IMPACT OF IEC 61850 ON SYSTEM ENGINEERING, TOOLS, PEOPLE-WARE, AND THE ROLE OF THE SYSTEM INTEGRATOR

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1 Introduction

The crucial focus of IEC 61850 is the provision of interoperability. Interoperability in IEC 61850 is defined for the communication **between engineering and configuration tool** and **with and between intelligent electronic devices** (IEDs). Interoperability means the ability of two or more tools or IEDs from the same or multiple vendors, to exchange information and use that information for correct configuration by tools or execution of specified functions in an IED.

The fist step of interoperability requires that all inter-connected engineering tools understand the XML schema of part IEC 61850-6 (SCL, substation configuration language), generate and exchange compliant SCL files. In the second step the SCL files (providing the crucial input for the configuration of systems and IEDs) must be interpreted according to the XML schema. The definitions selected from the standard, e.g., details on data models, services, stacks, and networks et cetera guarantee that the configured IEDs interoperate according to the standard.

Tools for various tasks support the engineers in reaching a high level of interoperability and doing their job safer, more reliable, faster, and cheaper than before. These tools and the experts using these tools are being said to slash expenses of building substation automation and asset management systems. First experiences show that this is true. An essential question is still to be answered. Who will benefit most from the reduction of costs: utilities, system integrators, or vendors? There is a simple answer: The system integrator with a comprehensive set of smart tools and skilled experts (peopleware) will really benefit from the application of the standard.

The role of system integration can be played by the utility, third party system integrator or by the system and device vendor. Whoever wants to reduce his costs has to focus on the system integration – supported by the right tools. Utilities that do not care about the system integration may end up in a quite serious dependency on the third parties or vendor playing the role of system integration with the help of powerful tools. Who has the tools has the power.

The development and especially the application of tools for various tasks and the new relations between utilities, system integrators and vendors seem to be the pivotal point. This paper discusses the role of the system integrator for IEC 61850 based systems. It shows how well educated system integrators may use the tools and their skills to really benefit from IEC 61850. The potential dependency on comprehensive and comfortable tools – in the hand of a few experts or vendors – will be presented. Based on experiences with some ten utilities in writing procurement specifications based on IEC 61850, the paper shows that utilities have to pay special attention to tools and peopleware.

2 Needs of utilities

The technical requirements for substation automation systems are – to certain extend – independent of IEC 61850. Most parts of the specifications used to describe the system requirements today could und should be used when IEC 61850 comes into play. There are many aspects that may not thought of today that are of high interest when it comes to the application of IEC 61850. Today it is impossible to talk to an IED and ask the IED what kind of data it provides and consumes. This is known by some databases or other specifications. Consequently there is no need to specify a requirement for self description – it simply is technically not possible! With the event of IEC 61850 this becomes a crucial service provided by an IED.

Today there is no common method of describing the amount of data to be produced, communicated and consumed by IEDs in a substation. Part of the information flow is supported by wires and marshalling of wires. Other information is communicated using one or the other field bus, protection monitoring protocols like IEC 60870-5-103, or by a myriad of proprietary protocols. With IEC 61850 there is a modern and standardized method to describe all this information, the information flow and much more.

Another issue is about the testing of IEDs and the whole automation system. Every utility has one or the other method to do testing at various stages: pre-selection of IEDs by tests, conformance tests, stress and performance tests, interoperability tests, system integration and verification test, factory acceptance test, and last bat not least the site acceptance test. With IEC 61850-6 (substation configuration language) it is possible to have a single, comprehensive XML file that describes the whole substation from the single line diagram to the use of Ethernet, TCP/IP and a web browser. This file can be used to drive the various tests – **one specification** for **many uses**! IEC 61850 does not require the different tests listed above. Test are mainly run to increase the confidence that the automation system and the applied IEDs meet the user requirements for a safe, reliable, and efficient operation of the electric power system.

Before IEC 61850-6 was published there was no need to specify such a unique formal and detailed specification. With the introduction of IEC 61850 this and several other new aspects will become part of the procurement specification. Today's standard practice of doing automation may be extended a little bit here a little bit there. Many new and enhanced (standard based) methods will be added to the daily business of the substation experts of the future.

