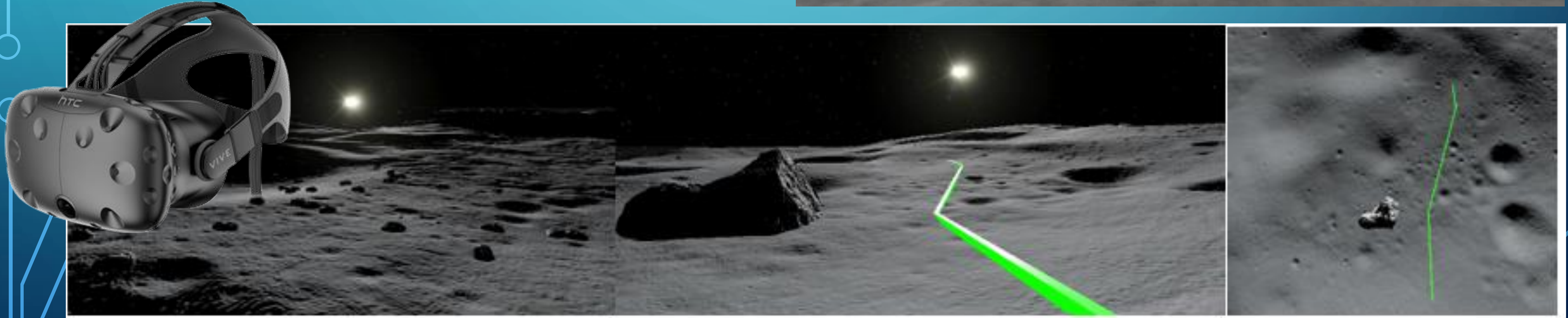
Science

HARDWARE INTEGRATION & TEST

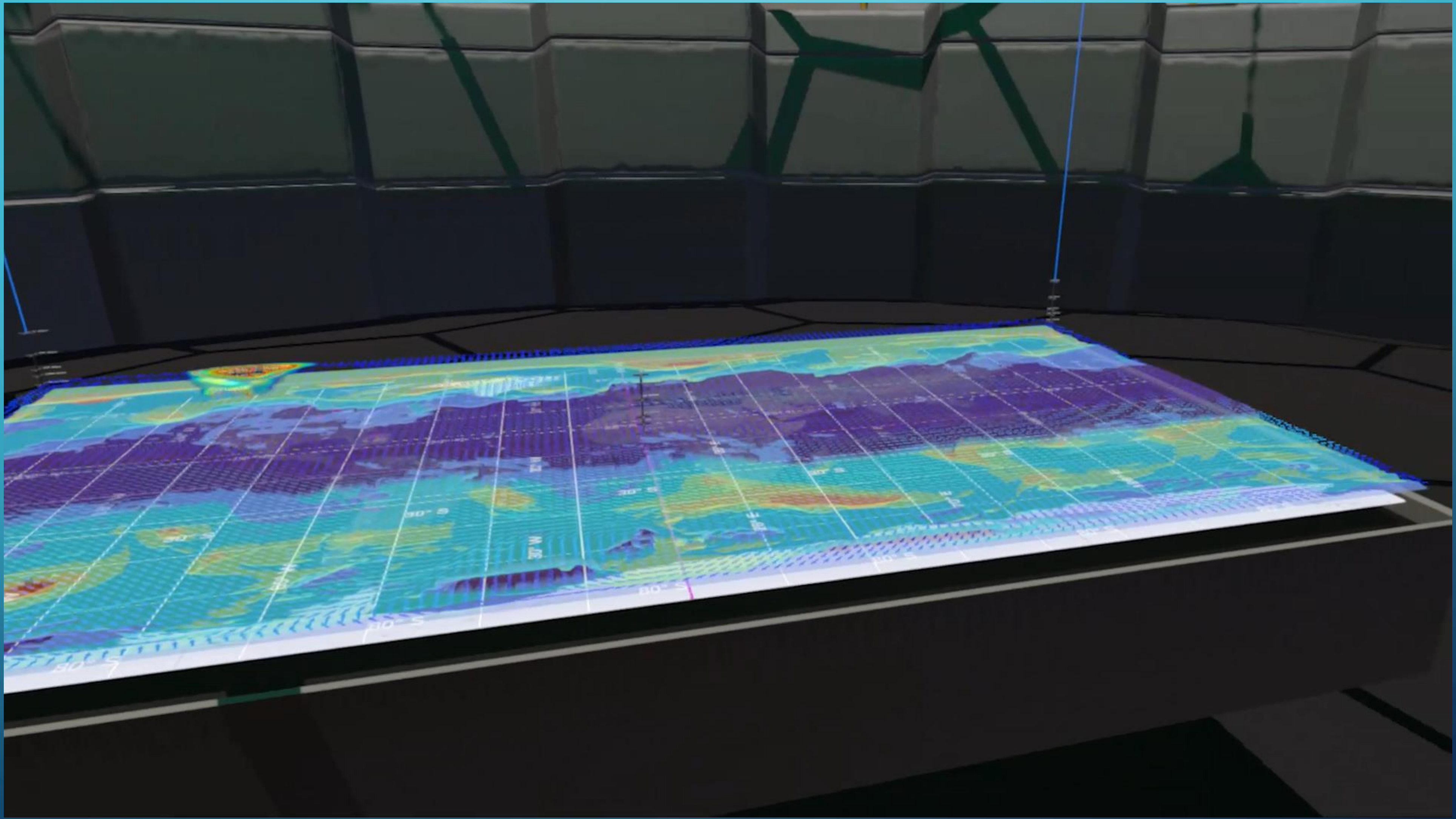


LUNAR SOUTH POLE VR

- For scientific evaluation of dynamic surface conditions (sunlight, geology, topography) to plan & visualize future missions
  - Challenging terrain, dramatic lighting conditions, different geology than Apollo
  - Terrain from LOLA data, with procedurally generated lunar rocks and hi-def textures for sub-5 meter views
  - Dynamic Lighting Tool based on actual Lunar location and Sun position
  - Lunar Textures and Assets
  - Interactive EVA science tools
- Mission Operations could be driven from telemetry, Science point cloud data could be overlaid



