DISTRIBUTION NETWORK AERIAL PHOTOGRAPHING BENEFITS IN PRACTICE

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ABSTRACT

Maintenance inspection has an important role for distribution network companies. Inspections should be homogeneous and cost-efficient, and, at the same time, additional values should be created where possible. Elenia Oy has made use of an aerial photography system for its overhead line medium and high voltage network. Clear benefits and additional values are observed with the technique. This paper presents experiences and benefits that Elenia has gained from this. Aerial photography is a more cost-efficient inspection technique than traditional walking inspection, and it offers additional values of scale for the Elenia organization and its partnership network in a variety of areas.

INTRODUCTION

Using maintenance inspection results is a challenge for every large distribution system owner (DSO). Data gathering, quantity, quality, and upkeep are most important for the efficiency. The role of inspection results is increasing, especially in relation to future trends like a large reconstruction period for the old distribution network. [1]

A common way to make initial inspections in overhead line networks is by walking. Inspectors go pole to pole and record observations of (remarks about) the object. This technique is time-consuming and expensive, so the sequence of inspection can last six to eight years in a distribution network [1]. Also, inspection results are based on the inspectors' subjective opinion, which can vary between inspectors. These results support maintenance actions and investment planning, but other benefits are hard to find.

A second common way to do inspections is by helicopter with an inspector inside. With this technique, inspection is made visually from a helicopter and remarks recorded with the gps-system to a computer or using paper maps. This inspection technique is quite expensive as helicopter speeds cannot be high, normally 20–40 km/h, which means more flight hours and correspondingly higher costs. Additional value cannot be seen, although the inspector can take images for work planning. Still, photographing by an inspector is complicated because of issues with image quality, the large number of photos required, and the identification of manual images of photographed network components.

Elenia Oy, formerly Vattenfall Nordic Distribution Finland, is the second largest DSO in Finland, operating over 60 000 km of electricity distribution network. Now, Elenia Oy (henceforth, Elenia) has tested alternative inspection techniques for greater efficiency in operations. Elenia started the pilot project for aerial network photography with Visimind AB (henceforth, Visimind) in 2006. After the pilot, Elenia decided to inspect the whole medium voltage overhead line network, totally 22 000 km, using the Visimind aerial photography technique during 2008–2010. Nowadays, aerial photography is an everyday tool in Elenia and included in the maintenance program. This paper presents some experiences and results of aerial photography from the Elenia operations.

SYSTEM DESCRIPTION

The Visimind aerial photography technique is based on a helicopter with a PC, GPS or GLOSNASS system, high-class optics cameras, and a laser-scanner [2]. The helicopter navigates over the electricity lines taking high sequence images while scanning the area with a laser. Navigation is based on network data delivered by the DSO. There is no traditional network inspector in the helicopter, just the pilot and system operator, who operates the cameras and navigates through the network. As there is no need for a manual optical inspection, the operation speed can be high. This reduces the costs, since flying expenses make up the main cost of the presented technique. It should be noted that operating speed only can be maintained in medium (10kV or higher) or high voltage network. In low voltage networks (0.4kv – 1.0 kV), helicopter speed becomes too low for cost-effective photography.

After the data is gathered, it is saved to hard drive and some post processing performed. Then, after post processing, the data is ready for viewing. With Visimind DPM software, one can fluently navigate through a distribution network and see network components on the monitor. [2] The laser material is also available for viewing and making measurements.

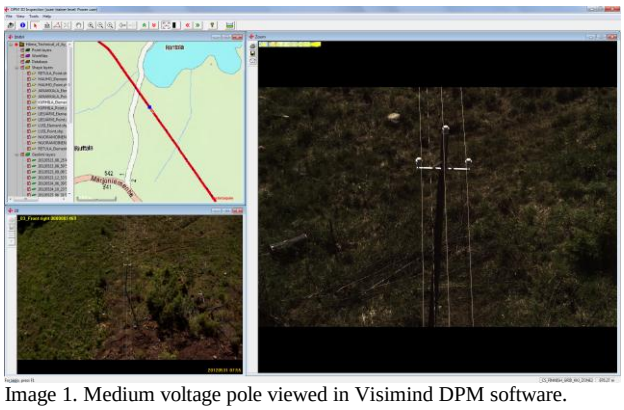

Image 1. Medium voltage pole viewed in Visimind DPM software.