With the event of IEC 61850 experienced people should not get out of the substation automation domain – the most experienced experts are required when IEC 61850 based solutions will be planned for big scale applications in the next five, ten or 20 years. Only those experts (their knowledge and long term experience) could help to assess if the new technology that extends the way of doing automation really meets all current technical and financial requirements and new ones already visible at the horizon.

Somebody would argue that we have already good solutions that meet 95 per cent of the requirements. Is it worth to add all these new possibilities provided by IEC 61850? It is not worth to change clothes when you almost reached the peak of a mountain. It is recommended to just continue climbing and make to the peak before the sun sets. But in our case of the future of the power grid automation we have to climb a volcano that adds some meters to its peak every day – on some days even much more! Before we just continue climbing such a volcano we should think about additional thermo clothes, new boots, oxygen masks, more food, and the like … and of course an XML – e**X**tended **M**etal **L**adder for the next mile up or down.

There is another very crucial aspect we have to consider when discussing the involvement of utilities in the automation of the electric power delivery system. The crucial question with regard to IEC 61850 (from a utility's perspective) is this: **Who is in charge of the system integration?** The future system (applying IEC 61850) is an all integrated solution. Communication, information, asset management and monitoring, and engineering technologies become an integral part of the whole system (whether we focus on protection, control, asset management, maintenance, or condition monitoring). System integration is not any more a one step process at the birth of a substation. The system lives; while we go, the system grows. System integration is more a process during the life time of the system than a single step.

There are several use cases how to build, design, engineer, configure, operate, maintain, extend, and service substations when taking IEC 61850 compliant devices and tools into account:

1. **Utility** specifies substation automation as in the past and **requests IEC 61850 in general terms** and buys turnkey substation (vendor or third party may be the system integrator)

   1.1 As 1. + **vendor** or third party extends, replaces IEDs, maintains, services the system

   1.2 As 1. + **utility** extends, replaces IEDs, maintains, services the system

2. **Utility** specifies substation automation with **detailed requirements with regard to IEC 61850** and buys turnkey substation (vendor or third party may be the system integrator)

   2.1 As 2. + **vendor** or third party extends, replaces IEDs, maintains, services the system

   2.2 As 2. + **utility** extends, replaces IEDs, maintains, services the system

3. **Utility** buys turnkey substation for the **first n** substations /according to 1. or 2.) + from substation (**n+1**) on **utility** builds the substations (utility or third party may be the system integrator)

   3.1 **Utility** extends, replaces IEDs, maintains, services the system

4. **Utility** builds all substations (utility or third party may be the system integrator)

   4.1 **Utility** extends, replaces IEDs, maintains, services the system

In the first case there is little knowledge about IEC 61850 required (this is likely the preferred use case for big vendors). In case four there is a comprehensive knowledge and experience required.

This brief list shows that it is quite important who does the detailed system specification (general and IEC 61850 aspects) and who plays the role of the system integrator!

Depending on the answers to these questions it could be decided by the utility which steps are required to get the maximum benefit of applying IEC 61850 in power system automation and asset management.

Lesson learned: The crucial issue for utilities is to **understand and to define the role the utility people want to play in conjunction with IEC 6**1850. The functional specification of the substations may be extended partly. Most of the specifications can be re-used.

Recommendation: Utilities – Start to figure out your role; and then get started (if you have not yet done it). Vendors – Think about your license policy to allow fair sharing of the benefits from the use of IEC 61850 for all parties involved in the market. Third party system integrators – Start to figure out your role.

3 The basics of IEC 61850

A brief brush-up on the basics of IEC 61850 helps to understand what aspects of the automation and asset management systems are covered by IEC 61850. All these aspects need (in one or the other way) be taken into account when we further discuss the benefit of SCL and tools.

