ENEDIS FIELD EXPERIENCE OF AUGMENTED AND VIRTUAL REALITY TECHNOLOGIES AT THE SERVICE OF NETWORK OPERATORS

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ABSTRACT

The technologies of virtual and augmented reality reach maturity: after growing application in the field of video games, these technologies seem today able to answer needs for the industrial world. In that context, Enedis (ex-ERDF) conducted an innovation challenge opened to start-ups and innovative SME companies in order to detect promising AR and VR solutions able to support the "next generation field technician". A field-test program was conducted with the selected companies with the aim of experimenting prototypes of new tools, and among them tools based on virtual and augmented reality technologies focussed on network and substations operation. The main outcome expected is to identify the new technical solutions capable of bringing in the short and medium term most value to the technicians in terms of performance and safety, and then to develop the corresponding operational tools and solutions. This paper presents three complementary prototype tools which take advantage of augmented and virtual reality to help the field technicians to perform network operation in a more effective way and with an increased safety.

INTRODUCTION

DSOs are traversing a period of profound change, in a global context of energy and digital transitions. The local authorities have expressed their expectation that DSOs will make possible and facilitate these transformations. Enedis, the main French DSO, is fully committed to this approach. As a corollary, new systems and equipment are being deployed in the field, which must be mastered by the technicians. On the Enedis networks, we can for example cite the generalised deployment of the Linky smart metering system or the integration into the network of decentralised production…

At the same time, Enedis must manage the efficient training of new recruits in the profession's basics, and above all its requirement for safety.

Innovation is one of the key factors chosen by Enedis to address these challenges. What follows gives an illustration of this within the scope of network operation activities in the field.

APPROACH CHOSEN BY ENEDIS

Technologies in the telecommunications and image and data processing areas are progressing rapidly both in terms of performance and cost. At the same time, the expectations of the stakeholders and the technicians – and in particular the new generation of young technicians, who are often familiar with new digital technologies – require that we accelerate the process for developing new solutions. This is why, in addition to conventional R&D, Enedis has for several years been making use of numerous innovative start-ups and SMEs to identify and experiment new solutions for increasing the performance of technical interventions and the associated safety. We expect that this approach will deliver greater agility, complementarity across competencies within the Enedis teams, and a stimulation of the collective intelligence…

Thus, a first large-scale innovation competition targeted at start-ups was organised by Enedis in 2015. It was highly successful as almost 300 start-ups applied. Amongst the competition's themes proposed by Enedis, the "next-generation field technician" area attracted the most proposals for innovative solutions, with the accent being placed on the benefits of virtual reality and augmented reality. These technologies, which are becoming increasingly efficient and accessible, are in the process of transitioning from the gaming domain to that of the industrial world.

The rest of the document presents the definition, results and perspectives for three complementary experiments on applications of virtual reality and augmented reality for network operation, undertaken with innovative companies selected in the Enedis innovation competition. Some of these have already been adopted locally by the first operational teams, and for others we are still in the experimental phase, but the prospect of a short-term industrial usage seems close.

VIRTUAL REALITY FOR THE TRAINING OF TECHNICIANS

The context and the challenges

Workplace safety is a major pillar of Enedis's policy. Initial training is also essential to ensure a high level of

professionalism, which is itself a guarantee of a proper evaluation of the risks, the implementation of procedures and the necessary capacity to handle unforeseen events. The verification of acquired competencies throughout a career should also be taken into account.

In this context, Enedis wanted to widen its training methods for operation technicians through an additional "digital" offering over and above the conventional training courses. The solution being experimented uses virtual reality to immerse the trainee in the environment of an HV/MV primary substation and give support to carry out an MV lockout procedure. More precisely, the use case chosen is the lockout of the first section of a medium-voltage feeder. The target population is mainly some network technicians for whom this operation is a relatively infrequent intervention.

Several benefits are expected from this solution:

- More effective training: Trainee concentration and involvement is mandatory,
- More attractive training: A technology that is fun to use, especially for younger trainees,
- Reduced deployment lead time: Intuitive use of the tool, short training times,
- Possibility of using several learning situations: Different types of installations,
- Reduced investment compared to traditional training methods.

