

## EFFICIENT COORDINATION IN MAJOR POWER DISRUPTION

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### ABSTRACT

*Obtaining the right and up-to-date information is crucial for distribution system operators (DSOs) when coordinating a situation during weather-related major power disruptions. A typical challenge is that the needed information is scattered in various sources, databases and systems. Gathering and delivering the information from the current situation to internal and external parties is very time consuming and inefficient without a very clear and centralized system for the purpose.*

*Situation awareness has understandably a significant impact on decision making and thus also on the overall performance for recovering from a major power disruption. Major power disruptions cause notable consequences for the different parts of society which is nowadays highly dependent on reliable electricity distribution. Major power disruptions have also significant impact on a DSOs' financial performance due to the regulation model which has a factor related to the energy that is not served during the outages. Recognizing the worst affected areas and allocating the sufficient resources for these at an early stage is very important.*

*This paper will present in detail the situational awareness tool which was designed to meet the requirements for the overall situation awareness. The paper will also give practical examples of how the utilization of the situational awareness tool has changed the overall picture in a major power disruption.*

### INTRODUCTION

Finnish DSOs have faced several weather-related major power disruptions in this decade. In recent years, storms Tapani and Hannu of December 2010 have had the greatest impact on Finnish society so far. The storms Hannu and Tapani caused outages for over half a million customers in Finland.

After the two storms the Ministry of Employment and the Economy quickly drafted actions for improving the reliability of electricity distribution in Finland. The new regulations came into force via the Electricity Market Act (EMA) in September 2013. The regulations include a target for improving the reliability of delivery by the end of 2028. EMA has also a requirement for a plan for preparedness and also for the major power disruption management. Situation awareness is a key part of the management in this context. Therefore it was seen as one of the possible development areas and was also decided

to be studied further.

Graphical design and user experience were considered to be important in developing the new tool for situation awareness. The situational awareness tool was decided to be defined and implemented in collaboration with an external service provider – Futurice Oy.

Elenia Oy is the second largest DSO in Finland with 417 000 customers. The total network length is 67 000km and the network reaches over 500km in a north-south direction. 34% of the network is currently built as underground cables as the target for 2028 is 70%. These described facts mean that extreme weather-related incidents will still have a significant impact on overhead lines in coming years.

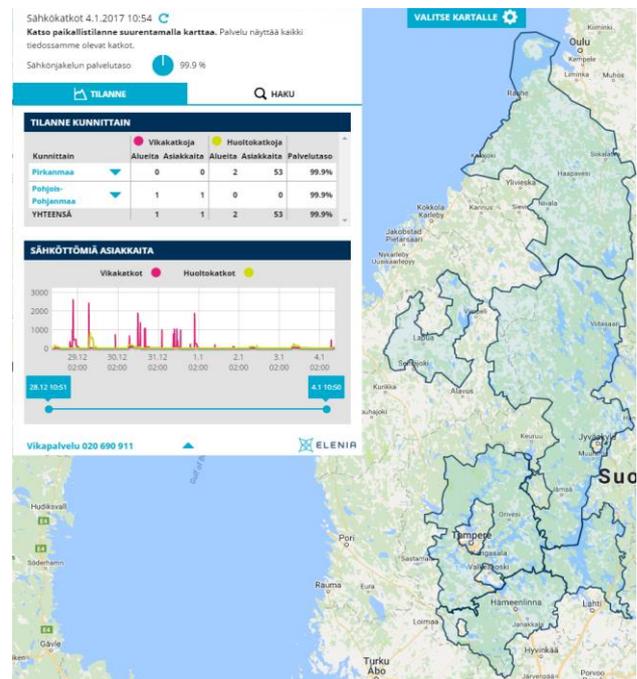


Image 1. Web outage information system

Elenia has developed automated customer outage communications and provides free SMS and e-mail outage information, a web outage information system and a trouble call service including an interactive voice response system. The web outage information system is presented in image 1. With these tools the outage management process can be made transparent to the customers, media and other stakeholders. The situational

awareness tool is aimed to enhance the viewpoint of the DSO's internal users and contractor partners by presenting the background information behind the outage situation.

Weather-related major power disruptions can and have caused hundreds of simultaneous outages. Because of the amount of outages these situations need coordination in the key areas of the major power disruption organization to ensure the right prioritization. Coordination is also very important for the effective use of the existing resources. The situation can change rapidly during a major power disruption and coordinators must be able to notice the significant changes at an early stage.

