



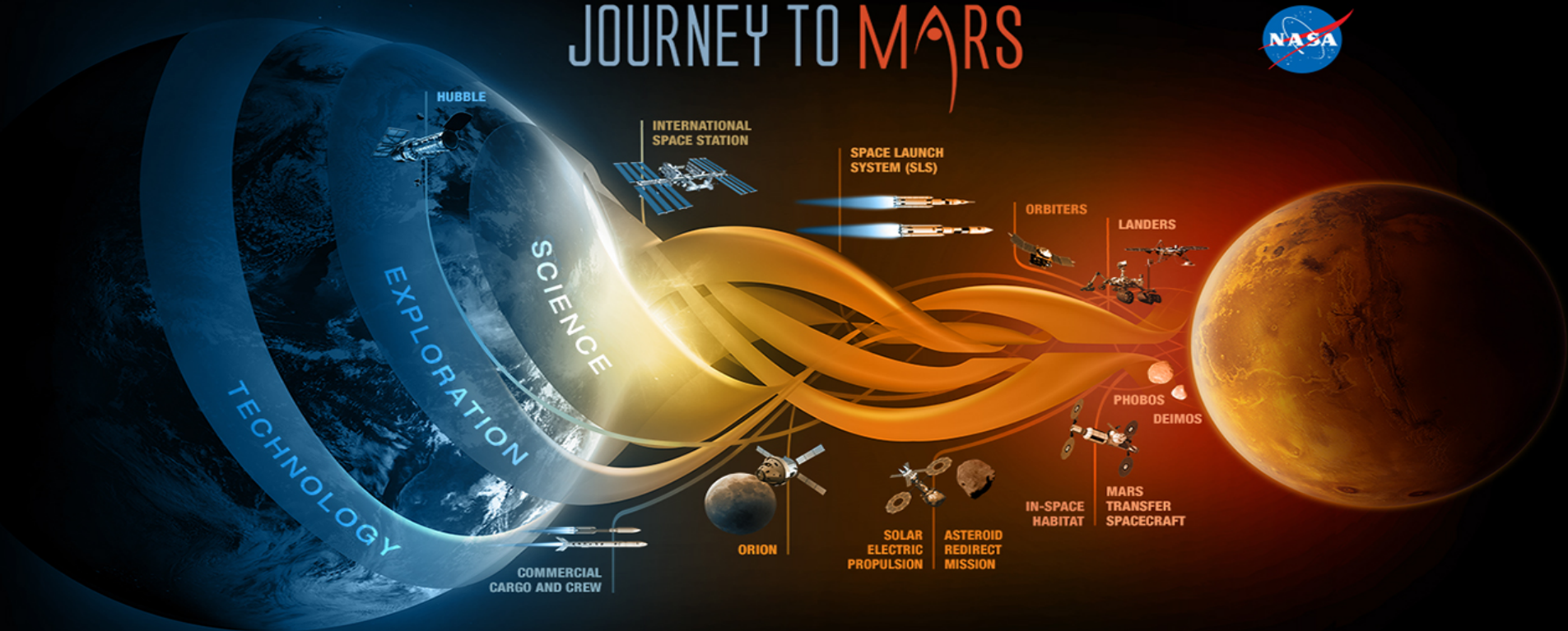
Hybrid Reality: A New Paradigm for Astronaut Training

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JOURNEY TO MARS



Problem

Going to Mars requires new
technology and training

New Technology = \$\$\$

Training = \$\$\$

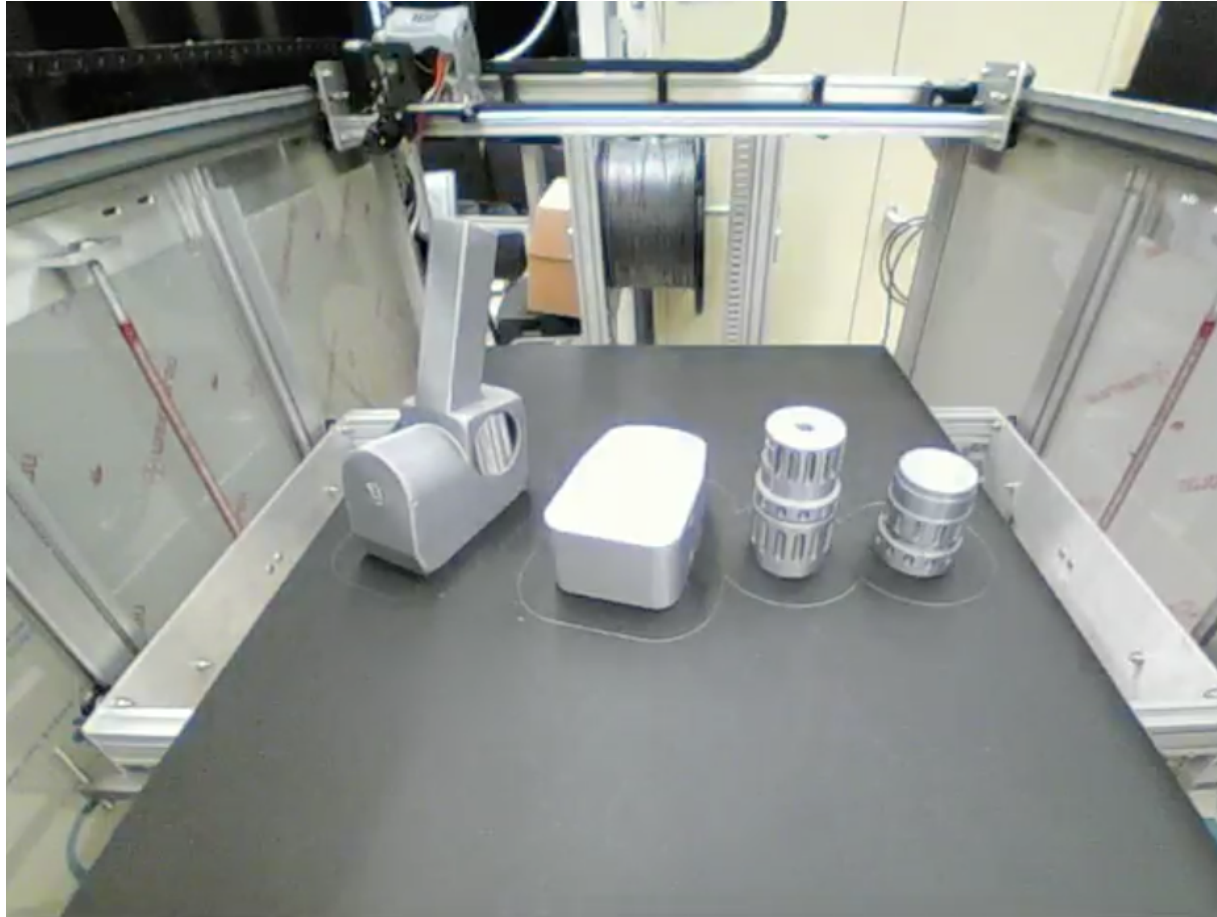
What is Hybrid Reality?

From Star Trek TNG Technical Manual:

“Matter conversion subsystem creates physical props using replicators. Replicated props are generally created when an object is likely to be touched by a participant.”



3D print plastic objects as substitutes for NASA tools

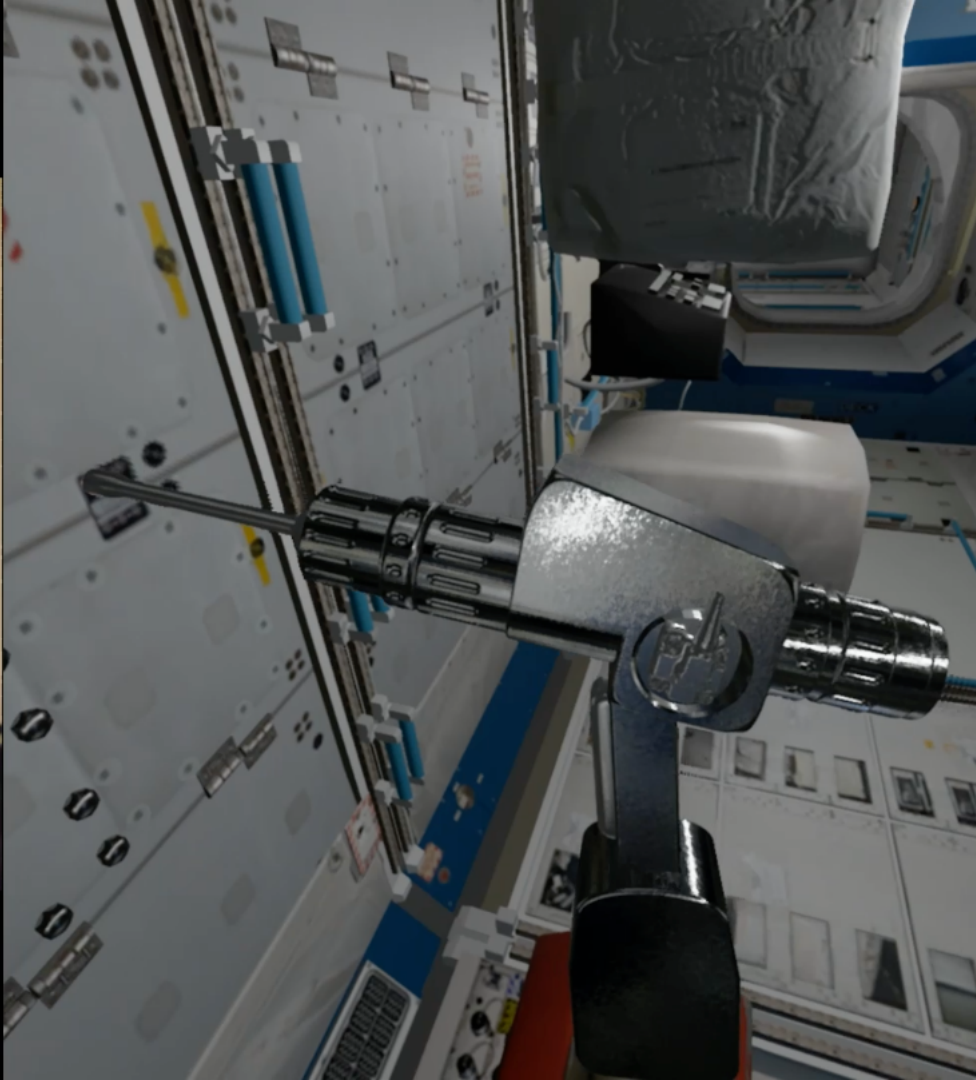


From Star Trek TNG Technical Manual:

“Holodeck imagery subsystem creates three-dimensional images of simulated environments. Shaped forcebeams give physical substance to foreground objects so they have the illusion of being solid.”