IEC 61850 mainly provides solutions for:

- The information model (a circuit breaker model, protection models, measurement unit, nameplate information, condition information, wave forms, records, limit violations et cetera). Many hundred "signals" are already defined in multiple standards (for substation automation, asset management and monitoring, wind power plants, hydro power plants and other domain).
- The communication services (Get, Set, Reporting events, Logging events, Control devices, exchanging GOOSE messages for real-time information, exchanging sampled CT and VT values, control, recording, transfer of COMTRADE (and other) files, retrieve self description of the devices "content" and other services).
- The mapping of the information models and communication services to concrete communication protocols like MMS (Manufacturing Message Specification, ISO 9506).
- The communication networks (TCP/IP, Ethernet, switches, routers).
- The specification of the whole substation (in the future: mashed networks of substation LANs) through IEC 61850-6 (SCL):
    - single line diagram,
    - binding of the information models to the single line diagram (lines, CTs, VTs, circuit breakers, …),
    - binding of the information model to the automation programs,
    - engineering of all communication details: relations between IEDs and the message traffic

The SCL is the powerful language to describe the whole system. As such it can be used for many tasks not intended or foreseen in the very beginning of the standardization process of IEC 61850 in the late 90s. Even today many experts all over understand the information models and communication solution but have (almost) no glue what it is all about the Substation Configuration Language (SCL). The name should be System Configuration Language – it can be used in any other application domain where IEC 61850 can be applied like for wind turbines or hydro power plants.

Lesson learned: IEC 61850 provides a comprehensive set of definitions that are expected to reduce the total cost of ownership of future substation automation and asset management systems.

Recommendation: One of the most crucial focuses for utilities, vendors, and system integrators should be to become familiar with the high potential of the use of IEC 61850-6 (SCL) for the many use cases described further down.

4 The engineering of substations and IEDs

Engineering is a very generic term. In the context of IEC 61850 the result of the initial engineering process (SCL files) can be used for many tasks in the life time of a substation.

The functional description of the process (one of the first and crucial steps of the engineering) and its binding to the automation system could be done as before. The use of text, tables, drawings, Excel sheets, data bases, et cetera could (and should) be used in the future, too. This is the domain specific language experts are familiar with! There is not yet a need to replace everything!! Keep the language and experience with automation (protection and control) and asset management systems. You will need the expertise in any case! **IEC 61850 DOES NOT replace the experienced engineers!** In this regard IEC 61850 is just a tool – a tool needs someone with the right skills to use it for the benefit of its user. Somebody has well said: “Even a fool with a tool is a fool”.

The functions configured for the automation and asset management system consume and produce meaningful data values (status, measurements, events, alarms and the like). These values have to travel between the IEDs involved in the functions. The **functional description** covers all these data and the communication (partly through copper wires connected to the terminals of an IED).

Another key question is the task of converting the **functional description** into one or many interconnected, interoperating IEDs (**operating according to their configuration**). Tasks for this conversion are mainly:

- How to tell an IED to which primary equipment it is (logically and may be physically) connected? With the IEC 61850 process bus there may be a logical connection only.
- How to tell an IED what functions it should provide (e.g., interlocking and control)
- How to tell these IEDs what data values it should provide for the functions inside the IED and for other IEDs?
- How to tell these IEDs what data values to send, when to send them and to whom?
- How to tell the IED which data values from which IEDs to receive (e.g., Breaker position) and how to receive (e.g., by GOOSE or by Reporting) and how to tell the IED which function needs these values?
- Et cetera

There are many ways to configure these IEDs. Each and every vendor has his own tools and philosophies. These tools usually do not support the configuration of IEDs from other vendors.

SCL provides a vendor neural representation notification (based on XML) of the configuration and partly of the functional description.

During the engineering phase, the engineering tools create and process a number of files and make them available for later use. There are three steps in the engineering process:

A. System specification and IED configuration

The main task is the specification of the single-line diagram, the basic substation functions and their relationship to the bays and primary equipment (station topology). The special SCD file – the SSD file (System Specification Description) – makes this information available to the engineering tools which are used later on during the next steps of the engineering. The functional description uses the IEC 61850-7-x model (logical devices, logical nodes, data, data attributes, etc.). The information can either be taken from the system integrator's project library, or it is generated by a special engineering tool, the so-called System Specification Tool.

