



VirWAIT

VirWAIT

VirWAIT

Virtual workplace for AIT&PA training and operations support

Kaj Helin, Jaakko Karjalainen, Timo Kuula, Paul
Kiernan, Paul-Eric Dupuis and Noellie Chauvet



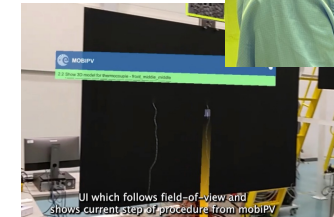
Final presentation

4000129549/19/NL/BJ
Virtual Workplace for AIT & PA Training and Operations Support



Content of presentation

- Project info
- Project objective
- Use cases
 - MR supported installation of thermocouples on *an Heat Plate used as GSE for the Solar wind Magnetosphere Ionosphere Link Explorer – SMILE*
 - MR supported phase 2 sensor installation on *TEDY (TEst DummY) for a vibration test campaign on the Hydra facility*
- Main functionalities of VirWAIT system
 - AR-player
 - Authoring environment
 - Remote observation
 - Reporting and STEP model update
- Videos of AR-player and off-site authoring
- User reviews
- Lessons Learnt
- Future extensions



Project info

- This study has been funded by the European Space Agency under contract 4000129549/19/NL/BJ “Virtual Workplace for AIT & PA Training and Operations Support ”
- 300 k€
- 2,5 years project (due to COVID -19 delays)
- Partners
 - VTT (Main), Finland
 - SKYTEK, Ireland
 - AIRBUS, France

Project objective

Main objective of this activity is to develop a virtual workplace supporting training, AIT and verification tasks of operators in order to reduce system& design induced human errors severely impacting the AIT schedule.

The sub-objectives of the proposed development are to

- The activity shall assess the state-of-the-art of technologies suitable for supporting AIT and verification tasks;
- Identify a pilot case where a Virtual Workplace can be applied across different locations/sites using AR/VR e.g. to execute ground system compatibility verifications and end-to-end tests;
- Perform the tasks as required to implement and test the pilot case and evaluate benefits based on criteria to be agreed with the Agency;

Use cases

To verify the main project objectives, two most relevant use cases were selected:

- MR supported installation of thermocouples on *an Heat Plate used as GSE for the Solar wind Magnetosphere Ionosphere Link Explorer – SMILE*
- MR supported phase 2 sensor installation on *TEDY (Test DummY) for a vibration test campaign on the Hydra facility*



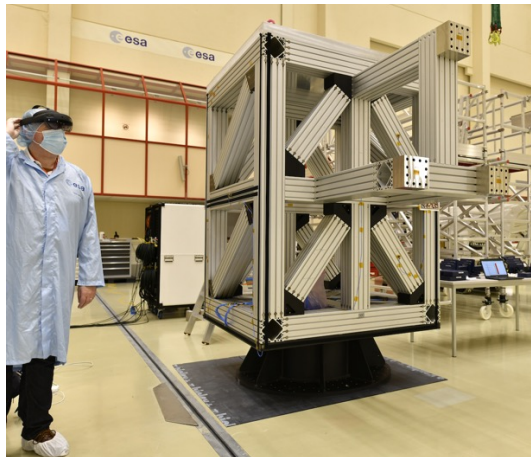
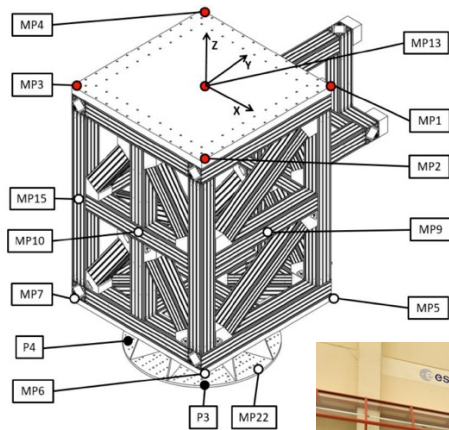
The system was preliminary tested for the configuration of the JUpiter ICy moons Explorer's (Juice) Network Data Interface Unit (NDIU) in preparation to the Thermal Vacuum test campaign held at ESTEC.

