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Engineering Process for IEC 61850

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1 Abstract

The power industry is facing significant challenges in the years ahead driven by increases in the number of projects, the proverbial skills shortage and now exacerbated by the squeeze on available funding. IEC 61850 was released in 2004 which has already been deployed in thousands of locations with tens of thousands of devices in service already offering significant advantages.

The early deployments of IEC 61850 have tended to be single vendor solutions proving that the basics of the technology work. Systems are now in service as multivendor installations in some cases consisting of over 200 devices in the substation. These projects have allowed the industry to learn much and refine the IEC 61850 devices but most importantly they have proven that the standard is robust and the fundamental principles of interoperability work. The next step is where to from here?

One of the intriguing capabilities that IEC 61850 provides is the freedom to design a substation independently and in advance of the vendor and device selection. In comparison previous design processes start with a vendor and device selection in order to start producing the wiring diagrams.

Clearly IEC 61850 introduces a new methodology to the design process that is not fulfilled by specifications simply stating “shall comply with IEC 61850 and use GOOSE messaging”. The essential process is, and should be, about making the specification phase more specific to the needs, making design process faster, make the commissioning processes far more robust and automated and most importantly, future enabling for the next augmentation, refurbishment or replacement of the substation automation system. This is predicated on the engineering process adopting the requirement to establish SSD and SCD files as the basis of specifying, developing and maintaining the “as designed” through to “as operating” documentation.

This paper describes the new engineering processes and benefits of the IEC 61850 standard and associated XML files when used with an appropriate new engineering tool. Investing in a new engineering system is the basis to achieve significant time and cost reductions as well as a dramatic change in requirements for creating documentation, drawings and databases for I/O and settings.

2 Changing the Engineering Process

New technology brings new processes and new skills, some of which are continuous evolutions. The motor car required us to learn driving techniques, invent new road rules, improve the roads for faster travel, decide to travel on left or right side of road, traffic lights, stop signs, give way signs, roundabouts, multilane roads, priority lanes/roads, toll roads, improve the basic vehicle technology such as radial tyres, seat belts, antiskid braking systems, turn indicators, air bags, fuel injection, emissions control… All this did not just happen based on our human DNA that somehow we wake up one morning and magically we know it all.

Clearly technology introduces complexities and new thinking; however it also demands applying our collective learning to the new processes so that the benefits the technology brings can be fully realised with confidence. It is not a matter of “*out with the old, in with the new, cross your fingers, here we go!*”

So it is no surprise that IEC 61850 presents the same challenges to the power industry. We know that the technology will bring benefits to our substations and the way we do things. We are starting to even see real returns on those investments – the promise of what I have coined as “More, Faster, Less, Less, Higher, Lower”[12] is a reality. It is these aspects that are being demanded of the power industry by the community and the corporate executives, whereas the engineering community are easily focused on the technical nuances of a Logical Node, a GOOSE message and process bus!

We have also generally moved past the question of whether technology, and in this case interoperability[13] really works. This is not a new requirement for engineering a substation. We know for example the requirements of specifying knee point voltage, excitation current and winding resistance to match the relay performance based on X/R ratios, saturation performance in the established interoperable realm of a 1Amp secondary CT with a 1Amp relay.

To the same degree, we should not be surprised that if we don't attend to the technical requirements of IEC 61850, it may not work as we had hoped. Understanding the context of a compliance certificate, what has been tested, what has not been tested, and most importantly what is contained in the PICS[a] document that the vendor has claimed in terms of the services the device supports cannot be overlooked. If we choose a device that does not provide the mode of operation that we need, it is not interoperability that has failed but our own lack of understanding. Certainly some people suffered in their projects as early device implementations were not based on a common understanding which marred the early experiences, but equally these same people are now more than ever committed to the deployment of IEC 61850 as their overwhelming preference to the extent of never going back to their old ways. "Plug and play" is not offered here, but rather **"engineer and plug-in"** is the process.

Hence there are a few key steps in undertaking IEC 61850 implementation and the engineering process which will be discussed in this paper:

- Understand the technology – what it means, its intent, its capability
- Identify new skills and technology domains that must be learnt such as architecture
- Use new processes and tools to maximise benefits
- Decide how to apply the technology such as GOOSE definitions

3 Understanding the Standard

It is always a good practice to understand what you are dealing with. Hence reading the Standard is naturally a good thing but is also a daunting task with over 1500 pages in the first edition alone. It contains a variety of material ranging from terminology definitions (substantial new jargon and acronyms) to detailed XML[b] code. So its perhaps not wise to attempt a cover to cover reading in the hope of "read.., get set…, Go!"

