VirWAIT

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

ESR – Executive Summary Report

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EXECUTIVE SUMMARY REPORT

This executive summary report introduces a Mixed Reality system for the space industry and the two main use cases of the project called VirWAIT - 'Virtual Workplace for AIT & PA Training and Operations Support'. The project outcome is a solution of authoring system, augmented reality visualizations for IPV procedure with MR capabilities and the automatic reporting. The VirWAIT system exploits the mobiPV IPV procedure viewer, which database has been expanded with MR capabilities. Also, the remote observation features have been introduced as outcome from the project. The VirWAIT system was evaluated during the user review and its result are introduced in this abstract. End of the document high-lights lesson learnt and future extensions.

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;

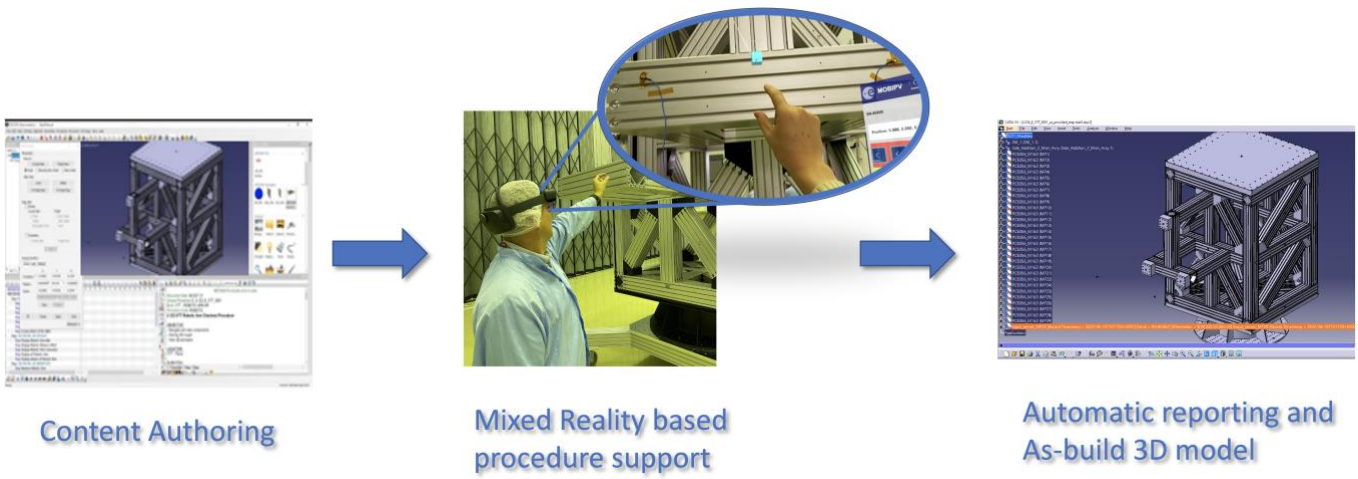

Figure 1. The VirWAIT system's workflow

The operational VirWAIT MR-systems workflow has been described in Figure 1. Worklfow includes three main steps:

1) Content authoring
    - Desktop mode (off-site authoring)
    - Mixed reality mode (on-site authoring)
2) Mixed reality based procedure execution
3) Automatic reporting and as-build 3D model generation

To verify the main project objectives, two most relevant use cases were selected. Them were use cases at ESTEC premises:

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

The VirWAIT MR 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 a Heat Plate used as GSE for the Solar wind Magnetosphere Ionosphere Link Explorer – SMILE

The main objective of the SMILE use case was the installation of thermocouples. Additionally, the use case also allowed to verify that sensors already installed in the specimen have been placed in the right location (see Figure 2). Procedure includes 32 steps. Procedure was authored based on STEP 3D model and procedure description.