**MR supported installation of thermocouples on
an Heat Plate used as GSE for the Solar wind Magnetosphere Ionosphere Link
Explorer – SMILE**

- Main objective of SMILE's use case was installing thermocouples
 - Visually evaluate already installed sensor's location
 - Procedure includes 32 steps
 - Procedure was authored based on STEP 3D model and procedure description
- (Video in later on presentation)



MR supported phase 2 sensor installation on TEDY (TEst DummY) for a vibration test campaign on the Hydra facility

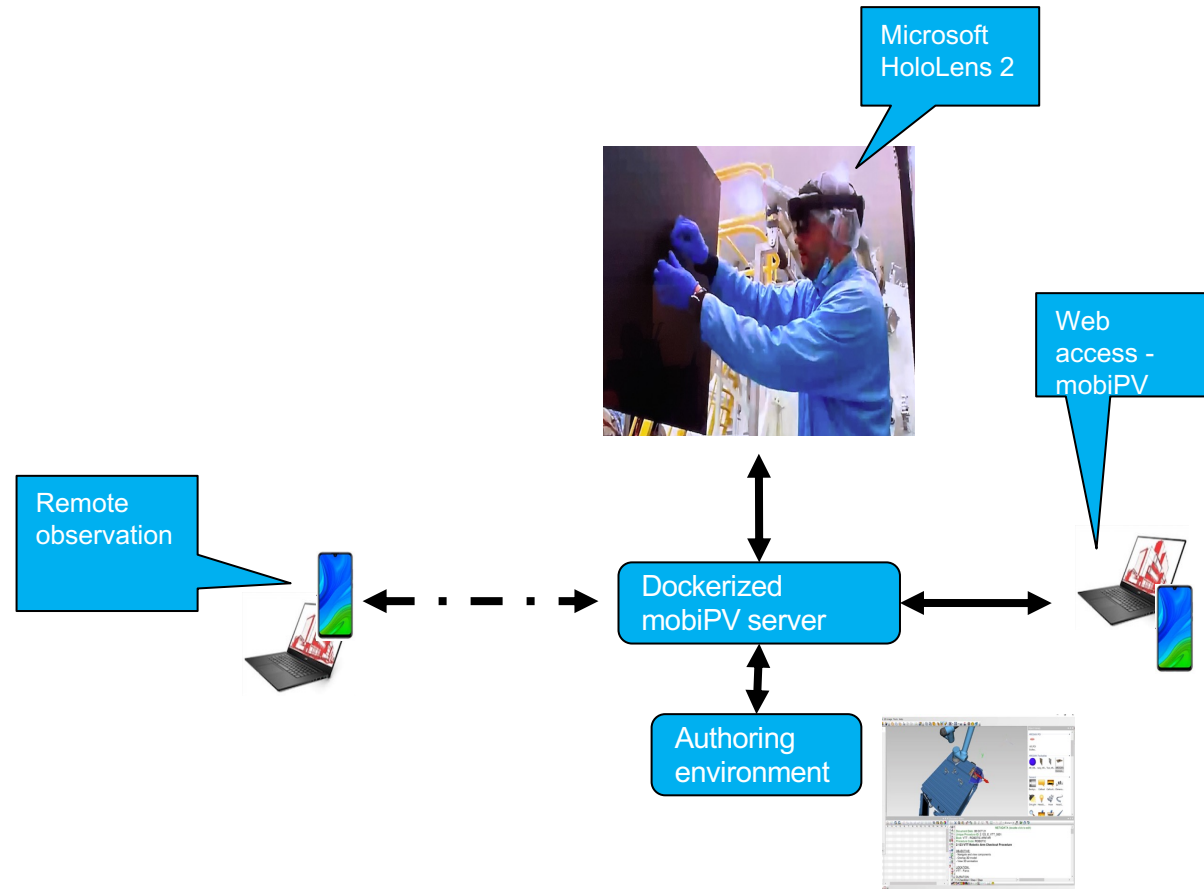


- Main objective was installing phase 2 accelerometers to TEDY
- Visually evaluate phase 1 installed sensors location
- Procedure includes 28 steps
- After sensor installation user used MR application to locate final position of sensor and took picture of its location
 - => VirWAIT system were able to update STEP model based on information
- Procedure was authored based on STEP 3D model and procedure description

