LEVERAGING EXTENDED REALITY TECHNOLOGIES WITH RFID TO ENHANCE ON FIELD MAINTENANCE OF BUILDINGS

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MOTIVATION

Combined use of Mixed Reality and BIM to improve productivity in several steps of project management processes in construction.

Multi-disciplinary inputs, enhanced information management and visualization.

MAIN ADVANTAGES OF USING MIXED REALITY:

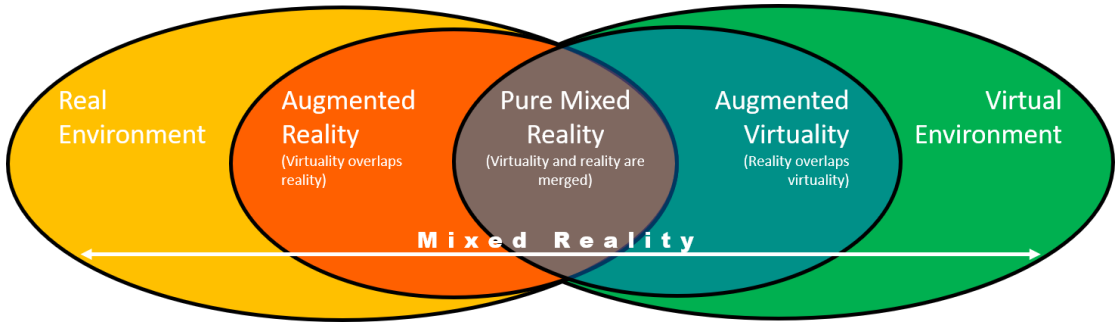
- Virtual representation of objects and space through context awareness;
- Interaction with BIM models superimposed over reality (e.g. query of virtual models);
- Theoreticallty, possibility of developing a distributed collaborative environment, where every participant can see the scene from a personal perspective;
- Improved effciency of data exchanged.

MIXED REALITY

With MR users can interact with both virtual and real components of the world.
The word MR is used with the companion technologies VR (the participant is totally immersed and able to interact with a virtual world) and AR (virtual world is superimposed over real world).

Virtuality Continuum Spectrum:

AR is used whenever digital content is superimposed on the users' real surroundings
AV isused whenever real content is superimposed on the users' virtual environment

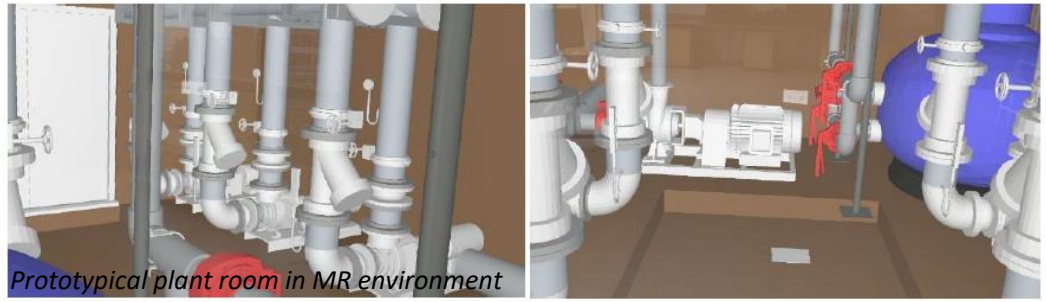


Ref: Milgram, P.; Kishimo, F. A taxonomy of Mixed Reality Visual Displays, IEICE Transactions on Information and Systems, 1994, Volume 77(12), pp.1321–1329.

