CONTRIBUTION OF AUGMENTED REALITY TO THE MAINTENANCE OF NETWORK EQUIPMENT

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ABSTRACT

Enedis, the main French DSO (ex-ERDF), conducted an innovation challenge opened to start-ups and innovative SME companies in order to detect promising solutions able to support the "next generation field technician". A field test program was conducted with the selected innovative companies with the aim of experimenting prototypes of new tools, and among them tools based on augmented reality technologies focussed on maintenance of equipment and network 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 technician in terms of performance and safety, and then to develop the corresponding operational tools. This paper presents three complementary prototype tools which take advantage of augmented reality to perform maintenance of network equipment 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.

From an operational perspective, these changes are giving rise to new technical solutions in the field, which must be mastered by the personnel. A few eloquent examples can be cited, such as the general deployment of the Linky smart metering system or the massive integration of decentralised production into the network…

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 maintenance activities in the field.

APPROACH CHOSEN BY ENEDIS

Technologies in the telecommunications 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 augmented reality for network equipment maintenance, 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.

INTERACTIVE EXPERTISE IN THE FIELD

The context and the challenges

The "pre-mobile phone" period seems to us like something from prehistoric times. We have forgotten the revolution brought by the mobile telephone in the context of our interventions: fluidity of exchanges, ease of access to an operating manager or a "knowledgeable person", then

access to technical data…. Today, with real-time interactive video solutions, it is possible to go much further in the support provided to the field technician, especially in the event of unforeseen circumstances or new situations. These functions are particularly suited for supporting new recruits in the professions.
Of course, this solution, just like the mobile phone, is simply a tool at the service of performance and safety: it does not mean that the various professional rules may be sidestepped during maintenance interventions.

Experimentation and perspectives

The test is being carried out in two regional Enedis Departments in western France (*Pays-de-la-Loire* and *Bretagne*) with the technical solution provided by the French startup Apizee.
Network technicians from several sites are particpating in the experiments, and have given very positive feedback: it is a true shared diagnostic on the equipment that can be performed, with the support of an expert, which is more precise and reliable because of its visual nature, and enriched via augmented reality by the indication on the image of a point requiring particular attention or annotations.

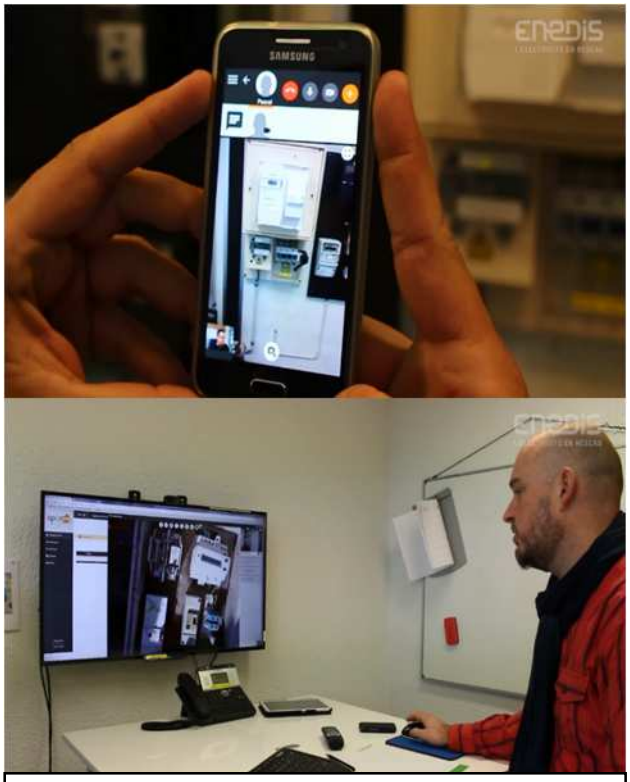

Figure 1 - Video dialogue between a field technician and a remote expert

Furthermore, in addition to the real-time management of a situation, it is possible to save videos taken in the field for re-use in the frame of risk-prevention or e-mentoring initiatives. An important quality of the solution tested is its simplicity of integration into the company's mobile communication systems, and its capacity to remain operational under variable transmission conditions.
The solution has already been adopted by several teams. But it seems certain that this type of solution will become as widespread as the smartphone.