Situation awareness consists of various sources in a major power disruption. Supervisory Control and Data Acquisition (SCADA) is used for the medium and high voltage network control. Distribution Management System (DMS) holds a comprehensive amount of data related to the ongoing outages and outage notifications. Low voltage network is also monitored in the DMS through AMR meters. SCADA and DMS are cross-referenced together. The challenge is that the data for overall situation awareness is in different places of the DMS and must be constantly processed and analyzed in a separate system in order for it to be up-to-date. This is very time consuming and also inefficient if it has to be done manually and separately by different key area coordinators. [1]

A very important aspect for the situational awareness tool was to design it to serve all the different areas of the major power disruption organization. All the data comes from the same source but it is filtered and stressed in order to meet all the different coordination area information requirements. For clarity the situational awareness tool was designed to have different views for different coordinators. Even though the original data remains the same all coordinators have their own view of the situation which supports the overall situation awareness.

## MAJOR POWER DISRUPTION COORDINATION

Managing and coordinating a major power disruption organization in a multi-function and multi-organization environment with hundreds of persons involved requires a clear situational awareness and understanding throughout the DSO's organization and contractor partners.

Different roles of the major power disruption organization were modeled into the situational awareness tool to highlight the most important decision making information at contracting area level. The roles of the major power disruption organization that were included in the situation awareness tool were general operations management, medium-voltage outage management, low-voltage outage management, management of outage notifications and field resource management.

The situational awareness tool is a powerful system for

managing the overall situation from the operations management perspective. Information describing how a situation is developing is presented on the left side-side of the map and visualized with different shades on the map. Map view of the situational awareness tool is presented in image 2. Information includes critical bottlenecks like outages that have not been isolated by remote control, the total number of medium- and low-voltage outages, amounts of workgroups needed for medium- and low-voltage outages, number of fault notifications. All of these are presented at contracting area level, making it easy to see in what areas special focus and actions are needed.

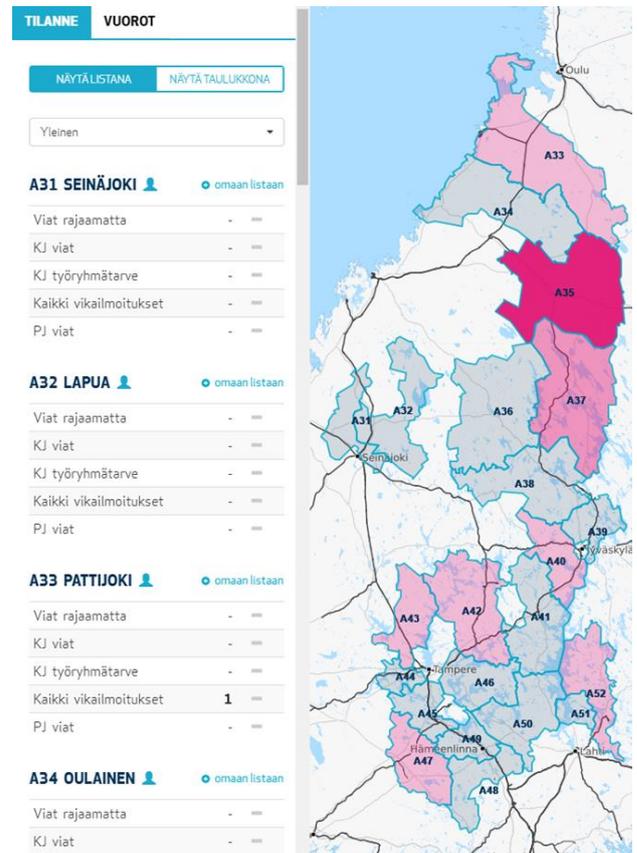


Image 2. Map view of the situational awareness tool illustrating Elenia's network area and different contracting areas

The medium-voltage outage coordination is responsible for isolation, restoration and repairing for both high- and medium-voltage level outages. It is notable that the biggest impacts for DSOs, customers and society are caused by the numerous medium-voltage outages in a major disruption situation. Effective prioritization and handling of the medium-voltage outages is very important. Equally important is to be able to recognize the rapid changes in the number of medium-voltage outages which are characteristic in a major power disruption.

Low-voltage outage coordination is responsible for fault notification management, restoration and repairing of

low-voltage outages. For low-voltage network the outages have been divided into two criticality categories in the DMS to prioritize outages that are causing safety risks.

Resource Management is responsible for the overall management of the contractor partner resources in the field. For example the amount of the resources available should be in proportion to the current fault repairing situation. Resource Management works in co-operation with contractor partners by relocating resources from one area to another when necessary. Allocating the resources to the most critical outages and outage announcements according to prioritizing is vital as well.

## **PARTNERS AS A PART OF THE COORDINATION**

Elenia purchases all of its electricity network construction, maintenance and fault repairing services. Elenia manages this contractor environment with different kinds of agreements. These agreements include that all the Elenia's contracting partners are obliged to carry out fault repairing in weather-related major power disruptions. For example during stormy weather conditions a variety of contracting partners are able to offer a significant amount of electricians and woodcutters working on the field.