APPLICATION EXAMPLES

1 Checking of design models

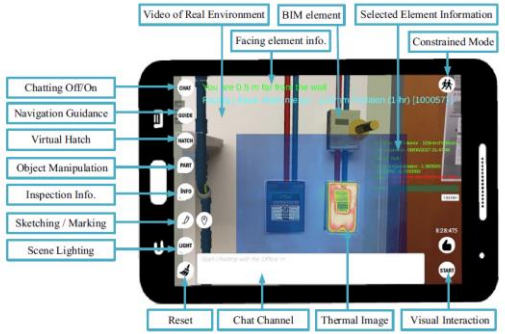
(ref. Abhinesh Prabhakaran et al. An Approach for Integrating Mixed Reality into BIM for Early Stage Design Coordination, MATEC Web of Conferences 312, 04001 (2020) EPPM2018)



Prototypical plant room in MR environment

2 Retrieval of data and advanced visualization in Facility Management and during construction works

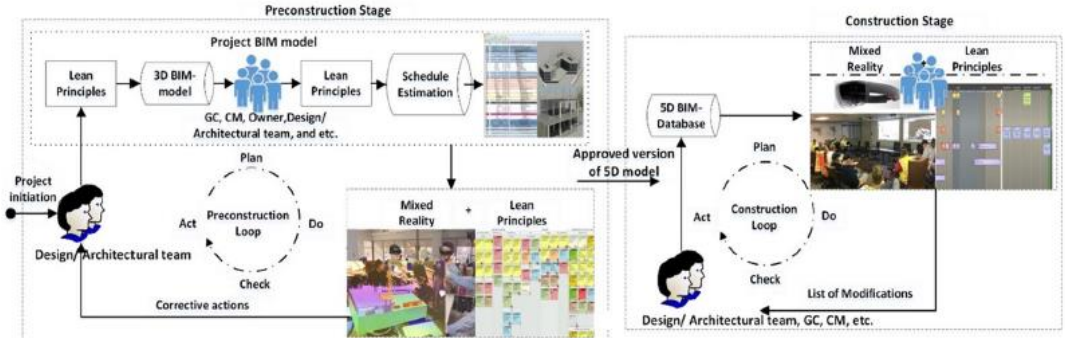
(ref. Khaled El Ammari, Amin Hammad, Remote interactive collaboration in facilities management using BIM-based mixed reality, Automation in Construction 107 (2019) 102940)



Graphical user interface

3 Lean construction project delivery assisted by BIM/MR

(ref. Sepehr Alizadehsalehi et al., BIM/MR-Lean Construction Project Delivery Management System, 2019 IEEE Technology & Engineering Management Conference (TEMSCON))

