A MOBILE APPLICATION FOR ON-SITE RISK BASED DECISION SUPPORT

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ABSTRACT

Maintenance and renewal decisions are essential parts of distribution system asset management as means to control cost, performance and risk.

This paper reports on the development of a mobile application used for in-the-field decision support concerning maintenance and renewal in the distribution grid. The application contributes to a more consistent and time-efficient decision-making process; from findings on field inspections, to risk informed decisions implemented as work orders in the DNOs workforce management system.

INTRODUCTION

Electricity distribution companies are facing the challenges associated with managing a generally ageing infrastructure, using the principles of *asset management* as guide for their activities, [1], where *risk* is a key issue, together with *overall cost* and *performance*.

There has been developed theoretical frameworks which address how to include risk in the network maintenance and renewal [2] – providing a basis for systematic differentiation between network components due to different probabilities for and consequences of undesired events, covering a variety of risk categories – e.g. economy, safety and environmental impact [3, 4].

Still, it is a challenge for distribution companies to make the theoretical risk based principles for asset management operational in everyday practical management of the grid. To achieve this, it is important to make risk based decision support tools available to in-field workers, doing the practical inspection and condition assessment of the thousands of components in the grid.

To deal with this challenge the Norwegian distribution company, TrønderEnergi Nett, and the software solution provider, Powel, are developing a mobile application to make the risk based decision framework available for field use. SINTEF Energy Research, a research institute having worked with these topics together with Norwegian distribution network operators (DNOs) over a long time, assists the work.

The aim of the mobile application is to make a user-friendly tool, but which still is consistent with the overall risk-based principles of the distribution company's asset management policy. The tool contributes to a more consistent and time-efficient decision making process, from findings on field inspections, to risk informed decisions implemented as work orders in the DNOs workforce management system.

This paper describe the overall framework that lies behind the concept, and show how this is implemented in the mobile application. The paper also comments on how the application will contribute to the DNOs maintenance management process, and show examples from the user interface of the app.

BACKGROUND

Risk management

In [5], risk management is defined as *coordinated activities to direct and control an organization with regard to risk*, stating that risk management generally includes the sub-processes:

- Risk assessment,
- Risk treatment,
- Risk acceptance
- Risk communication.

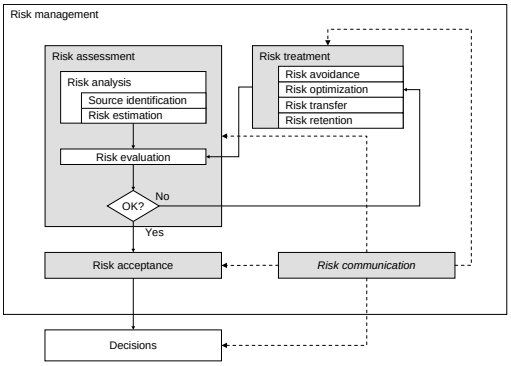

Figure 1 - Risk management process - based on ISO/IEC 2002 [5]

The concept of the mobile application mainly emphasises the sub-process of *Risk assessment*.