Manufacturer-specific IED Configuration Tools are used to configure the IEDs for the actual application and technology. These tools create the ICD (IED Capability Description) file, which describes the capabilities of each IED type used in the substation automation and asset management system. SCL provides a mechanism for describing the following capabilities of an IED type:

- Available functions in the form of logical nodes (basic functions) and the associated data/signals
- Communication services which can be used
- Maximum number of useable control blocks for reporting, logging, GSE, and sampled value exchange.
- Configuration options: what cannot be modified and what can be changed using tools or even online? The ICD Capability Description file can also be used as the basis for IED conformity testing. An automatic test station can import the list of capabilities and automatically verify the IED.

B. System configuration

During the second step, the IED description files are imported by a System Configuration Tool. This tool is used to specify the relationships between the basic functions which are defined in the system specification, the station topology and the IEDs which will be installed. The physical and logical communications relationship between the IEDs and the communication addresses are also configured at that time. The System Configuration Tool creates the so-called SCD (System Configuration Description) file, which contains the following information:

- A model of the single-line diagrams including codes and operator-friendly texts for the primary devices and (optionally) the electrical connections between the devices (topology).
- The IEDs required and their configuration as logical devices and nodes
- The relationship between the logical nodes and the substation IEDs
- The exact data content of all logical nodes
- Communication configuration: which IEDs are attached to a communications network which are able to communicate without a router, what are their addresses, what control blocks and data sets are available for communication, what client do they use, what routers are used to connect sub networks, etc.
- Configuration parameters: which parameters cannot be modified online or should not be modified and which are visible in the IEC 61850 model or are needed to be communicated to other IEDs

C. Manufacturer-specific configuration files

These specific files are used to generate real IED configuration data. The various IED configurators use device-specific and system-independent parameters and systems parameters from the SCD to generate IED manufacturer-specific parameter files which can be loaded directly into the IEDs. The standard defines an optional, SCL-based file format, the CID (Configured IED Description).This means that vendors can provide their own format which can be loaded and used. It is important to note that the CID generally does not contain the complete IED configuration, and there is normally some additional manufacturer specific data in the file.

The loading process can either be implemented by private protocols (local access) or, if the device is already accessible using IEC 61850 communications and if it supports file transfer of configuration parameters, communication services can be used for the loading process. The MMS-based IEC 61850 file transfer services could be used for this purpose.

D. Other tasks to use SCL for

In the future, it will be possible to base the entire planning process on SCL. SCL has been largely harmonized with CIM (Common Information Model, IEC 61970-301). If CIM is used at the network control end and IEC 61850 is used at the SAS end, the SCL file can be imported to automate most of the gateway configuration between substations and control centers. The SCL syntax can be used to specify configuration parameters that cannot be read online or that can be loaded into the IED but cannot be changed online. This functionality can also be used for protection parameters. SCL is also suitable for describing the allocation of parameters to different setting groups. Planned system expansion can be specified as SCL files with additional function descriptions which can be given to manufacturers. These files make it easier for the manufacturers to perform feasibility and cost analysis, and it cuts down the time involved.

SCL files contain a static description of an IEC 61850 compatible IED. These files provide a standardized method of including IEDs in system design and planning, for example during retrofit or system extension. These files can be used to configure complex IEDs, or they can at least be read from the IED. **An ICD file must always be provided for every IED.** Finally, the complete system description (SCD file) can be used as an input for extensive communication simulation if certain assumptions are made regarding the frequency of various events such as trigger signals and alarms. There are many tools under development, planned or expected that build on the various types of SCL files.

Lesson learned: The Substation Configuration Language is the most important part of the whole series of the 14 parts of IEC 61850.

Recommendation: Get started with the SCL.

5 Tools generating and using SCL files

SCL (IEC 61850-6) is a crucial key element in the lifetime of future substation automation and asset management systems and other application domains. There are many tasks for which IEC 61850-6 provides the right (configuration) information to simplify mainly the following tasks (the table shows also a rough classification of the developer of the tools (IED or system vendor (V), third party or system integrator (TP), utility (U)):

Task	**Description**	**Provider**
Design	generate and use SCL files	TP, V, U
Validity check	to verify that the SCL file is well formed and valid	TP, V, U