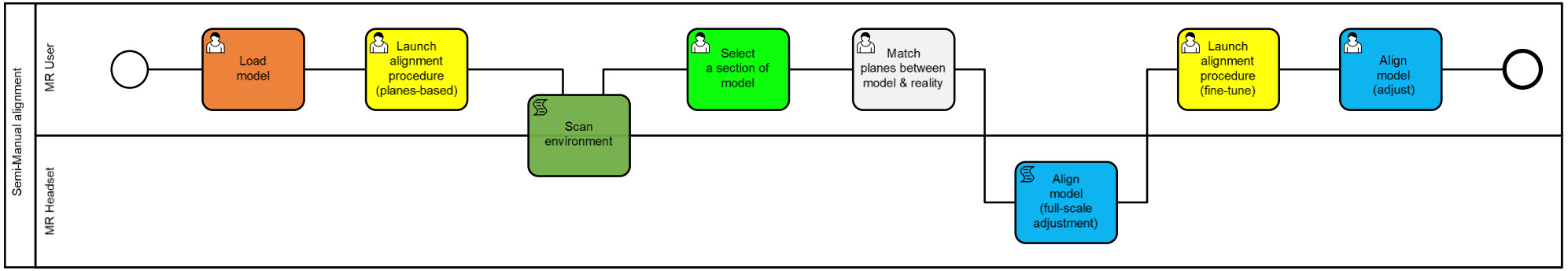


4 Education

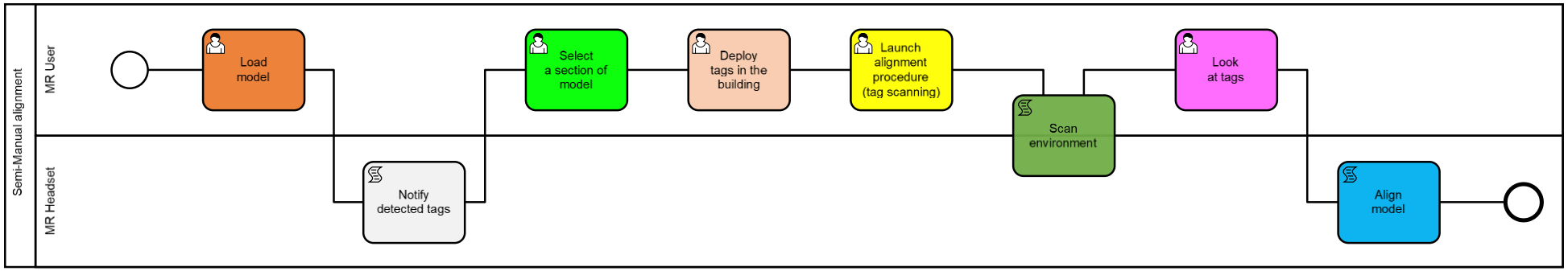
MODEL ALIGNMENT

Manual VS marker-based alignment approaches.

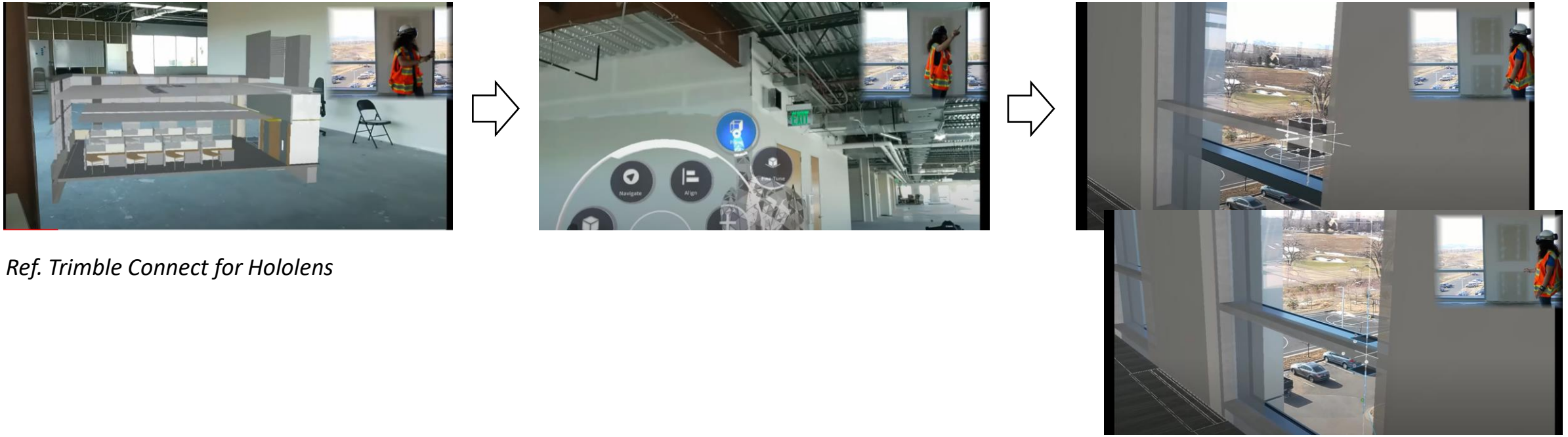
Manual alignment requires that a surface is first aligned, then it is moved and scaled in order to match virtuality with reality.



Marker-based alignment is currently supported by AR engines (e.g. Vuforia SDK).
A marker must be scanned through the headset and the same code must be included in the model.



EXAMPLE OF A MANUAL ALIGNMENT



Ref. Trimble Connect for Hololens

To be noticed:

- manual alignment is made possible just in case the real counterpart has been built, e.g. two walls have been built physically to form their corner; whenever the real component corresponding to a virtual entity is hidden, alignment cannot be performed.
- the model must be displaced as a whole.