Elenia has four different kinds of images and a laser scan in system. The images consist of 1) a general view from the line corridor area as in the image 1 above, 2) front high resolution image of components as in the image 1 above, 3) back high resolution image of components, and 4) a 3D-image created from two general views. The laser scan material gives point cloud information, enabling network viewing and measurement, for example between the line and structures as in the following image 3.

These images and the laser material are used for maintenance inspection. Inspection can be made in office conditions using a modern computer with large screens. Elenia has a file-based interface between the inspection program (Visimind DPM) and its own network information system NIS (TeklaNIS) as in the following table 2. The NIS network component data and topology can now be transferred to the DPM, and inspection remarks can be directed to a unique component instead of an x,y coordinate.

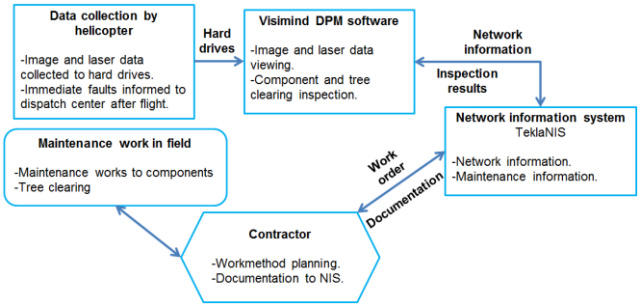

Table 2. System integration and process.

EXPERIENCES OF SYSTEM USE

The aerial photography inspection results diverge somewhat compared to those of walking inspections. The number of top-side remarks is higher. A significant number of nearby distance markings are noticed. Especially, the level of secondary substation isolator breaks observed is much higher than that derived from the traditional walking technique. One of the most noteworthy outcomes is the homogeneity of inspection results. With aerial photography, inspection does not require more than a few inspectors so inspection is made with only a few different human perspectives leading to little subjective deviation between inspection analysis and greater comparability of results across networks. This is apparent from comparison of results with those of walking inspections, which show a greater, thus suspect variance between inspectors even when the inspected network is very homogeneous.

One must remember that inspection based on aerial photography can be performed very quickly and therefore a lot of maintenance data becomes rapidly available for planners and decision makers. This means that a re-planning of the company maintenance program is necessary. Elenia reorganized its maintenance program based on aerial photography after the pilot and a three-year photography program. The previous six-year inspection sequence was changed to a four-year one for medium voltage networks. This means that Elenia will photograph 7 000 km per year of medium voltage network, with appropriate maintenance actions ordered within half year of flights (data collection). Actually, process can be even faster in case of Elenia but it needs efficient data transfer and strong project leading. Elenia has experienced aerial inspection results very useful and inspection quality validation can be done easily with quite many checkpoints compared to walking inspection results which quality assurance needs site surveys.

Aerial photos are not only used for component inspection. With used the Visimind DPM-system it is possible to print the photo file from the remark-image with the necessary information to the attachment in the work order. This helps external partner work planning. From the photo file, it is easy to analyze the environment of the maintenance target, for example is there a road for the crane truck nearby.

Elenia and Visimind have also developed tree-clearing inspection techniques during their cooperation. Nowadays, Elenia performs a separate tree-clearing inspection based on the images produced. This inspection is not only made for single line parts since it is possible to do it for several line parts with linear remark markings. Inspection is also broken down into several categories, including branches, underline vegetation, and corridor width. Traditionally, tree-clearing is performed with a time-based plan but the technique Elenia's using can be directed to needs-based tree-clearance. All the tree-clearing inspection results are transferred to NIS where a maintenance planner can execute the analysis and prioritization for network tree-clearing. On account of the comprehensive knowledge of tree-clearance needs gained, together with that of the network and also customer information, one easily can direct major maintenance actions like machine- or helicopter tree-clearances to most necessary areas.