However Table1 of Part 7 of the standard (Figure 1 below) guides different users to the key aspects of interest to their specific needs which will save a lot of confusion. Interestingly, there are several Parts of the Standard that are not listed in this table, but that is not to say they should they be overlooked, the benefit is more in telling you what parts are of less interest to your needs.

[a] PICS Protocol Implementation Conformance Statement

[b] XML: eXtensible Markup Language – a structured text file with delimited data to enable computers to share data independent of manufacturer and protocols

	User	IEC 61850-1 (Introduction and overview)	IEC 61850-5 (Requirements)	IEC 61850-7-1 (Principles)	IEC 61850-7-4 (Logical nodes and data classes)	IEC 61850-7-3 (Common data classes)	IEC 61850-7-2 (Information exchange)	IEC 61850-6ª (Configuration language)	IEC 61850-8-x IEC 61850-9-x ª (Concrete communication stack)
Utility	Manager	x	–	Clause 5	–	–	–	–	–
Utility	Engineer	x	x	x	x	x	**In extracts**	x	–
Vendor	Application engineer	x	x	x	x	x	**In extracts**	x	**In extracts**
Vendor	Communication engineer	x	x	x	–	–	x	–	x
Vendor	Product manager	x	x	x	x	**In extracts**	**In extracts**	**In extracts**	–
Vendor	Marketing	x	x	Clause 5	**In extracts**	**In extracts**	**In extracts**	**In extracts**	–
Consultant	Application engineer	x	x	x	x	x	–	x	–
Consultant	Communication engineer	x	–	x	–	–	x	x	x
All others		x	x	x	–	–	–	–	–

The "x" means that this part of the IEC 61850 series should be read.
The "**In extracts**" means that extracts of this part of the IEC 61850 series should be read to understand the conceptual approach used.
The "–" means that this part of the IEC 61850 series may be read.

ª These documents are under consideration.

Figure 1 Recommended Reading from IEC 61850 Part 7-1

Next is to understand what we want this Standard to do for us. This is neatly stated although not overtly emphasised in the early part of Chapter 1 of Part 1 of the Standard which states".

> *The purpose of the standard is neither to standardise (nor limit in any way) the functions involved in substation operation nor their allocation within the Substation Automation System.*

This is fundamental.

- It is not prescriptive, it is a technology to suit your needs
- It is not constraining to our processes and designs of the past
- It encourages innovation, now and in the future
- It is about the way things WORK in the ENTIRE substation, not just providing a mere protocol to monitor what is going on or issue an instruction to the system like a general giving orders.
- It doesn't tell us how to build it, with what or what functions should be located in what device.

There are many other aspects built in to the standard to make sure it is a smart and sustainable choice of a new engineering process and platform that won't 'ditched' when something better comes along.

Certainly the ubiquitous Logical Node has been created as fundamental building block that can be used in any SAS requirement, just like a basic Lego toy building block is used to build a myriad of things as imagination requires. More building blocks have been defined for example in the latest expansion of the standard into Wind (IEC 61400[5]) and Hydro power domains. There are many references that attempt to explain the makeup of a Logical Node but in principle, we can take confidence in being able to "just grab it" and use it knowing it has all the characteristics we need for that function and it can work with other

Logical Nodes interoperably. In essence just like Lego, by just looking at a LN allows us to know how we can use it.

It is also strong comfort that the Standard doesn't attempt to "reinvent the wheel" of technologies that are developing at much faster rates in the Information Computing & Telecommunications industries. It instead leverages these technologies such as Ethernet systems, IP addressing and the respective communication layers. It grows with these technologies and benefits from the experience of these technologies. The Standard is then focused on the specific requirements of the electricity industry in designing, implementing and operating an electrical power network at least in terms of information, monitoring and control of the power network.

This last point also leads to another emerging area in the power industry – that of the "Smart Grid". Even though there are many concepts (and arguably no single definition) of Smart Grid, as information monitoring and control are fundamental to being "Smart", it is not surprising that IEC 61850 is being seen as a key enabling technology for the Smart Grid. A degree of caution is required as implementing Smart Grid is not just about using an IEC 61850 based device and therefore stating the Smart Grid exits!

Rather than having evolved as a compromise of a variety of solutions, IEC 61850 started from a "blank sheet of paper" to answer the question "what do we need in a substation". The strength of this is that there is considerable industry "buy-in". As a result, apart from the plethora of information available on the web, organisations such as CIGRE have developed significant reference material in the form of conference papers and Technical Brochures. Obtaining copies[7] of TB 326[8] as the Implementation Guide, TB 329[9] Guide to implementing SAS and the new Guide for Testing (to be published shortly) are fundamental "must haves" as very useful references for novice and experienced persons alike.