EXAMPLE OF A ALIGNMENT BASED ON QRCODE MARKERS

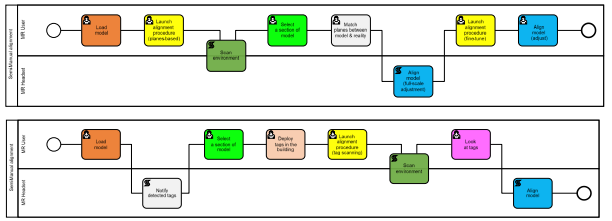
Ref. Trimble Connect for Hololens

To be noticed:

- markers must be visible;
- markers must be placed in the real environment in advance.

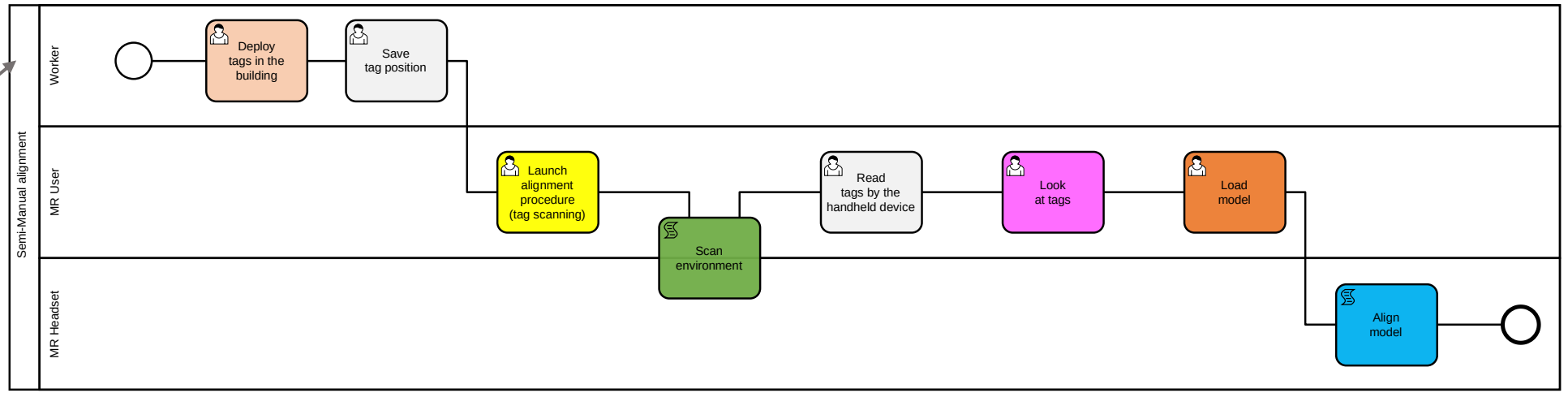
THE USE OF RFID AS MARKERS

Advantages derived form using RFID tags:



- RFID tags can be kept embedded in building components;
- they can be used even in case the virtual components have not their real counterpart in the real world;
- no requirement that these markers are preliminarily affixed on walls.