Consumer VR makes 3D printed objects look like the real thing



From Star Trek TNG Technical Manual:

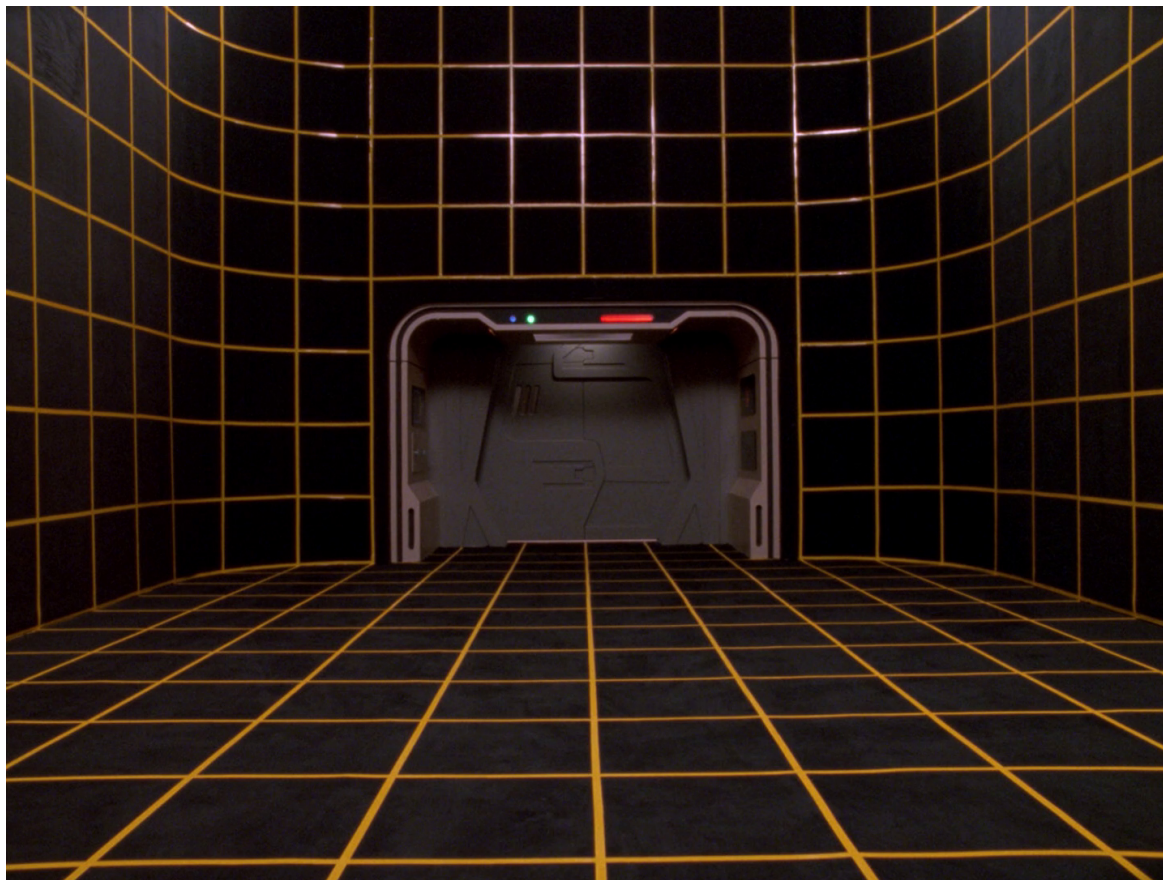
"Some props are animated under computer control by precision-guided tractor beams."



Recreate interactive tool displays and interfaces digitally.
Animate moving parts in software when possible.



- Combine consumer VR headsets with 3D printed tracked objects for better touch feedback
- “Works” like the Holodeck from Star Trek





NHRL

NASA Hybrid Reality Lab

Tools

Create a low cost, scalable HR platform combining:

Head/Body Tracking + Visual Feedback

Sensation of Weightlessness

Tactile feedback

Photorealistic Graphics

Physics

Multiplayer

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Original NASA VR Headsets



Modern NASA VR Headsets



Consumer VR Headsets



Create a low cost, scalable HR platform combining:

Head/Body Tracking + Visual Feedback

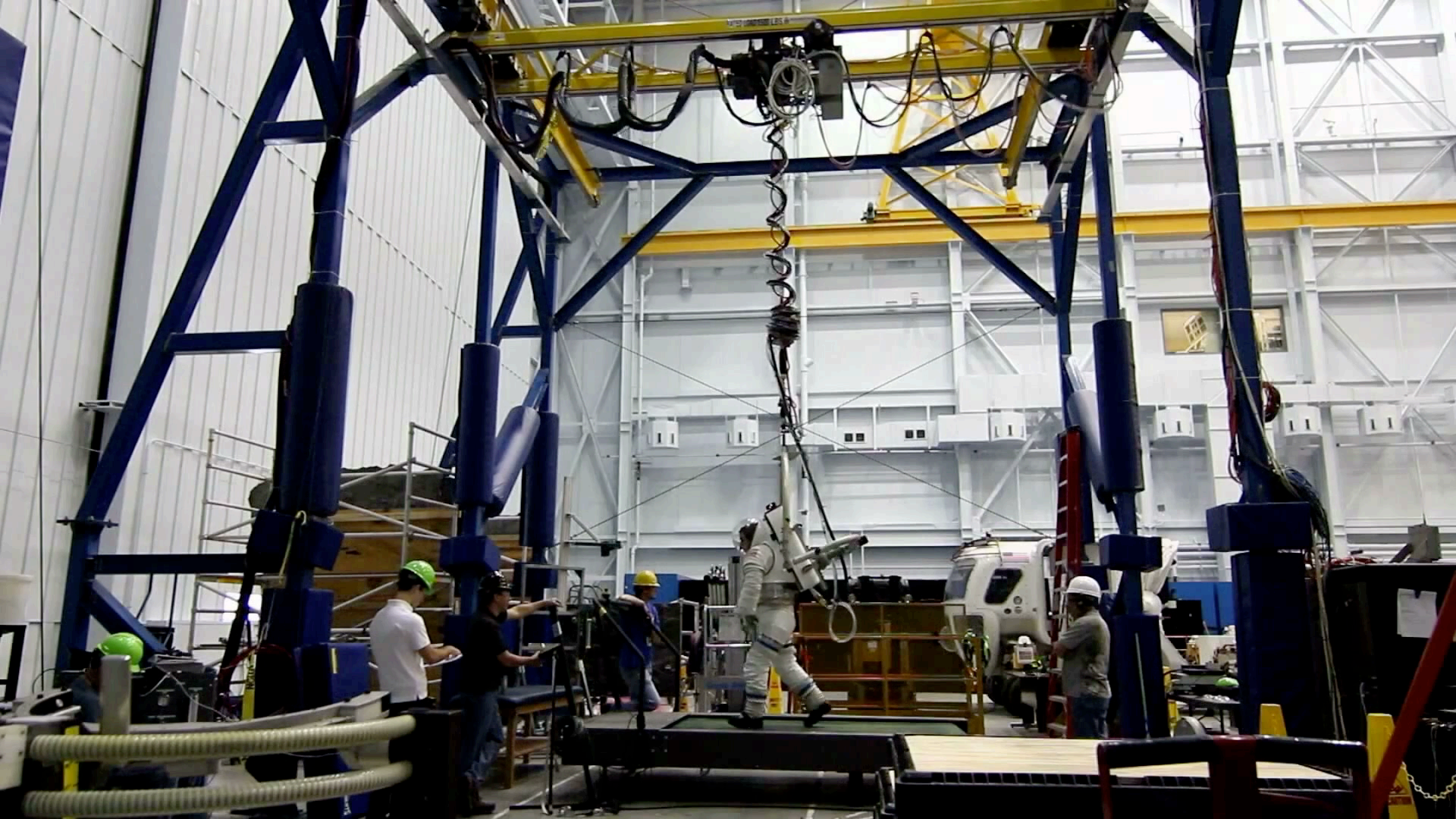
Sensation of Weightlessness

Tactile feedback

Photorealistic Graphics

Physics

Multiplayer



- Navigate around spacecraft with real-world handrails
- Subject moves around virtual ISS in Hybrid Reality



- Conduct sample retrieval (planetary operations, asteroid redirect mission, etc.)
- Conduct virtual repair or equipment deployment missions



Create a low cost, scalable HR platform combining:

Head/Body Tracking + Visual Feedback

Sensation of Weightlessness

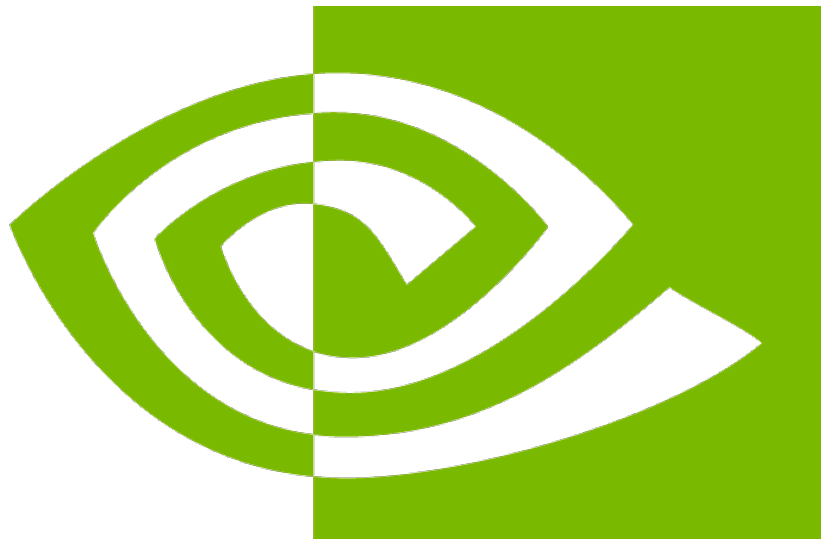
Tactile feedback

Photorealistic Graphics

Physics

Multiplayer

NVIDIA Graphics & Unreal Engine Rendering



Applications

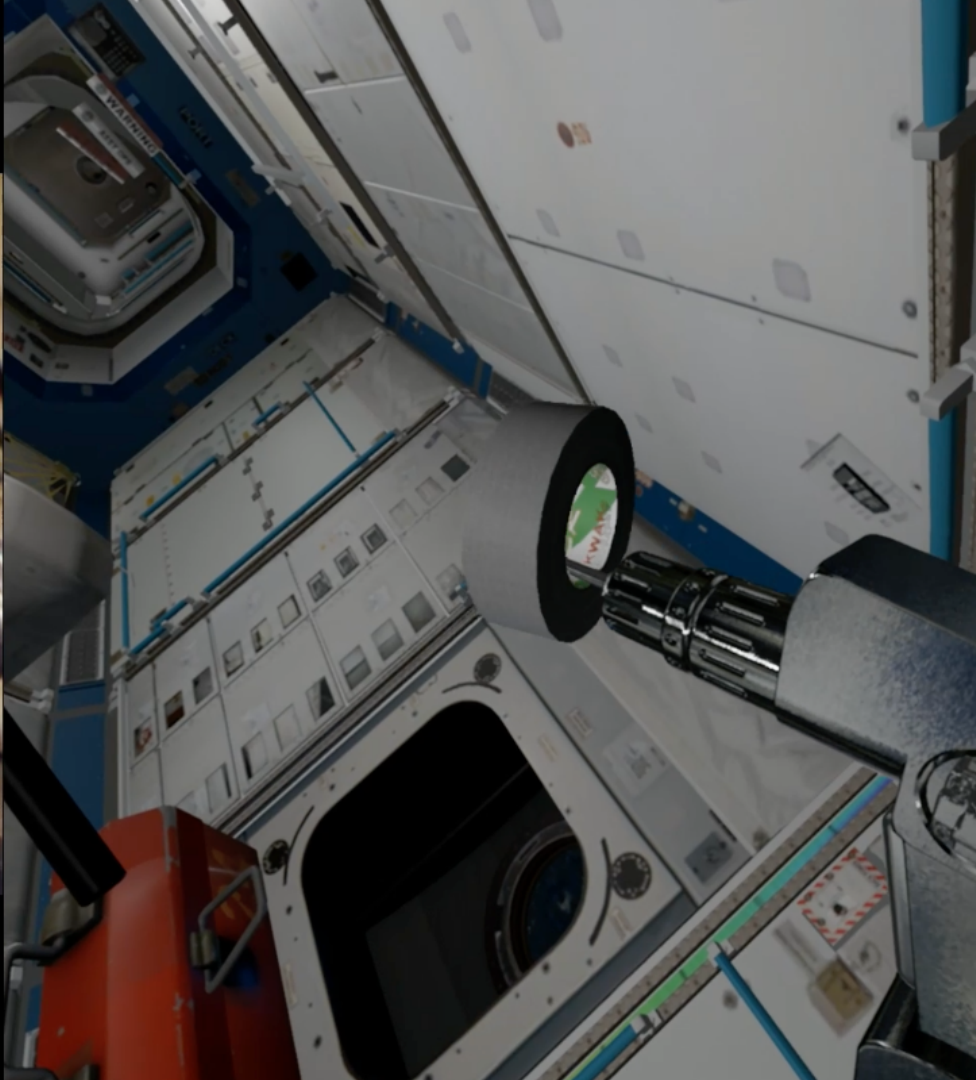
International Space Station (ISS)



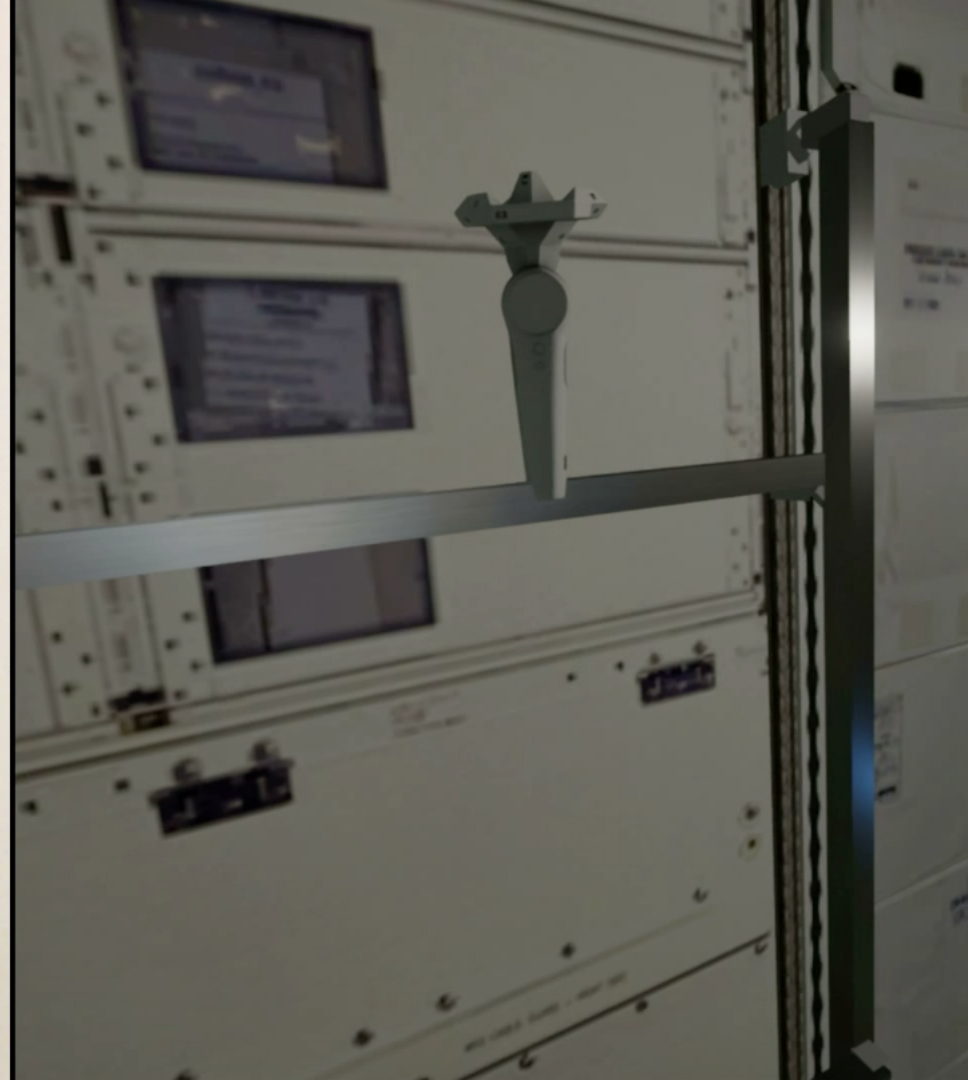


POI-Based Teleport

- Eliminates simulation sickness
- Simple controls
- Small interior space
- Directing attention
- Avoid wall overlap
- Easy vertical movement