Task	Description	Provider
Engineering	of the whole substation including IEDs from one or several vendors	TP, V, U
Evaluate ICD files	in a procurement process to compare what is provided by the IED, figure out differences and extensions	TP, V, U
Tool to expand the ICD (CCD, SCD) files	tool to expand the XML element types to get the complete tree of the information model, i.e. SCL data type references in the IED sections are replaced by the types defined in the section <DataTypeTemplates>…</DataTypeTemplates>. This would make the information models easier to read.	TP, V, U
Tool to browse ICD (CCD, SCD) files	tool to add hyper links to the XML element names to easily browse SCD files	TP, V, U
IED configuration	configure directly or indirectly the IED (e.g., programmable controller	V
Consistency checks	checks of whole substation and each IED if for each signal consumed a source is defined	TP, V, U
Validation of the information model implemented in IEDs	validation if the model is as it has been engineered, validation that the model conforms to the standard, generating an SCL file from the self description of the device retrieved by communication	TP, V, U
Configuration of clients	configure the points in the data base and the mapping of the communicated data to the data base	TP, V, U
Traffic engineering	the SCL file contains the sources and sinks of any communication; this allows to calculate the expected traffic – number of messages per time – based on the configured relations	TP, V, U
Application wizards	the single line diagram is part of the SCL file; a wizard can figure out the nearest sampled value source for currents and voltages and can use the corresponding logical node as a source of sampled values	TP, V, U
Generating mapping tables for function programming, gateways or RTUs	rules for programming automation functions and data generated for the functions and consumed by the functions could be used to bind the program input to a data communicated	TP, V, U
Providing maintenance data to be stored in the IED	the IED may later on update the values according to dedicated rules for monitoring	TP, V, U
Protection parameter setting groups	groups of protection parameter settings can be stored in the SCL and used for the initial setting of an IED, these settings can be edited later on through communication services	TP, V, U
Error diagnosis and network traffic analysis	analyzers use the SCL file to interpret the content of the messages exchanged; which device sent which data to which destination, …	TP, V, U
Conformance, interoperability, and performance tests	SCL file for the configuration of the test system to run automated tests	TP, V, U
Testing HMIs	HMI and IED configured through SCL file. Tasks: ▪ test HMI or substation computer ← IED ← process inter-	TP, V, U

Task	Description	Provider
	face (I/Os) ▪ test HMI or substation computer ← IED ← I/O simulator configured through SCL fiel ▪ test HMI or substation computer ← Replace missing IED by a simulation configured through the IED section of the SCL file	
Protection function test	test equipment and IED can be configured for the tests	TP, V, U
…		

Almost all tools listed above can be developed by all three parties. There is one exception: the IEC configuration tool has to be provided by the vendor of the IEDs. To some extend it is possible to create the IED's data dictionary by importing the corresponding IED section of an SCD file. IED 61850 server software is available to build the dictionary and some simulation of process variables directly from the SCD file.

The IEC working group for IEC 61850 (TC 57 WG 10) discusses an additional level of formal specification: The domain of logic (function) modeling, e.g., modeling an AND or OR function. The discussion was about the use of additional logical nodes or the use of either IEC 61131-3 (PLC programming) and IEC 61499 (Function blocks). Utilities would like to export and import logic function specifications independent of the IED vendor. And they would like to link the function specification with the SCL specification. During the coming months (beginning of 2007) IEC TC 57 WG 10 will continue discussing these issues.

Vendors of IED programming tools have already converted logical nodes (e.g., CILO, XCBR, CSWI, …) to their function block library of the programming tool. These function blocks can directly be used in the specification of the function logic, e.g., for inter-logging control.

Today (end of 2006) there are first tools available for various tasks in the whole chain of engineering and for the whole life cycle. Availability of tools does not automatically mean that it is easy to use the tools nor that the tools can be used by everybody. Tools are usually developed and owned by companies or individuals – for a specific business case. Their use will normally depend on a license agreement between the vendor and user of the tools. Some tools will be available under the GNU license agreement, e.g., the MMS Ethereal analyzer tool to analyze the messages according to IEC 61850-8-1 and 9-2.

A very powerful and comfortable tool from vendor X may really reduce the total cost of ownership of a substation with IEC 61850 based automation and asset management systems. But vendor X may decide to use his comprehensive set of optimized and interrelated tools for his own IEDs only! This would allow him to maximize the use of a set of tools that are well harmonized and coordinated. Why to allow other people to use his tools? This may be not at all his business case!