Experimentation and its benefits

The project is the fruit of a collaboration between Enedis (*Technical Head Office* and *Nord Midi-Pyrénées Regional Department*) and the start-up NUMIX, a digital creation company based in the south-west of France and specialised in multimedia, communication and 3D infographics creation.

Figure 1: trainee equipped with a virtual reality headset

Equipped with a virtual reality headset, the apprentice discovers, understands and analyses a situation and reacts to visual and sound stimuli, and carries out a task with unforeseen circumstances. Four modules are available: quiz, lockout training, lockout-removal training and two

associated evaluations.

Figure 2: training-sequence menu

Over the 6 months of the project, frequent exchanges with users in the operational teams for which the training tool is intended allowed us to refine the scenario and improve ergonomics. Today, the training solution is available and feedback from the first users is very positive. It is too soon to quantify its impact in terms of competency-acquisition effectiveness, but no-one can deny that immersive virtual-reality based training courses represent a promising field to advance the training offering and guarantee the professionalism and safety of the network technicians.

Figure 3: image of a training sequence in immersive reality

In its current form, it is envisaged to extend the number of use cases for technician interventions, in particular for the replacement of the hubs for the Linky smart meter system in the MV/LV secondary substations.

AUGMENTED REALITY IN SUPPORT OF NETWORK OPERATION

Context and challenges

The performance of an electrical distribution network depends on the reliability of its components, the way in which it has been developed, designed and built and the way in which it is maintained and operated. Infrastructure operation is defined through regulations and through the internal policy, implemented by the network operator,

which represents a long-term commitment based on feedback. The role of the operator is therefore of fundamental importance in this chain.

Over and above the innovative approaches used in training, and described in the previous section, Enedis has committed to an approach to develop new tools benefitting from augmented reality to support efficiency and safety in the operation of its networks.

The definition, development and experimentation steps were therefore conducted in collaboration with SIREA, an innovative SME located close to Toulouse (south-west France), and tested by the *Nord Midi-Pyrénées* Regional Department of Enedis. SIREA already has experience of tablet-based operation and maintenance support for industrial electric installations (equipment recognition, lifecycle sheet and maintenance procedure, lockout steps, etc.). With Enedis, the aim is to now extend this concept to the operations procedures for all equipment likely to be encountered in MV/LV secondary substations and in the HV/MV primary substations on a network such as that of Enedis.

The functions of the operations-support prototype solution

At this stage, the tool provides information and support for operations:

- For MV/LV secondary substations, three use cases based on an automatic recognition algorithm (type of MV switchgear, type of LV panel) were implemented on a tablet: the removal of LV fuses, the manipulation of the LV switch and the operation of the MV switchgear. Specific developments were conducted to respond to the high degree of variability of the installations and equipment. On this basis, for LV interventions, a safety-instructions implementation support tool was integrated into the tablet application.
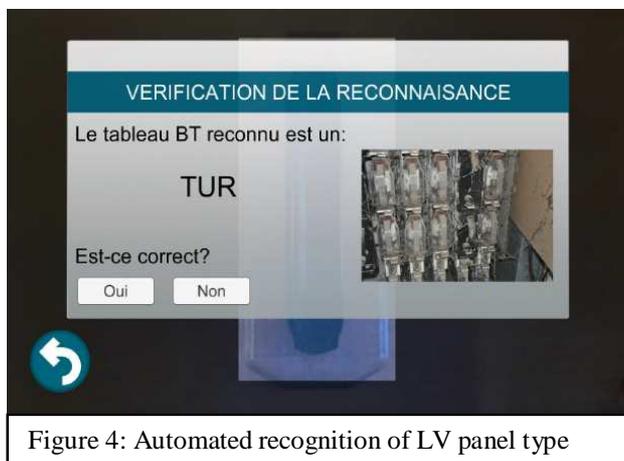