So now we are armed and dangerous! As engineers we can sort out anything – after all we have the collective wisdom of hundreds of years of substation engineering "in bred" and at our finger tips! However, the rest of this paper could be summarised as "knowing how an internal combustion engine and a gearbox work, does not mean we can design a complete Formula One race car from scratch, let alone drive one". There are many elements to engineering a Substation Automation System, in particular in the context that the SAS covers every signal and data element that is not directly the primary "kV or kA" although it does involve information from, to and about the primary plant and switchgear.

4 Architecture

The move from tens of thousands of wires and terminations to a Ethernet LAN introduces a completely new requirement to define the architecture of the LAN itself. This can be a scary thought for the substation engineer allowing "IT things" into their sacrosanct domain. However the substation engineer must learn these new systems and in fact draw on the experience of people who have deployed Ethernet in a variety of areas such as control systems for industrial manufacturing plants, petro-chemical industries and even nuclear industries. These applications also need to provide redundancy, security and reliability. Is it any wonder that standards such as IEC 62349 "High Reliability Networks" first of all exists, but that IEC 61850 refers to it is as a basis for considering what types of networks may be suitable. We don't need to dream up different architectures and then guess what are the characteristics and benefits – that is already done, although we must still do the engineering of what suits our needs.

Certainly at higher voltage levels there are the Australian National Electricity Rules that guide how technology must be deployed to meet key network performance and security requirements. Even outside the NER domain, "good industry practice" should not be used. The NER states:

> *S5.1.9 Protection systems and fault clearance times*
>
> *Network Users*
>
> *(d)….the primary protection system must have sufficient redundancy to ensure that it can clear short circuit faults of any fault type within the relevant fault clearance time with any single protection element (including any communications facility upon which the protection system depends) out of service.*

Whilst the NER is the overarching requirement for utilities operating in the National Electricity Market, the above requirement is effectively only a requirement about dealing with the relatively rare occurrence of a power system fault. This clause in the NER is silent on how the system must be configured to perform all the routine tasks of operation and maintenance of the substation on a daily basis. Never the less, redundancy in this context is generally taken to draw on the definition[14] as having a duplicate system without a common mode of failure. Of course the operative words here are "sufficient"[15] and "ensure"[16] - the combination of these two words means that the system can NEVER fail to clear the fault despite any one thing not operating! This demands the substation engineer develop understanding and skills in failure mode analysis in a whole new realm of internet protocol based networks, so it is worth some initial consideration here.

Firstly the substation engineer has dealt with traditional hardware failure modes in the substation. These can be mitigated by choosing vendors with experience in electronic components and devices destined for a substation environment. This means attending to the requirements for high ambient and higher operating temperatures is vital, especially if electronics are going to be located in the yard exposed to temperatures form +45 degrees in full sunlight to minus 45 with wind chill. Add to this interference issues for EMF emissions and susceptibility, high frequency disturbances and fast transients. Hence IEC 61850 Part 3 includes reference to other Standards that address these issues. Finally, consideration must be given that all this equipment is operated by many types of people ranging from fully trained electronics technicians to general maintenance crews dealing with equipment in the substation. All this must now be applied to the choice of IT type equipment and the installation of a 'flimsy' optical fibre.

However there are now a large range of other failure modes to be considered in order to meet the requirements of "sufficient" and "any single element out of service". Just to get started these include aspects such as bandwidth limitations, deterministic latency and data storms. Even issues such as IT access permissions, viruses and cyber security are more critical than ever as this whole system is now TCP/IP based and may be connected to the web, and/or, will be accessed by people with laptops that may be virus infected or provide the web connectivity.

Even at the physical level, we know that substation staff would think twice and follow some sort of isolation procedure before just unscrewing an electrical connection to a device. On the other hand they are equally familiar and comfortable with unplugging their LAN cable on their office PC whilst it is still switched on without any consideration of what information is passing over that fibre that is network critical. Generally this is safe because in that environment it generally isn't a critical data stream, but the substation it could well be vital. Hence the essential basics of investment in training and procedures cannot be overlooked or under estimated.

So assuming these aspects have been attended to, we can now turn to the network solutions in regards to the schemes that are going to operate in the substation, after all, the standard is about the "functions involved in the operation of the system".

