

AUGMENTED AND VIRTUAL REALITY AT ESOC

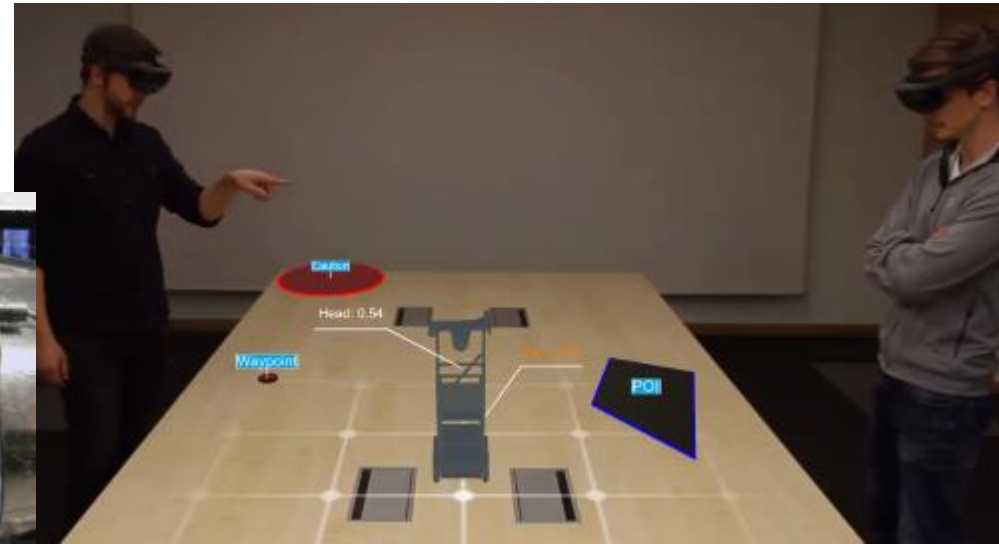
- **GROUND STATION AND TELESCOPE MAINTENANCE**
- **SPACECRAFT OPERATIONS**

Nebras Nassar (Terma GmbH), Sebastian Martin (ESA ESOC),
Ruediger Gad (Terma GmbH), Manuel Olbrich (Fraunhofer IGD)

Results of Studies for ESA/ESOC
Performed by Terma GmbH & Fraunhofer IGD

Context

- Previous Activities
 - VR Virtual Lunar Base
 - AR for Interactive Manuals and Rover Operations
 - Aspects
 - Use Case Ideation
 - Integrating AR/VR & ESA Software
 - Operational Simulator
 - Mission Control System
 - Technology Demonstrators
 - ESTEC ARVR 2019 Presentation
<https://indico.esa.int/event/316/contributions/5256/>



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Context

- Lessons Learned

- Integration

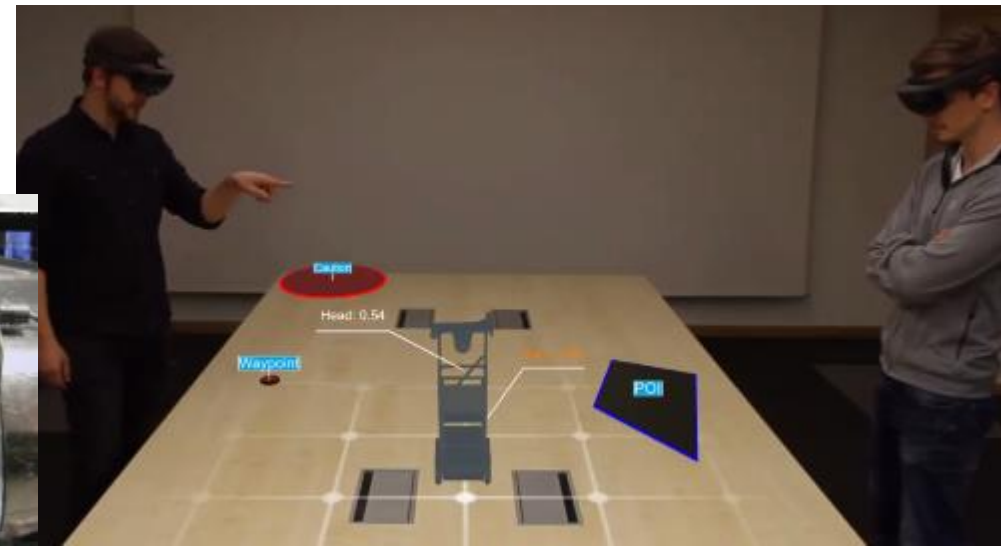
- “Doable”

- Content is Expensive

- 3D Models
- Authoring
- ...

- User Adoption / Change is Difficult

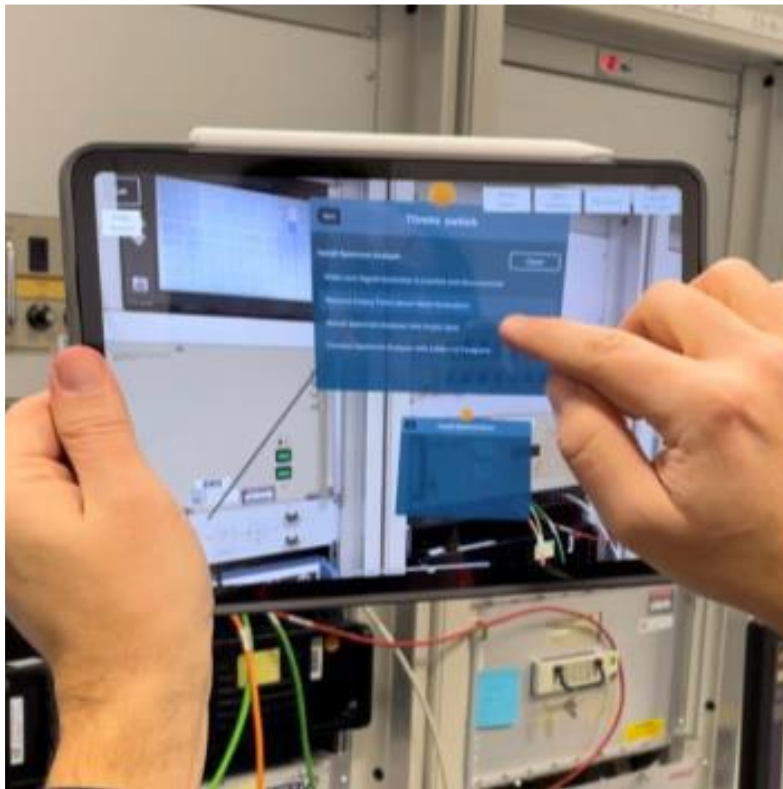
- “Alpha Numeric Display is Enough”



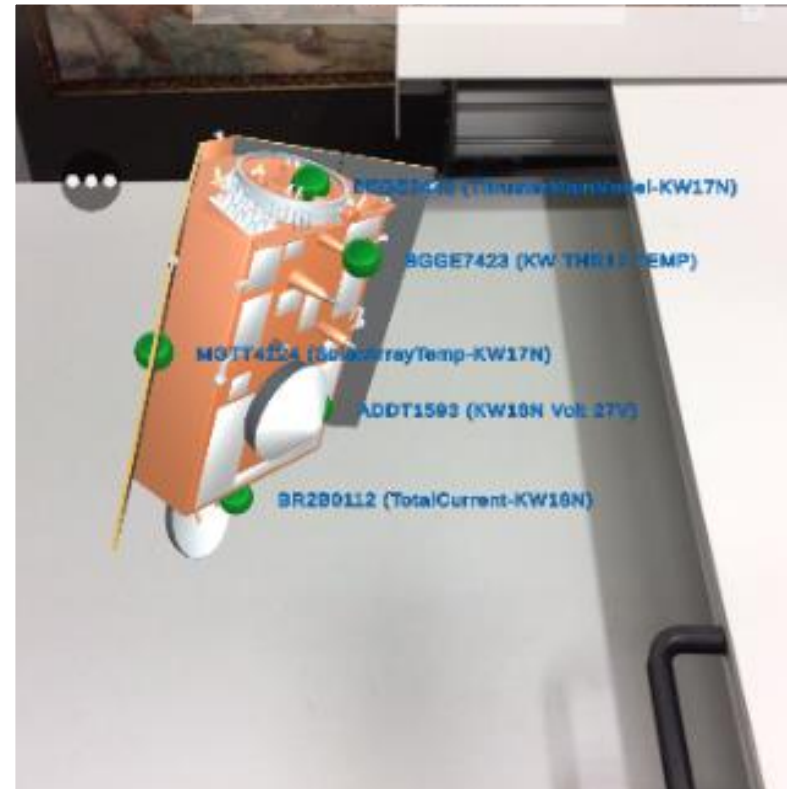
<https://indico.esa.int/event/316/contributions/5256/>