One of the most important contracting environments is the Annual frame agreement for Regional Contractor Partners (RCP). Elenia's network region is divided into 20 geographical contracting areas. RCPs are mainly responsible for the regional fault repairing and the cooperation model.

The main purpose of the RCP's cooperation model is to make better use of the RCP's understanding of the local environment, their knowledge of the needed machinery and the qualifications of the personnel. The model aims for efficiency by giving more responsibility to the RCPs regarding the coordination and resource management in their own areas. The idea is to optimise fault repairing by directing the right equipment and staff to the fault locations. [2]

The situational awareness tool enables the sharing of the processed status information between the RCPs and the other contractors in real time and in an integrated manner. The sharing of the processed information enhances the RCP's ability to coordinate resources. For example the situational awareness tool enables the RCP's foreperson and the coordinator to see at a glance the current fault situation in their responsibility areas and the other areas' situation as well. This enables to use more efficient resource management in cooperation with Elenia's Control Centre including the transfers of the resources from one area to the other.

## **DESIGN AND CONTENTS OF THE OUTAGE COORDINATION MAP**

Futurice Oy is a digital consultancy company focusing on building new digital services and helping their customers

to succeed using their Lean Service Creation methodology. Currently operating in Finland, Germany, Great Britain and Sweden, the company employs over 300 people representing almost 30 different nationalities. The company also has a long history working with energy companies.

## **Technologies and project preparations**

Technologies used for the situational awareness tool include modern web development technologies such as Node.js, Leaflet and React. For security reasons, service is hosted inside the DSO's own network, but it is possible to host everything also on a cloud platform.

Implementation project started with a service design study and user interviews. The aim was to find out which kind of key roles Elenia has for people who are part of the major power disruption organization.

Futurice organized an internal planning meeting known as ExEx (Expert Exchange) where technology options for this kind of platform were discussed. The main purpose was to find scalable technologies which would support the future needs of Elenia and potentially very large amounts of data related to future development of the tool. The situational awareness tool was designed so that fetching the data from multiple sources (such as weather and GPS data) is possible in the future, even if in the beginning there is only one data source.

Users of the service were determined to be mainly desktop users, so enabling mobile use was not a priority. The amount of data in the service is challenging for small screens and requires further design efforts to determine what part of it is relevant for mobile users.

The situational awareness tool's backend makes queries to the DMS database every 30 seconds. This makes the situational awareness tool's data in practice real-time. Users of the situational awareness tool are working with this cached data, so they will not create any load to critical systems like DMS with individual database queries.

The backend of the tool stores all the changes in data in its own database. This enables the DSO to go back in time to see when something interesting happened. Currently browsing the history requires knowledge of SQL queries, but it's possible to create simpler interface for non-technical users.

Changes in different key figures are also highlighted in the situational awareness tool with symbols and numbers stating how a value has changed during the past 60 minutes – did the number go up, down or stayed the same. With this feature the coordinators can make decisions in which area they need to put more effort.

The situational awareness tool has several predefined algorithms that calculate the severity of the incidents for each contracting area. It is notable that there are no predetermined levels for severity. Severity is in other

words totally scalable and it is determined to an area after comparison with other areas. The most critical areas are highlighted on the map view in dark red. Different user roles have different criteria for the calculations and switching from role to role changes the map's view accordingly.

There are two different versions of the map available depending on whether a user is an internal DSO person or an external contractor.

The user interface is split into three different views: situational view (can be viewed as map or a filterable table) and shift planning. The situational view has multiple different sub-views which provide relevant data for different coordination areas and change how, for example, severity is calculated for an area.

**Situational view**

Map view enables the user to select areas of his or her own interest as favourites and the selection highlights them on the screen. Clicking an area on the map shows specific information for the area as a popup-type box and the same data can be viewed also from the sidebar located on the map view's left side. This function is presented in image 3. Changing the major disruption organization role is done by using a dropdown box and changes are reflected immediately on the map and tables.

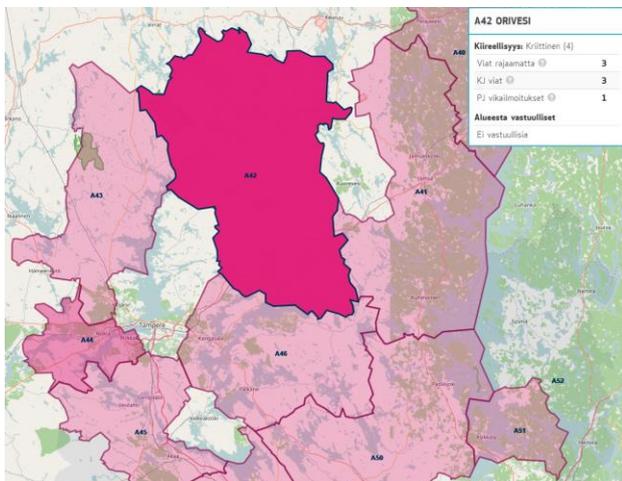


Image 3. Close-up of situational view, area 42 selected and showing details in a hovering info window.