The one of the biggest benefits derived following implementation of the Visimind system is related to daily use of the DSO. Elenia has an extremely centralized organization with a wide network area resulting in high expectations of the system and its uses. Even so, Elenia has been surprised by the utilization rate of the Visimind DPM by its personnel. Connection and reconstruction planners use the system daily in network planning, operators use it for operational planning and technical customer service likewise. In most cases, the benefits that can be gained include better or more ready network plans, improved customer service, less wide planned interruptions, and better analysis of most probable fault locations. Also there is a reduced need for company employees to travel or site survey.

There are some challenges and striking issues also. It is to be noted that with the technique presented there is no possibility of rotten pole inspection. The unique markings of components are difficult to see and inspect. Therefore, walking inspections are needed in places where these issues are present, but still not with a very high frequency if used in combination with aerial photography. Based on Elenia's experiences, one must plan to carefully interface any aerial

photography system with the individual network and maintenance system.

TECHNIQUE DEVELOPMENT AND FURTHER STUDY

Elenia is concerned to develop the aerial photography system to provide increased efficiency in network maintenance and operations. Currently, there are three different aspects of this being developed.

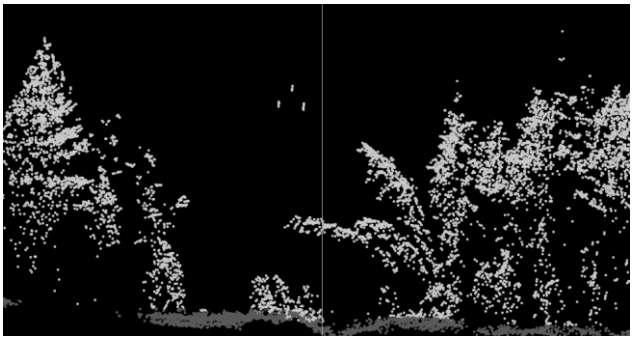

Image 3. Line corridor view.

First, tree-clearing inspection should be made fully automatic based on laser scanning data as in the image 3 above. When performed automatically from laser cloud, there is no subjective variation in results and algorithms can analyze the precise line parts that need to be tree-cleared. Algorithms could have growth models, danger distance estimation, and environment information. [3] Elenia sees that in overhead line networks, this new technique could give substantial benefits in terms of fewer faults and planned interruptions because tree clearing can be planned more carefully.

Second, one development idea is that of making aerial photos available to contractors. Elenia has now outsourced all of its network construction, maintenance, field service, and fault repair. For every separate action, Elenia has a fixed unit price. If Elenia can share the collected aerial photos with its partners in the future, they can benefit from the images in their everyday operations, which, in the future, will probably slightly reduce certain fixed prices . This will also have some environmental benefits, since the need for site visits decreases as network structures can be observed directly from the images. Also, plans for construction and maintenance jobs are improved as the network can be viewed while making the plans.

A third development idea is around concerns the creation of a single system. Elenia sees that integration of Visimind DPM with DSO's NIS is required for efficient and easy daily aerial photograph viewing. There is no need for two separate systems to do the same things to survey the same object. After integration, a "Visual NIS-system" may be established, in which one sees both the network information and object image in one window. The benefits of this can be calculated as time saved by (both sets of) system users. Also, the use of images through different mobile solutions is being investigated.

CONCLUSIONS

Elenia has been taken a major step by including aerial photography inspections in its maintenance program and employing it as an everyday tool. The decision has been seen as correct. If a DSO company structure is centralized or has a large overhead line network area, obvious benefits are present. Already, the combination of aerial photography and inspection from images is probably more cost-effective than walking inspections, and also the inspection quality can be observed. When notifying additional values, such as laser-based tree-clearing inspection, work planning, and no need for site survey, one can see the aerial photographing is a tool of great potential tool for DSO (appreciating the limits of bird's eye view inspections).

National interest around aerial photography is increasing all the time. More DSOs are using aerial photography as their maintenance inspection tool, and new developments around the technique are ongoing. Therefore, Elenia sees that in the future aerial photography will become standard for maintenance inspection.

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