Current Activities

Ground Station and Telescope Maintenance



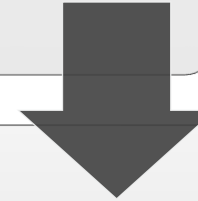
Spacecraft Operations



Activity Phases

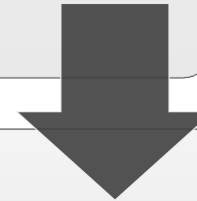
Explorative Phase

Use Case Ideation,
Technology Re-assessment



Development Phase

Architecture Design,
Prototype Implementation

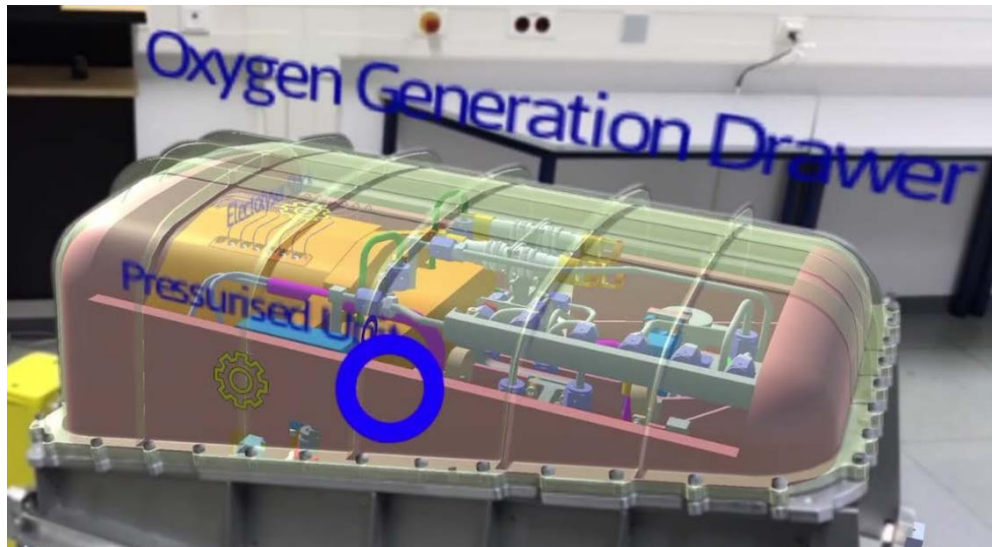
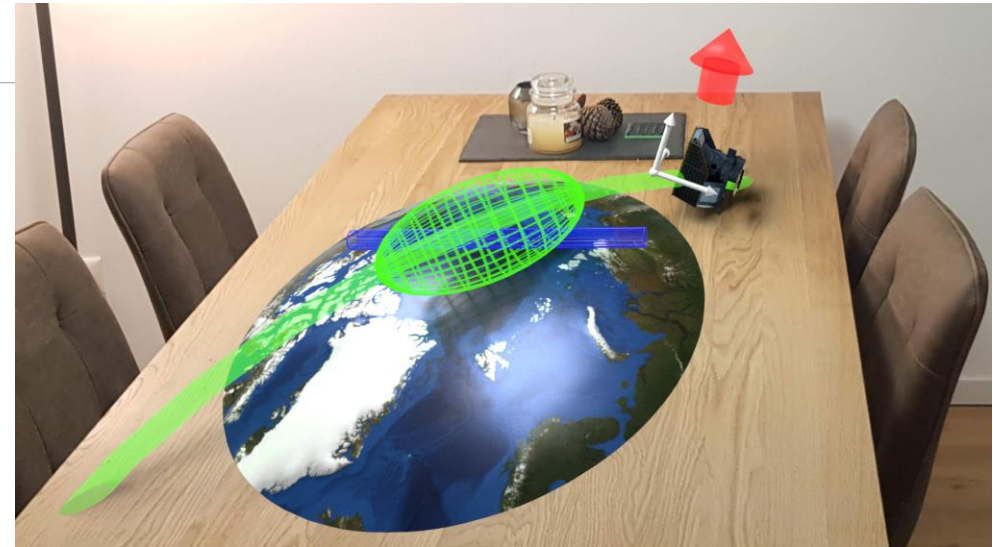


Application Phase

Demo Application at ESOC

Added Values / Distinguishing Factors of AR/VR?

- 3D/Stereoscopic Visualization (VR, AR)
- 3D Haptic Interaction (VR, AR)
- AR Overlays (AR)
- Immersion (VR)
- Object Tracking (AR, VR)
- ...