Figure 4: Automated recognition of LV panel type

Figure 5: Assisted recognition of LV panel type

- For locking out switchgears of HV/MV primary substation, the application gives step-by-step guidance for the technicians for the actions to be performed, and thus guarantees compliance with the operating rules. In this frame, the developments thus related to optimal guidance for the operator, display ergonomics or automatic text recognition (to identify feeder name and MV switchgear type).
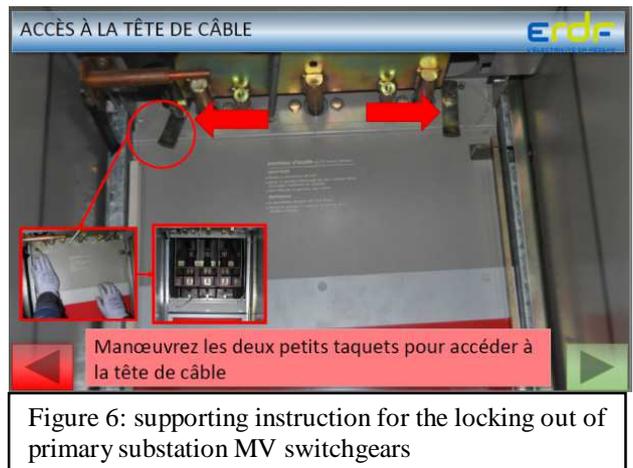

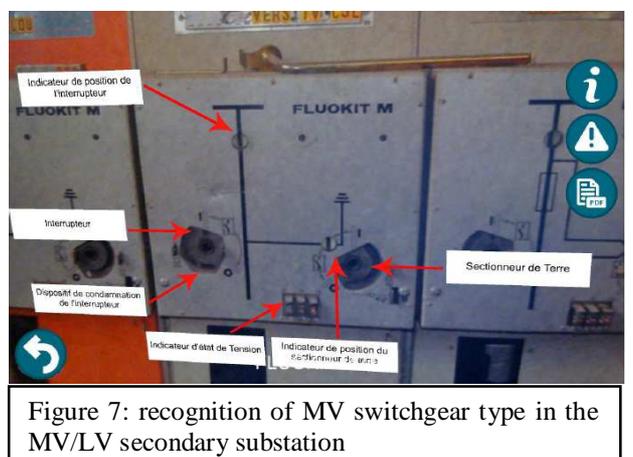Figure 6: supporting instruction for the locking out of primary substation MV switchgears

Figure 7: recognition of MV switchgear type in the MV/LV secondary substation

The perspectives

The results obtained are positive and the feedback from the experimenting technicians very encouraging. On this basis, Enedis has undertaken to develop the procedural guidance for other types of operations as direct support for the implementation of operating prescriptions. Through augmented reality, and after the step of infrastructure recognition (type of equipment and geo-referenced position), it aims to record, verify, perform and follow operation procedures. The application must thus ensure:

- The availability of a critical analysis of the operation procedures performed,
- Access at all times to infrastructure characteristics, procedures to be performed and characteristics of the infrastructure,
- The follow-up of manoeuver performance sheets
- The verification of the completeness of infrastructure databases and their updating if necessary,
- The availability of a remote expert using the interactivity capabilities of augmented reality (communication of drawings and real-time indications …).

Through this experimentation, augmented reality has clearly demonstrated its worth as a support tool for infrastructure operation and maintenance, which should allow Enedis to continue to improve the performance and efficiency of its procedures and intervention safety.

FAULT LOCATION ASSISTANCE FOR UNDERGROUND CABLES

The context and the challenges

The fault location on underground cables, both for Medium Voltage and Low Voltage, is a common operation for an distribution network operator.

Figure 8: Typical fault location operation

This type of task requires a great deal of preparation, in particular the gathering of cartographic information to know precisely the cable routing in the studied zone. These maps are often not very user-friendly for the technician who must additionally move across the zone during the operation whilst at the same time using his cable-detection equipment to follow the cable route. He therefore needs to be able to constantly refer to the maps, including their digital version, to be able to conduct the search as efficiently as possible.