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



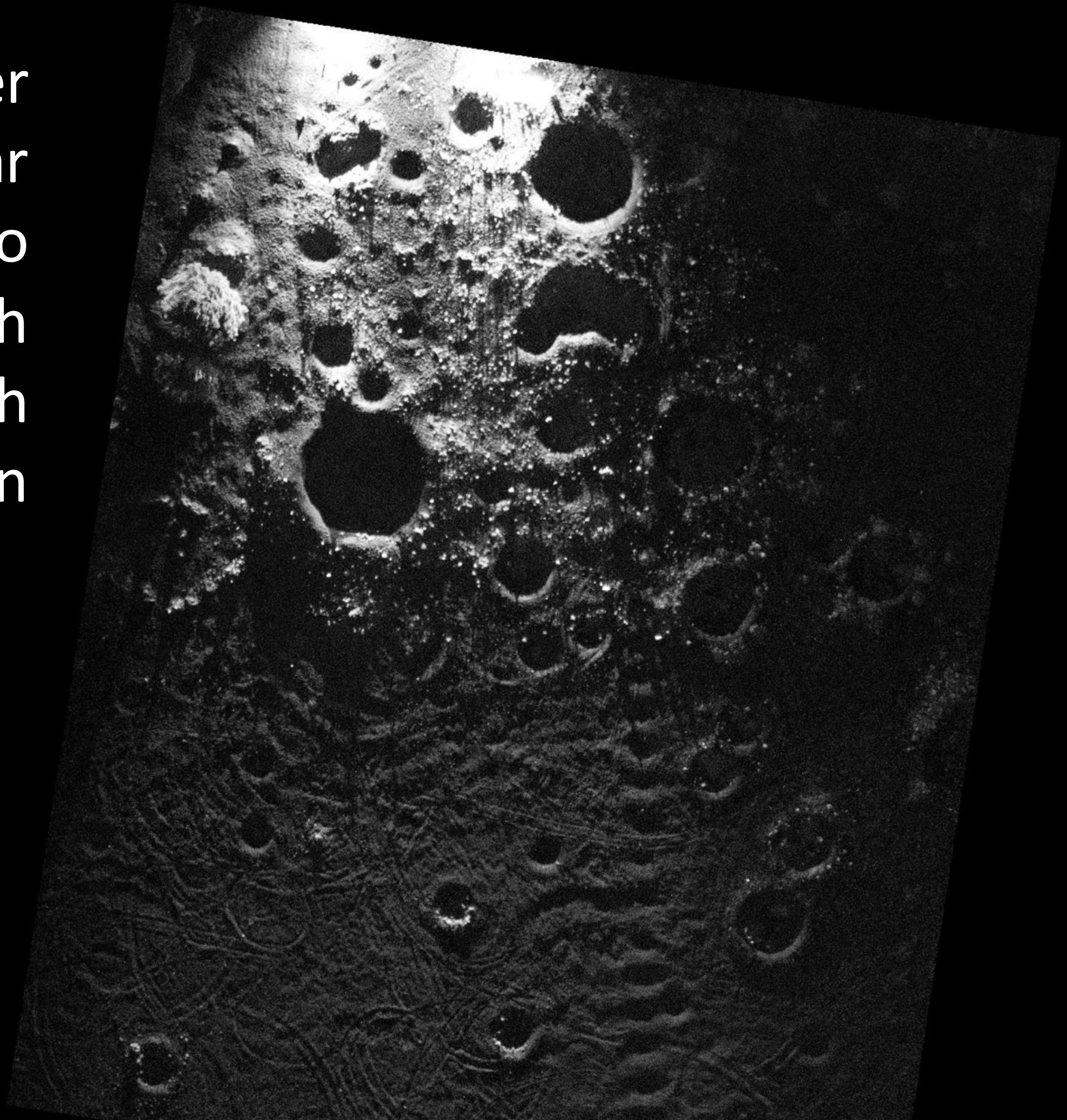
AUGMENTED REALITY DATA VISUALIZATION ANALOG RESEARCH CAMPAIGN (ARDVARC)

SIMULATED LUNAR CONOPS USING XR

ARDVARC is a 3-phase project that will assess the use of Augmented Reality (AR) data visualization in both rover and astronaut analog missions using low-angle lighting conditions similar to those present at the lunar south pole.

Findings will contribute to data visualization methods and concept of operations for future Artemis missions to the lunar surface.

We used the Cinder Lake Crater Field near Flagstaff AZ at night to simulate a lunar south pole terrain, with artificial low-angle sun lighting.