<https://indico.esa.int/event/316/contributions/5256/>



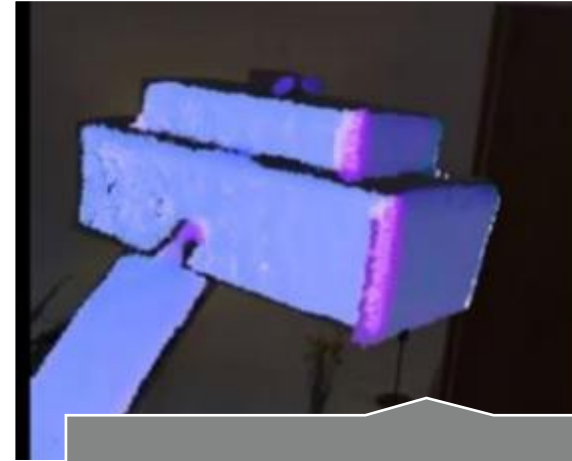
Spacecraft Operations

Use Cases

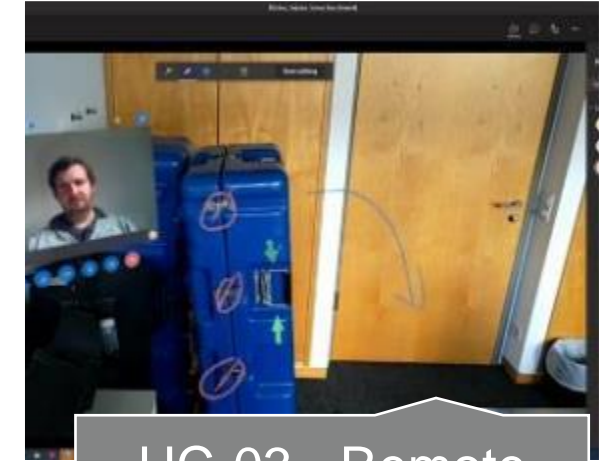
Highest Voted



UC-01 - 3D Planning



UC-02 - 3D Content



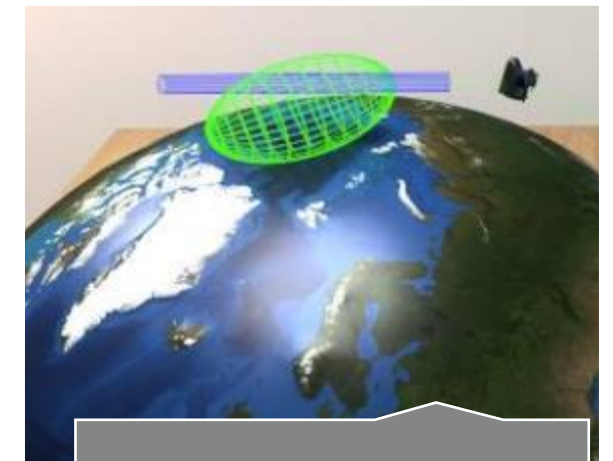
UC-03 - Remote Support



UC-04 - Virtual Data Systems Assets



UC-05 - Virtual On-site

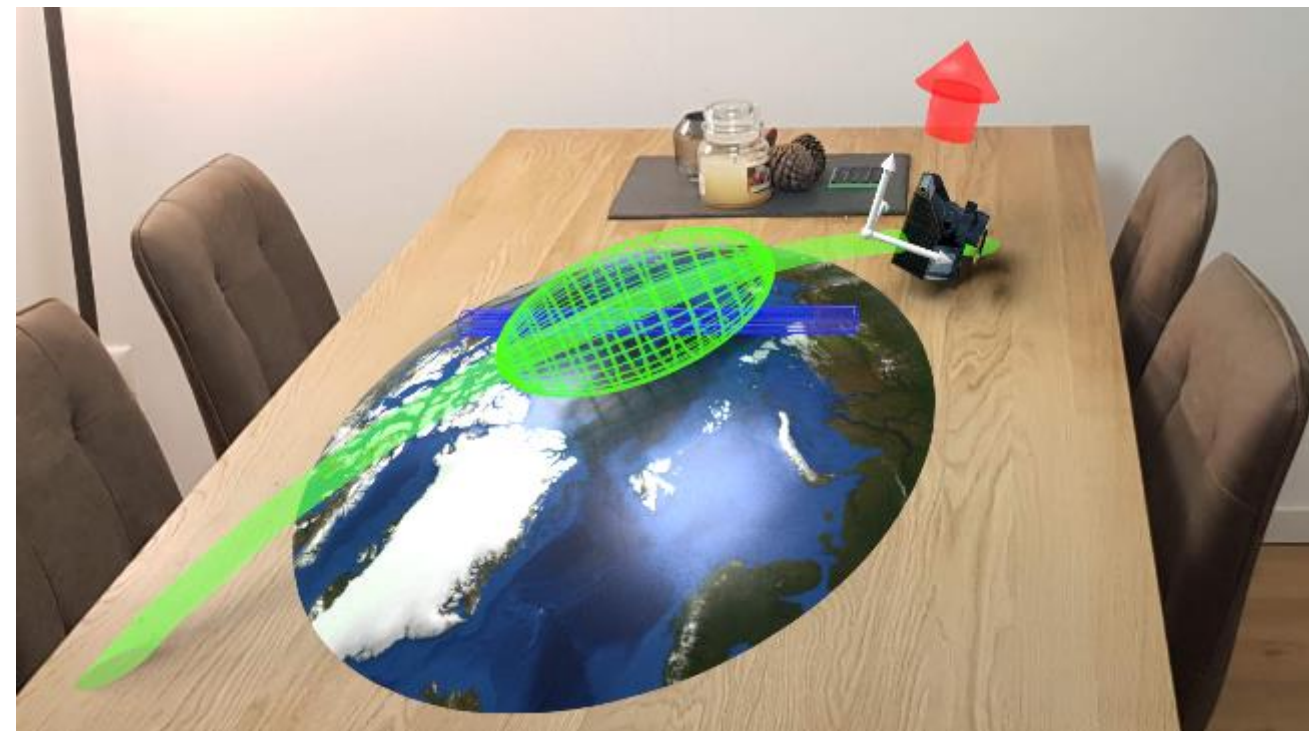
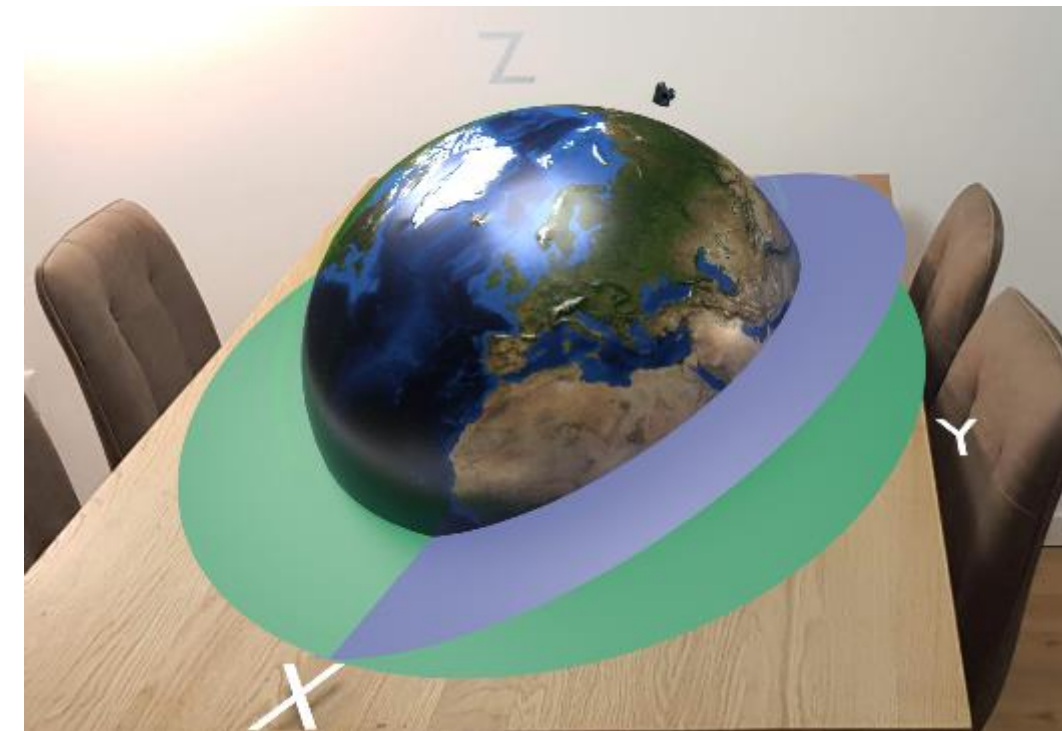
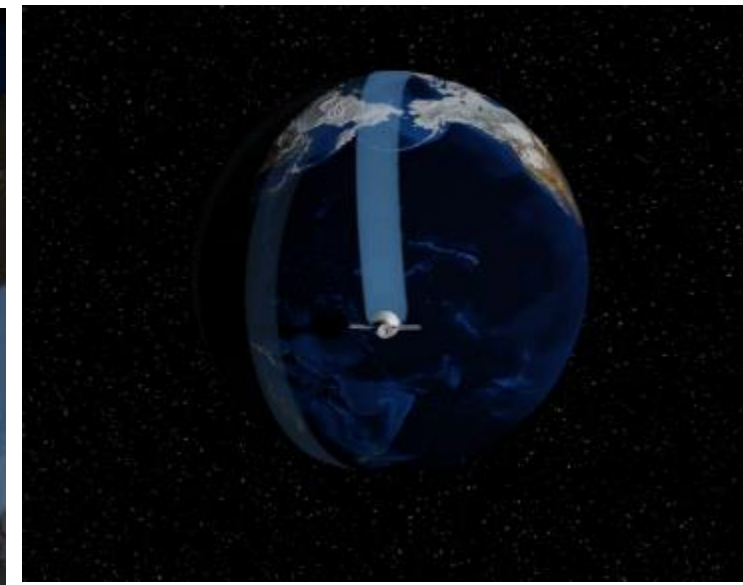