With the event of more and more powerful tools we have to understand that each vendor (of IEDs, systems, and tools) has a business case: To reduce his own cost and maximize his profit. It usually does not help him to give good tools away. On the other side it is quite crucial to apply tools for the various tasks described above. The license policy of the tool vendor and the negotiation with potential users of the tools is very important. To really tap the benefits of IEC 61850 it is required to have the right tools and the skilled people that can use the tools.

It is recommended to start early negotiations with the tool vendors. The negotiation should cover the use of the tools for IEDs of competitors, the training, the service, the updating and upgrading policy et cetera.

One could expect that (to some extend and some time down the road) a vendor may give away the IEDs for free if he could do the system integration (by some finger tips for his own tools) and the service for the whole system for its complete life time.

IEDs without tool support from the IED vendors may be very powerful – but it may be quite costly and time consuming to integrate them into a system with other IEDs from multiple vendors. If tools are not bundled together with IEDs then it would be quite costly to integrate these devices. Again: It is up to the users and system integrators to early start negotiations with the vendors with regard to the availability and use cases of their tools.

There is an important role for utilities and third party system integrators when it comes to the definition and application of rules to be build-in in the engineering tools of IED vendors. Tools rely on the standards and on many rules for using or not using the various options in the information models and the configuration language. Optional things may be used or not. A more crucial issue is how the tools fill out the areas where the standards give the freedom to fill out those parts of the specification that were intentionally left "open, or to fill it out completely different compared to the competitors (example follows).

One example is how to build or organize logical devices. The standard requires the mandatory use of logical devices (logical devices are not at all optional!). **But the standard gives freedom how to package logical nodes into logical devices.** One vendor may put all logical nodes in a single logical device and may allow the engineering tool to assign any name from "myDevice" to "FizzliPutzli" to the logical device. Another tool may provide always five logical nodes which may be fixed, i.e., they cannot be changed by the system integrator. One logical device "CONTROL" may contain all control related logical nodes, the logical device "MEAS" may contain all measurements, et cetera.

Another vendor may have a completely different philosophy how to package the logical nodes to logical devices. But all these methods to organize the data and logical nodes are compliant with IEC 61850 – no question. If – during system engineering – the system integrator wants to organize them in a utility specific way, it may not be possible because the tool of a vendor may not support this (not foreseen in the rules that have been applied). The IED of that vendor may support other organizations of data and logical nodes. The tool may restrict these free allocations to logical devices.

Tools may also follow strict rules on **how to name logical node instances**. A logical node class XCBR may be instantiated as MyXCBR or as Q0XCBR01 according to the build-in rules. The development of tools needs special attention by the third party or utility system integrators. The expectations in the standards may not be met, because the implementations of IEDs and tools may restrict the possibilities specified by the standards. The implemented IEDs and tools are between the standards and the users of the IEDs and tools. **Not everything supported by the standards may be supported by the IEDs and tools.**

There is another aspect we need to briefly look at: The skills needed to efficiently use tools. Tools could only help to reduce costs and safe time when the user of the tool knows what the tool provides and how to use it. Training and experience is crucial to tap benefits from a tool.

Note these sayings: "A fool with a tool is still a fool." and "A fool with a tool can foul up projects faster than a fool without a tool."

Lesson learned: The standard IEC 61850 does not at all define:

- How to use the standard!
- How to implement IEDs
- How to implement tools
- How to use IEDs and tools
- How to operate and maintain a substation

Recommendation: Some time down the road experienced people from utilities, vendors, and system integrators have to put their heads together and exchange their experiences with the application of the various IEDs and tools. A useful platform could be a group under the umbrella of the UCA® International Users Group; a Users Group should have at least as many members from users than from vendors (which is not yet the case in the UCA IUG).

6 Peopleware

Experienced people ("**the most important asset**" as I have read in the lobby of an engineering department of a big utility) are quite crucial when it comes to the specification and interpretation of the standards, the implementation of the many aspects of the standards in IEDs, systems, tools, and the application of these!