Year 2 – Student Led Analog Rover Mission

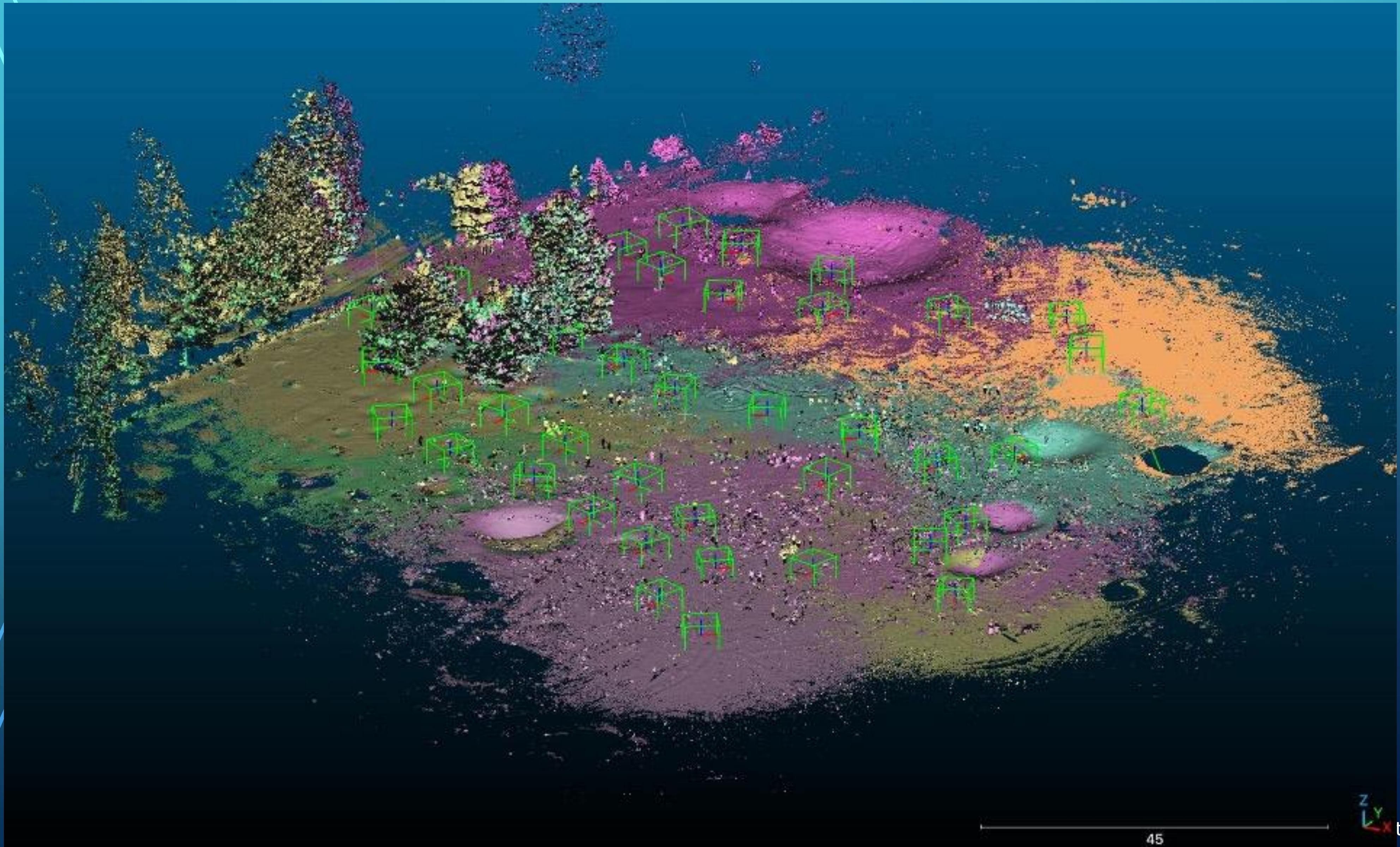
ARDVARC deployed Mission Control Space Services' HUSKY rover to the field site and allowed a team of trained students from UTEP to lead rover operations from a remote mission control center.

This served as an analog pre-cursor rover mission with the goal of collecting LiDAR and image data that was used in the Year 3 analog astronaut deployment.

ARDVARC

MISSION CONTROL™

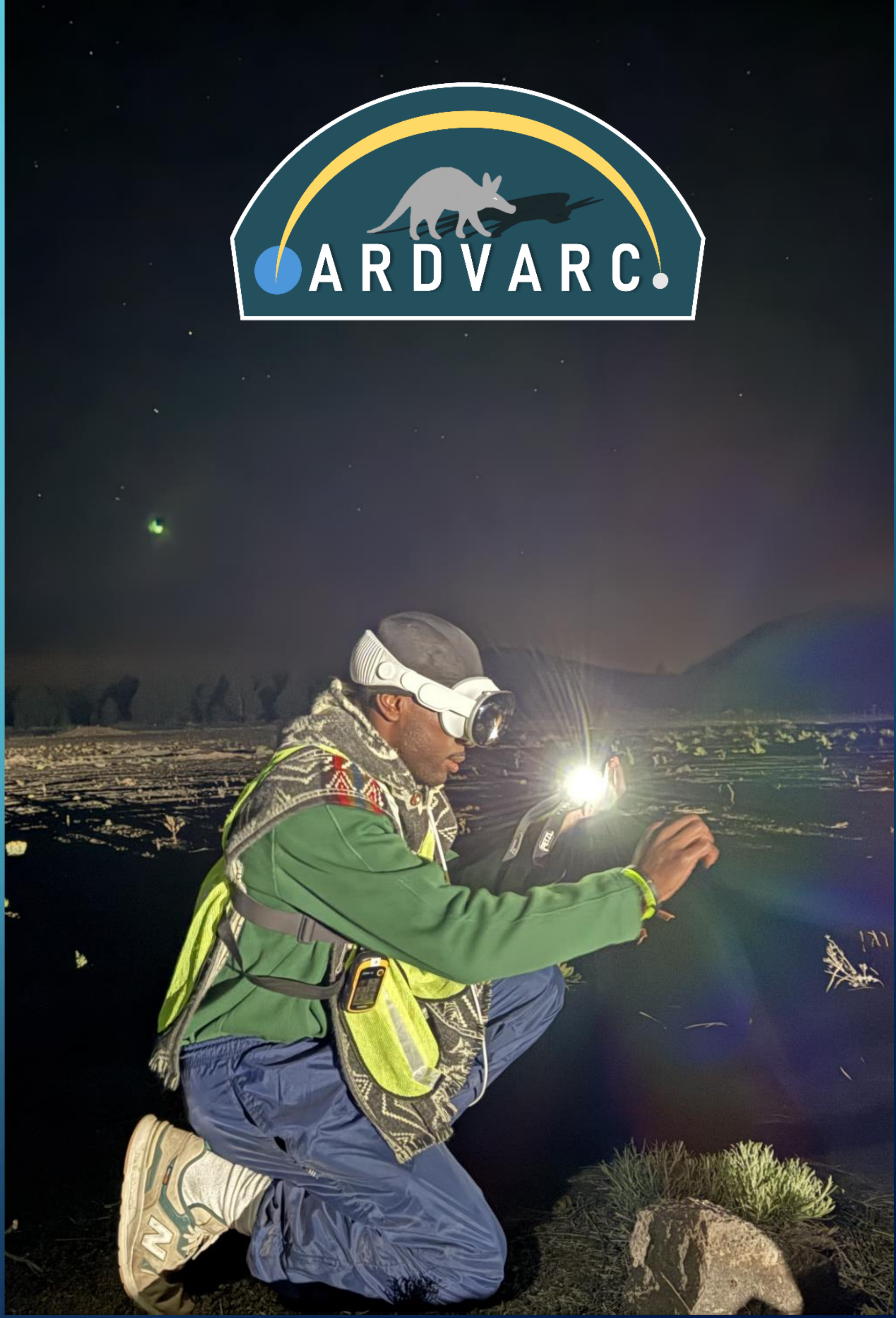
The ARDVARC Rover collected a detailed LiDAR Point Cloud of the operational field



Year 3 – Analog Astronaut Mission

ARDVARC returned to the same field site to conduct a series of simulated astronaut traverses that incorporated various levels of AR data visualization into the low light angle field operations.