UC-06 - NEOs

Spacecraft Operations

UC-01 – 3D Planning

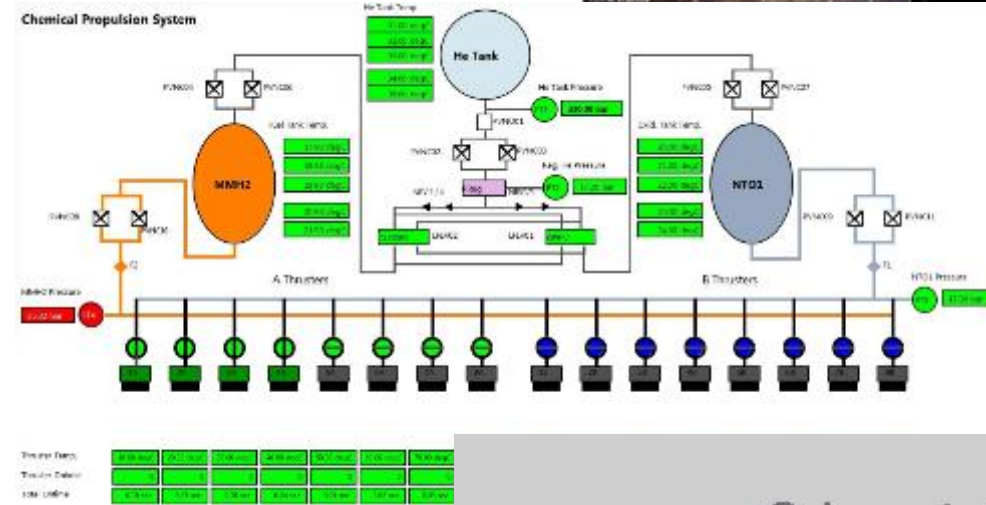
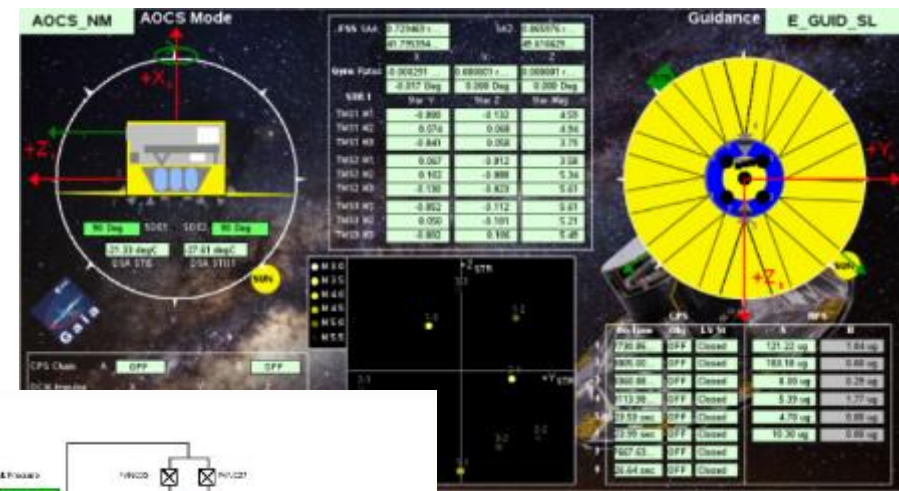
- Spacecraft Positions (Probabilities)
- Spacecraft Orbit, Attitude
- Spacecraft Vectors/Thrusters Directions
- ...



Spacecraft Operations

UC-02 – 3D Content

- Overlay Schematics/Visualizations with Data
- Similar Concept to “2D Mimics”
- But use 3D Models/Visualizations
 - More Intuitive Perception
 - “Natural” 3D Perception
 - Reduce Mental Load
 - More Capacity to Focus on Tasks
- AR/VR for Content Creation



Highest Voted
→ **Selected for Proof-of-Concept**

Ground Station and Telescope Maintenance

Use Case Categories

- **Local Maintenance Support for Ground Station**
 - Single Local User at Ground Station
- **Remote Assisted Maintenance Support for Ground Station**
 - Local User
 - Supported by Remote User
- **Telescope Use Case**
 - Hands-free Demands
 - For Work within the Telescope