To overcome these constraints, the idea is to directly display the cable routing in the technician's field of view using augmented reality. Thanks to the geo-location and directional sensors incorporated in augmented-reality glasses, a 3D projection of the network is presented to the technician, built on the basis of Enedis network cartography.

The use of augmented reality in this context, supported by an advanced network location function, provides veritable added value at operational level.
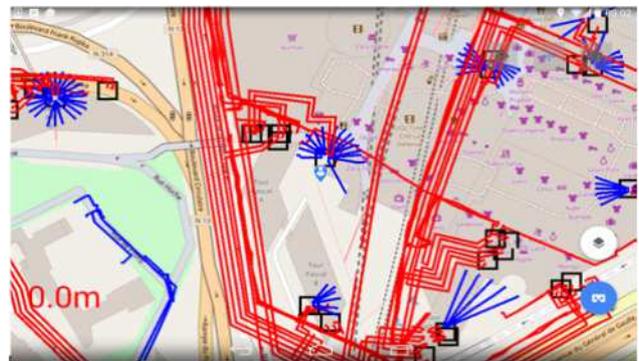

Figure 9: Example of an underground network for display

In this frame, Enedis (*Technical Head Office* and *Champagne-Ardenne Regional Department*) is co-developing an augmented-reality solution with Levels3D, a French start-up based in Troyes, specialised in the field of real-time 3D scanning. As for the two other experiments cited above, the dynamic collaboration between the start-up and the Enedis field teams allows the projects to be conducted in agile mode, making the most of the available technologies to respond to the distributor's business constraints.

The project's goals

After a first "Proof of Concept" in 2015, which allowed the validation of the solution's feasibility and the positive impact for the profession, the most recent developments were integrated to address, together with Levels3D, the technical challenges that needed to be resolved before an operational deployment was possible, and in particular:

- An improvement of GPS underground cable positioning precision to ensure that the operator is able to locate the cables exactly and improve operation efficiency,
- Overcome constraints related to strong variations in lighting levels and the numerous movements and displacements during the search for faults,

- Improve the user interface to respond to operational needs and improve business performance.

Figure 10: Technician equipped with augmented-reality glasses

Expected benefits and perspectives

The potential benefits of this solution are wider than we may think. Indeed, the feedback from the testing of the prototype solutions allows us to anticipate the following benefits:

- A reduction in intervention preparation time (estimated to be about 1 hour per intervention),
- An increased level of safety as the operator's field of view is no longer limited by paper maps,
- A real improvement to comfort and location lead times compared to the previous working methods and the involvement of employees through advanced technologies,
- Faster interpretation of indications by the technicians compared to a maps-based methodology thanks to augmented reality.

Large-scale experiments across 4 towns (Reims, Troyes, Lyon and Saint-Étienne) took place over the end of 2016/start of 2017 to validate the new developments. For the next steps, new advances such as the deployment of SLAM (Simultaneous Localization And Mapping) technology will allow us to continue to improve displacement tracking during the operation and the

precision of cable location, so as to achieve the required level of performance.

Figure 11: Visualisation of underground cables through augmented reality

Although the cable-visualisation tool has not reached the required level of maturity to be deployed operationally, it seems certain that this will be achieved very soon.

CONCLUSION

Several virtual reality-based tools are already being used operationally by Enedis Regional Departments. Others, such as cable fault-location assistance, require improved technological maturity before being able to provide truly effective assistance, but this should be the case in the very near future. Of course, the technologies deployed for these applications are evolving rapidly, and challenge the step-wise approach traditionally applied in the network operator world.

On balance, the feedback for these experimental developments is very positive. The cooperation between a major company and budding young talent proved very stimulating for both parties. The expected reactivity was achieved. Enedis intends to pursue this innovative approach for the experimentation and development of innovative solutions in partnership with start-ups. It represents an additional lever for improving performance complementing both the conventional R&D programme and the traditional relation with the sector's industries. Last but not least, it is a major factor of motivation for the operational teams, via their contribution to the development of innovative solutions that will allow them to improve their performance at the service of distribution network users.