Evolvement of Augmented Reality System for AIT/AIV and Operations

Four Use Cases



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http://www.youtube.com/user/VirtualAndAugmented/videos

AR/VR for European Space Programme @ESTEC 2.12.2019

Space related VR/MR/AR research ~15 years



2005 - Multimodal astronaut virtual reality training prototype (View-of-the-future)



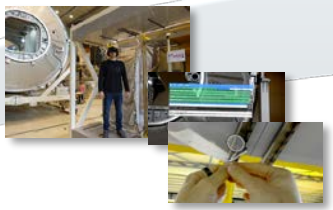
2013 - Multimod AR-presence system th Mars rover prototype (V HyperSpace)



2009 - Satellite assembly design in VE (ManuVAR)



2016 - Augmented Reality for AIT, AIV and Orbit Operations (ESA-EdcAR)



2017 – AR supported installation of the mporary Stowage Rack in SS (WEKIT)



2018 – AR based Rover Maintenance in Mars Terrain Demonstrator (WEKIT)



2019 – ISS procedure view to Hololens (ESA-MobiPV4Hololens)

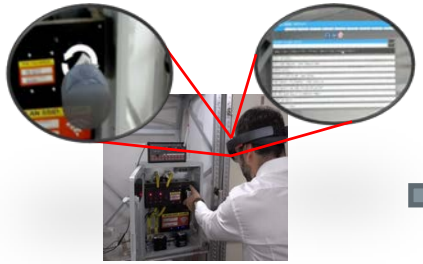


202 /21 – Augmented reality base S and ground applicat ns (ESA-AROGAN)

2005

2021

Timeline for development



2016 - Augmented Reality for AIT, AIV and Orbit Operations (ESA-EdcAR)

The European Space Agency contract 4000113373/15/NL/MH **"Augmented Reality for AIT, AIV and Operations"**



2017 – AR supported installation of the Temporary Stowage Rack in the ISS (WEKIT)

The European Union's Horizon 2020 research and innovation programmes project **WEKIT** under grant agreement No 687669



2018 – AR based Rover Maintenance in Mars Terrain Demonstrator (WEKIT)



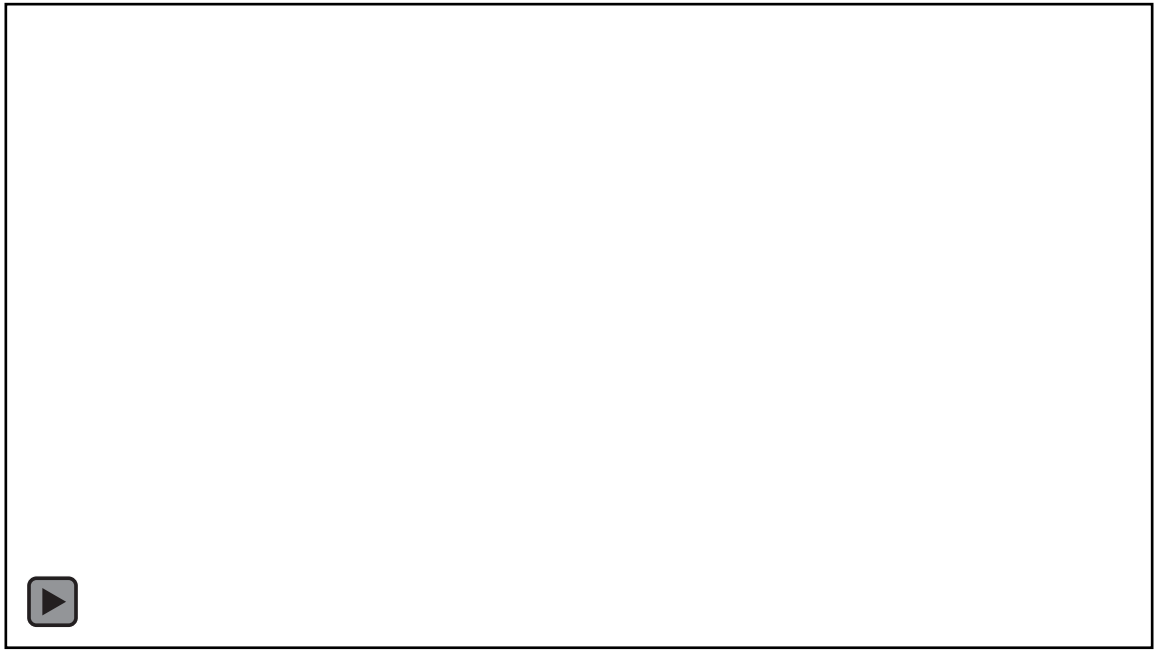
2019 – MobiPV procedure viewer to Hololens (ESA-MobiPV4Hololens)

The European Space Agency contract 4000125238/18/NL/AF/as **"Prototype a Media Helmet for MobiPV Implemented Using MS HoloLens"**