*Ground Station
local AR maintenance support*

*Ground Station
remote AR maintenance support*

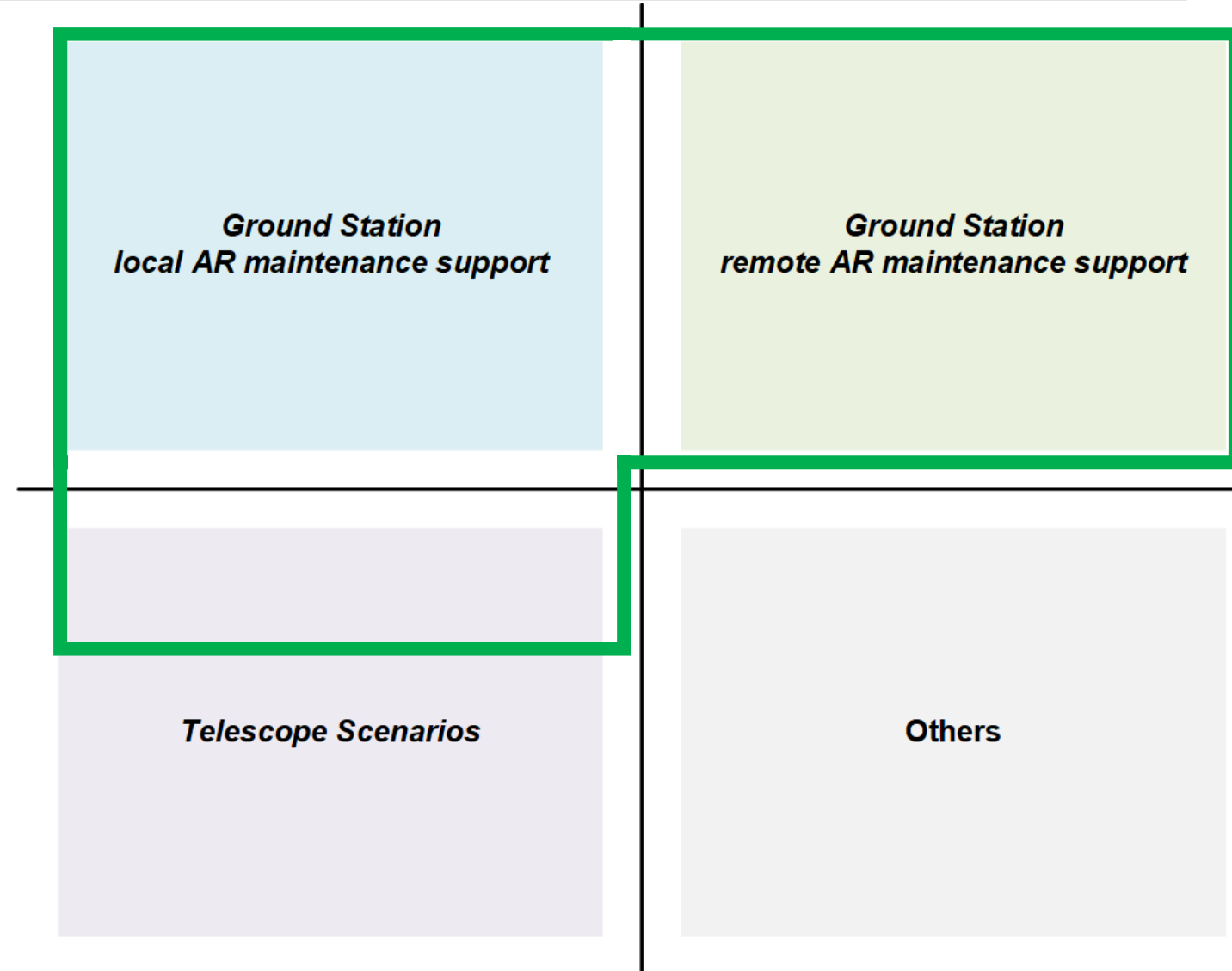
Telescope Scenarios

Others

Ground Station and Telescope Maintenance

Use Case Categories

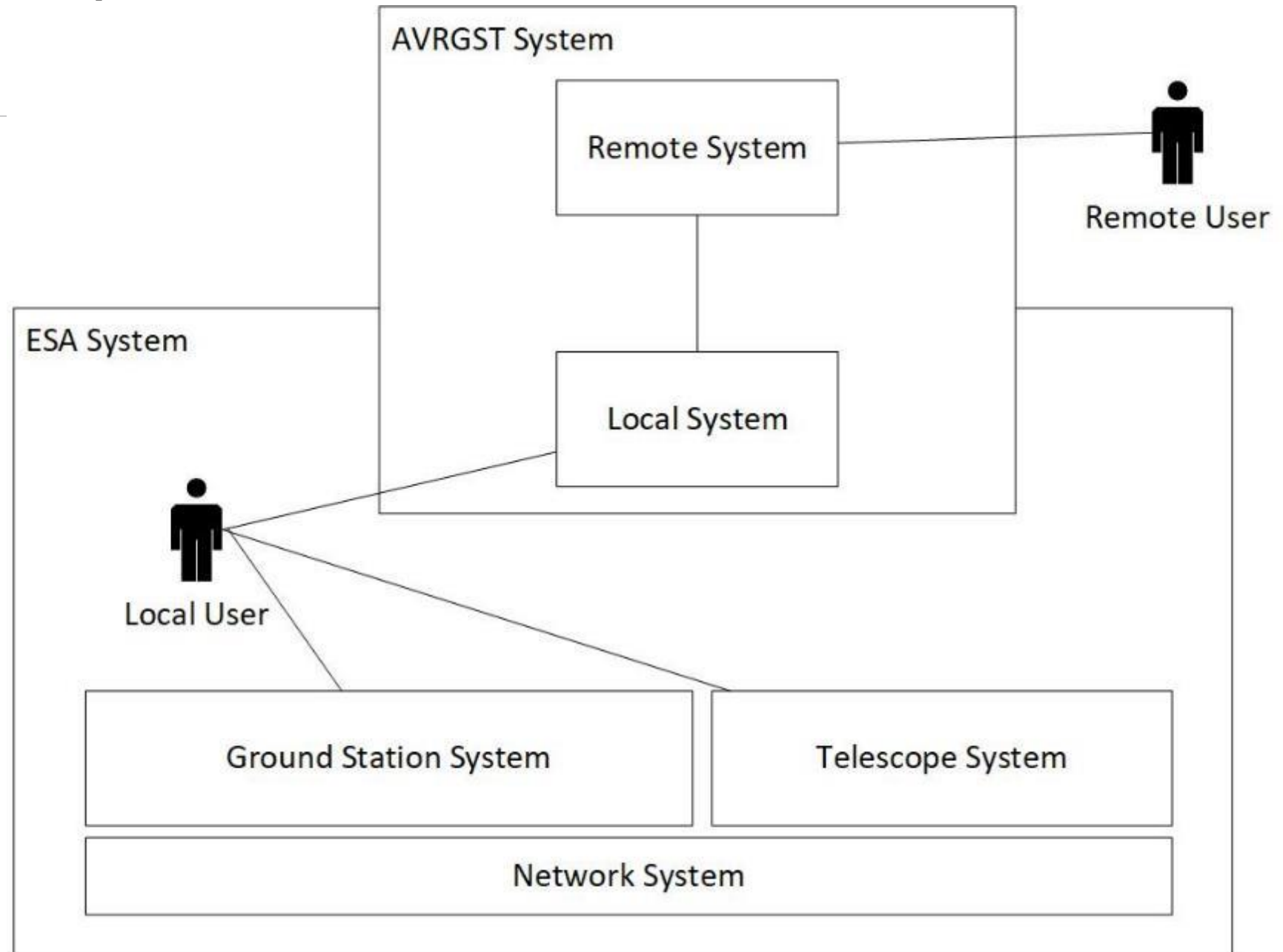
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Ground Station and Telescope Maintenance

Envisaged Use Cases

- Local
 - Local User
 - AR Manual
 - AR Orientation Aid
- Remote
 - Local User
 - + Remote User
 - Remote Support
 - AR Overlays



Technology Assessment & Usability Considerations (1/2)

- AR/VR Device Usability
 - Some Users already Familiar
 - Typically, Short Familiarization Periods
 - Head-bound Devices
 - Often Uncomfortable after some Time
 - Text-based Input Considered Complicated
- AR/VR for Navigating 3D Worlds
 - E.g., Own Location or Selecting and Moving Objects
 - Intuitive for Most Users
- AR/VR Content
 - Should be User Maintainable
 - Required Considerable Effort and Cost, e.g.,
 - 3D Models
 - Management,
 - ...

Technology Assessment & Usability Considerations (2/2)

- AR/VR Device Usability **“Good Enough”**
 - Some Users already Familiar
 - Typically, Short Familiarization Periods
 - Head-bound Devices
 - Often Uncomfortable after some Time
 - Text-based Input Considered Complicated
- AR/VR for Navigating 3D Worlds **“Good Enough”**
 - E.g., Own Location or Selecting and Moving Objects
 - Intuitive for Most Users.
- AR/VR Content **Improvement Needed**
 - Should be User Maintainable
 - Required Considerable Effort and Cost, e.g.,
 - 3D Models
 - Management,
 - ...

Ground Station and Telescope Maintenance

Demo System at Ground Segment Reference Facility (GSRF) at ESOC

- Two Phases
 - Preparation Phase
 - Content Creation
 - 3D Models
 - Room Alignment
 - Object Locations
 - Tasks/Procedures
 - Operational Phase
 - Local User
 - Remote-assisted



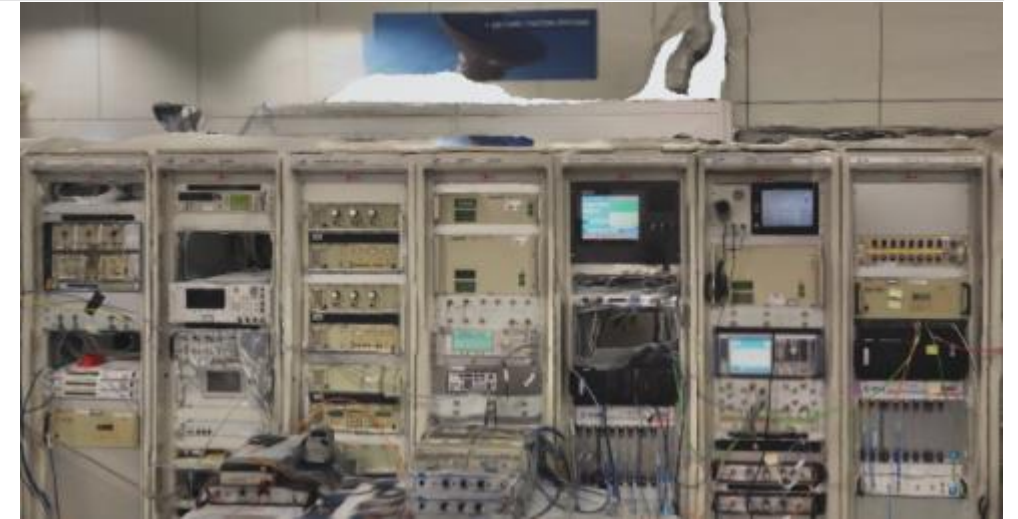
[https://www.esa.int/ESA_Multimedia/Images/2013/04/ESOC_GSRF]

Ground Station and Telescope Maintenance

Preparation Phase

- Create 3D Models
 - Scan Room & Devices
- Room / Object Locations
 - QR Codes
- Room Alignment
 - AR Assisted
- Prepare Content in CMS