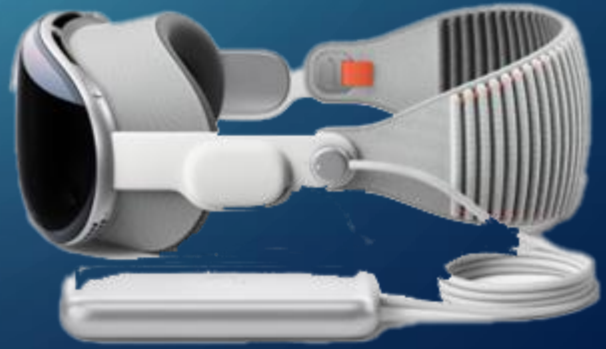
These deployments acted as a post-cursor follow up to the rover deployment, using rover-generated data to aid astronauts with in-situ navigation and investigation of the field site.




NASA
tv

ARDVARC TECHNICAL GOALS

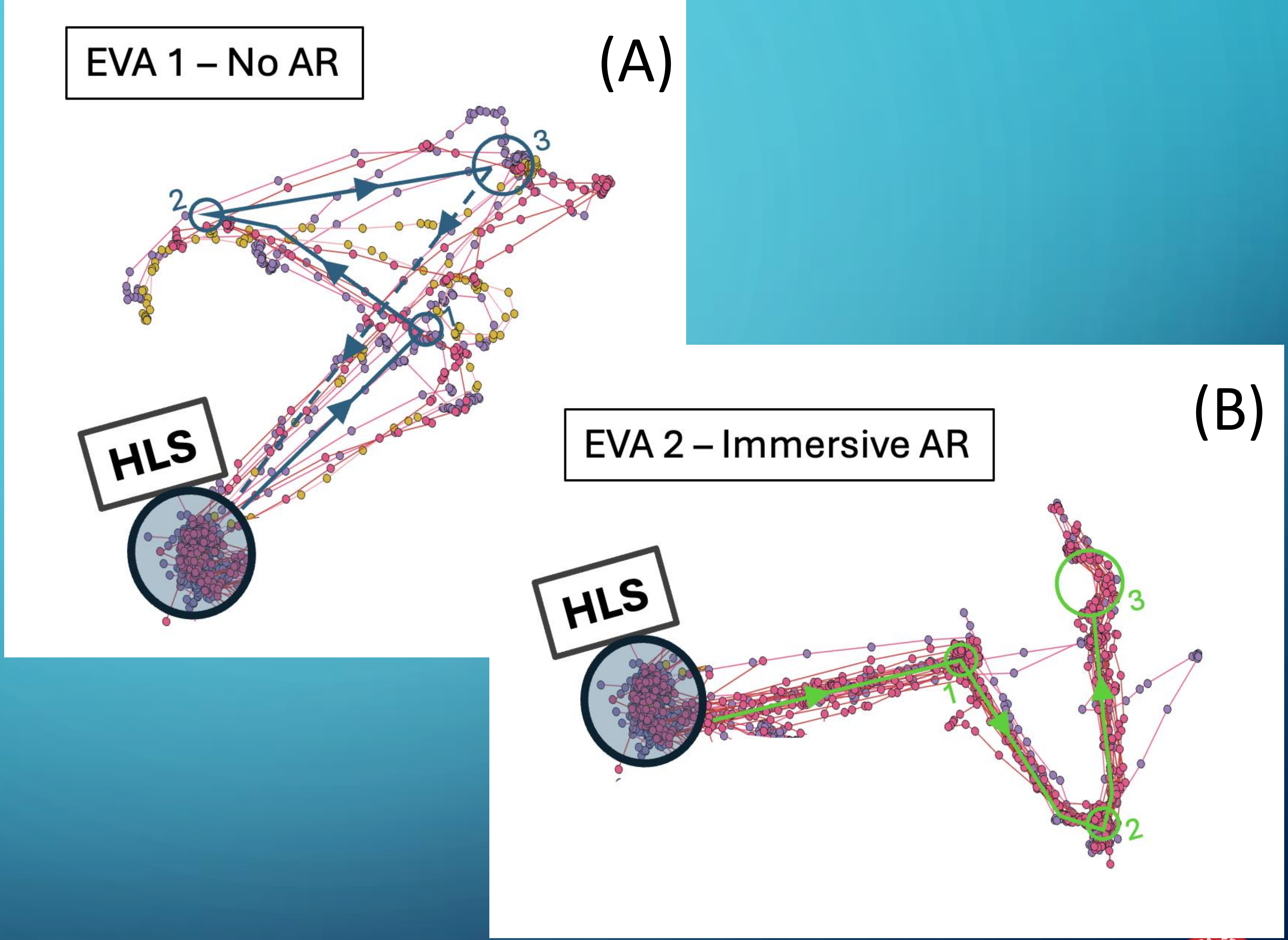
- Assess the use of Augmented Reality (AR) data visualization in both rover and astronaut analog missions using low-angle lighting conditions similar to those present at the lunar south pole
- Use MRET to enhance mission control teams' spatial awareness of a rover platform in the field and to improve the communication and collaboration between mission control personnel and analog astronauts on simulated EVA
- Expand existing MRET platform to enable real time AR / VR communication and visualization between mission control personnel and astronauts on EVA



GPS Tracking Results:

For traverses with no AR assistance (A), GPS tracks of participants show a range of paths taken.