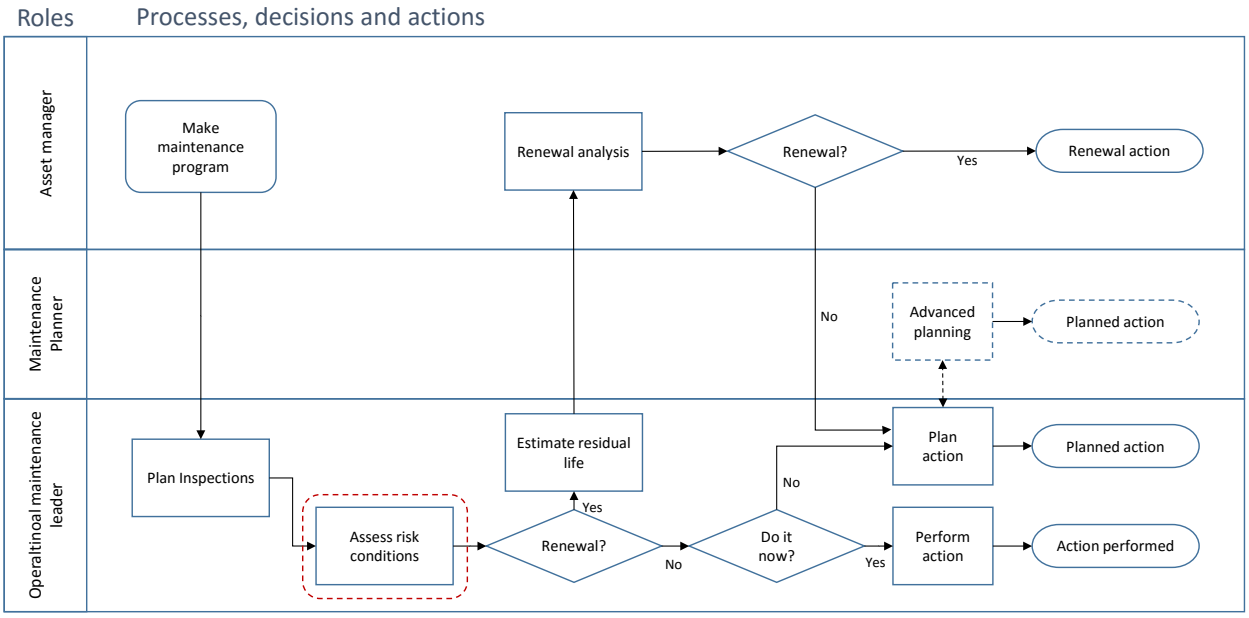

Figure 2 - General process of maintenance management at TrønderEnergi Nett

Risk relates to future events and their consequences, [6]. Risk analysis is relevant in most decision situations since by assessing risk, we seek to look into the future and to this insight to make robust decisions.

The essence of "What is the risk?" for a given process or activity can be captured by answering a triplet of questions [7]:

- What can go wrong?
- How likely is that to happen?
- If it does happen, what are the consequences?

The answers to these three questions will give a picture of the risks. The questions are quite simple, but the answers are not straightforward – see e.g. [2].

To make the general concept of risk practically applicable, simplifications and adjustments have to be made – without compromising the validity of the risk assessments made. This has been given much attention in the development of the mobile application.

Supporting the maintenance management process

The mobile application is designed to support the general maintenance management process at TrønderEnergi Nett through as illustrated in Figure 2. The different parts of the process are as follows:

Make maintenance program
This process consists of making the overall maintenance program for the grid assets based on a risk-based approach, [3].

Plan inspections
This process deals with planning the field activities. This includes planning the order of inspections, considering repair and other activities to be executed simultaneously, providing crew and equipment for execution and informing about planned outages.

Assess risk condition
This part addresses the identification and evaluation of conditions that represent a risk, e.g. when doing the inspections on e.g. a MV/LV substation. **The mobile application mainly supports this field activity**, through providing access to predefined and standardised risk conditions, gathering relevant risk parameters and compilation and calculation of risk level.

Estimate residual life
This part of the process deals with doing a qualified estimate of the useful remaining life of network assets, in order to decide whether further maintenance or renewal is the way forward.

Renewal analysis
When identified as a candidate for renewal, the renewal analysis will be a more thorough investigation (evaluating different risk conditions) to decide to go further with renewal or to continue on the maintenance loop.

METHODOLOGY

To make the task of risk assessment manageable in field-work, the task has been aided through establishing a database of predefined risk conditions fitting the different

classes of network assets in the MV distribution network. This work has been done involving relevant experts from the DNO to benefit from their experience and knowledge.

Figure 3 shows an example of the hierarchy of risk conditions for inspections of MV/LV substations.

Control point level 1
0 General
1 Access and building
2 MV installation
3 LV installation
4 Transformer
5 Signs and marking
6 Earthing
7 MV Discharger
8 LV Discharger

Control point level 2
21 MV Switch
22 Cable termination
24 Termination
29 Miscellaneous

Risk conditions
221-Cable termination – Oil leakage
222-Cable termination – Oil level
223-Cable termination – Visible damage
224-Cable termination – Discharges
Non standard - Describe

Figure 3 - Example: Control point hierarchy of standard risk conditions for MV/LV substations

The mobile application supports a number of relevant consequence categories, acknowledging that the risk based decision is a multi-consequential decision problem, [1, 3].

The selected consequence categories are:

- Health and safety for own personnel
- Safety for the general public
- Interruptions of supply
- Environmental impact
- Reputation
- Voltage quality
- Economy

Each of the predefined risk conditions have also a predefined consequence category profile attached to it, as illustrated in Figure 4 for the risk observation of discharges in a cable termination. *Interruption of supply* is considered the predominant consequence category.

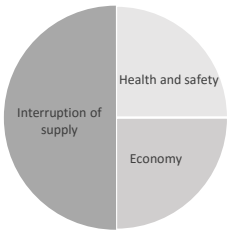

Figure 4 - Consequence category profile for discharges in MV cable terminations

The predefined consequence category profile can be overruled by the inspector in the field, if she considers it appropriate.

For MV/LV substations, approximately 100 standard risk observations have been predefined, and made available in the database of the mobile application. For MV overhead lines, a similar number of standard risk observations has been found. Figure 5 show how the risk observations for MV overhead lines are categorised with regards to the consequence categories (the sum exceeds 100 % since many of the observations have more than one consequence category attached to it).