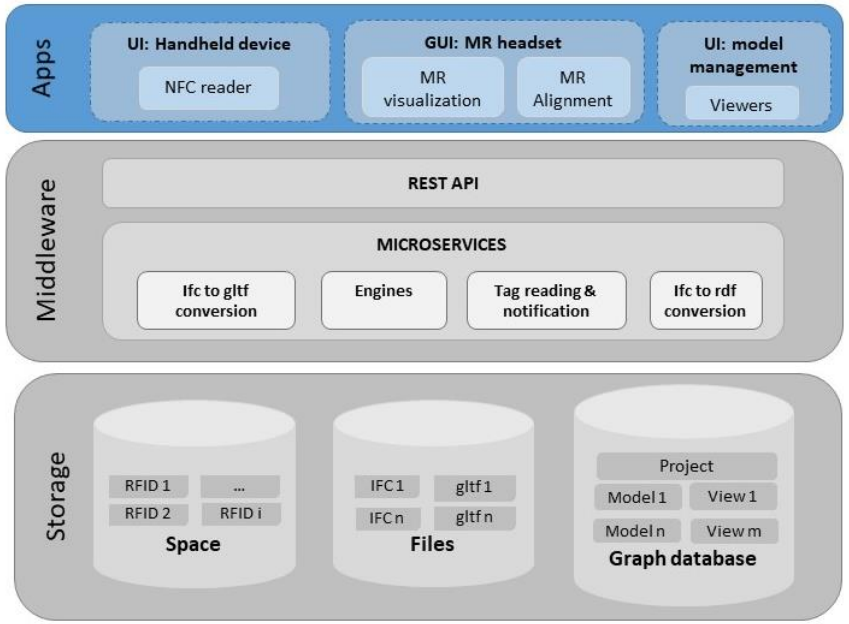
Enhanced workflow:



THE SYSTEM ARCHITECTURE

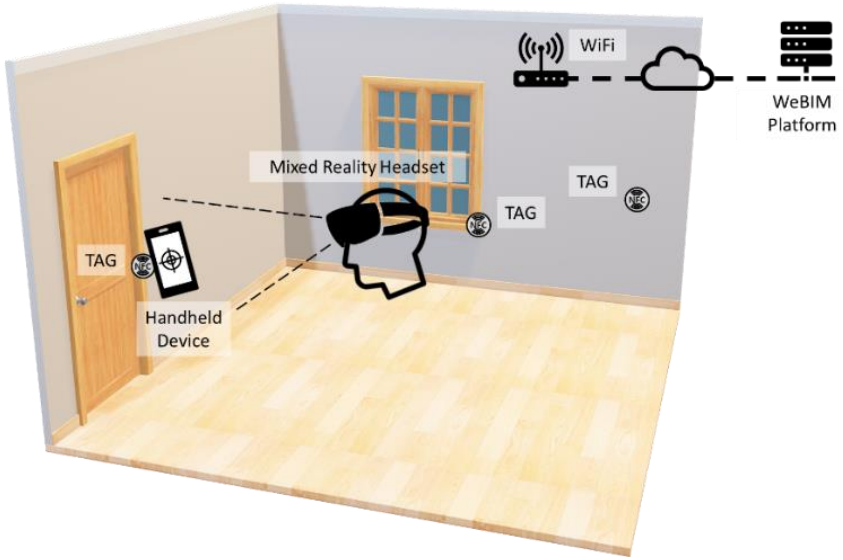
- A RFID tag is represented as a unique permanent identifier device (UID)
- The coordinates of every UID are stored in the platform
- The RFID tags are located in the BIM model, too (the user can calculate absolute coordinates through this model)
- Physical tags can be installed either during construction or during the first on-site survey
- We used HF tags, ISO 14443 and MIFARE standard compliant
- They can be scanned using NFC enabled handheld devices (0.04 m range)
- The model is assumed horizontal, hence two tags at least are necessary to align the model around its vertical axis.