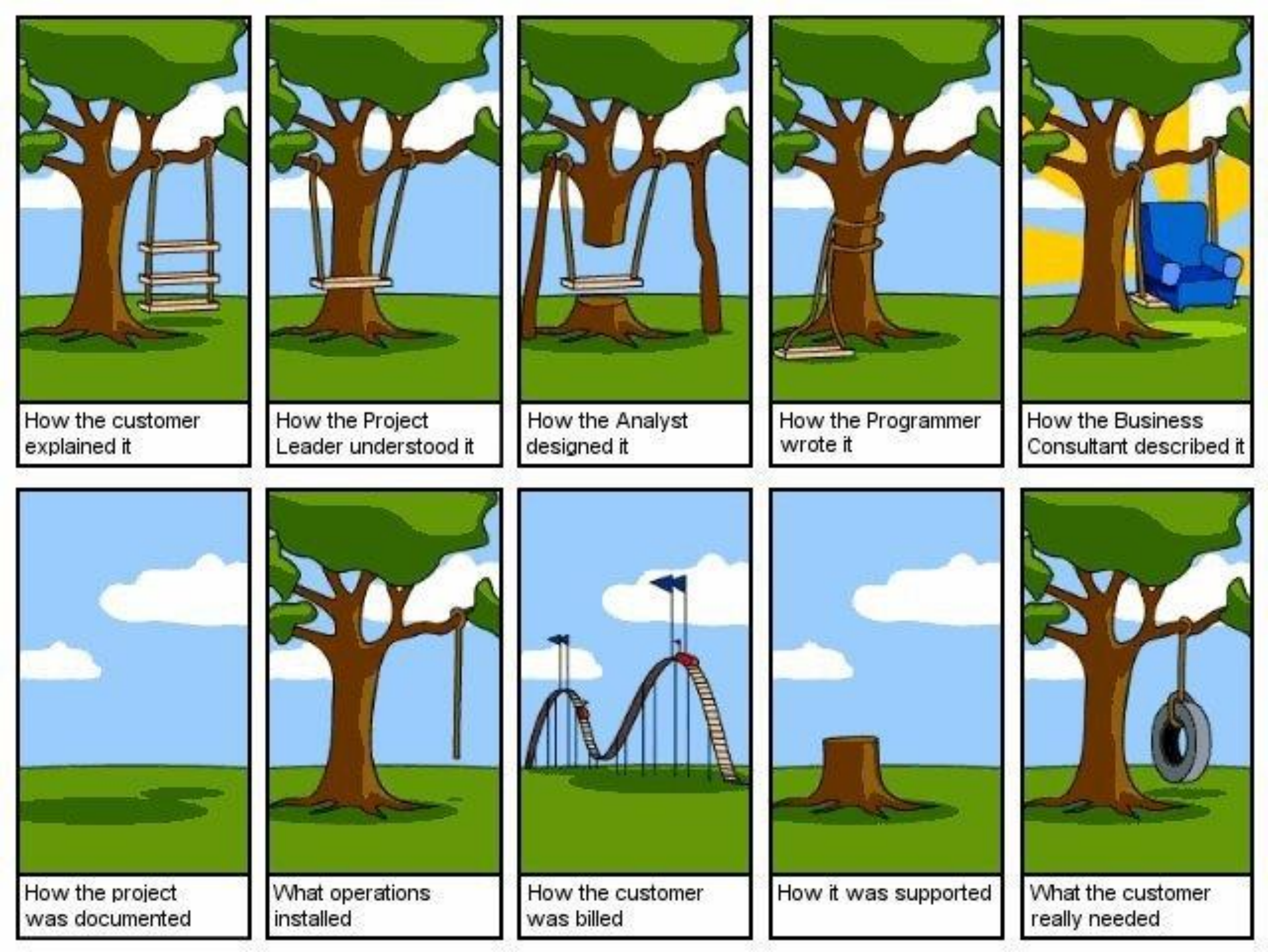
For traverses with AR guidance (B), GPS tracks converge tightly on EVA path and stations.



PORTING MRET TO APPLE VISION PRO

"Plans are useless, but planning is indispensable."
– General Dwight D. Eisenhower

PORTING MRET TO AVP



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PORTING MRET TO AVP

Initial goals

1. Track AVP position in darkness by matching its internal LIDAR scan results to our LIDAR map acquired during prior ARDVARC steps
2. Overlay "astronaut's" reality:
    1. Designated path
    2. Waypoints
    3. Pointcloud of prior LIDAR scan to help navigation in dark

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Reality check [tracking]

1. Can't get LIDAR output from AVP
2. Camera-feed-based positional tracking in darkness.. ? Nope.
3. AVP internal GPS precision is about 40m; pairing it with an iPhone doesn't help (a Unity app)
4. **What did work**: Image Matching allowed us to match AVP user's physical location to LIDAR scan' visualization and correlate it with the map shown in MRET@HQ.

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Reality check [Unity 1/n]

1. Wasted about 1 month on back-n-forth with Unity Enterprise Support while trying to figure out runtime error spam:

```
LayoutNotFoundException: Cannot find
control layout 'SpatialPointer'
EXCEPTION LayoutNotFoundException in
PolySpatialCore:
```

2. Never found out what caused those errors: instead, we brought MRET source over to an AVP sample project, alleviating <u>that</u> issue.

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Reality check [Unity 2/n]

1. Unity has an application on AVP, Play to Device, that is intended to help you see the result of a Unity "Play" session without building and deploying it to an AVP.
2. Once you get to more interesting functionality, like Image Matching, shaders, .., .., .., those might not show up in the P2D. No errors, no warnings. To test those components, you must build and deploy to AVP.

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Reality check [Unity 3/n]

1. Unity has a bug that invalidates an Xcode project (?) if you attempt to "append" it while building a Unity project.
2. Therefore, you must (re)build into an empty folder from Unity each time you make a change: then customize the Xcode project as needed (set signer, add custom files, etc.), and only then build&deploy it into your AVP. Hours of wasted time.

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Reality check [Unity 4/n]

1. Lesson learnt: when facing an inconsistency or a problem with Unity, and it seems that you have followed the manual or (rare) examples to the dot, **assume its Unity's problem** / fault / issue / bug, and **not your error.**
2. Once we started following that approach, it saved us time while debugging issues and finding workarounds.

PORTING MRET TO AVP

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Reality check [Unity 5/n]

1. If your team has enough members, assign someone to track the issues your team is facing with Unity, report those to Unity (Enterprise) support, and follow up with them to extract actionable(!) answers.
2. In contrast, Apple developer support team was very helpful for our project and helped us avoid getting stuck with unsolvable issues.