VTT has been main AR-developer in all use cases

ESA-EdcAR

Augmented Reality for AIT, AIV and Orbit Operations



Evaluation methods:
- Observations
- Expert evaluation

Number of the subjects: 14

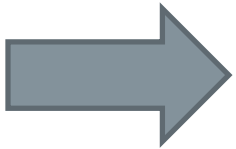
https://youtu.be/djUdsQ5pY0s
https://www.vttresearch.com/media/news/augmented-reality-increases-maintenance-reliability-at-a-space-station

Note, Hololens video captures resolution is less than in real device

Results and updates based on use case

Results from use case

- System was working properly for the first Hololens application
- No issue with voice commands
- Sensor visualization was nice feature
- Symbols and safety symbols (ISO 7010:2012) are working nicely
  - ODF-symbols and layout should be supported in the future

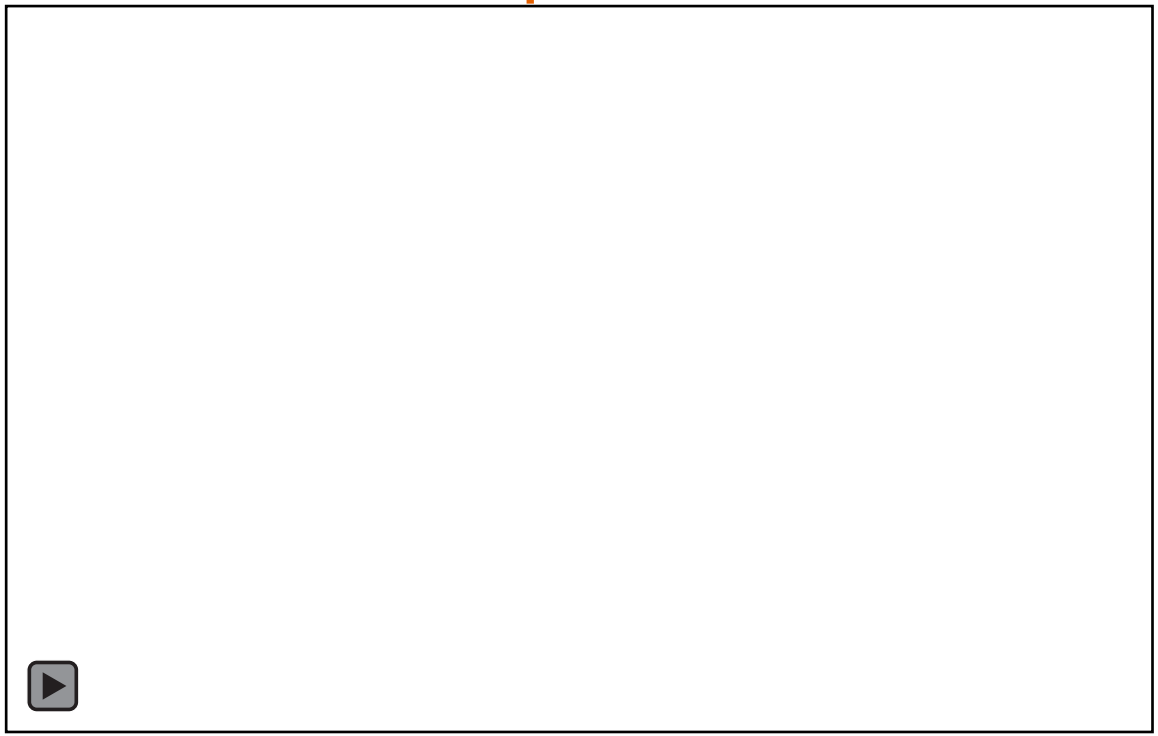


Updates for next use case

- Full support for ARLEM (Draft Standard for an Augmented Reality Learning Experience Mode)
- The first draft for guidance to annotation
- Support for video and image in 3D space
- Automatic initialization from image marker

WEKIT

TSR installation to Space Station



https://youtu.be/fNEqOBMKhGg

Evaluation methods:

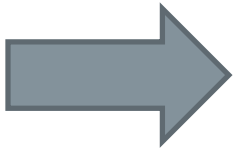
- System Usability Scale (SUS)
- Observations
- Expert evaluation
- …

Number of the subjects: 39

Results and updates based on use case

Results from use case

- The 3D space UI and annotations were working properly without any delay and the image quality was good
- The main downside of the system is the narrow field of view, the user has to looking for information
- SUS score average: 68
  - According to validation studies, the acceptable SUS score is about 70 (Bangor et al., 2009; Brooke, 2013).