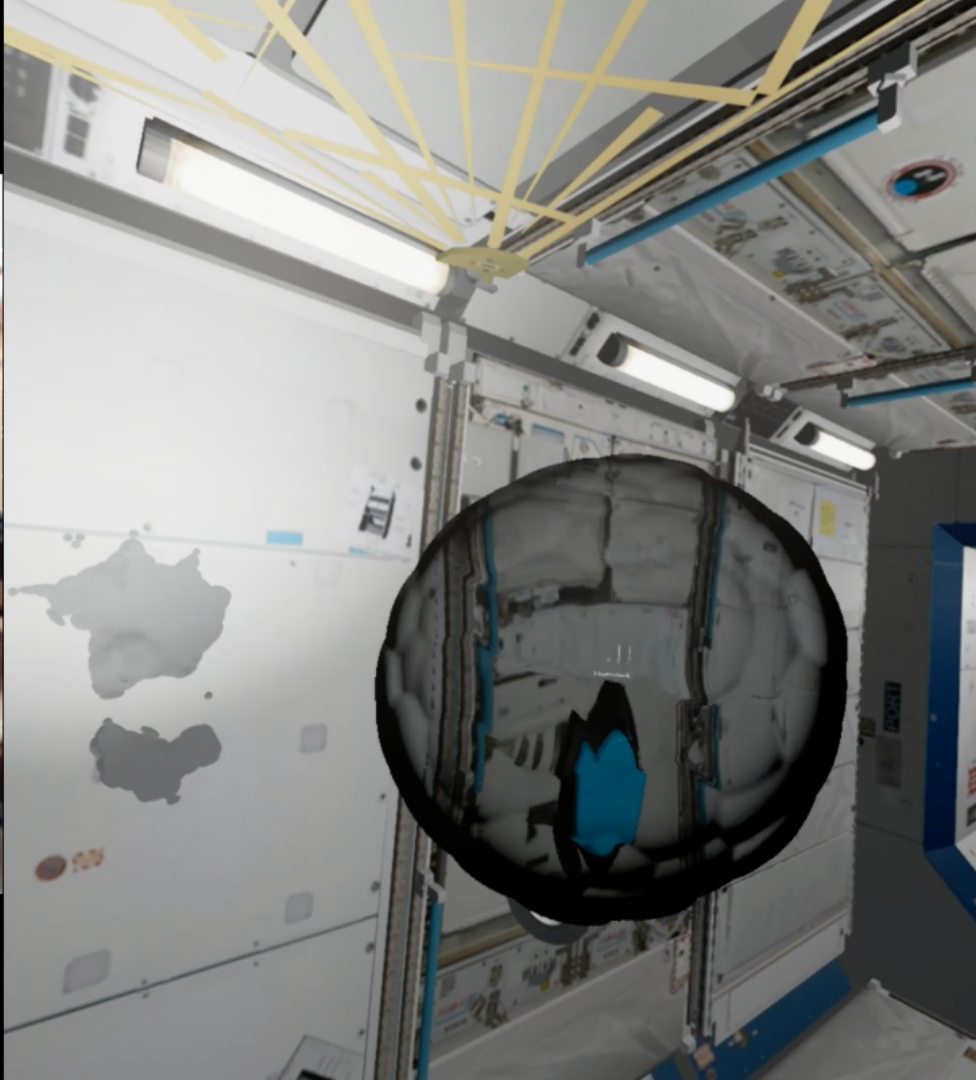


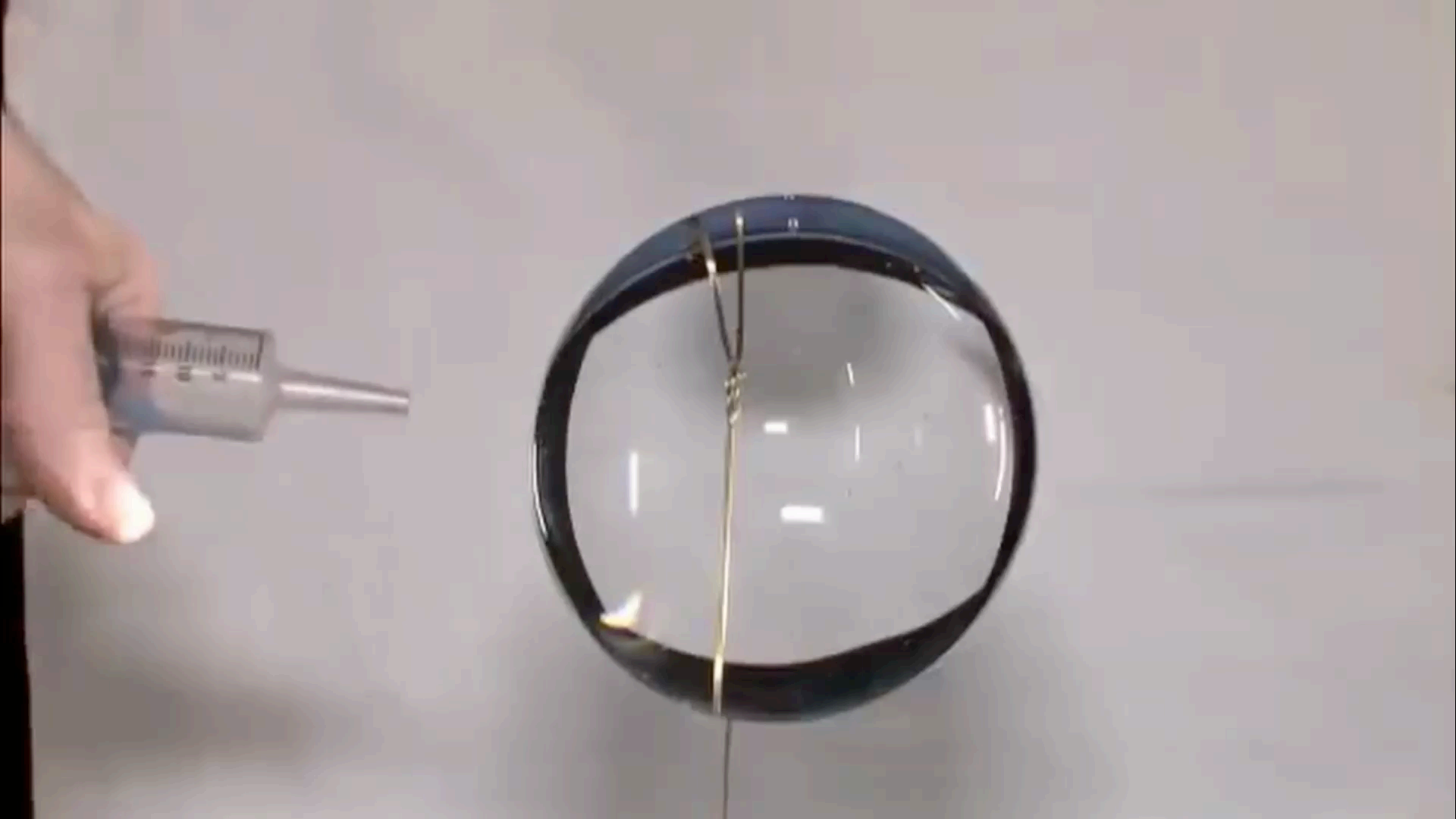




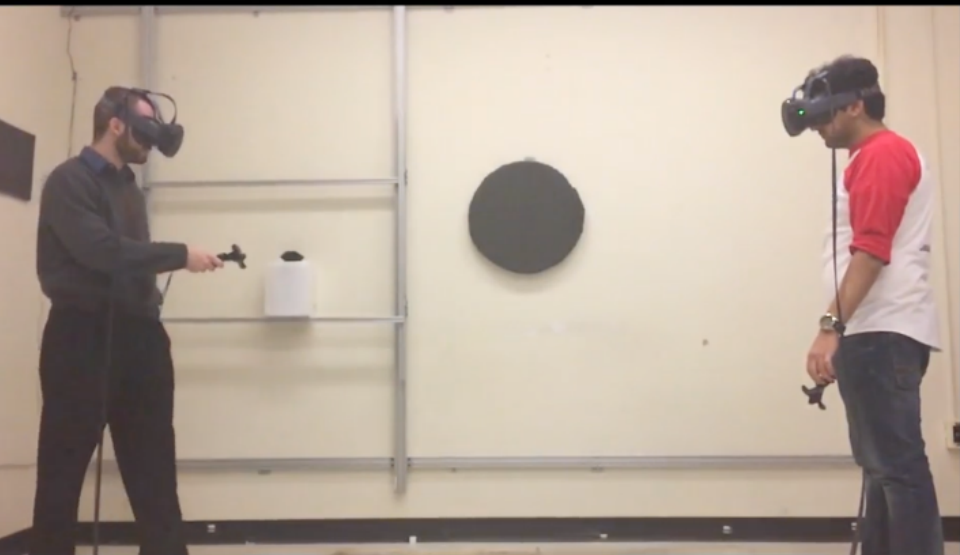




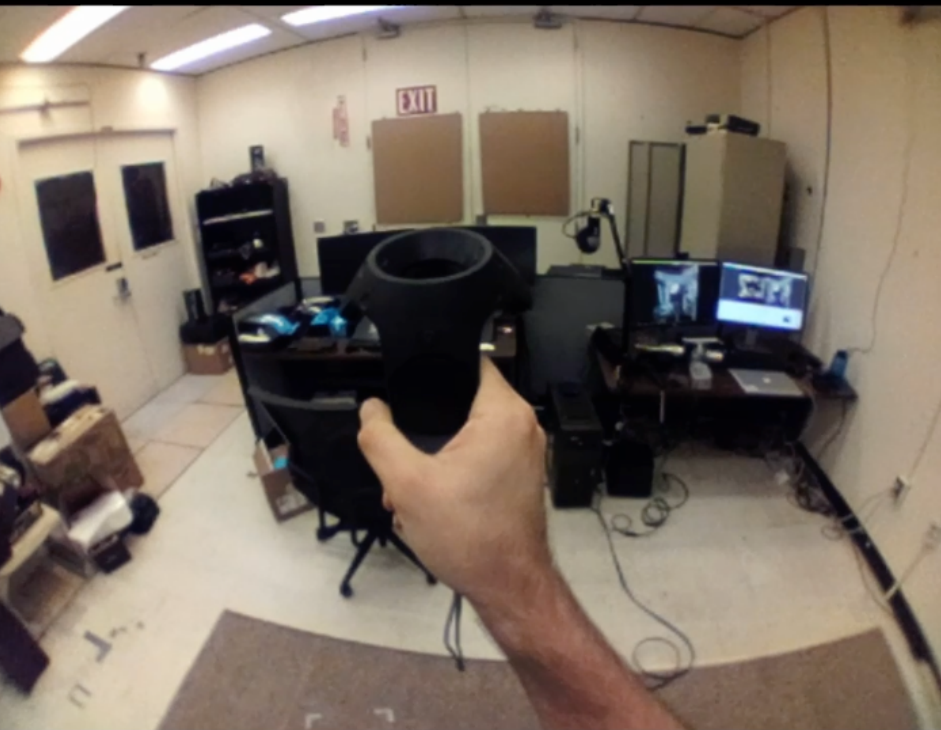












Eye Adaptation

- New sunrise/sunset every 42 minutes
- 30 minutes (bright to dark)
 - Pupils dilate; rhodopsin synthesis; Purkinje Effect
- 5 minutes (dark to bright)
 - Pupils contract; rhodopsin photobleaches