Scanning
Process



Scanned 3D Model of a Room



Scanned 3D
Model of a Device

Spacecraft Operations

3D Annotation

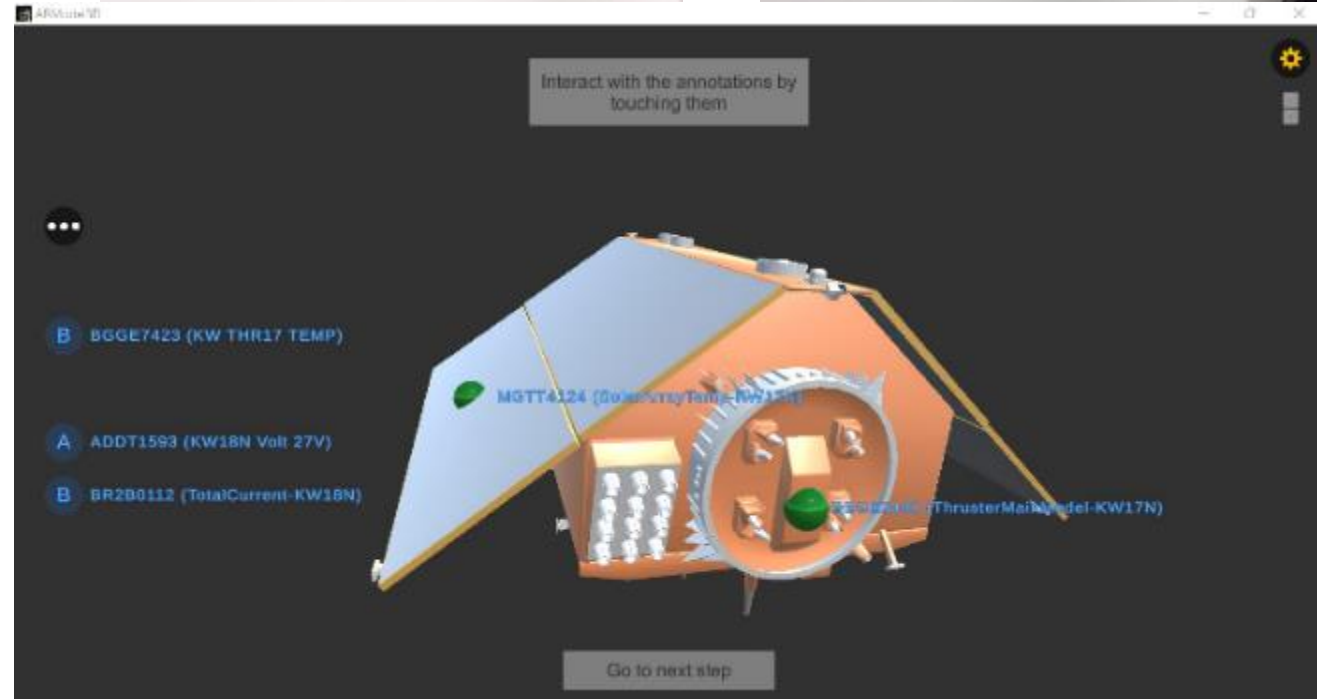
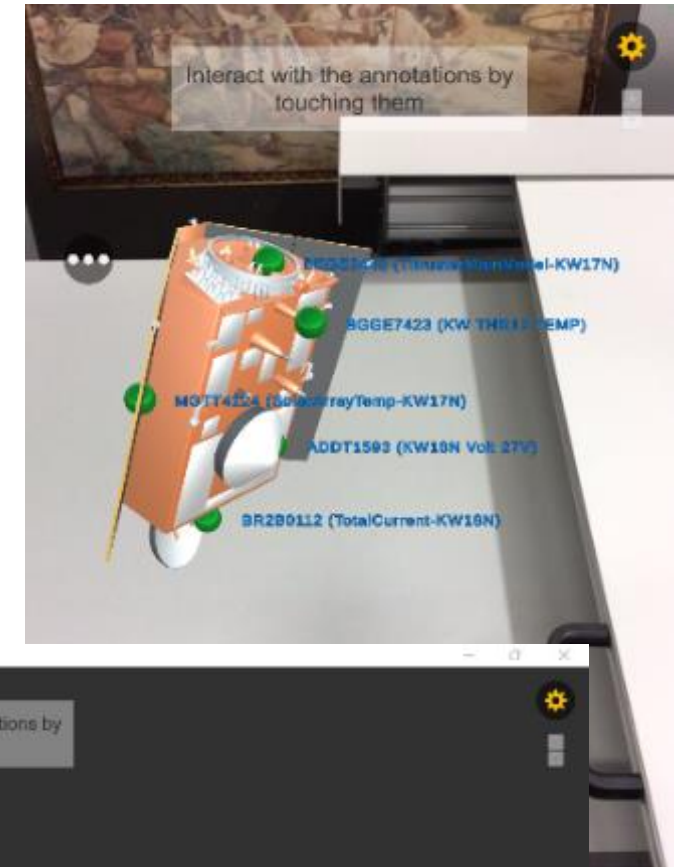
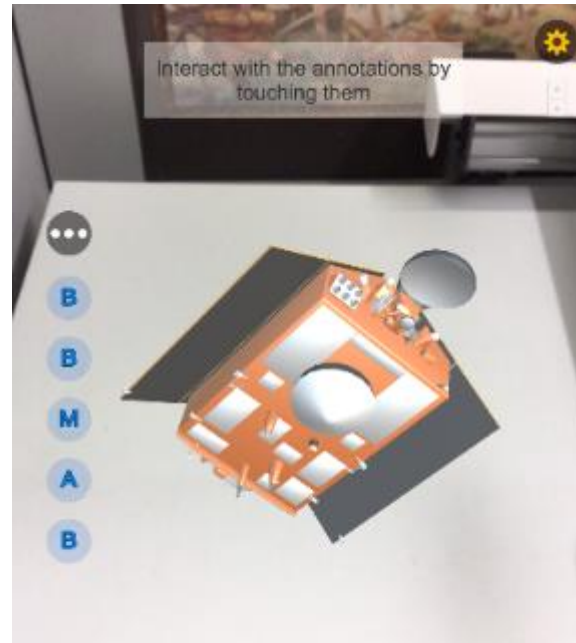
- Link 3D Models with Data
 - Locations to Show TM Data
- Aims
 - Ease of Use
 - Intuitive Process
 - 3D Placement of “Markers”



Spacecraft Operations

3D Annotation

- Link 3D Models with Data
 - Locations to Show TM Data
- Aims
 - Ease of Use
 - Intuitive Process
 - 3D Placement of “Markers”
- Annotation in AR and Desktop



Ground Station and Telescope Maintenance

Operational Phase

Local User with Tablet

- Interact with AR Overlays
 - View Tasks
 - Display Device Components
 - View Media and Relocate Spatial Media
- Connect to Remote Support

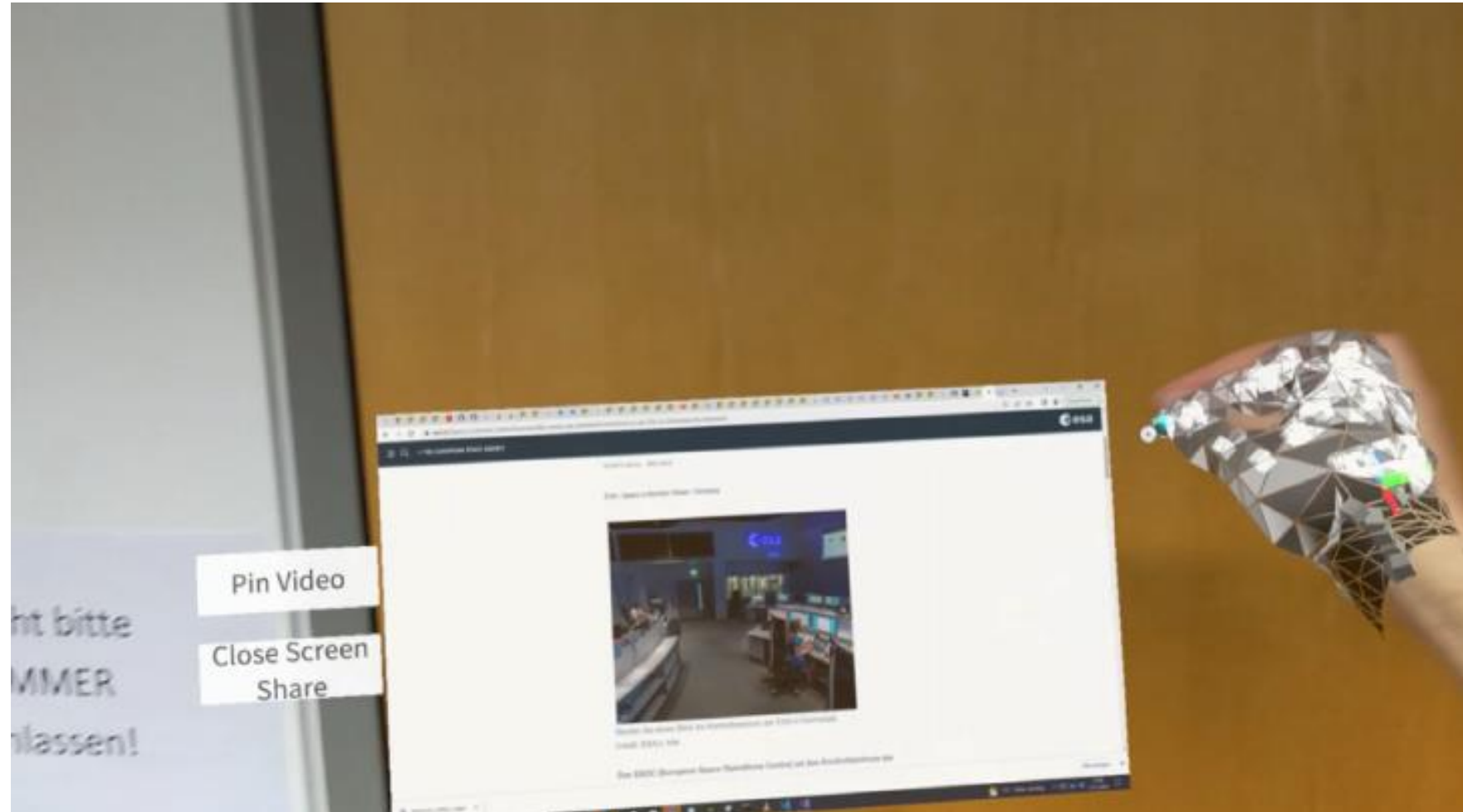


Ground Station and Telescope Maintenance

Operational Phase

Local User with HoloLens 2

- Same Features as Tablet
- Plus:
 - Handsfree Operation
 - Remote Display/Desktop Sharing



