DEPLOYMENT OF SMART SUBSTATION STANDARD IEC 61850

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ABSTRACT

To fully benefit from the value offered by IEC 61850 the standard has to be applied in a context where all aspects are considered. Vattenfall Distribution Nordic therefore initiated a project to define and prepare the implementation of internal processes for deploying IEC 61850 as the primary enabler for smart substations, and to compile a strategy for substation projects. The outcome includes several parts; a process description and implementation of deployment of IEC 61850, a review of tools and other work environment devices for the complete life-cycle, definition of standard functions that a smart substation shall include and definition of interfaces to Vattenfall system architecture. The results have been incorporated in an updated technical guideline and in a specification of a substation automation project. The next phase includes a test of the new strategy and processes using state-of-the-art IEC 61850 solutions in a pilot installation in Upplands Väsby 70/20 kV substation in Stockholm to verify the results in close corporation with the SAS supplier. As results from full deployment of IEC 61850 this paper gives an overview of how IEC 61850 affects different aspects of substation automation projects and how the evaluation of this pilot project including novel protection and control functionality is conducted.

INTRODUCTION

IEC 61850 is an important part of any technical solutions for the future substation automation systems, including totally integrated protection and control. To be able to specify, procure and operate with optimal functionality and maximum cost efficiency, internal competence/know-how and processes needs to be developed. Vattenfall initiated a project to define and prepare the implementation of internal processes for deploying the IEC 61850 standard as the primary enabler for smart substations, including a strategy for substations and a specification of a pilot installation.
The content of the deployment phase is to test the new processes and the strategy for IEC 61850 on a pilot substation.

THE TEST OBJECT

The selected project involves refurbishment of a 70/20kV substation in Upplands Väsby. This station, ÄT89 Upplands Väsby, includes two incoming 70 kV line feeders, one three winding 40 MVA 70/20/10 kV transformer (T3), one two winding 40 MVA 70/20/10 kV transformer (T2). The medium 20kV switchgear consists of two outgoing feeders and the 10 kV switchgear consists of a number of outgoing feeders belonging to a second network company.
To ensure a deep engagement from the supplier to fulfill the demands so that Vattenfall will get the most out of this project the pilot is performed as a cooperation project between Vattenfall and a selected supplier. The contract for Upplands Väsby substation was signed end of 2012 and the commissioning is expected summer 2013.
A visual project model has been created to clarify the responsibilities of different activities between Vattenfall and the vendor in the pilot project. The project is divided in eight steps and for every step there is a main responsible part (either Vattenfall or the vendor). See Figure 1.
The requirements and steps that are special for the pilot project are:

- The list of data signals that shall be available internally in the substation and to the control center as part of the requirement specification also defines the corresponding IEC61850 data objects.
- The functionality, scope and interface of the tools have to support easy use and export/import of specifications, configurations and definitions.
- The SCD-file shall contain all documentation of the system and preserve the substation data from the SSD-file.
- The system integration shall be made in close cooperation by all parties involved and shall be verified in two steps with the suppliers tool as well as with a third party tool.
- Tools for the different phases and tasks have been selected, and templates and standard test procedures will be developed.
- Special emphasis is put on the visualization of the documentation data, both IEC 61850 data and other data. To be used for the first order headings.

VERIFICATION AND VALIDATION

A separate evaluation project has been set up to follow-up and analyse the results of the project, and to verify expected benefits and and also to validate the decisions made regarding functions, processes, tools, technical design and procurement strategies. This evaluation is done in parallell to the the delivery project where experiences and results are continously collected. A third parallell activity is the ongoing development and deployment of business processes, where the results from the evaluation is continously fed into the development process.