Figure 2 shows a simple conventional duplicated single feeder protection system with the X system (blue) and Y system (red) consisting of a CT, relay and trip coil. We can pose directly equivalent IEC 61850 based systems using IEDS to replace the CT relay and circuit breaker elements and some additional hardware as network switches. Two simple network solutions are shown in Figure 3 as a duplicated star network and Figure 4 as a duplicated ring network where the current sensor is represented in the network as a Merging Unit IED providing IEC 61850 9-2 Sampled Values and the CB trip coil is replaced by an intelligent CB module IED,

Figure 2, Figure 3 and Figure 4 all comply with the NER in that the failure of any one element[c] be that a failure of a wire or a device, does not affect the operation of the duplicate system. Hence both ring and star topology can be valid NER compliant arrangements.

[c] Except may be due to fire or explosion and hence some prefer to use different panels and different cabling trenches for segregation of X and Y schemes.

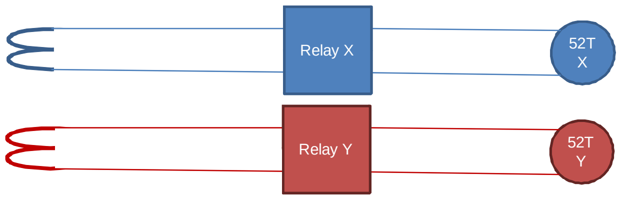

Figure 2: NER compliant duplicated feeder protection system - hardwired

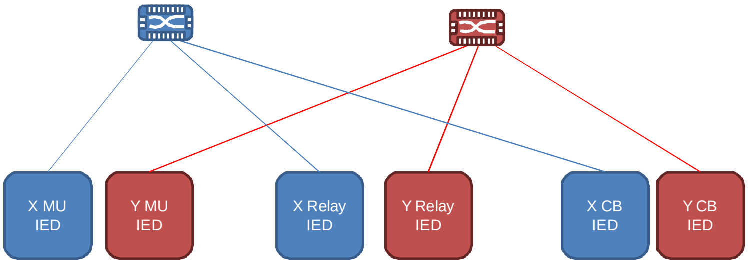

Figure 3: NER compliant system – duplicated star network

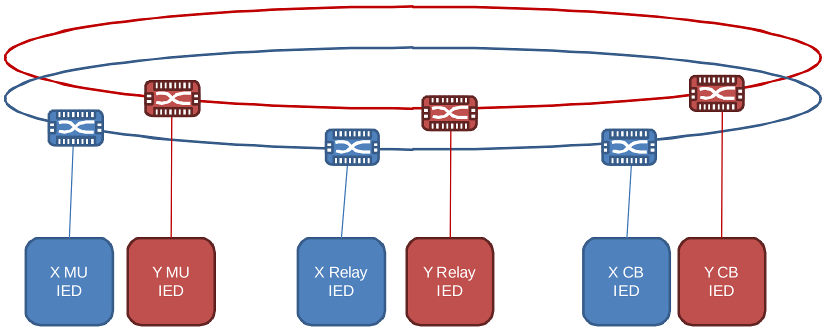

Figure 4: NER compliant system – duplicated ring network

At first it might therefore seem that the NER can only be satisfied by having two fully duplicated and independent systems as shown in either Figure 3 or Figure 4. Interestingly though the requirement for redundancy under the NER can be filled by using a single ring as shown in Figure 5, despite even using less network switches for the Y system in a partial star arrangement due to the likely physical proximity of the CB and MU IEDs in the yard. Consideration of data storms as a failure mode may alter this view in respect of NER compliance, however outside of the NER, Figure 5 provides a significant degree of reliability.

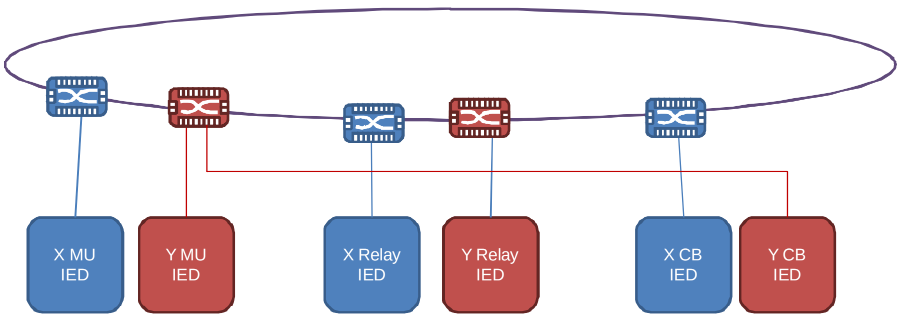

Figure 5 NER compliant single ring system

Having established some basis of equivalency between conventional duplicated systems and both star and ring networks for a single feeder, the same considerations can be applied for bay to bay communication and voltage level to voltage level applications right through to the SCADA system and substation to substation communications. These considerations include such things as whether it is necessary to have both systems still fully operating when one element fails, the ability to fully isolate one system or component from another for upgrade and testing, and indeed whether fully independent redundant (duplicated) systems are necessary. No doubt there are many more potential schemes so in order to assess what is appropriate we need to consider this in terms of RAMP: **Reliability, Accessibility, Maintainability and Performance**, all of which is focused on how the system operates continuously, how it is operated, how it is maintained in all circumstances and for all reasons, not just when a power system fault occurs.