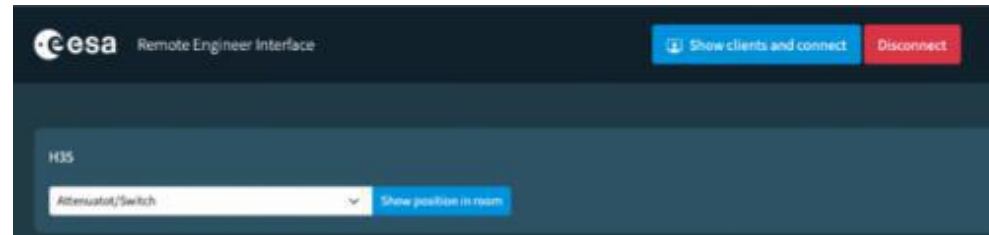
Ground Station and Telescope Maintenance

Operational Phase

Remote Support

- Room 3D Model View
- Video/Audio Call
- Remote AR Drawing
- Send Navigation
- See Position of Device

Remote AR Drawing
in Tablet App



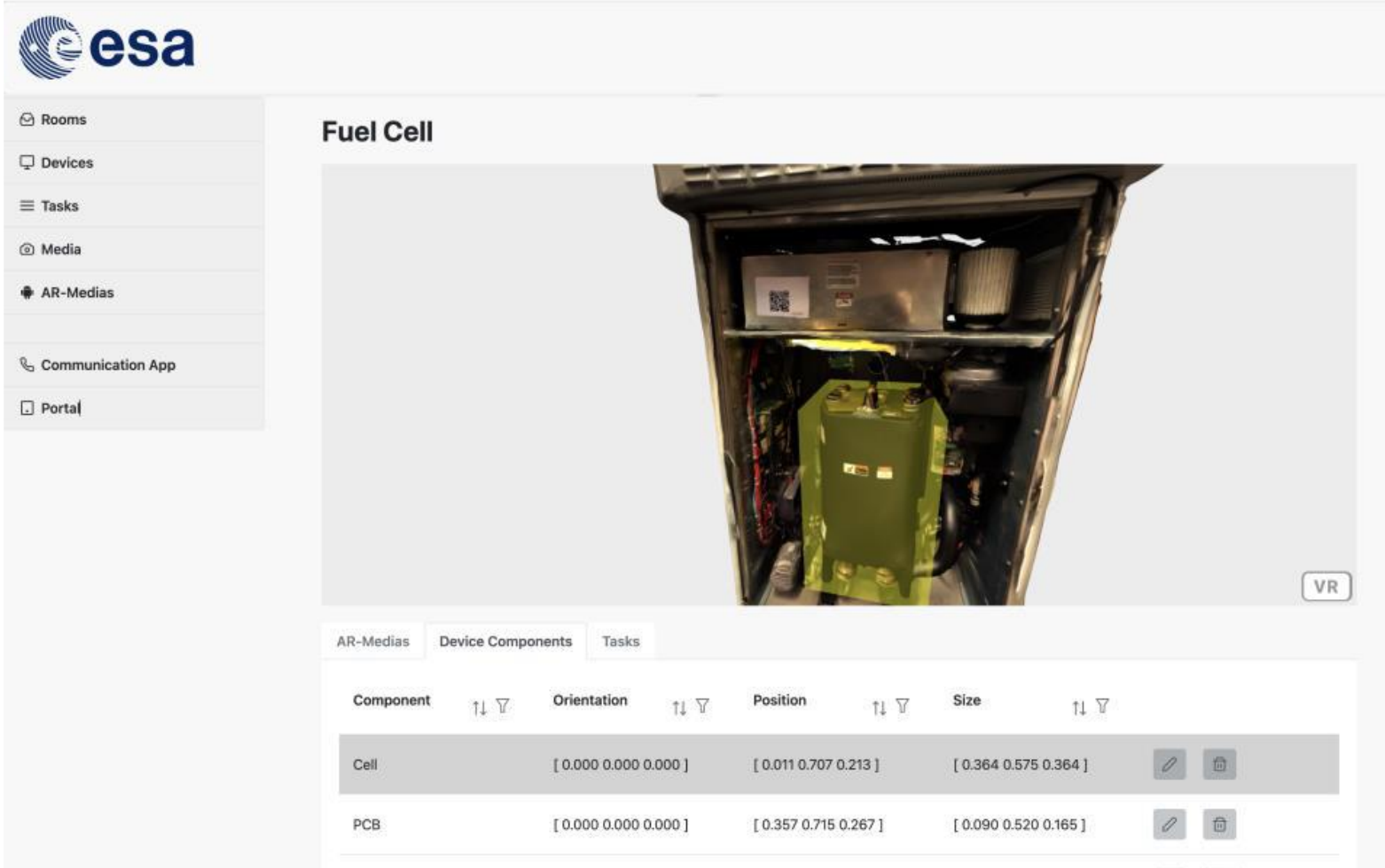
Remote Support
Web App

Ground Station and Telescope Maintenance





Developed Applications

Content Management System (CMS)

- Manage Content, e.g.:
 - Rooms
 - Devices
 - Media
 - Tasks
 - ...



The screenshot displays the ESA Content Management System (CMS) interface. On the left is a navigation sidebar with the ESA logo and menu items: Rooms, Devices, Tasks, Media, AR-Medias, Communication App, and Portal. The main content area is titled "Fuel Cell" and features a 3D model of a fuel cell unit. Below the model are tabs for "AR-Medias", "Device Components", and "Tasks". A table lists the components with their orientation, position, and size data.

Component	Orientation	Position	Size	
Cell	[0.000 0.000 0.000]	[0.011 0.707 0.213]	[0.364 0.575 0.364]	 
PCB	[0.000 0.000 0.000]	[0.357 0.715 0.267]	[0.090 0.520 0.165]	 

Ground Station and Telescope Maintenance

Developed Applications

AVRGST ME Application

- Scan QR Codes
- Display and Position AR Objects
- Overlay Information and Annotations
- Establish Communication Channel