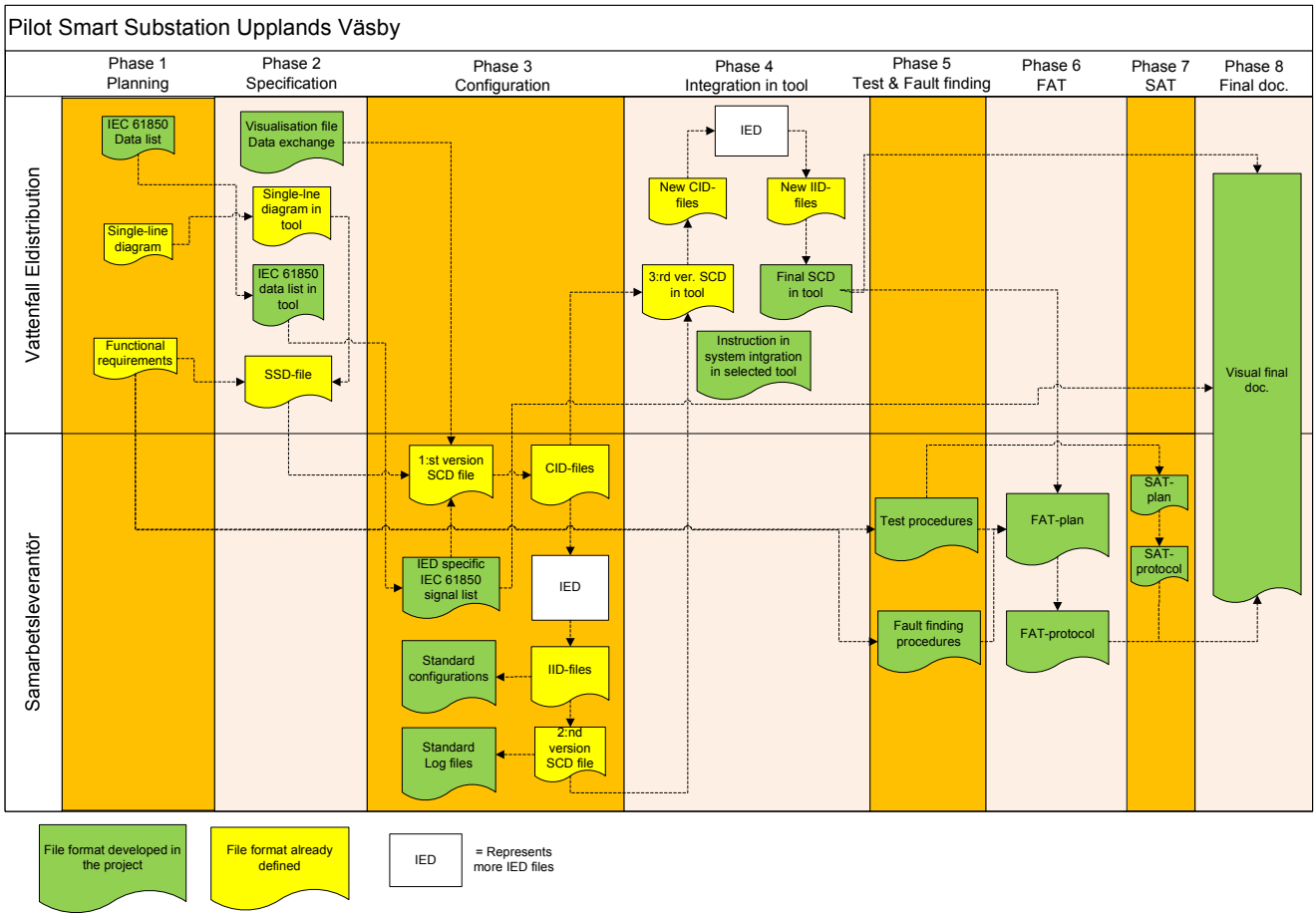

Figure 1 – Overview of the complete pilot project

TOOLS

In order to manage digital substation automation systems during their complete lifecycle, from planning until the station is taken out of order, different types of tools are needed. The following tools are of special interest for the utility and the system operator:

- Specification tools to handle Substation Specification Description (SSD) files
- Configuration tools for maintenance, upgrade, extension, etc. (SCL files)
- Test equipment and tools for communication and protection functions
- Analysis equipments for disturbances, power quality, etc.