The table view gives a more detailed look into the figures and it can be filtered by clicking the column titles. The user can also see the chosen favourites only, or select a specific contractor partner to focus on all the partner's areas. The data can also be exported in Excel format. The table view is presented in image 4.

Image 4. Table view

**Shift planning view**

Normally Elenia as a DSO does not require any kind of workforce management in a way which would require shifts to be planned. This is normally the job of a RCP. However, during major power disruptions, shift planning becomes essential for DSO to work efficiently.

The shift planning view presents the information about a person's role and also which contracting areas he or she is responsible for. The shift planning view has several purposes:

1. To provide a centralized tool for the DSO's coordinators to plan and log the work shifts of the major disruption organization. This is important as major disruption situations can last several days or even weeks and the number of personnel on a shift can be very high.
2. To provide the collective shift information for the DSO's personnel. The information is crucial for personnel arriving to their shift and also personnel on the shifts. The collective and up-to-date shift information helps the personnel to perceive who is responsible for a regional contracting area. It has been noticed that the shift and responsibility area changes can be effectively informed with the shift planning tool.
3. To create overall transparency at the DSO so everyone can see who is currently working with the specific area or in the specific role.

The shift planning view shows personnel currently on a shift and a planning tool for the next shift. The current area responsibility data is also available in the map view. When a new shift takes over, single "start shift" button activates all prepared people and ends the previous shift.

All the data is stored on the situational awareness backend so it is possible to later go back and see who was handling which area during some specific time. Currently browsing the history requires knowledge of SQL queries.

## RESULTS FROM UTILITY OF THE OUTAGE COORDINATION MAP

The situation awareness tool has been piloted in a real major power disruption and also in smaller disruption situations that have required separate coordination. The most significant major power disruption situation with the use of the situation awareness tool has been the low pressure storm Rauli in August 2016. The storm Rauli caused outages for 96 000 Elenia's customers.

Overall and detailed situation awareness has improved with the situation awareness tool. With the designed visual approach it is very easy to recognize the worst affected areas. At the same time it is now much easier to recognize significant changes in different coordination areas than before.

Time spent on data gathering and processing has been reduced significantly. The coordinators have now the tool that compiles the needed practically real-time data from the DMS. This enables the coordinators to constantly analyze and compare the situation in different contracting areas and also make important decisions accordingly.

The coordinators must cooperate during a major power disruption. With the situation awareness tool it is easy to check the situation from another coordinator's point of view. This has been considered to be very effective since issues can be discussed in cooperation before they possibly create a problem in some specific coordination area.

RCPs are also a user-group of the situation awareness tool. The RCPs have the same centralized view of the current situation as the DSO without time consuming data processing. This has especially helped the partners to create situation awareness with their own contracting areas. The feedback of the situation awareness tool has been positive and it has been considered to be effective and easy to use.

The overall experiences in utilizing the situation awareness tool have been very promising. Due to the experiences gathered, it has been decided that the situation awareness tool is to become a standard application for both the DSO and partners in major power disruptions. The situation awareness tool is in operation all the time and ready to be utilized by any authorized user at any time.

## SUMMARY

In 2016 Elenia and Futurice initiated a development project concerning operative situation awareness in major power disruptions. It was defined that a separate tool must be developed for this purpose.

The project's deliverable was the situation awareness tool which can be used with a web browser. The situation awareness tool gathers in practice real-time data from the DMS and presents it in a compressed and targeted way to the user. The situation awareness tool contains different views for different major power organization

coordinators. The base data remains the same but it is filtered and stressed differently depending on what coordination area is the case.

The situation awareness tool has enabled overall transparency in key coordination areas during major power disruptions. It has also made decision making more effective with recognizing the worst affected areas and rapid changes at an early state in the ongoing situation.

The developed situation awareness tool has resulted more efficient major power disruption coordination and also more efficient use of the existing DSO's and contracting partner's resources. Development project has resulted more efficient major power disruption management. This means shorter outage times for customers and hence reduced operative and regulatory costs for the DSO. A development project for a second version of the situation awareness tool has been initiated.

## REFERENCES

- [1] K. Pylkkänen, T. Ihonen, "Managing Situation Awareness in Power Disruption Grid Disturbances", *The 23<sup>rd</sup> International Conference on Electricity Distribution (CIRED)*
- [2] T. Ihonen, T. Kupila, T. Keränen, "Development of Major Power Disruption Management", *The 2016 International Workshop on Electricity Distribution (CIRED)*