Main functionalities of VirWAIT system

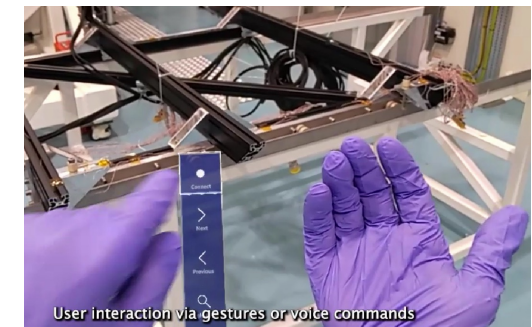
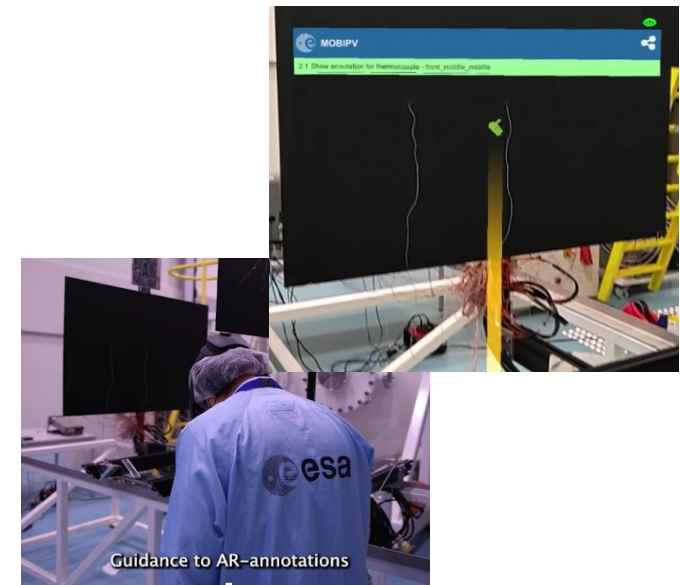
System includes:

- Microsoft HoloLens 2 with VirWAIT MR-player app,
- mobiPV – server for all Operations Data File (ODF) content, MR annotation and 3D models with animation
- mobiPV's web interface, which also allows to the user interact with systems
- Authoring environment, which is including on-site and off-site authoring.
- Remote observation via web access
- Reporting, including the as-build STEP model



VirWAIT MR-player

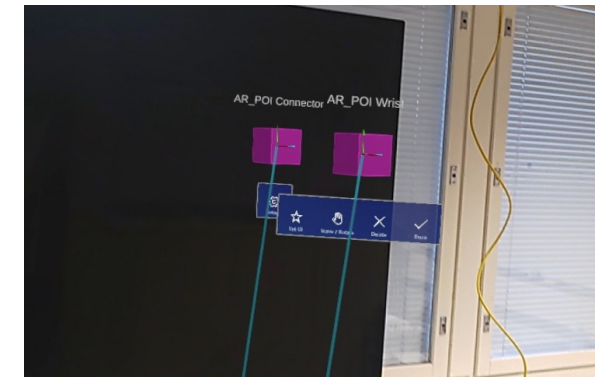
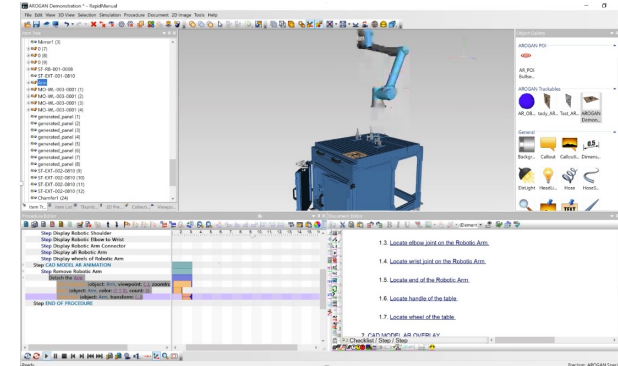
- Voice and gesture based control
 - Voice commands e.g. “Betsy Next” *
- Augmented reality annotation in 3D space
 - 3D models
 - 3D models animation
 - 2D symbols
- Guidance to information in 3D space
- Pictures and videos
- Linked to mobiPV server (websocket)
- Using the built-in HoloLens 2 camera for Notes images and video clips capture
- Text-to-speech (as an astronaut preference feature, from earlier project)
- Locate additional information to 3D space
- Select installed sensor and cable from list
- Add the final location of installed sensor