Goal

- Per-user eye adaptation
 - Measure adaptation times and tune algorithm

Factors Affecting Eye Adaptation

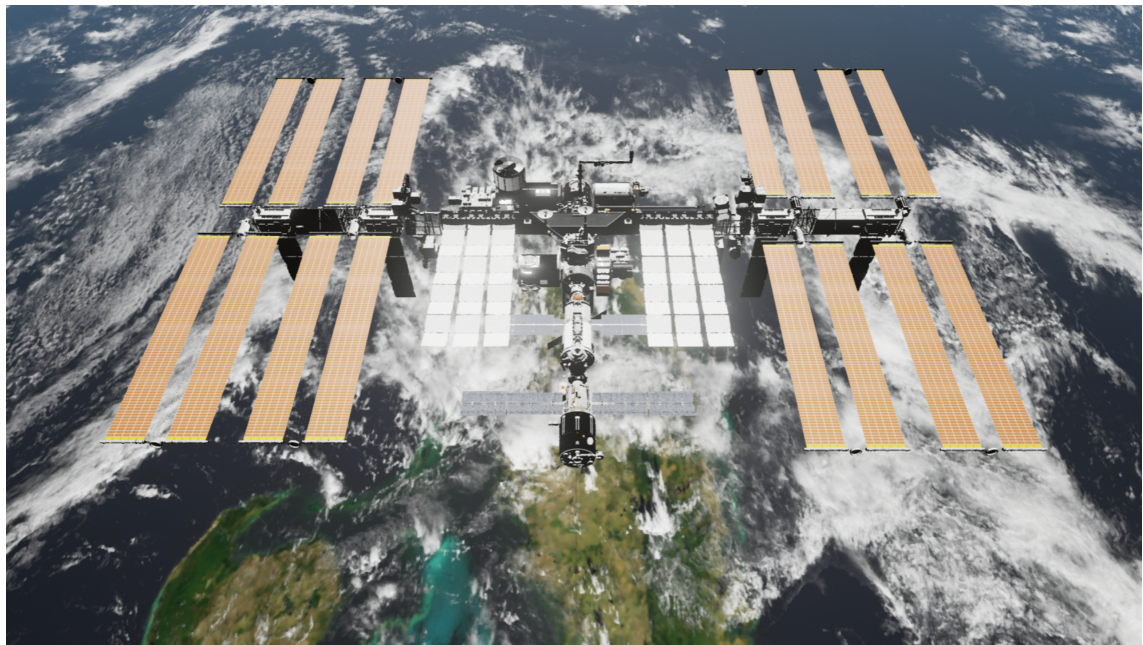
- Light intensity
- Size/Location of light on retina
- Light wavelength



- Weightless object dynamics
- 3D printed tools
- 3D scanned tools
- Microgravity fluid simulation

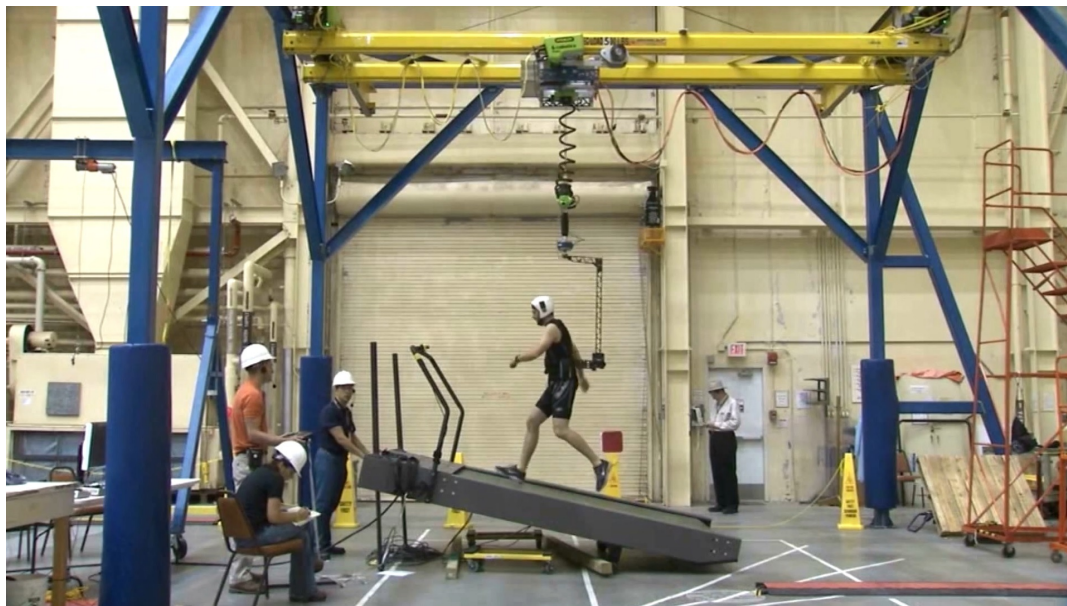


- Realistic Earth Model built from satellite imagery
- Simulated logarithmic eye adaptation to ambient light changes



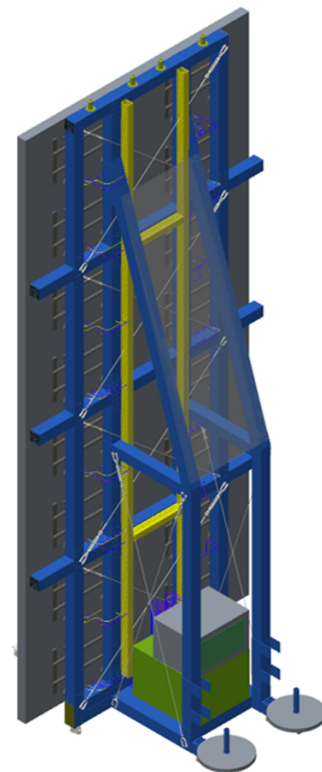
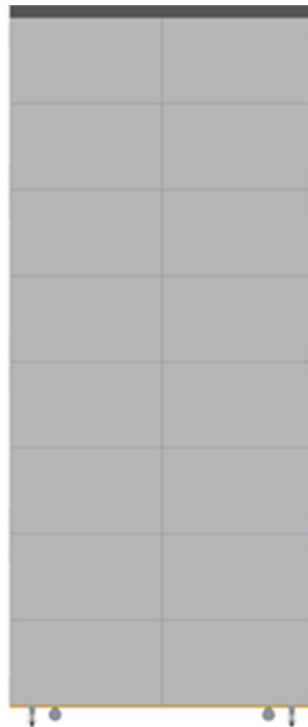
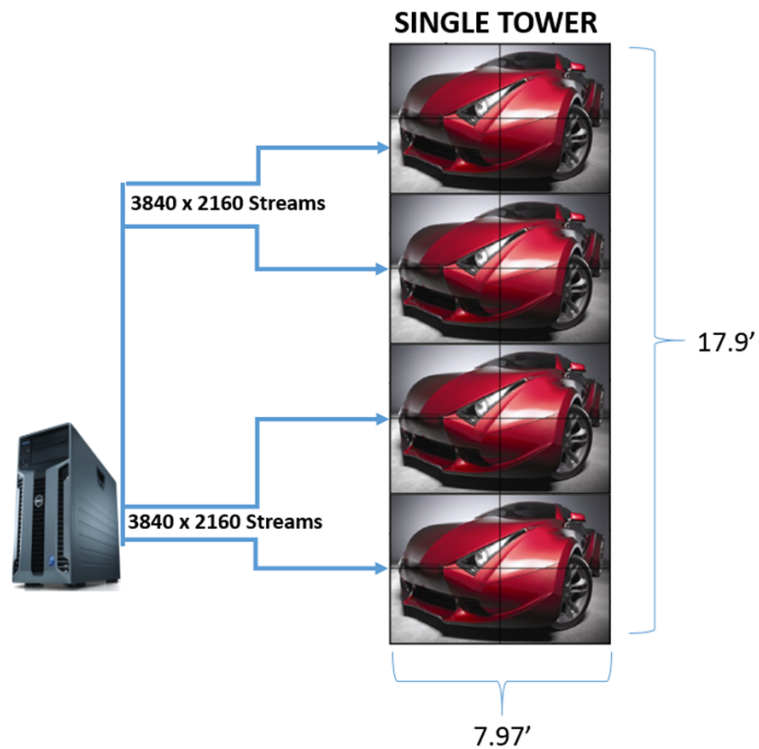
Active Response Gravity Offload System(ARGOS)

- Consumer VR Headsets well-suited to shirt-sleeve ARGOS operations

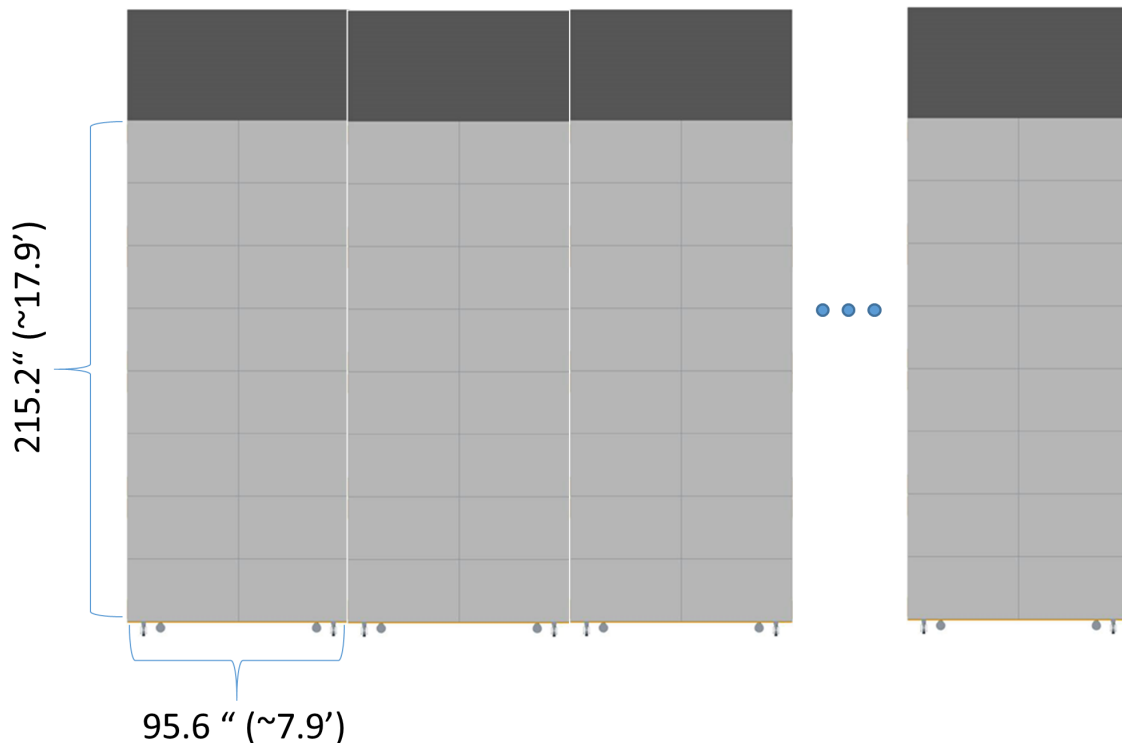


- Current VR headsets poor candidate for pressurized space suits
- Potential solution: CAVE or Video Wall visualization