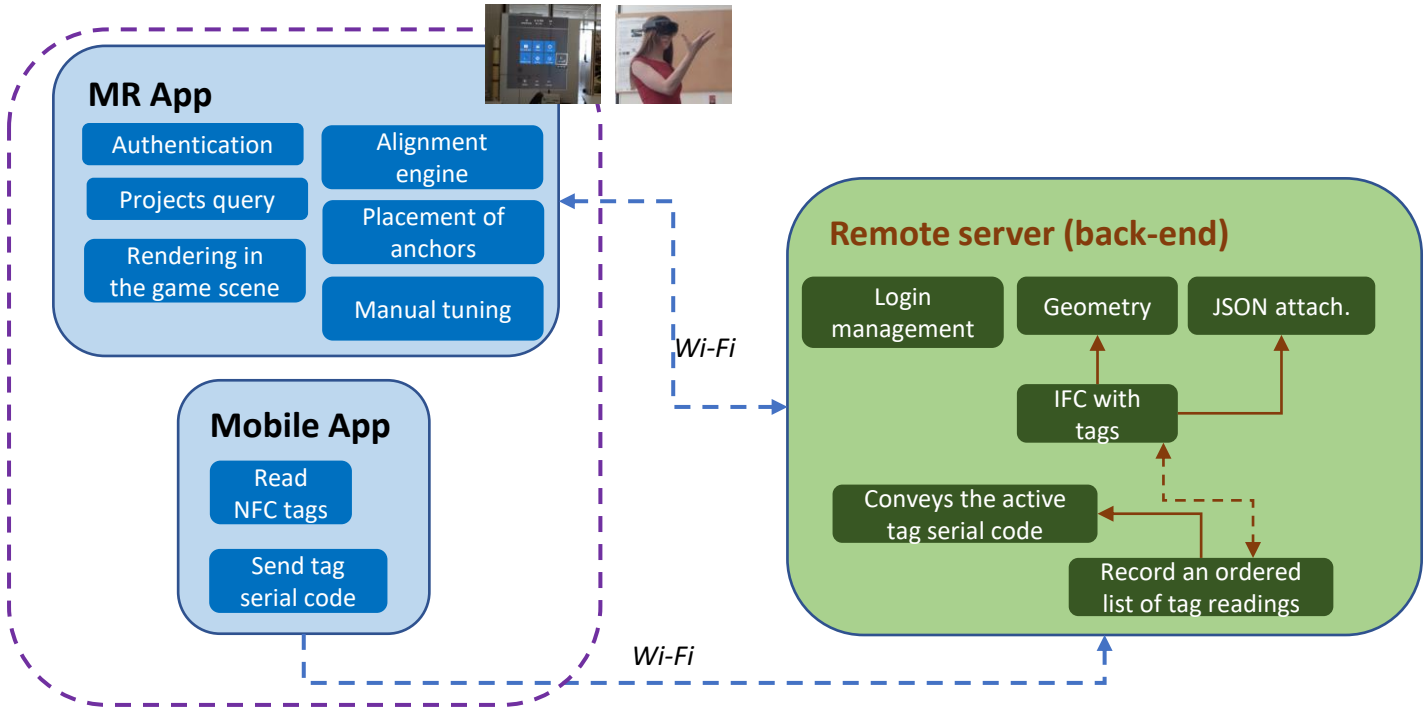
WeBIM platform



ALIGNMENT IN PRACTICE

Once the first tag has been read, geometry is displayed from the server platform into the MR headset App and aligned over the real building.
The alignment is refined as long as further tags have been scanned.
The target image is displayed by means of a smartphone and scanned through the MR headset, then the smartphone sends the serial code of the latest read tag to the server platform.





SLAM

SLAM: Simultaneous localisation and mapping.