* “Betsy” added to all navigation commands to minimize side-talk issues

VirWAIT authoring environment

- Off-site authoring:
 - Usage of a 3D model for interactive definition of Point-of-interests
 - Associated of icons to be used for highlighting of POI items
 - Create of 3D animations through applying simple verb E.g., Screw/Detach Object etc.
 - Link these to ODF step
- On-site authoring:
 - Create new Object and Trackable Instances
 - Create and/or modify Resource Messages containing the AR Object and POI data needed for mapping the real-world environment



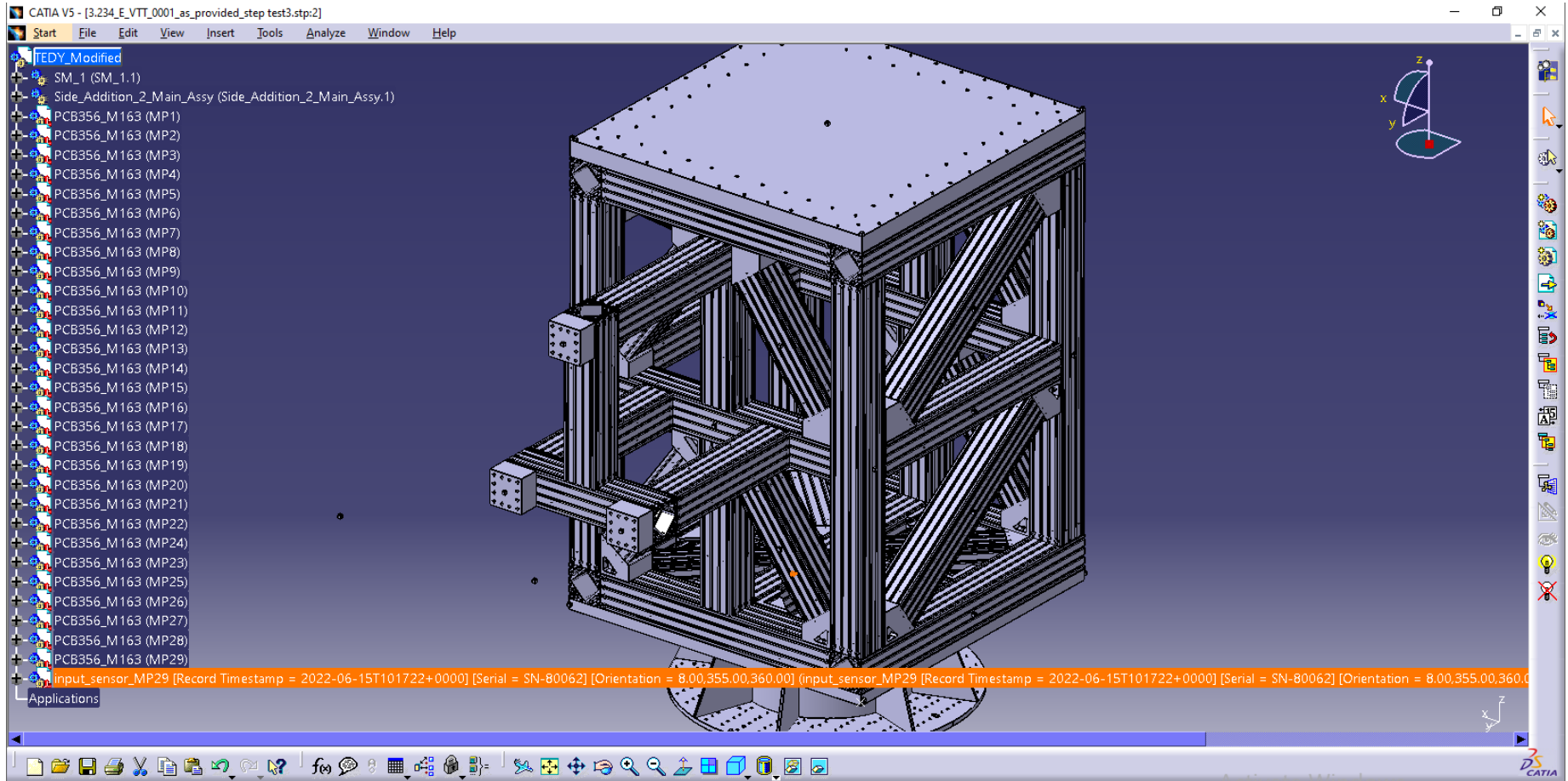
Remote observation

- Video streams are captured both from the iOS tablet and from video camera e.g. GoPro device connect to Hololens 2.
- Streams are accessible via WebRTC during execution from remote server i.e. <https://ant.skytek.com:5443/> by a remote observer using standard browser.
- Streams are also stored for later access, playback and download.
- Archived streams can be searched for and accessed via:
 - Procedure number.
 - Procedure identifier.
 - Date/Time of test campaign.
 - Sensor identifier.
 - Cable identifier.
- Result launches related video at relevant timestamp.

Reporting and STEP model update

- ‘As run’ STEP model with placed sensor positions and metadata are generated during procedure execution.
- Reports i.e. STEP files and Excels saved onto central server for access via a standard web browser.
- Generation of STEP file implementation updated to support Catia V5 compatibility with stricter STEP parsing.
 - Unique and increasing without gaps in numbering of each line in STEP file.
 - Removal of not allowed symbols in meta-data.

Reporting and STEP model update



Catia V5 showing 'as-run' configuration with sensor placed

Reporting and STEP model update

- Reports are now saved in a hierarchical structure on web server.
- Each test campaign procedure execution has a unique folder and contains related original STEP, 'as run' STEP and Excel.
- Accessed via /reports folder and structure is:
 - <Procedure_Identifier>/<Date>T<Time of procedure start>
 - E.g. 3.234_E_VTT_001/2022-10-12T095012

Index of /reports/3.234_E_VTT_0001/

Name:	Last Modified:	Size:	Type:
../		-	Directory
2022-10-15T004249/	2022-Oct-15 00:51:41	-	Directory
2022-10-15T232312/	2022-Oct-15 23:23:13	-	Directory
2022-10-15T234155/	2022-Oct-15 23:41:56	-	Directory