The term peopleware is often used in connection with the popular book about project management "Peopleware - Productive Projects and Teams", written by software consultants Tom DeMarco and Timothy Lister. In this paper the term peopleware is used as a common term for "Human capital" or just "experienced engineers and programmers".

As we have seen above the future implementation and application of advanced information, communication, automation, and engineering systems according to IEC 61850 require well trained, experienced, and highly motivated experts in various technology disciplines.

In general it is true that projects need a good management. It is also true that teams involved in projects need to be cooperative and communicative! In the same way as we want to make systems and devices talk together we have to make sure that the engineers developing and using these communicate together before they implement and use them. How can devices understand each other if the developers of these devices do not talk together or talk together but do not understand each other? Disconnections in human communication lead to disconnections of the technical communication and more blackouts.

Lesson learned: The various experts required for the development and application of IEC 61850 based solutions need to have very good skills and experiences. Many advanced non IEC 61850 based substation automation projects in the past failed because of lack of the right "peopleware". Vendors deeply involved in the standardization of IEC 61850 have excellent people to implement

IEC 61850 and to do the system integration job. Utility people or third party system integrators have to catch up so that the user community becomes an equal partner of the vendors.

Recommendation: Education and training of all experts involved in the life cycle of substation automation are crucial issues in any project plan describing the implementation and application of IEC 61850.

7 Conclusions

The migration to IEC 61850 compliant substations requires more than just a handful of good IEDs and tools and a general introduction into the new possibilities. The training is most important for utility engineers (peopleware!) that are involved in system integration. Experts from vendors gain a lot experiences with the system integration of the many projects already underway. Many utilities require IEC 61850 but do not at all care about any detail. The experience is unbalanced on one side only: On the vendors' side.

The firm that provides comprehensive systems, intelligent devices, and powerful tools is likely to offer everything for a turnkey solution. These firms may restrict the use of their engineering tools for their own devices and a few other (system tested) IEDs from other vendors. Utilities or third party system integrators that want to get involved in the various phases of the system life cycle should start early negotiating with the device and system vendors that provide comprehensive and powerful tools – to allow them to use these in an efficient way.

Negotiation during procurement with regard to tools becomes a crucial issue! Or the system integrators and utilities have to develop their own set of harmonized and coordinated tools applicable for multiple device types from different vendors. But these tools may not provide the same powerful and comfortable support than the vendors' own tools. Vendors do need to care many for their own IEDs. Third party tools need to take many IEDs from many vendors into account.

System integration depends on experience with the same or similar technologies, device functions, device and function performance, and tools and even more tools! Number one is: tools; number two is: use of tools (peopleware).

Finally: Vendors, users, and system integrators have to go through a learning curve. Most big vendors have started this process during the standardization. Several utilities and third party system integrators have already started (or have planned) projects like lab tests, pilot projects, and other projects to train their experts, to gain the needed expertise, to decide how and when to use IEC 61850, and to come up with everything that is required for a big scale application of IEC 61850 based IEDs and tools.

Now is the right time for utilities and third party system integrators to get started – if they want to keep control (or get control) over your substation automation and asset management systems! **The big vendors are speeding up quite fast – they are not waiting for other people to share the benefit of the use of IEC 61850.**

8 References

[1] IEC 61850-1, Communication networks and systems in substations – Part 1: Introduction and overview

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[3] IEC 61850-3, Communication networks and systems in substations – Part 3: General requirements

[4] IEC 61850-4, Communication networks and systems in substations –- Part 4: System and project management

[5] IEC 61850-5, Communication networks and systems in substations – Part 5: Communication requirements for functions and devices models

[6] IEC 61850-6, Communication networks and systems in substations – Part 6: Configuration description language for communication in electrical substations related to IEDs

[7] IEC 61850-7-1, Communication networks and systems in substations – Part 7-1: Basic communication structure for substation and feeder equipment – Principles and models

[8] IEC 61850-7-2, Communication networks and systems in substations – Part 7-2: Basic communication structure for substation and feeder equipment – Abstract communication service interface (ACSI)

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[14] IEC 61850-10, Communication networks and systems in substations – Part 10: Conformance testing

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