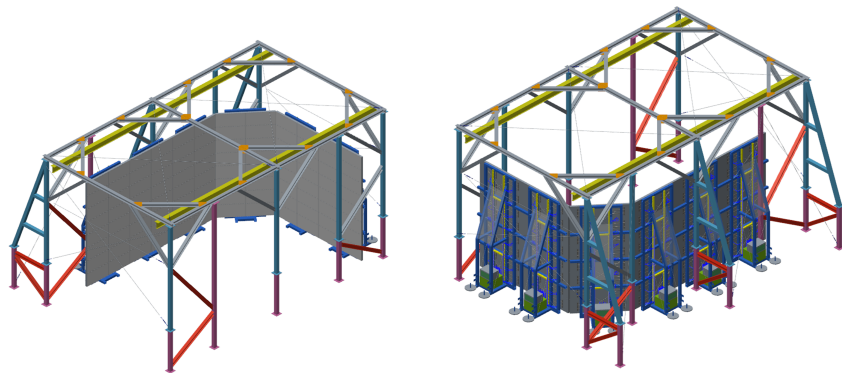




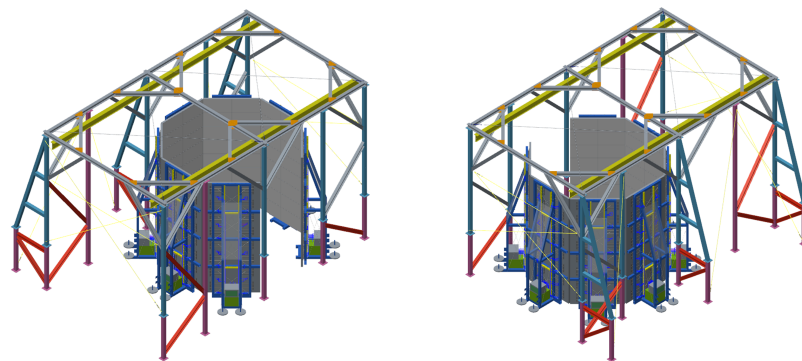
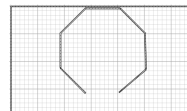
- Concatenate multiple towers together to create a variably sized video wall
- Each tower powered by a separate computer synchronized over a network

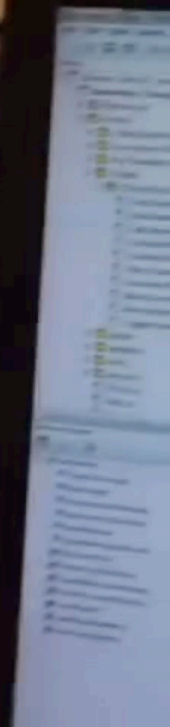


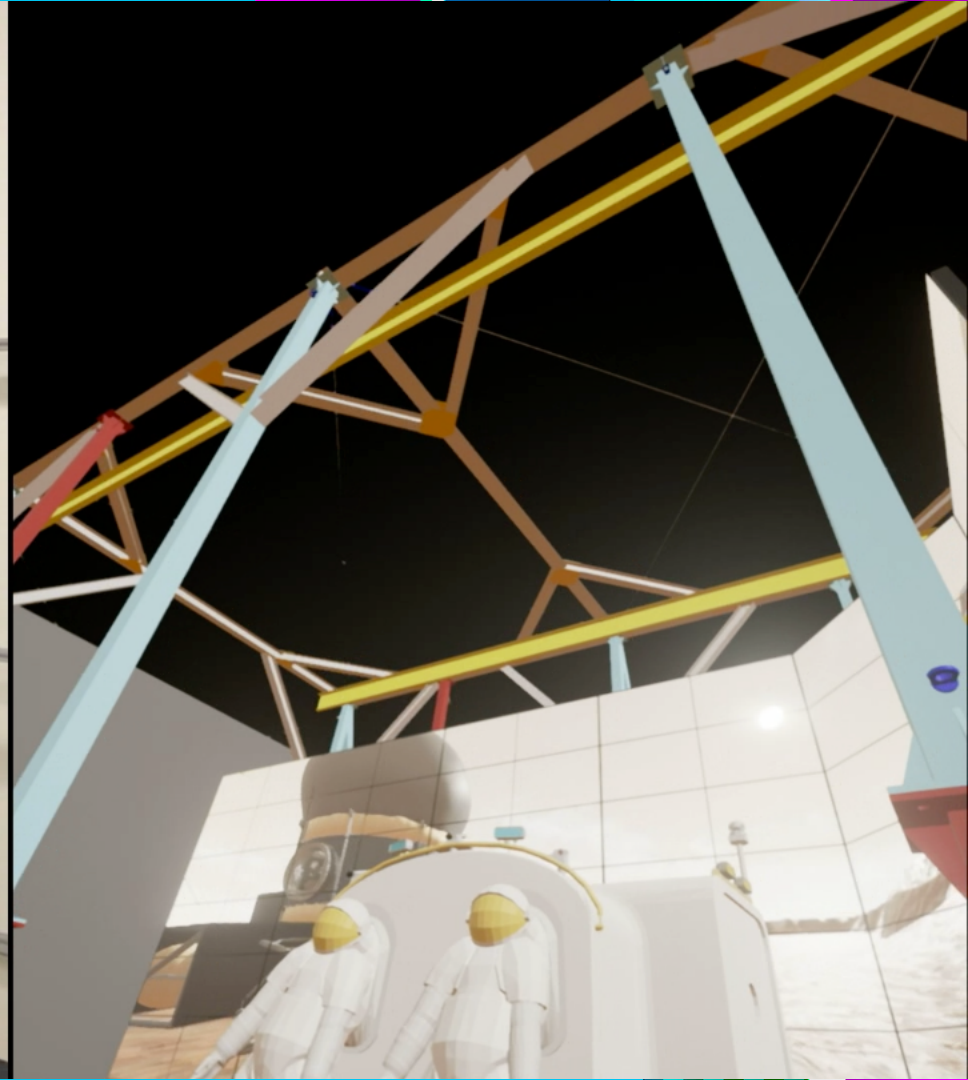
Configuration 1



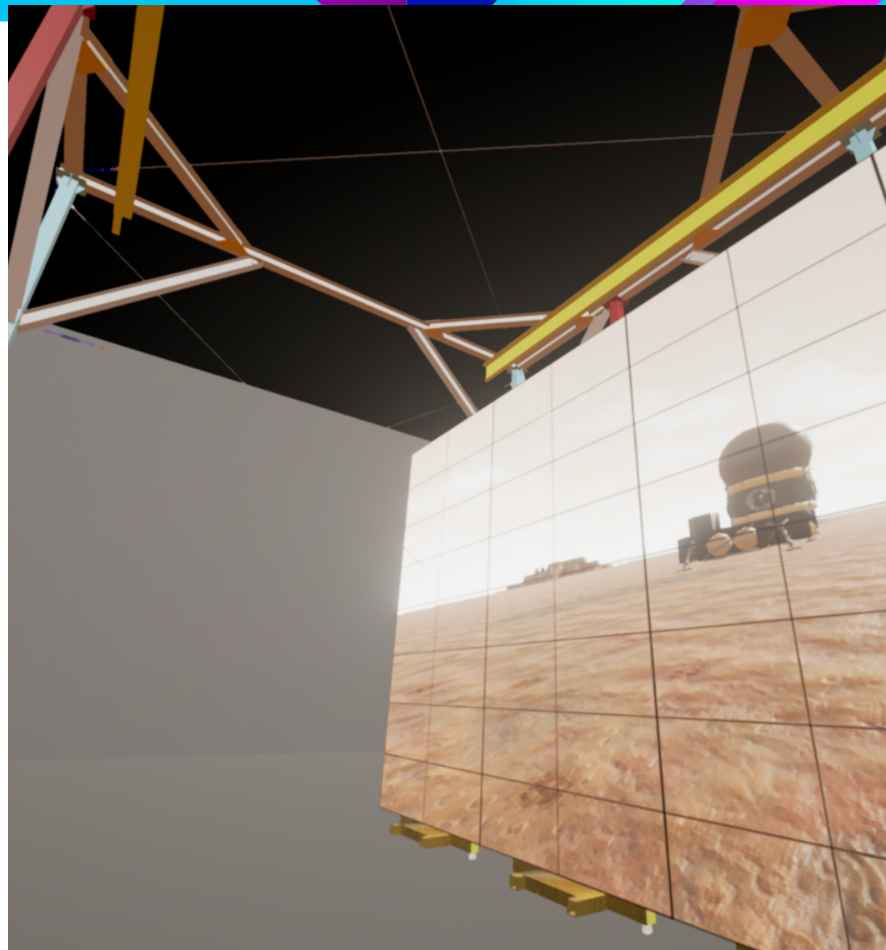
Configuration 2







- Use consumer VR headset to prototype video wall
- Write video wall view management software for virtual walls, then deploy to physical device