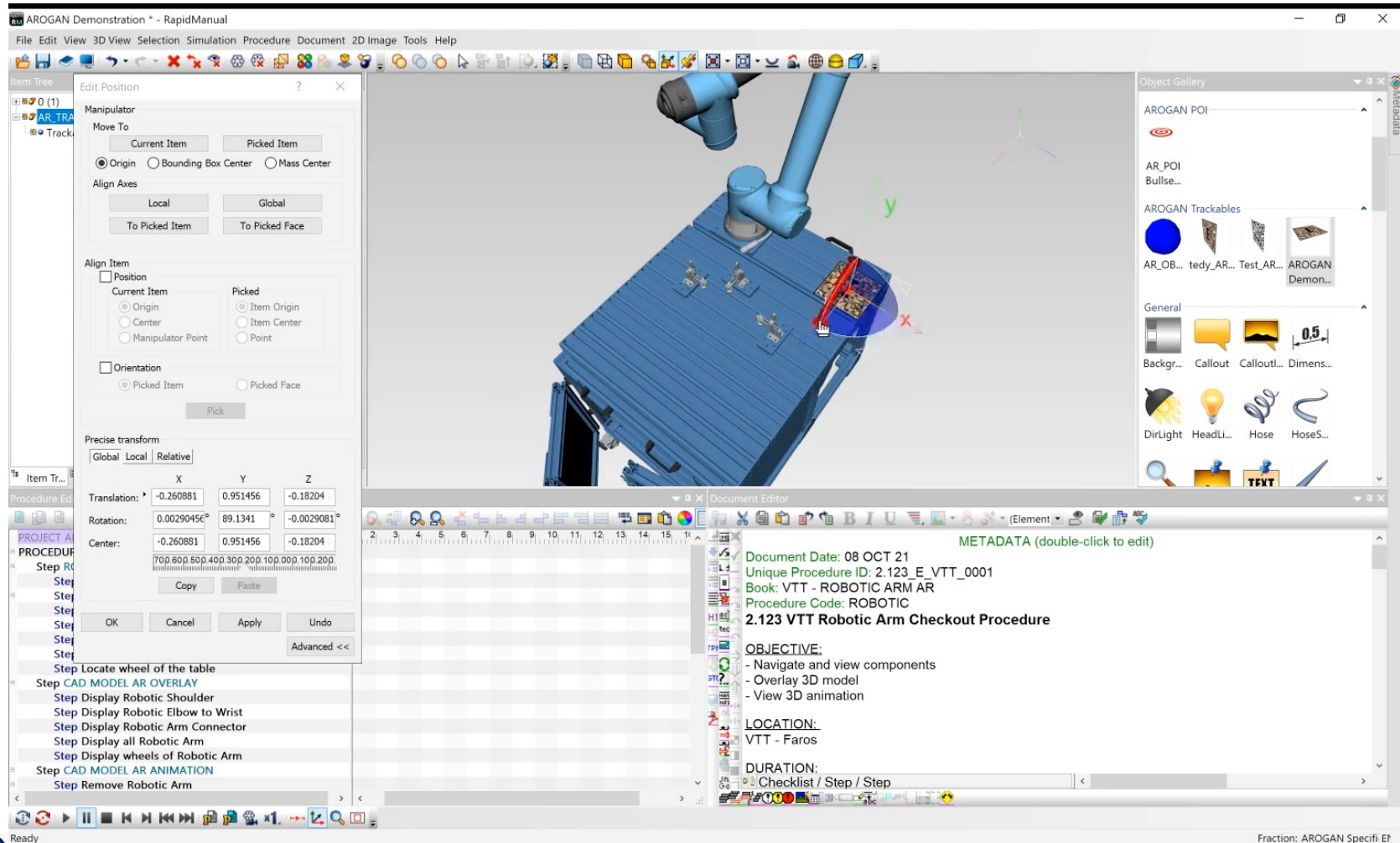
lighttpd/1.4.45

Index of /reports/3.234_E_VTT_0001/2022-10-15T004249/

Name:	Last Modified:	Size:	Type:
../		-	Directory
3.234_E_VTT_0001_as_provided_step.stp	2022-Oct-15 00:42:49	15.7M	application/octet-stream
3.234_E_VTT_0001_as_run_step_20221015_004249.stp	2022-Oct-15 00:42:49	15.7M	application/octet-stream
3.234_E_VTT_0001_as_run_step_20221015_004947.stp	2022-Oct-15 00:49:48	2.8M	application/octet-stream