IED tools are outside the scope because the customer cannot influence the choice of them. A supplier that delivers the substation has his own IED-tool. [2] provides an overview of the various tool-based tasks that will appear over the life-cycle phases of an IEC 61850 based substation. The flows of SCL files is described during all phases of a substations life cycle to illustrate how IEC61850-based DSAS should be handled. The focus is not on the contents of SCL-files, but the tools to handle these files and how the exchange of the files between tools should work. Due to the wide diversity of requirements, a common tool for the complete life cycle will be neither reasonable nor commercially feasible. But regarding IEC 61850 based substation automation systems, at least all system level tools for the different phases have to be applicable for multi-vendor systems.

FOLLOW-UP AND EVALUATION OF WORK PROCESSES AND ACTIVITIES

Processes of the complete substations life cycle is reviewed to identify to what extent the implementation of IEC61850 affects the different phases. The processes are divided into Network planning and project and Operation and maintenance, where the first group represents activities from early specification until the station has been taken into operation and the second group includes the activities needed to maintain and optimize the system.

Methods to evaluate processes related to network planning and projects

The evaluation focuses on activities identified to be mostly

affected by IEC 61850 and measures to what extent the gaps are closed by the pilot project. It is important that the evaluation covers the complete lifecycle. Workshops are held in each process step to identify benefits and possible challenges related to the process, tools and documentation. In the next step the value of each benefit is estimated.

Maintenance program frames based on long term maintenance program

Follow-up on the effects on the way Vattenfall Distribution specify the maintenance programs, and effects on contracts.

Collection of data, disturbance recordings, event lists, and protection indication

Follow-up on the effects on time and money for the personnel to retrieve and process data for immediate analysis and time for fault restoration. Study how the personnel adapt to network based technologies. Analyse how supplier meets the requirements on standardized interfaces for transmission of disturbance records and event lists, even at protection unit level.

Layout of substation

Estimate the work needed to translate the signals from different protection functions where IEC 61850 standard signals are connected to the existing signal list and alarms correspond to logical node data. What is the need to build up competence about the standard and how it works? Is there a need to be involved in the technical design?

Substation specific functional specification

Follow-up on the effetcs on quality when the address structure, substation structure, and plant documentation can be made in the same way (digitally) in all stations. Estimate the supplier's awareness regarding receiving SSD-files as part of the requirement specification. Will suppliers make product changes, for example functional naming instead of product naming?

Review of protection and control schemes, review of substation automation, and review of documentation

Analyse how automatically generated documentation can save time and money. Compare effects on time for reviews if the selected information is presented in a flexible way. Estimate the effects on human errors through built-in checks. Check how different generations of engineers with different experience from computerized environments adopt to this kind of review. Analyse to what extent the presentation tool is independent from the supplier of the control system.

Participation in factory acceptance tests

Compare the time used for FAT, SAT and in total with IEC 61850 compared to a traditional station. How is the cost of corrective actions affected if errors can be identified before SAT and commissioning? Do the test procedures have to be adapted to a more extensive FAT, where the customer has the FAT check list and more extensive requirements?

IT software handling

Is it possible to compare how improved software management increases quality and makes it easier to do tests, maintenance, upgrades and security of equipment? What will be the effetcs if Vattenfall make a strategic decision on where files should be stored?

Methods to evaluate processes related to operation and maintenance

Testing

Follow up on time and costs for the new standardized test methods as well as quality assurance. Will self-generated test results from the intelligent test tools lead to faster documentation of testing? Interview maintenance staff if there is a need to attend practical "hands on" training courses before working in IEC61850-projects.

Collecting disturbance information

Review the effects on faster disturbance analysis and faster rectification due to improved collection of disturbance data. To what extent can the standard support better analysis and minimize maintenance and troubleshooting? Estimate if less physical visits have to be made to the substation which leads to cost savings and less CO2 emissions.

Maintenance (Periodic vs condition based)

Is it possible to move from periodic to condition-based maintenance also for primary equipment such as breakers, disconnectors etc? The project participants shall be asked about the effects on the maintenance budget and if it will decrease and be optimized.

Substation expansions

Compare the use of material during substation expansions. Compare the automation protocols engineering work with the work for older substation due to standardized SCL configuration files. Can the first pilot already verify a strategy for how to build SAS?

Documenting changes in SAS

Analyse the effect of self-generated documentation, such as test-results and other documents, on quality. Possibility for Vattenfall to define a strategy for version management and a common way of managing back-up files.