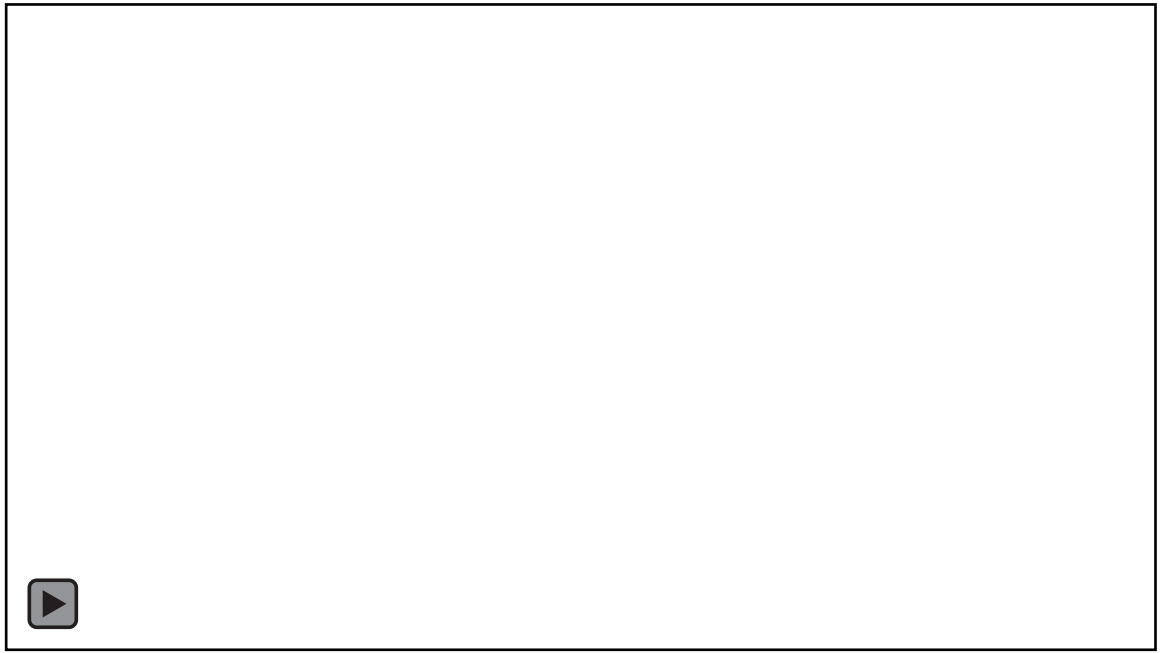


Updates for next use case

- The updated guidance to annotation
- Large area support
- No initialization needed
  - Calibration per Hololens per space
- Updated UI
- Updated sensor visualization
- Handling in the error situation

WEKIT

Moon/Mars rover maintenance support with AR



Evaluation methods:

- System Usability Scale (SUS)
- Observations
- Expert evaluation
- …

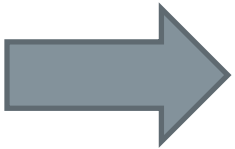
Number of the subjects: 199

https://youtu.be/JRMLs9SYg6k

Results and updates based on use case

Results from use case

- System was working properly as prototype for large amount of subjects
- Updated UI and guidance makes task executing more effective
- Hololens limitation was still issue
- SUS score average: 69
  - According to validation studies, the acceptable SUS score is about 70



Conclusion from use cases

- The ‘one-size-fits-all’ 3D UI does not work
- User has three options to interact with UI: (1) gestures, (2) voice commands and (3) clicker.
- Same analogy work with UI layout. User could choose: (1) list type or (2) card type

=> System was mature enough for ODF supported system (symbols and procedures)

ESA-MobiPV4Hololens

https://youtu.be/c-DVoLT4n9c

Image of MobiPV UI



Evaluation methods:
- Observations
- Expert evaluation

Number of the subjects: ~ 20
- 5 in formal evaluation
- 15 in demos in ISS ODF control board meeting

Results from MobiPV4Hololens

User test with 5 users

Main benefits

- Supports two hands-busy procedures
- Able to see introduction in next to the working area
- Images next to working area helps
- Text-to-speech supports procedure execution

Issues

- Usability/Comfort issues with Hololens
- Narrow FoV cuts some images
- Sometimes hard to read text

Demos in ISS ODF control board ~15 users

Main overall feedback

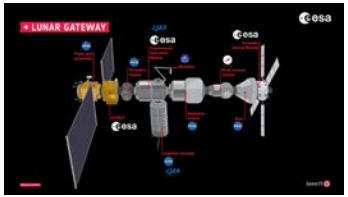
- It is working with standard mobiPV
- Voice commands are working
- Supporting system, not main app
- Hard to remember voice commands
- Narrow FoV and usability issues


EUROVR
2019 CONFERENCE
Best Application Paper Award
MobiPV4Hololens - HoloLens Based User Interface for Astronauts Procedure Viewer
Kaj Helin, Jaakko Karjalainen, Paul Kiernan, Mikael Wolff, David Martinez Oliveira
Signed:
TALLINNA TEHNIKAÜLIKOOL
TAL TECH
Date: 25.10.2019
Tallinn, Estonia, 23-25 October, 2019
4

Conclusion and next steps



- As the AR-system has been already partially implemented to the space system and its usability has reached a reasonable level
- It can be suggested that the AR-system is potentially a useful tool for supporting and facilitating AIT/AIV and operations, even though the tool is still in prototyping phase
    - => AR features will be implemented for AIT/AIV and operations in September started contract[1]
- Also new devices e.g. Hololens 2 should solve most of the current usability issues
- AR features should be defined into update ODF e.g. for the future Gateway -station



[1]The European Space Agency contract **4000127719/19/NL/GLC 'Procedure viewer and authoring tool for ground AIV/AIT applications'**





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