AUGMENTED REALITY IN THE HANDS OF A TECHNICIAN FOR PREVENTIVE MAINTENANCE

The context and challenges

Infrastructure maintenance is defined in a policy implemented by the network operator and is a long-term commitment based on feedback from the field. The quality of maintenance interventions is of fundamental importance in this chain. With the aim of going even further in supporting the efficiency and safety of maintenance interventions through the shared remote diagnostics presented in the previous section, Enedis has committed to the development of new technician support tools taking the full benefit from augmented reality technologies.
The definition, development and experimentation steps were therefore conducted in collaboration with SIREA, an innovative SME 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 maintenance-support prototype solution

At this point, the tool gives access to information and provides support for preparatory operations for the maintenance intervention itself:

- For 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 low-voltage fuses,
  - the manipulation of the low-voltage switch,
  - 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 2: Automated recognition of LV panel type

Figure 3: Assisted recognition of LV panel type

- For locking out MV switchgears of HV/MV primary substations, 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 names and switchgear type).

Figure 4: supporting instruction for the locking out of primary substation MV switchgears

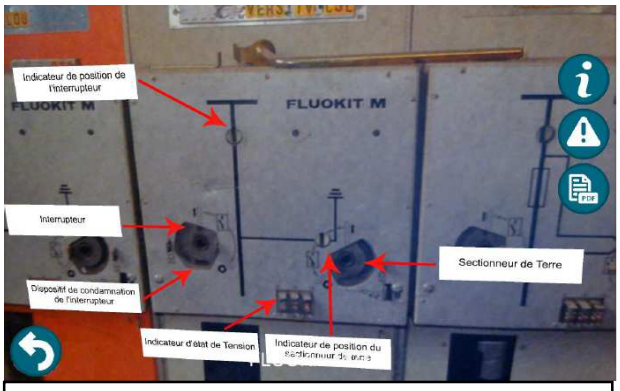

Figure 5: recognition of MV switchgear type in the MV/LV secondary substation

The perspectives

The results obtained are positive and the feedback from the experimenting technicians very encouraging. This is why Enedis has undertaken to extend the scope covered by the tool to include maintenance procedure guides: as the capacity to recognise infrastructures is already provided (type of equipment and geo-referenced position), the aim is now to record, verify, perform and follow maintenance on all infrastructures.

Developments are underway so that the tool can ensure:

- The recognition of parts to be verified, as a function of the maintenance operations to be performed,
- Access to characteristics and maintenance operations procedures up to date,
- Follow-up of “equipment lifecycle” sheets,
- The verification of the completeness of infrastructure databases and their updating if necessary,
- The support of a remote expert using the interactivity possibilities of augmented reality.

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

Figure 6: Typical fault location operation

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 7: Example of an underground network for display

In this frame, Enedis (*Technical Department* 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 8: 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.

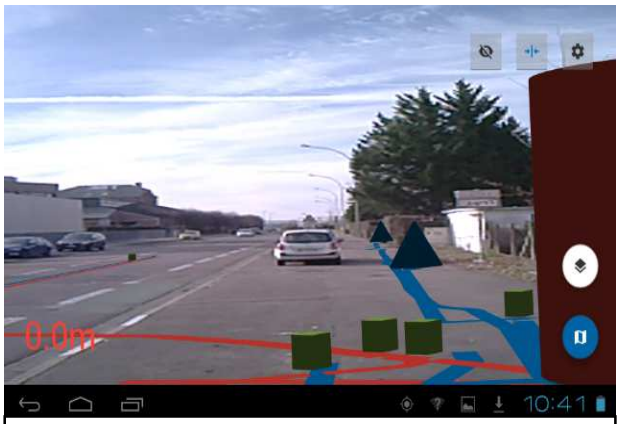

Figure 9: Visualisation of underground cables through augmented reality

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.

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.

CONCLUSIONS

The cooperation between a major company and budding young talent proved very stimulating for both parties. The expected reactivity was achieved: several tools based on augmented reality are already being used operationally by several Enedis Regional Departments. Others, such as cable-location support, require improved technological maturity to be able to provide truly efficient support, but this should be possible to achieve soon.

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. 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.