Algorithm for:
- Environmental mapping
- User localization in the environment

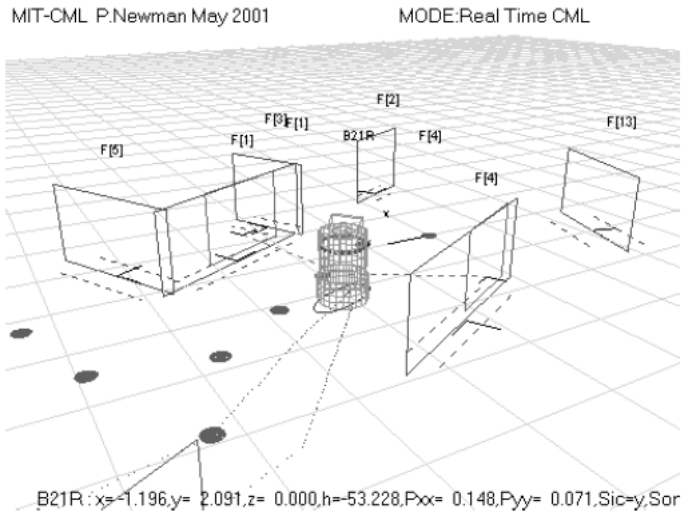
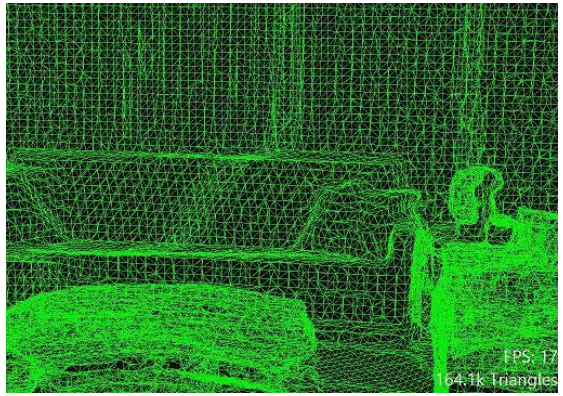


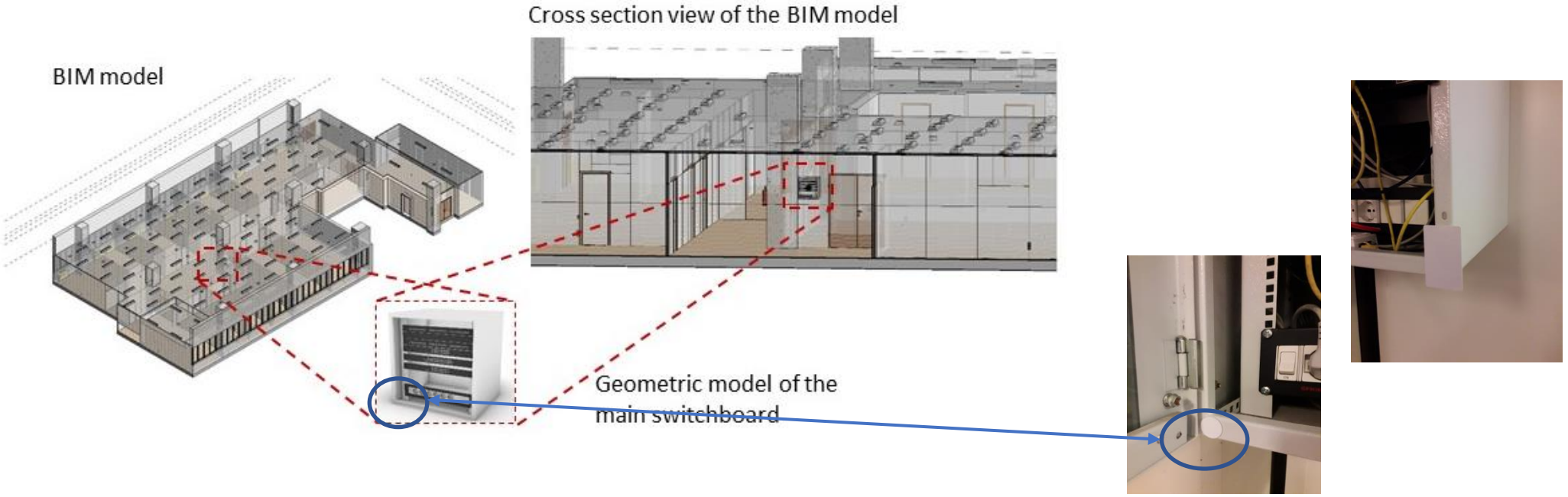
Fig. 6. *Real-time SLAM visualisation by Newman et al. [37].*



THE USE CASE

CONTEXT: DICEA Department: main switchboard of the communication system towards office rooms and server.