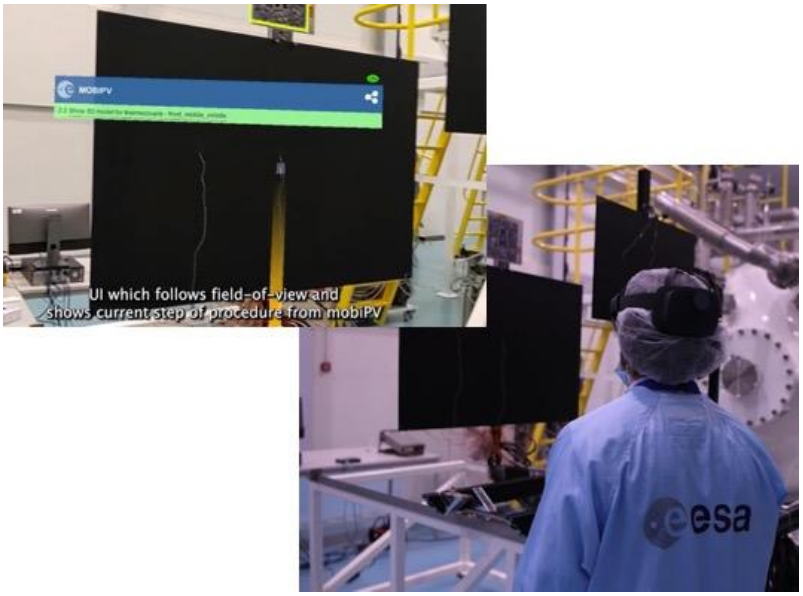

Figure 2. Visual verification of sensor locations.

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

The TEDY use case consisted in the preparation of the TEDY structure for the calibration of the Test Center shakers that will be used for a real satellite test a few days later. The VirWAIT system was used to place a subset of the accelerometers needed for the mentioned calibration, as well as, to verify the correct location of accelerometers already placed by Test Center operators the day before. The use case also made use of the as-installed STEP model feature of the system. The final position and orientation of the installed accelerometer, sensor and cable serial number can be saved the as-installed STEP model. User select from list installed sensors and cables serial number and locate virtual sensor to the actual sensor location. These informations were

added to the report and automatically generated by the system. User was also able to exploit of the image note taking capabilities.

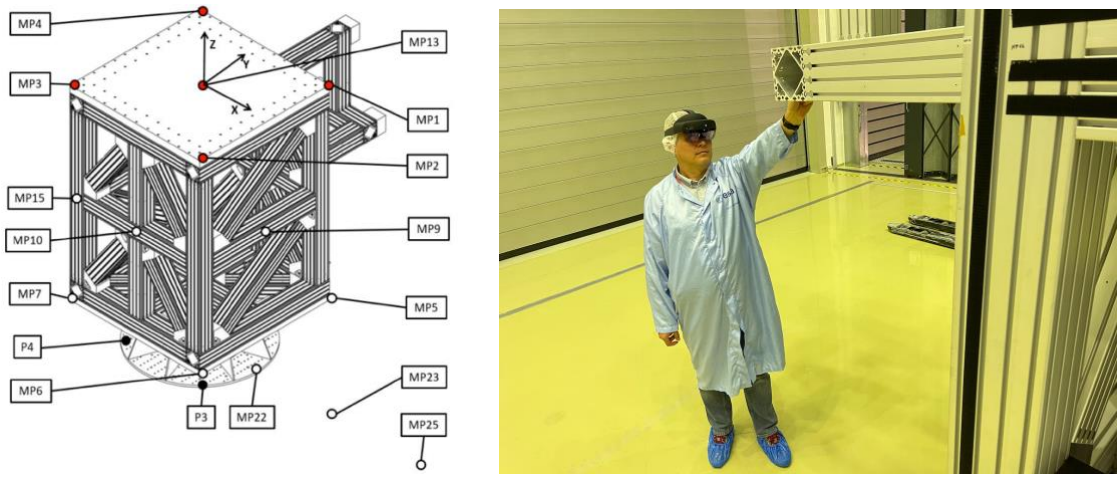

Figure 3. Left: Example from IPV procedure: Sensor location on TEDY. Right: AR supported installation of sensor

The user evaluation was done in two phases: the preliminary and the final user review. Test cases include SMILE heated plates test procedure and TEDY phase 2 sensors placement t procedure. The first evaluations have been performed remotely via online tools due to COVID-19. The methods for data collection have included observation, interview, and questionnaire. The main focus of the reviews have been on usability, user experience, and usefulness of the MR-system.

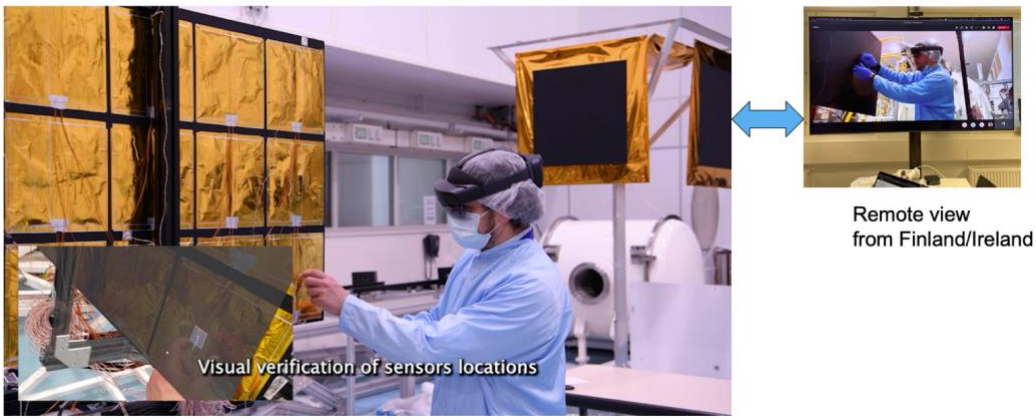

Figure 4. The set-up for the remote user test of the MR system. Left: Actual system installation in ESA-ESTEC. Right: Video and audio feed for observation teams in Finland and Ireland