Changing protection settings

Evaluate the effects on costs and also CO2 emissions due to less travel. Is it posible to get acceptance from the organization to make changes from distance?

Methods to evaluate tools for specification, testing and documentation

Separate analysis of the tool by collecting notes and results from the specification and verification activities. Report provided by manufacturer and reviewed by users. Separate report on the configuration tool by collecting notes and results from the configuaration and verification activities.

Methods to evaluate smart substation functions

Separat measurements and review, based on SAT and first operation period. Some functions may not be possible to measure during the evaluation period.

Methods to evaluate definition of system interfaces

Separate interviews and documentation of experience of

network topology, servers for disturbance recordings and IEC 61850 process bus together with supplier. These requirements will be evaluated as basis for final decisions on future standardized substation design.

Methods to evaluate the technical guideline and specification of the substation automation project

Scope and content of technical guideline

Review of the requirement spec. compared to the final design spec. What requirements are supported? This work will mostly be done by a team from Vattenfall Distribution.

INTITIAL RESULTS

The results so far come from the Specification workshop held with all actors in the project. The first part included the customers generation of the SSD file and associated documents as specification of the substation automation system, which was then imported in the suppliers tools. The evaluation of this phase shows that the participants can see several benefits during the specification phase and the transition to the configuration phase, related to the process, verification and documentation. Here is a sample of the comments that came up during the workshop.

Benefits

Process

Customers generating SSD-files leads to a "61850-fication" of the work process, ie a standardisation. There is a possibility for a more standardised way of working with different suppliers. IEC 61850 provides more possibilities to standardise the signal exchange. A standardised and common model ease the co-operation. A joint time schedule and well-defined tasks and responsibility, makes concurrent engineering possible.

Testing

SCL files make it possible to test the specifcation in an IEC at the office desk. The tool supports a library of standard bays with functions. The specification work is more efficient and less review is needed. Common tool for handling all signals on communication buss. The same tools can be used for design (spec), review and documentation.

Documentation

It is a good way to write a specification in a third-party tool and verify what will be delivered from the supplier. The customer knows what documentation will be delivered. The supplier knows what the customer expects.

Challenges

Process

It is a challenge to change the ways of working with specification, design, maintenance. The whole business needs to standardise on this way if working. Co-operation between major network companies is needed. It is important to remember that this is still a development project and will require iterativ work with processes during the project.

Testing

Version handling of software will be a challenge, and already is.

Several participants also listed challenges related to overall steering of the company, identifying the need for training, business development, re-organisation and steering.

These comments indicate topics for further investigation. Using the methods described earlier in the paper these topics and many more will analysed and when possible the benefits will be estimated. A second workshop will be held at the end of the engineering work when the results is exported from the suppliers tool and imported to the customers tool for verification, following by FAT and SAT.

CONCLUSIONS

Vattenfall Distribution has analysed the effects of deploying IEC 61850 from an organisational perspective (processes, roles, competence, tools, procurement strategies etc). The results have been implemented in a pilot installation. The benefits and value of using IEC 61850 is created by efficient processes, less manual work during import and export of data, specifications and documentation using tools that support most phases of the lifecycle of the substation automation system. The project is continously evaluated and results are forwarded to the business so that the experience is taken into consideration when deploying new processes and for developing the right training courses for the personnel so they learn the new way of working. The results can be immediatelly applied to project execution processes from day one but gradually introduced in the O&M processes, because it will take time to exchange enough substations to reach substantial amount of IEC 61850 substations. This paper presented several different methods that have to be used to evaluate the pilot project Upplands Väsby. The methods evaluates both hard facts and soft parameters. Common to all methods is that they follow up how people are working in a real project. Very few data can be collected from financial systems in the company. Early results show that the personnel can see a lot of positive effects from IEC 61850, if the work practice, processes, testing and documentation is adjusted to the standard. At the same time several challenges related to the overall steering of the company, identifying the need for training, business development, re-organisation and steering have been identified.

REFERENCES

[1] Vattenfall User's Guide for IEC 61850, Edition 2

[2] A. Johnsson, B. Kapkac, 2012 "Preparing of deployment of smart substation standard IEC 61850", Proceedings NORDAC 2012 conference.