PORTING MRET TO AVP

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Reality check [Unity 6/n]

1. If you start a new (larger, complicated) project for Apple Vision Pro and are considering to use Unity for that: **don't!**
2. Have your team learn Swift instead and build your project natively in Xcode.
3. Do find out who is your helpful developer contact at Apple and work with them!

PORTING MRET TO AVP

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Reality check [Apple]

1. Current AVP API does not allow low-level access to LIDAR results. We had to resort to using Image Tracking for positioning the user.
2. AVP uses sensor fusion to keep track of user position: as our environment was mostly dark (Lunar south pole), AVP was unable to rely on visual cues, while the open ground didn't provide enough anchors (landmarks) for LIDAR to latch on.

PORTING MRET TO AVP

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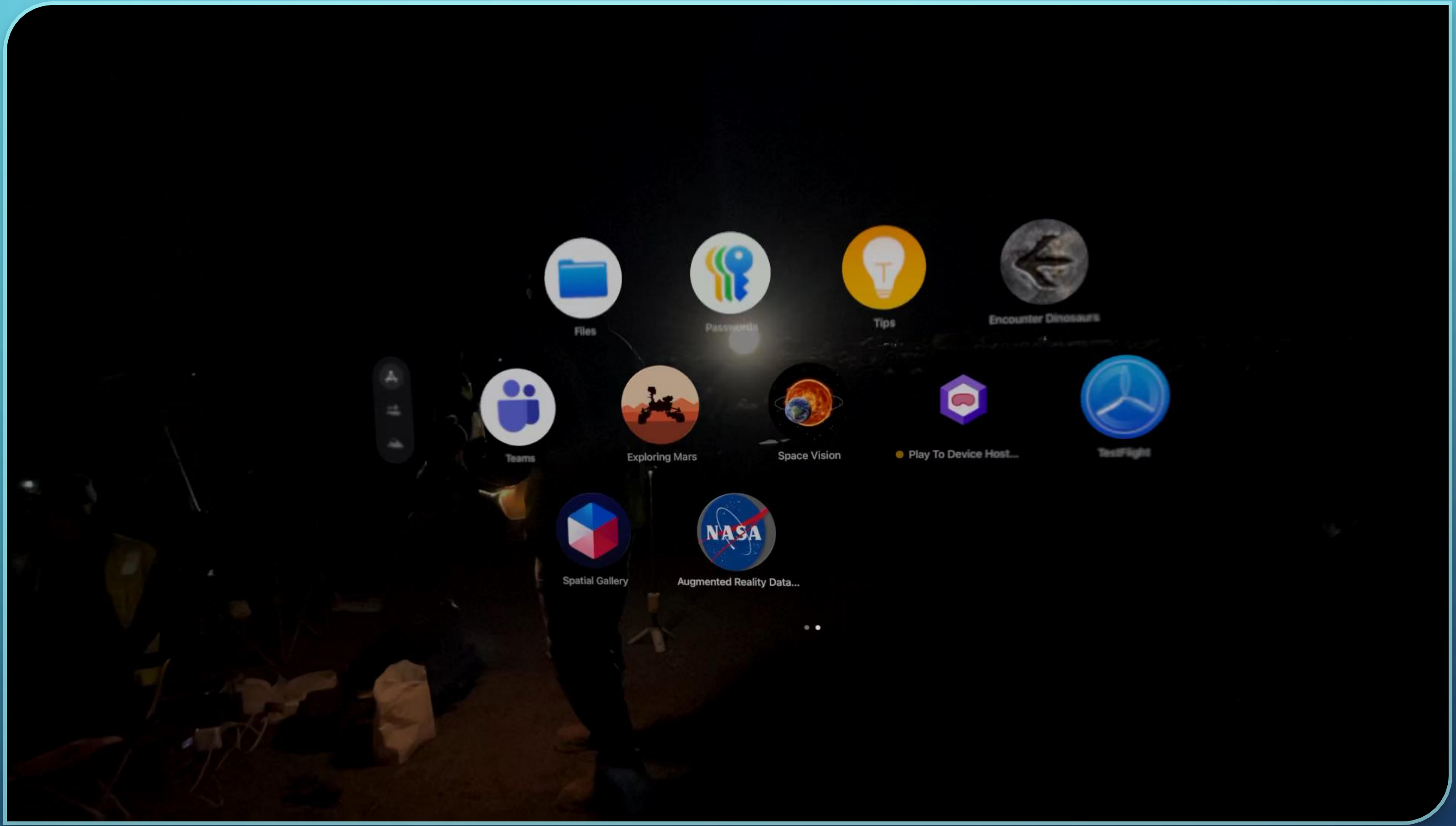
Achieved goals