lighttpd/1.4.45

Video of off-site authoring



Video of AR-player



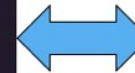
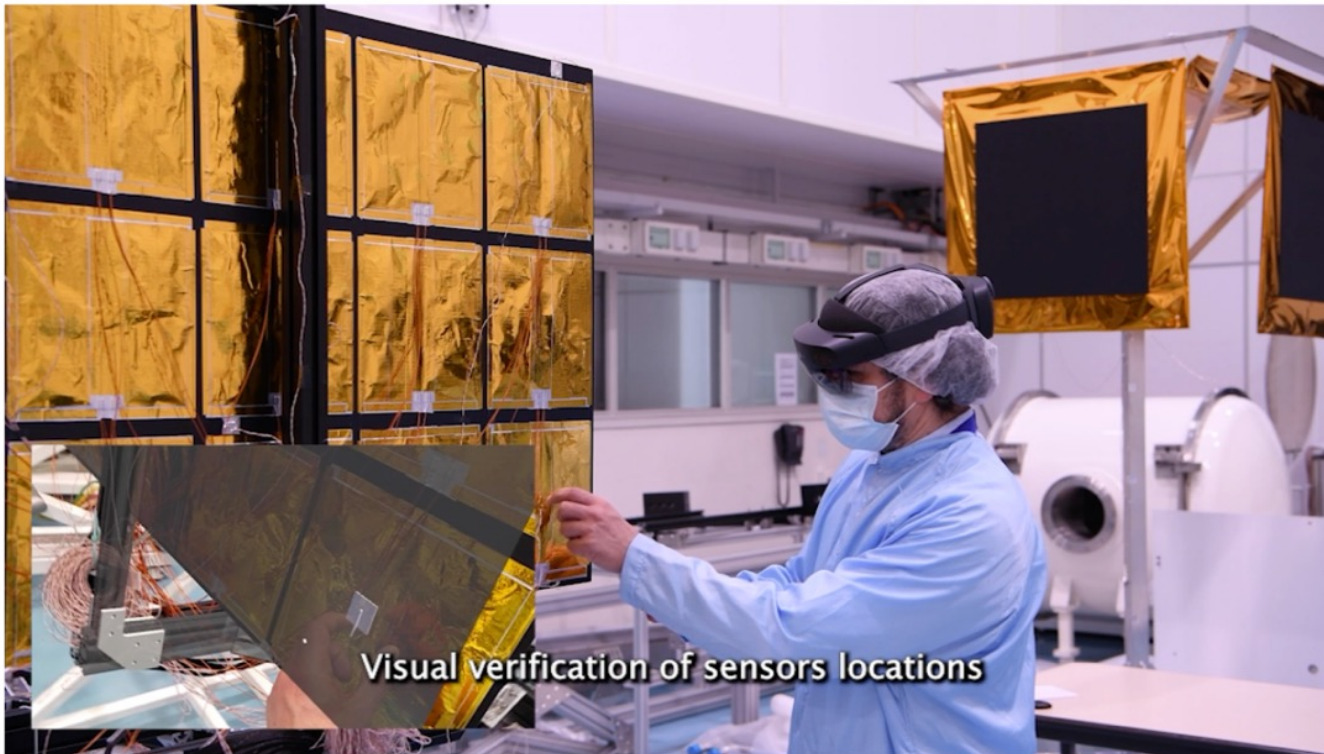
Visual verification of sensors locations

User reviews

The user evaluation was done in two phases:

- Preliminary user review - April 9, 2021
 - Case: MR supported installation of thermocouples on *an Heat Plate used as GSE for the Solar wind Magnetosphere Ionosphere Link Explorer – SMILE*
 - Remotely: Case in ESTEC and evaluation / development teams following via Teams
- Final user review – June 15, 2022
 - Case: MR supported phase 2 sensor installation on *TEDY (TEst Dummy) for a vibration test campaign on the Hydra facility*
 - Physically: Case in ESTEC
- Main results
 - The MR-system is seen to have the potential to improve the work task (and similar tasks) as the sensors have to be placed based on printed CAD models and guides.
 - The MR-system can significantly speed up the work
 - The system calibration is critical function for system reliability
 - Experienced and non-experienced user viewpoint could be utilized in UI
 - The SUS score averages (73) from the both tests indicate acceptable system usability
 - But do not provide statistical significance due to low number of test users