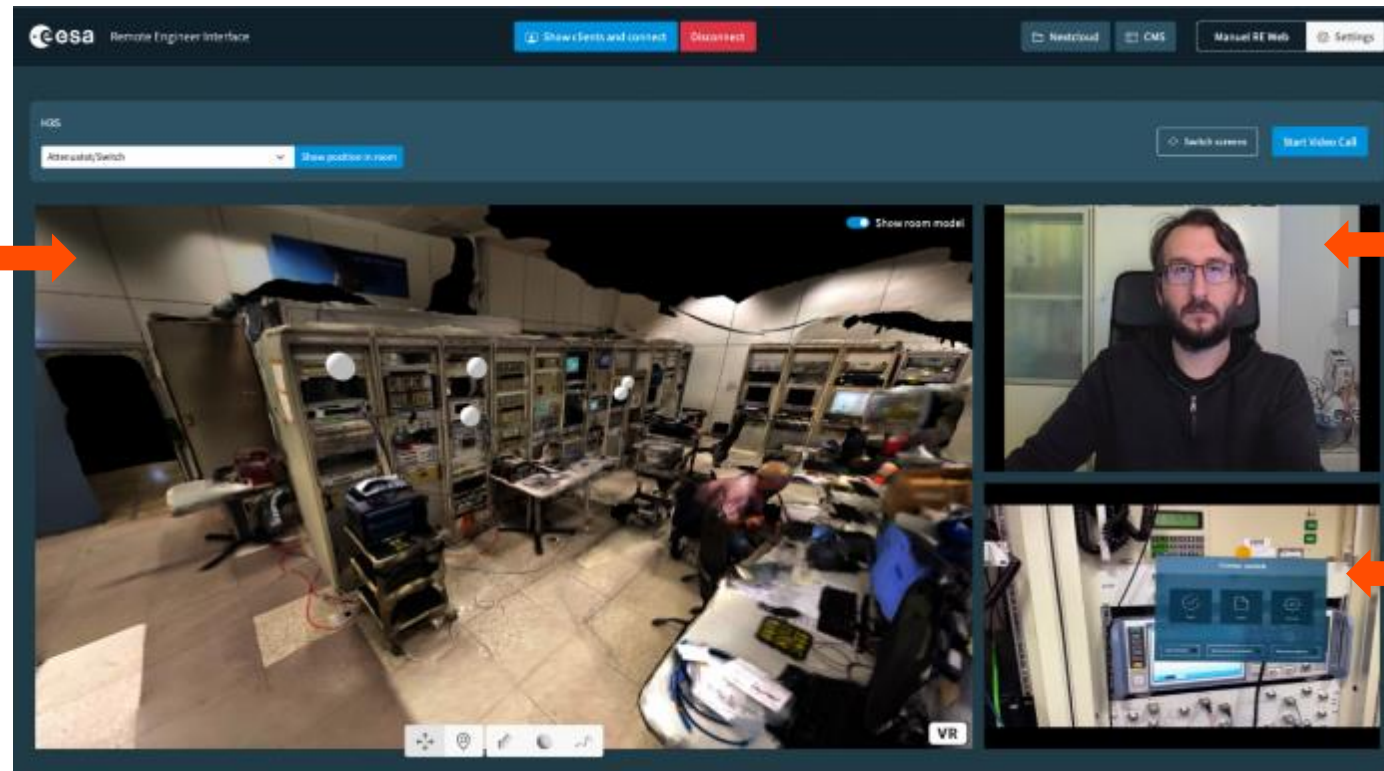


Ground Station and Telescope Maintenance

Developed Applications

Web-based Communication Application

- Audio and Video Calls
- AR Drawing



3D Model of the Room



Camera View of Remote Expert



Camera View of Maintenance Engineer



Conclusion

Studies Aimed at:

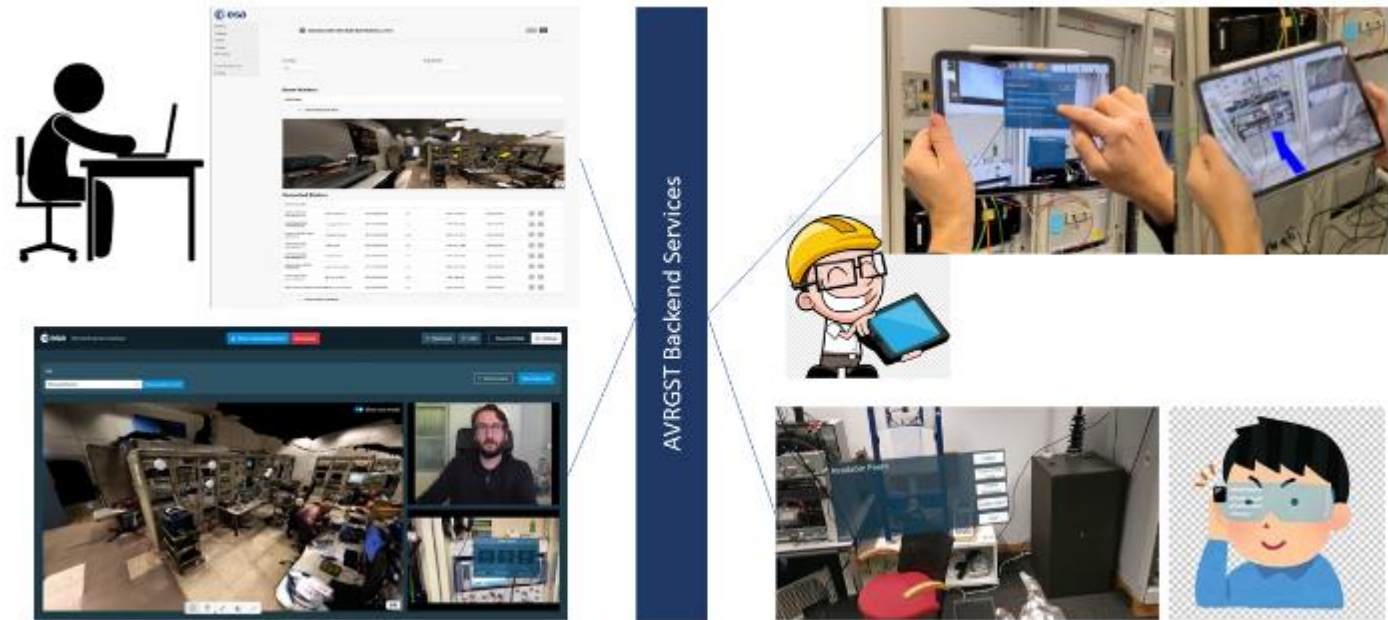
- Identify Use Cases
- Technology Assessment
- Architecture Design
- Prototype Implementation
- Demo at ESOC

Main Scenarios:

- Overlay Information on Physical Objects
- Interactive Remote Support
- Display Data in 3D Context

AR and VR Technology is Promising:

- Improve Work Efficiency
- Enhance Communication



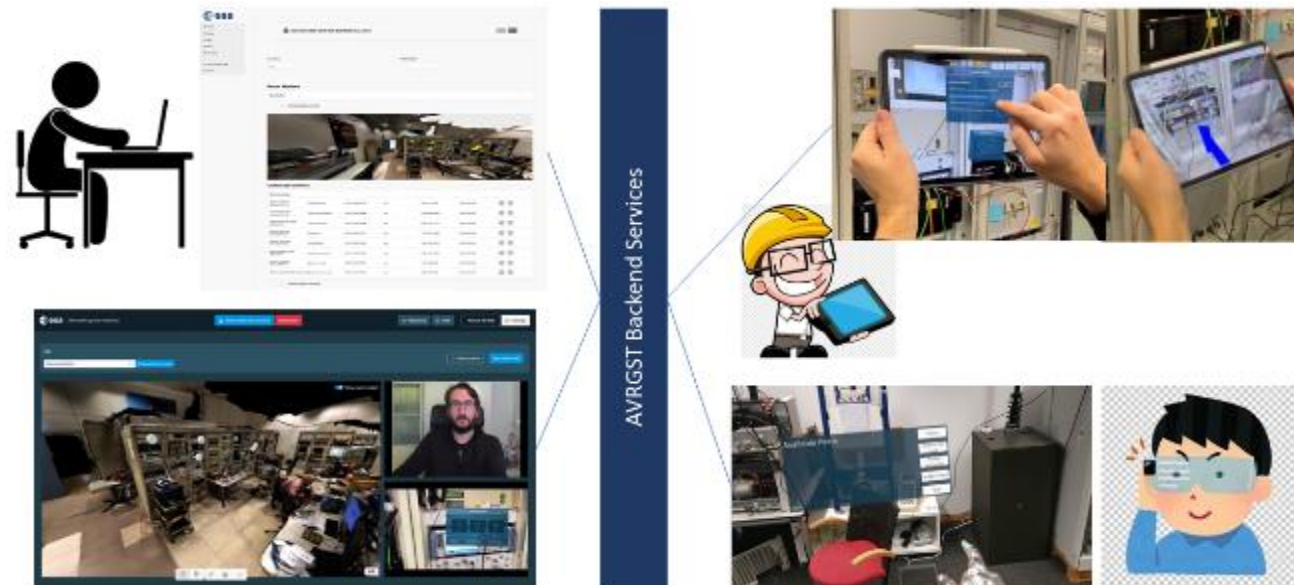
Remote Expert Tools

Maintenance Engineer Tools

Conclusion

**Thank you very much for your attention!
Questions?**

Demo available outside.



Presented on behalf of the team:
Ruediger Gad (ruga@terma.com)