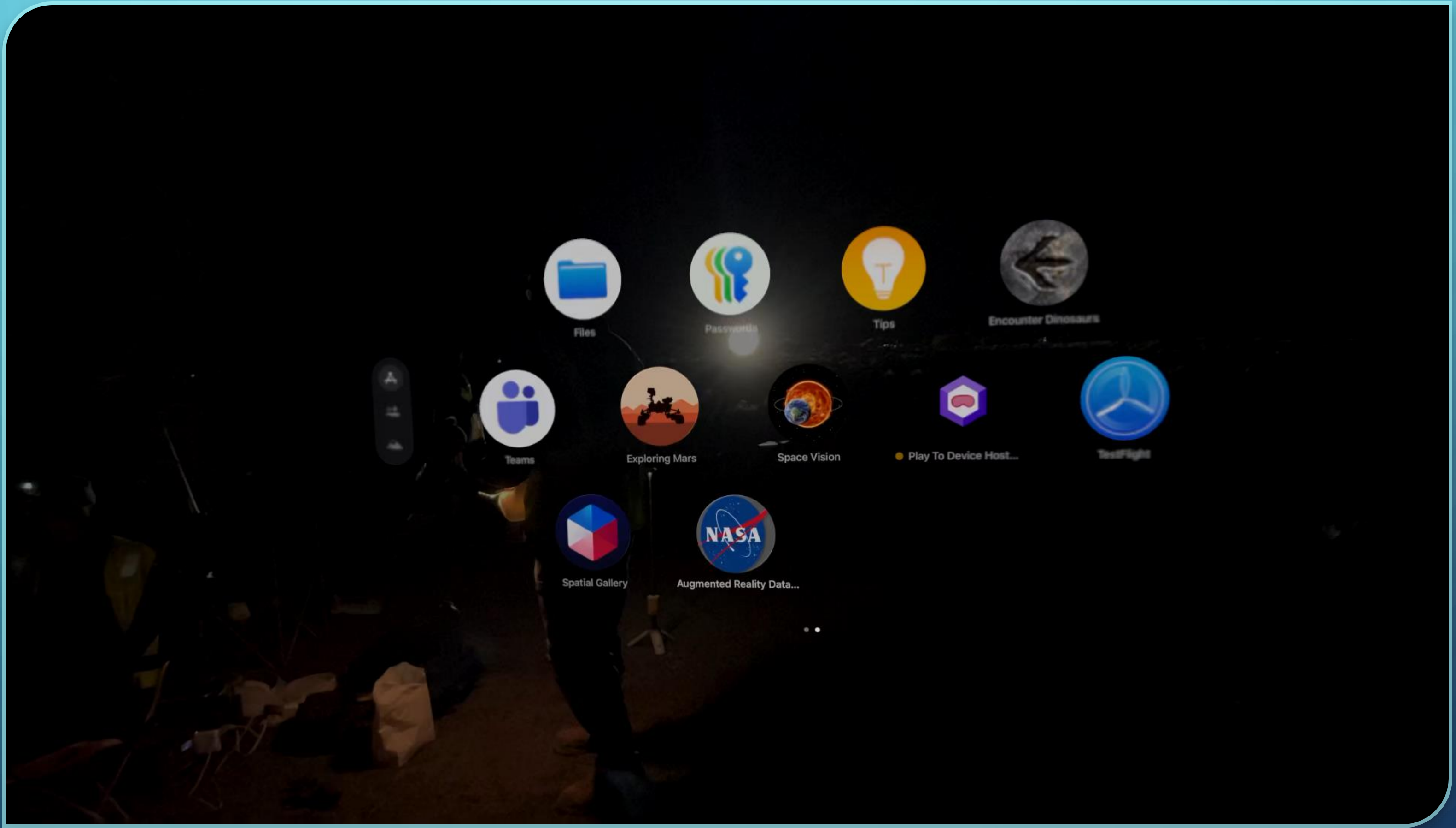
1. We ended up using flashlights to help AVP keep track of its surroundings and asked users to angle their head toward the ground (for better LIDAR tracking).
2. MRET got ported to AVP and can be used for future projects.
3. Extra Vehicule Activities were successfully tested at the Flagstaff site, with paths, waypoints and point cloud synced with GSFC view.

FIRST RUN



Files
Tips
Encounter Dinosaurs
Teams
Exploring Mars
Space Vision
Play To Device Host...
Spatial Gallery
NASA
Augmented Reality Data...