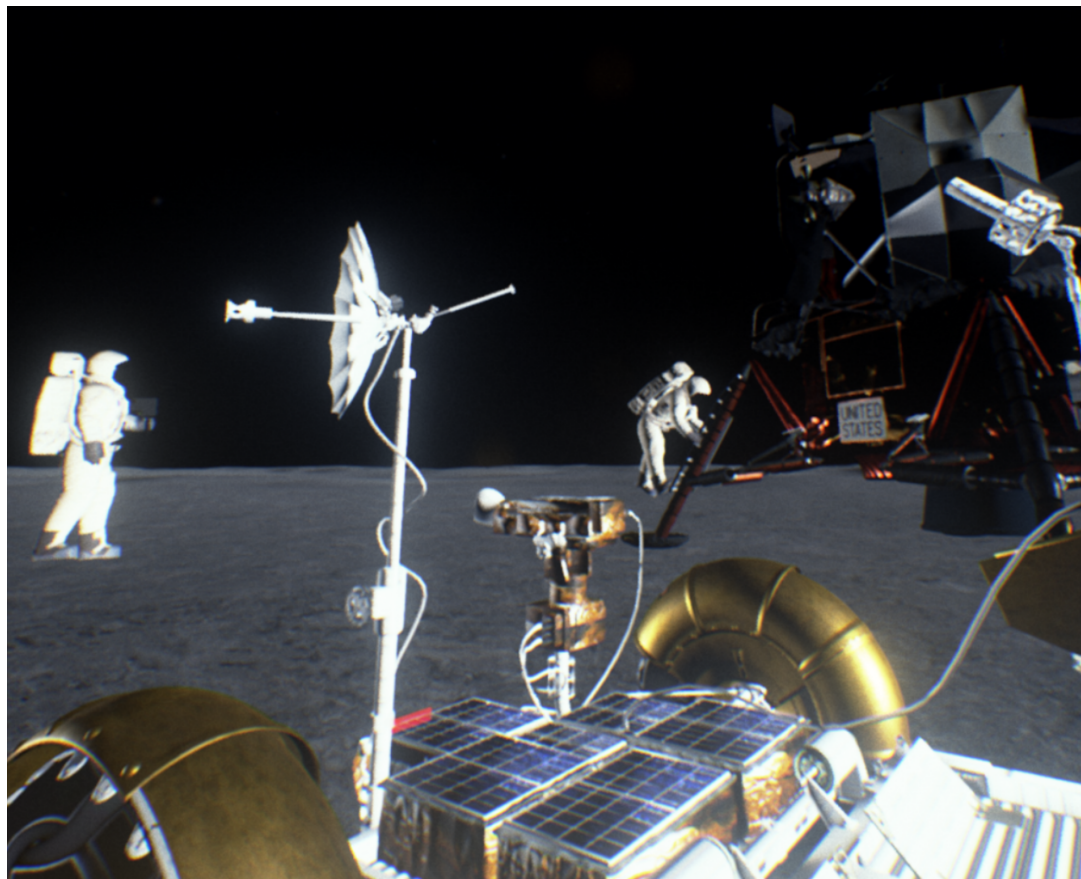
Habitats

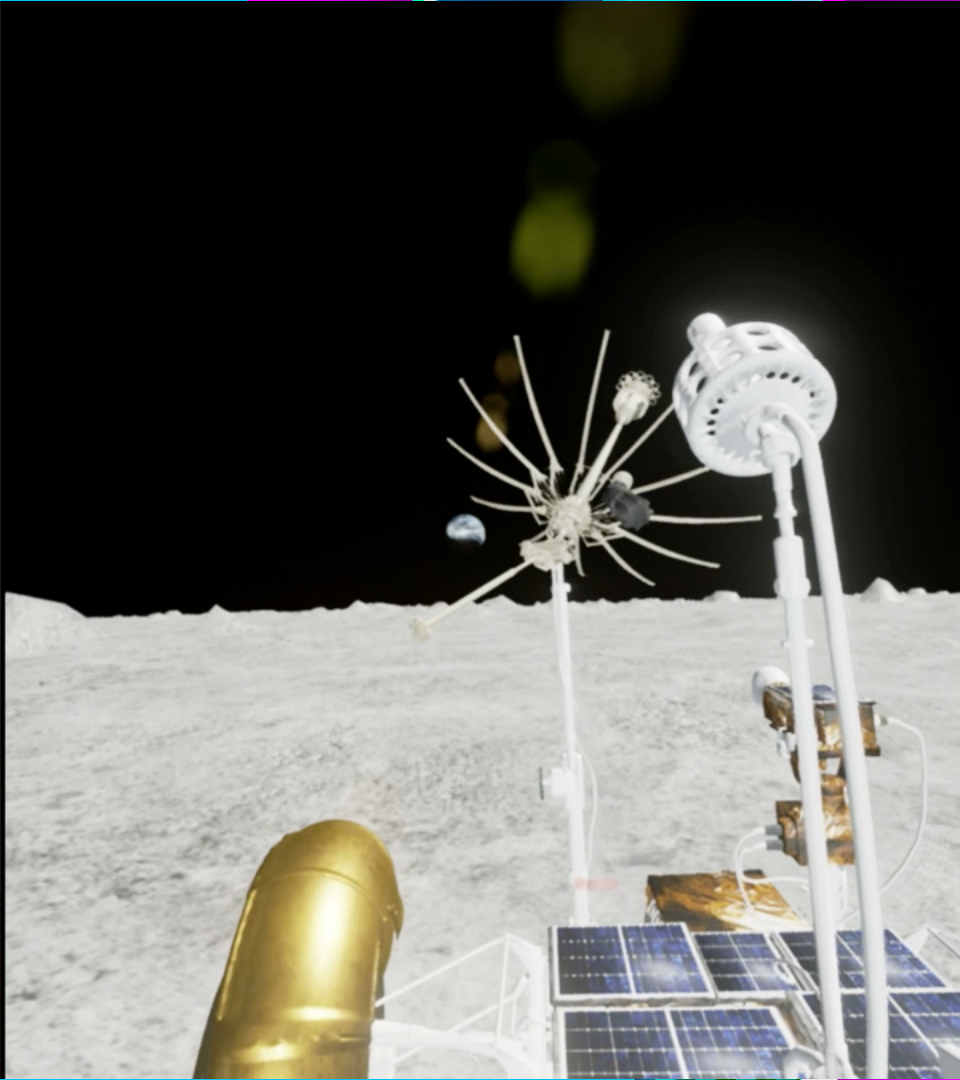
20 foot Habitat

- Prototype habitat designs in Hybrid Reality
- 3 stories tall, 20' diameter



- Seamless transition to rover simulation by physically exiting habitat





- 3D printed Rover control stick mounted on game joystick base
- Low cost physical feedback in Hybrid Reality



Exercise



HD

Uses (Data Display)

- Vitals
- Progression
- Daily planner

Uses (Motivation)

- Scenic virtual exercise environments (Mountain, Beach, etc.)
- Familiar virtual exercise environments (Personal favorite Earth running trail, etc.)
- Gamification
- External and Self-Competition

Uses (Training)

- Active Maintenance
 - Use augmented reality assistant
- Maintenance training
 - Simulate augmented reality interface

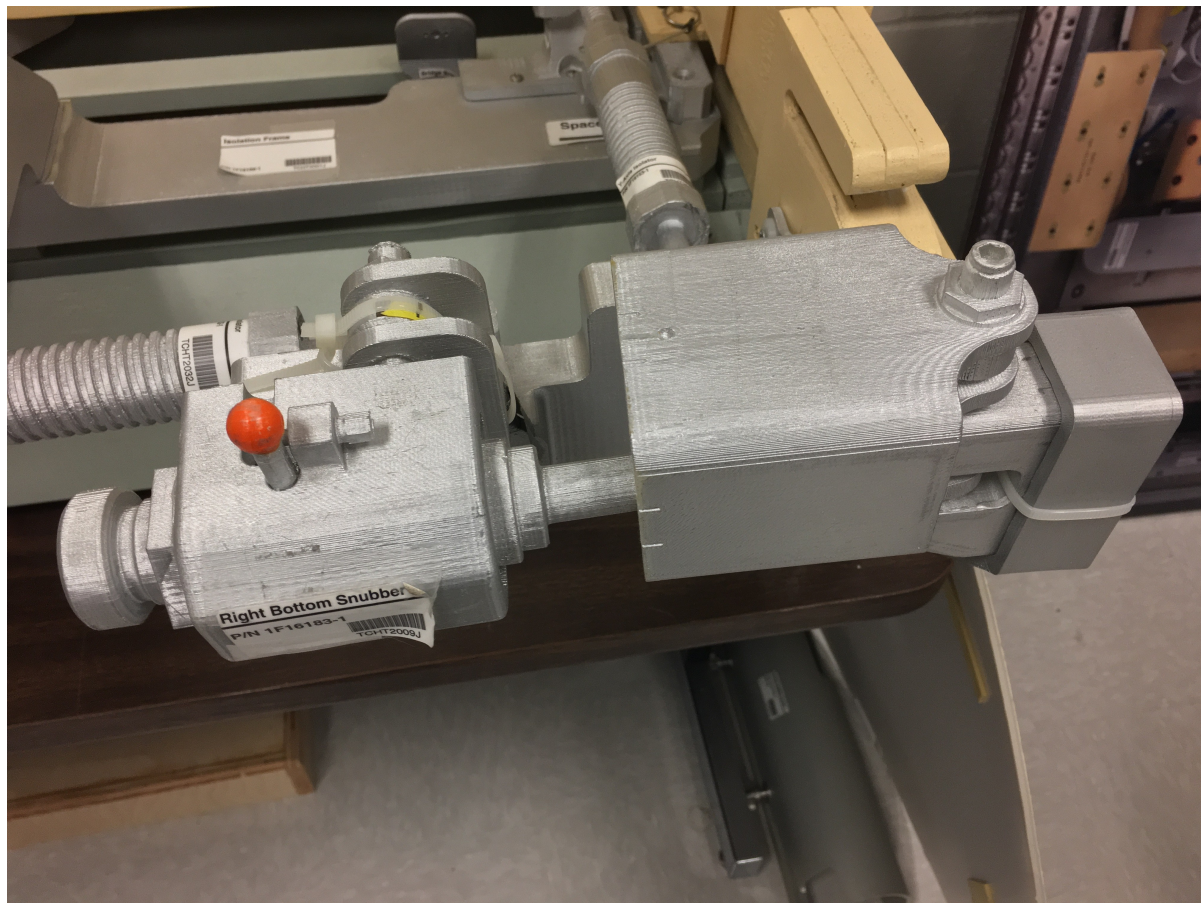
- COLBERT/T-2 Treadmill
- Used on International Space Station for cardiovascular fitness