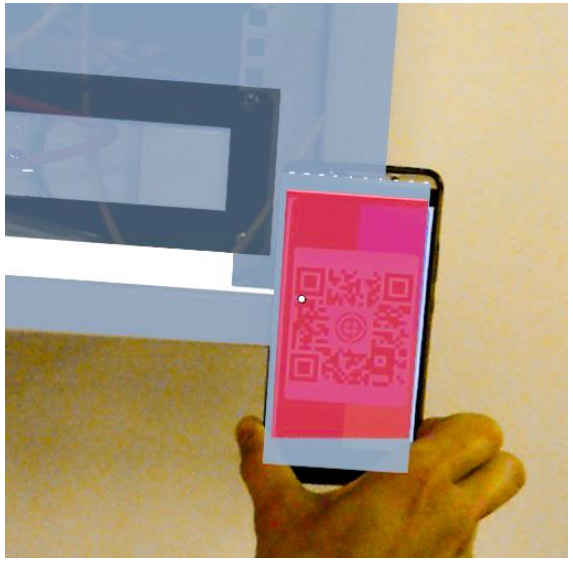
SCENARIO: Request from the O&M service: a plug of the communication system in one of the rooms does not work properly. The other end of the cable must be located in the switchboard in order to check for integrity and replace it, if necessary.
It is assumed that a BIM model of the communication system is available and stored in the platform.



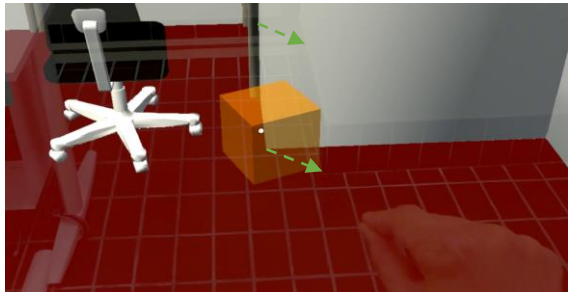
IMPLEMENTATION AND FULL SCALE TESTS

Development environment:
C# with Visual Studio 2019 Version 16.7.3 under Unity 2019.4.9f1 environment and compiled for x86 and deployed in Microsoft HoloLens 1.0.

The whole app is based on the Microsoft Mixed Reality Toolkit 2.4.0 and Vuforia 9.7.5 for tracking image targets. The target is displayed on the handled device when reading NFC RFIDs.



If required, manual fine-tuning:



FIRST-PERSON VIEW OF THE OPERATOR

Once the virtual model has been superimposed over the real asset, the user is allowed to retrieve information about any components he may be interested in.

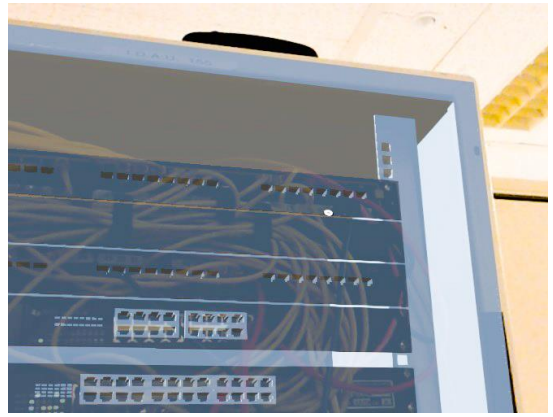
In this case he is expected to query the model to pinpoint that cable end correspinding to the plug that is subject to failure.

DISCUSSION AND CONCLUSIONS

- BIM models must be very accurate to be able to display every detail of interest for the operator working on-site.
- As compared to the manual method, there is no requirement that the whole model is uploaded in order to perform alignment, so it does not suffer big spaces. The computaiton effort is reduced and operations are faster, as a consequence.
- RFID tags are kept embedded in building components, they should be included in the As-built model of the asse; relocation is required during surveys.
- The accuracy is in the order of cm. The overall accuracy is dependent on the relative position between the handheld device and the RFID tag.

FUTURE DEVELOPMENTS:

- Reducing the reading range of tags
- Editing non-geometric information on-site
- Enriching the virtual model while working on-site



THANKS FOR YOUR ATTENTION!

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