Generally, the MR-system is seen to have the potential to improve the work task (and similar tasks) that was performed during the test. Currently, the sensors have to be placed based on printed CAD models and guides. The MR-system can significantly speed up the work. The MR system is envisioned to improve productivity and efficiency when working with complex structures and procedures. For simpler use cases the current approach is sufficient. The MR-system also provides positive and stimulating novelty value, described as “something out of a sci-fi movie”. The alignment took considerable amount of time during

the test setup. There should be clear and comprehensive procedures about how to prepare using the system.

The users' overall reaction to the system was positive. The system usability scale (SUS) scores were quite high in both test phases indicating already acceptable system usability. All the individual scores from the final user review reached the range of acceptable usability and were thus slightly improved from the preliminary test phase. It should be noted that the main test users in the final review were actual operators performing their real work task.

System calibration and reliability are main issues to be improved based on the final user review results. The calibration process took considerable amount of time during the test setup. The system also stopped functioning properly from time to time due to for example that connection to mobiPV was lost. From the user perspective it should be ensured, that comprehensive instructions are provided for setup and for problem situations.

Due to COVID – 19 issues, project was delayed as there wasn't enough face-to-face meeting and user reviews was postponed. Concept of the remote user review seems to work quite well, even it is needing technical expert in actual test facility side. Evaluation and development teams were able to get most important issues and improvement needs from reviews.

For the future extension, very interesting VirWAIT extension could be the ODF link to telemetry for system/devices monitoring function. Augmented Reality is in general very useful in showing physical objects and indicating operations to be performed on real hardware while it is usually of little or no use when the operator has to perform for instance monitoring and control operations on a computer. VirWAIT system could be connected to real devices and thus exploit telemetry or similar data in MR 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. Just as an example, when ODF procedure provided by mobiPV gives instruction for setting a parameter (i.e. a pressure) at a certain value, VirWAIT system can also provide, nearby the interface to be operated, the real-time value of the parameter so that the user doesn't have to jump back and forth from the setting place (i.e. the valve pressure regulator) to the device displaying the telemetry (i.e. the Portable WorkStation laptop). This will save crew time and prevent errors during procedural task execution. The picture below shows an example where the ESA-EdcAR Demonstrator displays in AR pressure telemetry data just nearby the physical pressure regulator valve (See Figure 5).

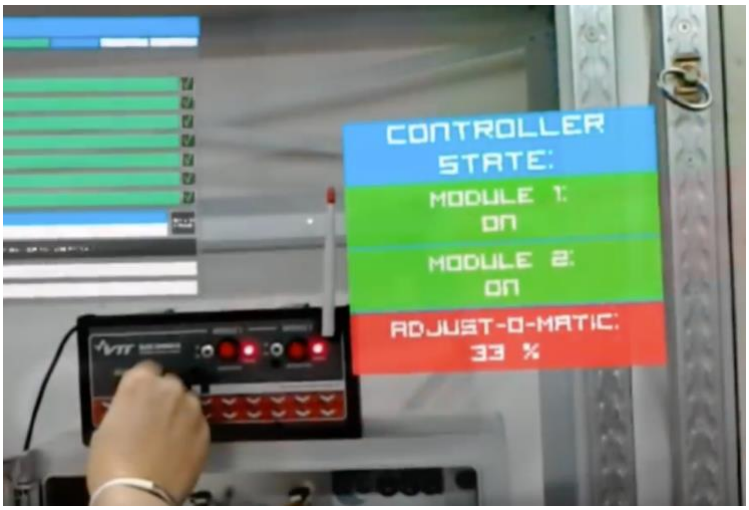

Figure 5. Telemetry data shown in Augmented Reality

Besides the visualization in MR of instructions delivered by mobiPV and concerning procedural steps to be executed, VirWAIT system can furthermore provide the crew with different types of additional information relevant to the task to be performed. One of the main benefits of augmented reality is to make invisible content visible and give correct information in correct place in right time. VirWAIT with MR X-ray function can provide a useful support to the crew during training sessions as well as during operations on real hardware.

Last but not least, VirWAIT system could be based line for the MR work support in Gateway to moon, as it has been connected to mobiPV which has been tested in the ISS.

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