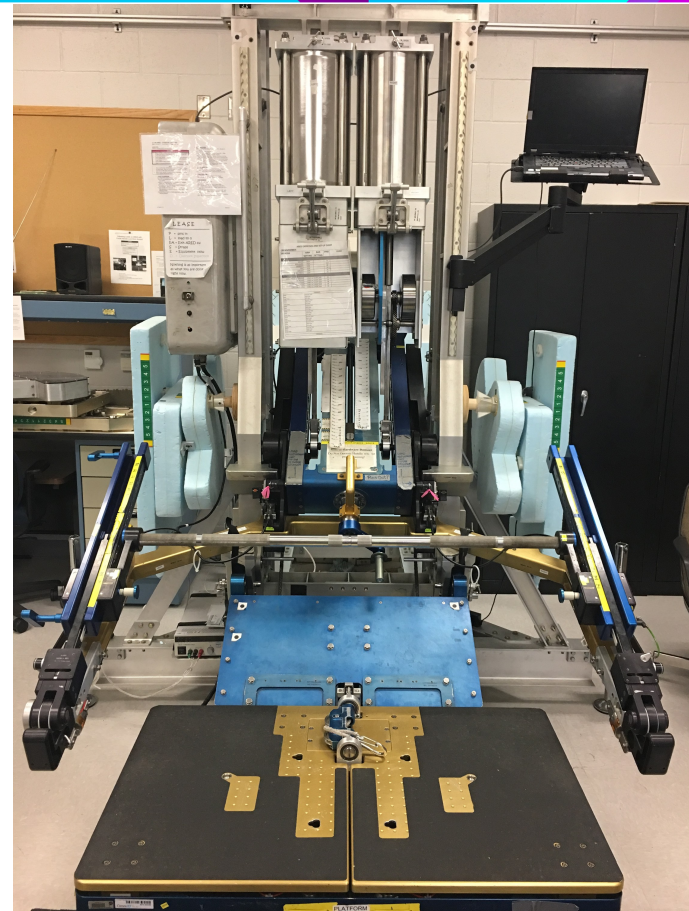
- Physical isolation mount for treadmill
- Mounts occasionally need adjustment/maintenance

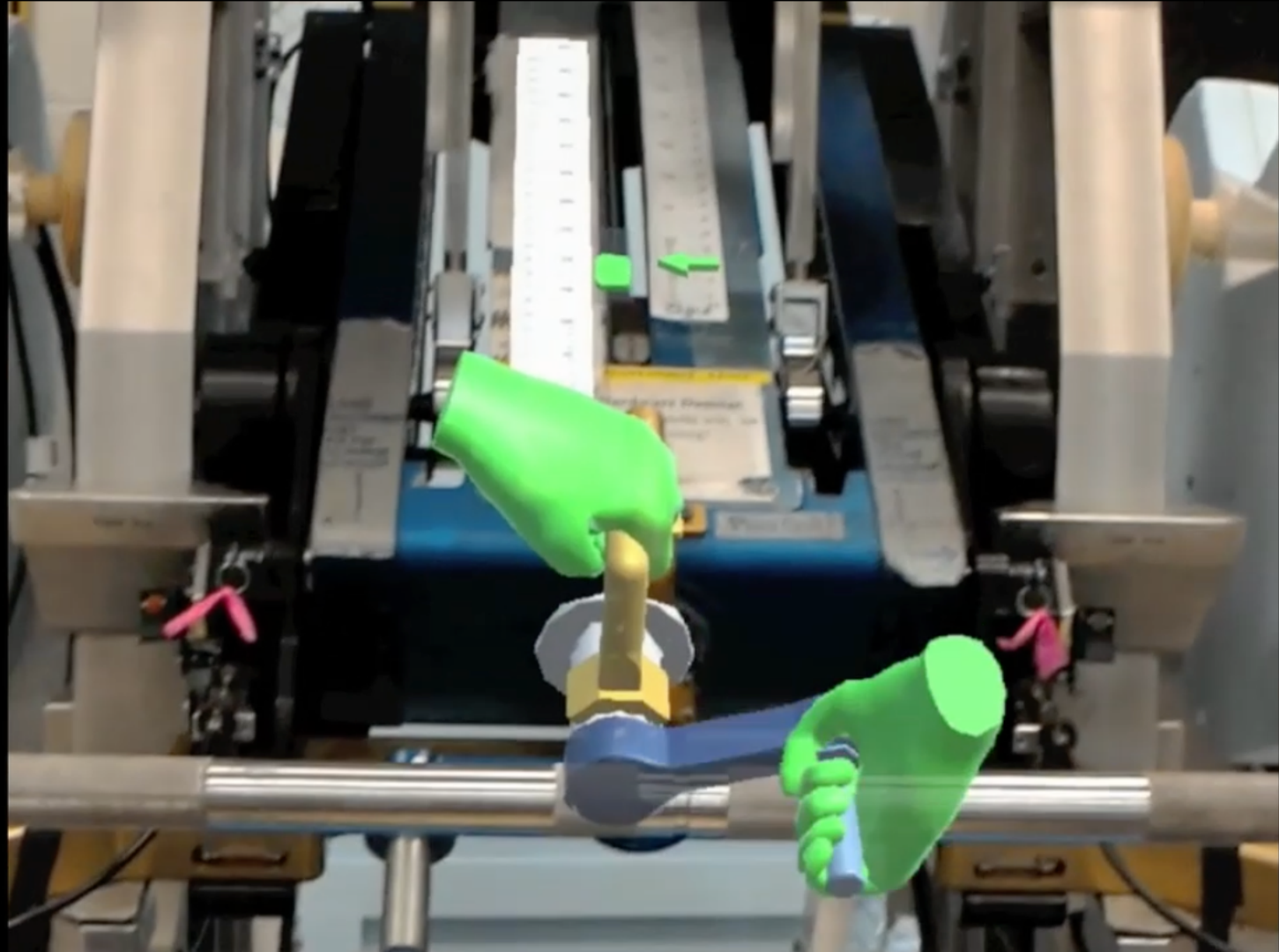


- 3D printed plastic replica for training



- ARED
 - Used for muscle growth/strength training
 - Augmented Reality procedure assistant aids with maintenance





Analog Missions

Field Analogs

- Advantages
 - Simulate physical and mental effects of spaceflight
- Disadvantages
 - Resources
 - Schedule

NEEMO

- Simulate extensive planning and equipment needed for work/life on spacecraft
- Hostile environment
- Buoyancy simulates low gravity



DRATS

- Simulate extensive planning and equipment needed for work/life on spacecraft
- Hostile environment



Hybrid Reality Analog

- Lava Tube
 - Simulated Mars mission to radiation- shielding lava tube
 - Higher likelihood of water/life/exposed rock
- Much lower impact on resources/schedule
- Analyze tracked tool usage data from Hybrid Reality to optimize tool/procedure design for sample collection

Useful Metrics

- How tools are used
- Exertion
- Sample collection rate

Earth Lava Tube



Virtual Mars Lava Tube



Public Outreach

Public Outreach (General)

- What NASA does:
 - NASA TV
 - Museums
 - Space Camp
- What Hybrid Reality can facilitate:
 - Virtual spaceship/facility tours
 - Live virtual astronaut training
 - The Overview Effect

Public Outreach (Professional)

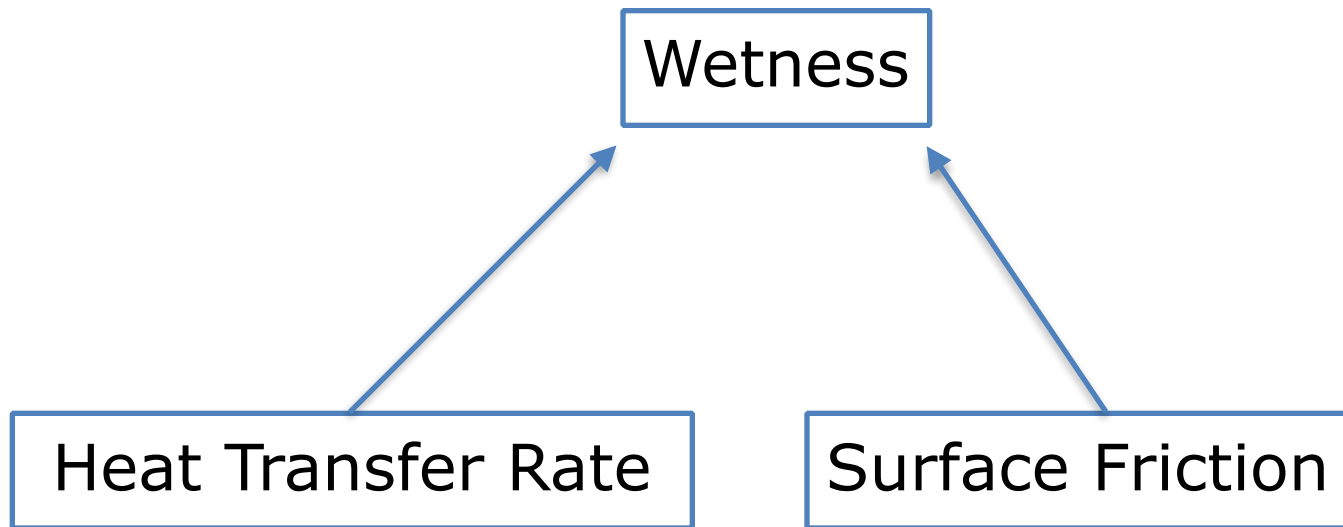
- What NASA does:
 - Internships
 - FIRST Robotics Competition
 - Student Experiments On ISS (SSEP)
- What Hybrid Reality can facilitate:
 - Appeal to millennial interest in video games for recruitment
 - Virtual SSEP proposals (“STEAM” focus, STEM + Art)
 - Communicate ideas with across NASA centers

Forward Work

Improvements to Surface Quality

Psychological
Properties
(What you
perceive)

Physical
Properties
(What can
change)



Establish correlations between physical and psychological surface properties for Hybrid Reality tracked objects

This helps build synthetic tracked objects which feel more like the real tools being simulated

Explore plastic metallization techniques

- Coat plastic with metal top layer to simulate ideal surface properties and sensation
- Methods
 - Arc/Flame Spraying
 - Vacuum Deposition
 - Electroplating



Conclusion



NASA Hybrid Reality Lab Contacts

- Project Lead - francisco.j.delgado@nasa.gov
- Software Lead - matthew.noyes@nasa.gov

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Questions