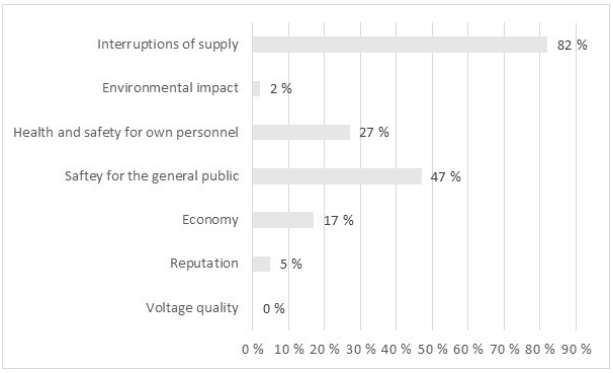

Figure 5 - Distribution of consequence categories for standard risk observations for MV overhead lines

Figure 5 shows that interruptions of supply and safety for the public are the most common risk conditions.

The following example illustrates how the risk model is applied when inspectors are using the mobile application to enter a new observation. The estimated risk level for a observation is based on data in the risk model for the selected component and its standard risk observations.

Examples from the application:

Figures 6 – 8 show examples of user interfaces from the mobile application.

Figure 6 - Example of user interface – entering risk condition

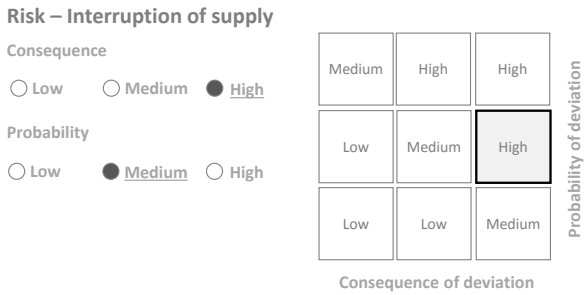

Figure 7 - Example of user interface – predefined Consequence and Probability – and risk

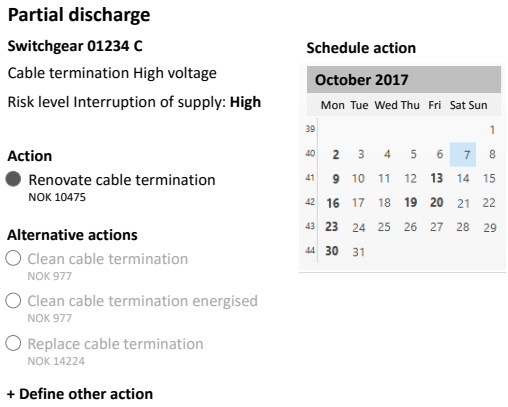

Figure 8 - Example of user interface – predefined actions and scheduling to address identified risk condition

System architecture

The mobile application interacts with the risk database, and a back-office Network Information System (NIS), as illustrated in Figure 9.

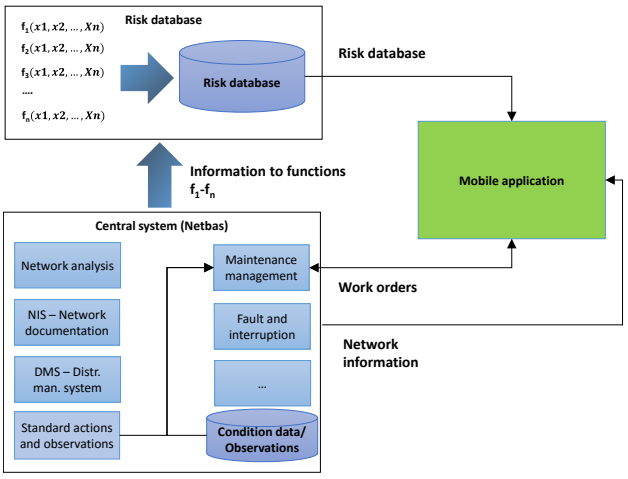

Figure 9 - System architecture: interaction between Mobile application and central systems

The functions f_1 to f_n represent mathematical functions that calculate different parameters in the risk database.

The *risk database* provides all risk data and the NIS provides network information needed, such as asset data and relevant maintenance data (e.g. observation history and maintenance plans).

CONCLUSIONS

The mobile application will be operational in 2017, and will support the everyday maintenance processes at TrønderEnergi Nett.

The benefits from using the mobile application can be divided into three categories:

- Benefits from risk awareness and differentiation,
- Benefits from standardization
- Benefits from the "mobile app" aspect.

Better risk awareness and differentiation in decision-making will lead to:

- Consistent prioritisation and differentiation of maintenance and renewal activities so that effort is systematically canalized towards high risk deviations
- Targeted risk-reducing actions: For example if the risk has to do with personnel safety, the solution to a problem might be to avoid personnel to come close to a component, and not actions to improve the condition of the component.

Standardized processing of risk conditions and remedial actions will give:

- Similar decisions among decision makers in the distribution company
- Awareness and control of risk exposure on company level
- Productivity improvements due to less time spent in processing maintenance decisions

The mobile application will make it possible to support:

- Decision-making and planning in the field (which previously used to be office activities). Hence, there will be productivity improvements through fewer people involved in the processes.
- Repairs immediately due to decisions and planning in field.

The mobile application will hence make it possible for TrønderEnergi Nett to take full advantage of the work that has been done through establishing their framework for risk based maintenance and renewal management.

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