FIRST FAIL


Files
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NASA
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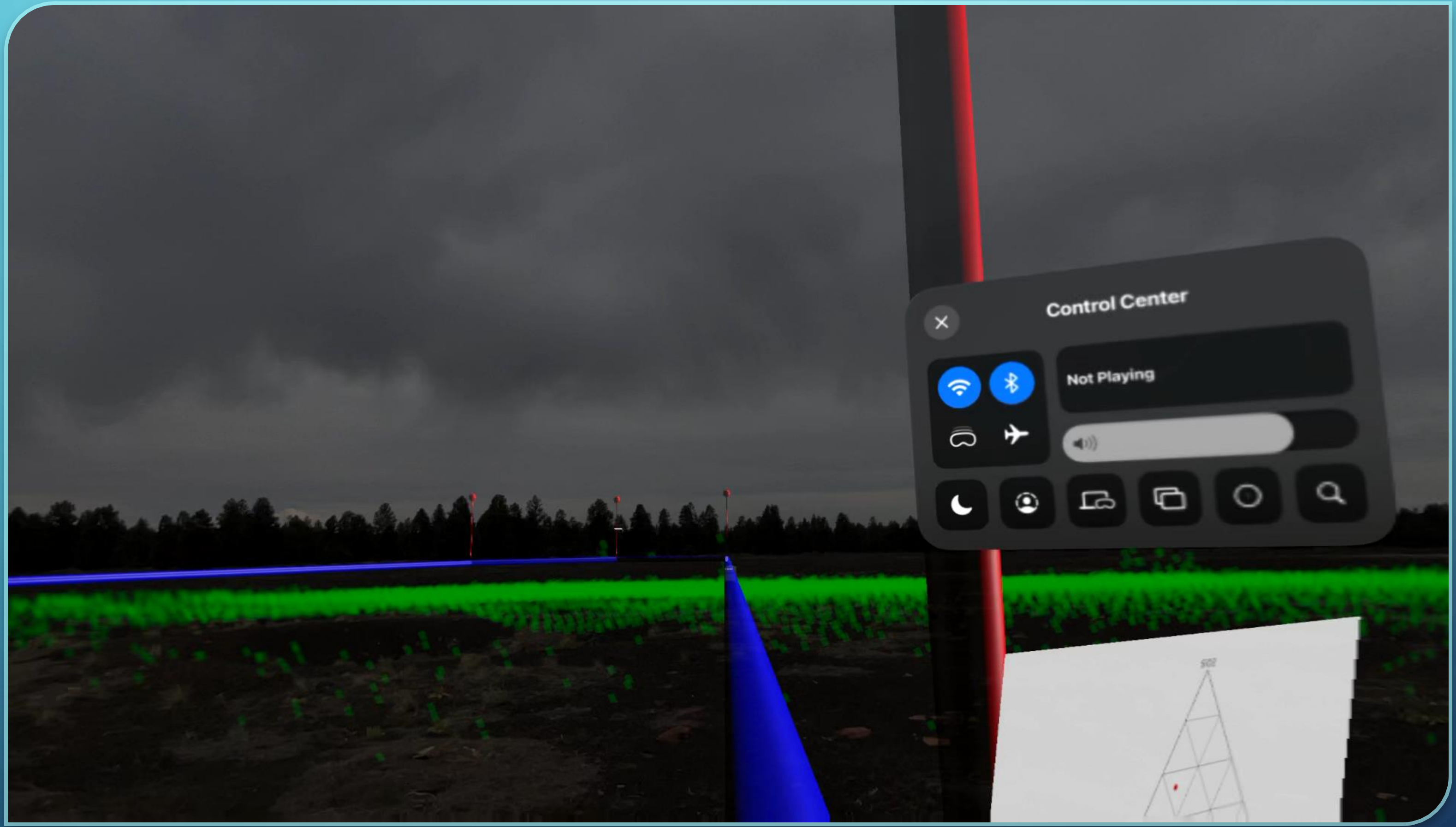
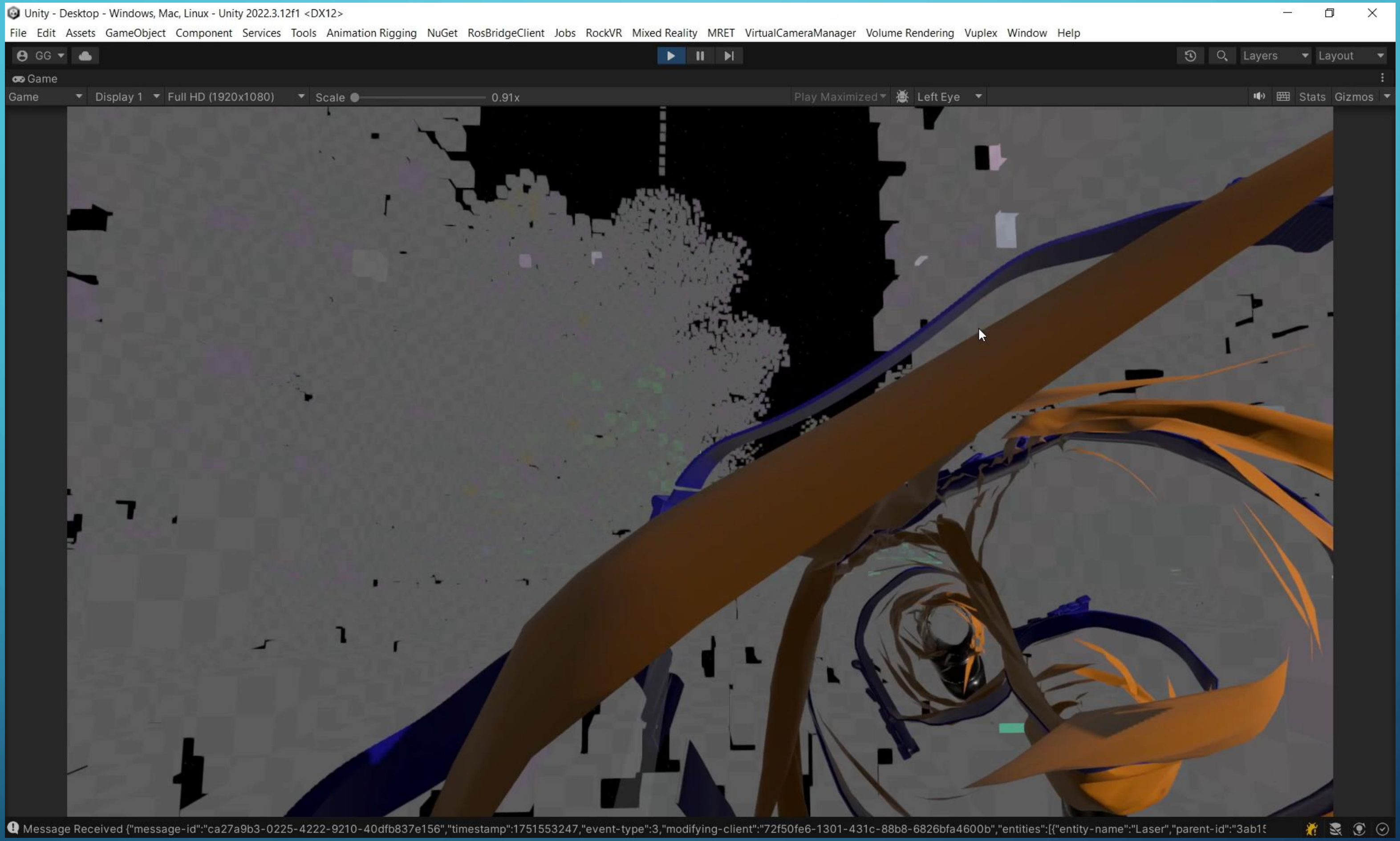
IMAGE MATCHING FOR POSITIONING



VR VIEW


Unity - Desktop - Windows, Mac, Linux - Unity 2022.3.12f1 <DX12>
File Edit Assets GameObject Component Services Tools Animation Rigging NuGet RosBridgeClient Jobs RockVR Mixed Reality MRET VirtualCameraManager Volume Rendering Vuplex Window Help
GG
Layers
Layout
Game
Game
Display 1
Full HD (1920x1080)
Scale
0.91x
Play Maximized
Left Eye
Stats
Gizmos
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CONCLUSION

- We had a large Unity project, MRET, that we were *mostly* able to port desired features to AVP
  - A few of (thankfully) unnecessary features had to be removed
- ARDVARC use case stressed the limits of hardware (Hololens 2, Apple Vision Pro)
  - Outside
  - Nighttime
  - Bright light source
- We were able to barely meet goals of our use case using Apple Vision Pro by managing requirements

CONCLUSION (CONT)

- If you are creating an app for Apple Vision Pro only, you probably want to use the Apple ecosystem and support
- If you are starting an XR app for multiple platforms (PC, AVP, etc.), consider carefully the cost/benefits of doing a Unity project vs Unity + Swift project
  - A Unity only multi-platform app can be done but you need to manage your expectations and requirements
  - Unity support for AVP is lacking
    - Development in Unity for AVP has issues
    - Unity APIs for AVP are missing or can behave differently
    - Full suite of AVP APIs may not be accessible from Unity

BACKUP SLIDES