Example of remote user review



Remote view
from Finland/Ireland

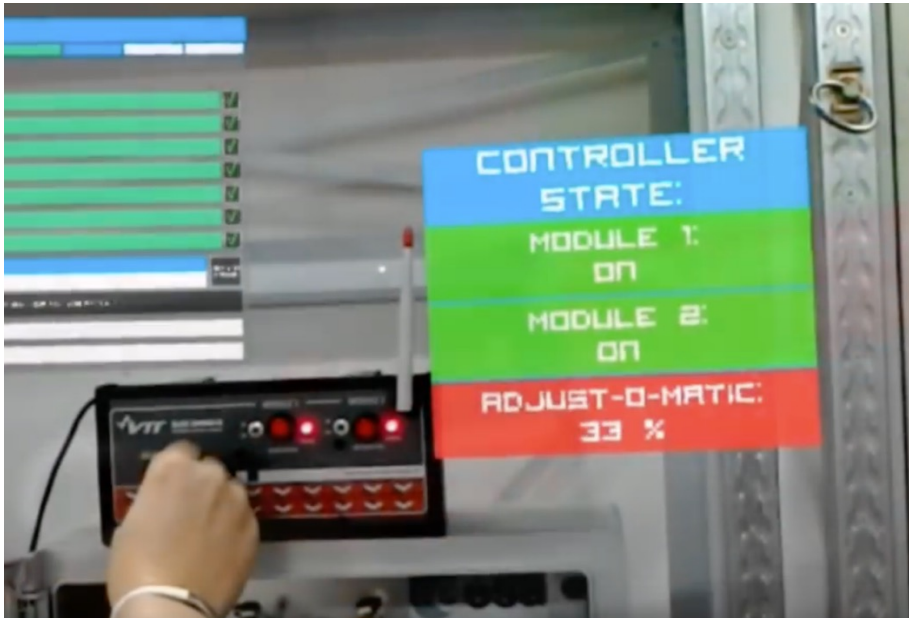
Lessons Learnt

- The results of the user reviews suggest that the developed MR-system has potential to become a useful tool for AIV/AIT applications
- The MR-system can significantly speed up the current work and provide motivating novel tool for the operators and engineers
- The system calibration is critical function for system reliability
- Due to COVID – 19 issues, project was delays as there wasn't enough face-to-face meeting
- Concept of the remote user review seems to work quite well, even it is needing technical expert in actual test facility side, and evaluation and development teams were able to get most important issues and improvement needs from reviews

Future Extensions



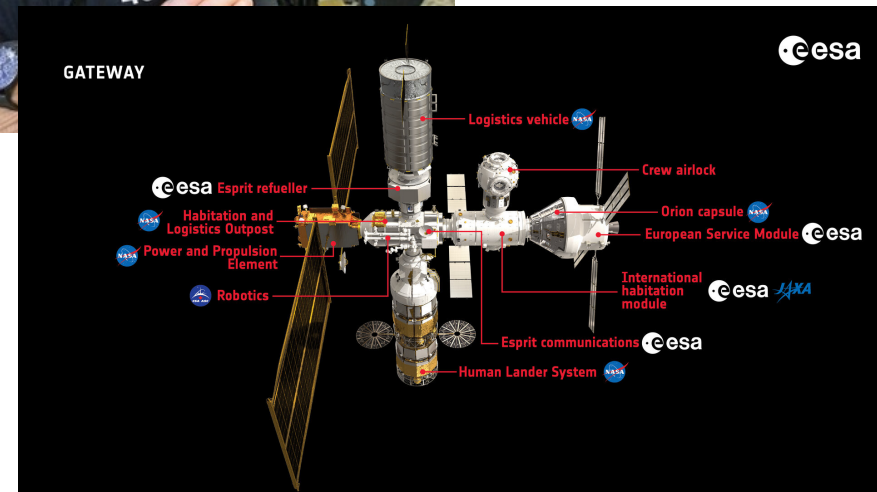
Telemetry data linked to ODF procedures and visualization in AR



- Very interesting AROGAN extension could be the ODF link to telemetry for system/devices monitoring function.
- Connections to real devices and thus exploit telemetry or similar data in AR e.g. via MQTT interface.
- This future capability could therefore be exploited very conveniently during the execution of ODF procedures when the operator has to monitor parameters data while performing the task.

MR in the Gateway to moon

- VirWAIT system could be good base-line for MR work support in Gateway to moon
- As it has been connected to mobiPV which has been tested in the ISS





Kaj Helin

Principal Scientist, Certified Project Manager IPMA

Human, Robot and Mixed reality solutions

VTT Technical Research Centre of Finland Ltd

Kaj.helin@vtt.fi