All this implies far more than a risk assessment even across the possible solutions posed by IEC 62439 or imagined as "well that works", but a complete 'need analysis' of all stakeholders from remote operators through to technicians and operators working on site.

5 The role of SSD & SCD

Two of the mind sets that can hinder obtaining full benefits of new technology are "habit" and "have a go". The first is that "we know what we know" and hence it is easy to keep doing things that way. Second is being unsure of something, but jumping in to engineer our own process as best we know how.

Undoubtedly every organisation is looking for increased efficiency. Improvements in processes that reap continual improvements are even better. We have seen significant improvements in our engineering work over the last many decades from laboriously typewritten specifications and hand drafted drawings to specification templates and computer aided drafting readily called up and modified on screen. This increased ability to modify and copy information and designs can however mask the fact that our engineering process is still largely manual in process. We are still faced with basic and extensive editing even if we are producing an exact duplicate of a previous design.

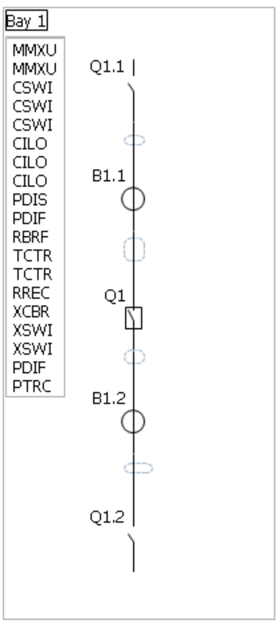

Figure 6 Using tools to link primary & SAS components

For example, at the simplest level of adding another bay to the substation, the effort to update a new drawing with new bay references and the finite detail of wire numbers is a mammoth task. It sounds so 'simple' to define one device configuration file and then copying, editing and loading it for the next device. Even having done so, the physical build needs the same full amount of testing from point to point wiring tests through to scheme operation in factory and site acceptance tests (FAT/SAT) and commissioning of the substation, despite on paper being the same as the existing construction. If the definition of insanity is "*doing the same thing over and over and expecting a different result*", we need to find ways to be smarter in our engineering process if we want to create efficiencies.

It is possible to deliver a fully functioning IEC 61850 system by simply configuring individual devices using their proprietary tools. All this can be done whilst still complying with the simplified statement "*to be compliant with IEC 61850 and using GOOSE messaging*". However unless specific measures are included in the specifications, over simplified compliancy requirements gives us no benefit in future scheme expansion, duplication or re-usability since there is no overall context in which every item of scheme is inherently linked and structured.

However IEC 61850 Part 6 introduces the possibility to significantly improve this whole engineering process through SCL[d] and the use of the SSD[e] and SCD[f] files. In this respect SCL allows the complete engineering cycle to be contained in the evolution of the XML files.

d SCL: System Configuration Language – the combination of XML files and tools to provide a complete engineering process
e SSD: System Specification Description – essentially the primary plant context for the scheme

IEC 61850 introduces the concepts of integrating and automating our documentation. Firstly the SSD file links the primary plant and secondary system functions as shown in Figure 6. Hence as either aspect changes, the complete design is captured. Adding an extra bay automatically drags in all the required secondary system functionality required.

The SCD file defines how the scheme will operate by combining the individual device capabilities as defined in their ICD files. The SCD then incorporates the aspect of communication process between the elements.

Self describing capabilities enhance the automation of the process. Firstly the device capabilities are readily obtainable from the vendor, possibly even off their web site, even before an order is placed for the equipment. Furthermore, it is possible to extract the ICD[g] file once you power up the devices straight out of their boxes.

The whole engineering process is now contained in the SSD and SCD files. It is possible to short circuit the process by direct device configuration but this destroys the automation of the process as much as using a calculator to determine the results of a repetitive calculation versus the benefits of using a spreadsheet with formulas and links for the complete engineering model.

Furthermore the whole system can be maintained by integration of the IID[h] files back into the SSD and SCD. The IID is a read out of the device of its current complete configuration including any non IEC 61850 aspects and capturing any changes by site staff. Never mind "As Built" drawings which take several months to be red lined and updated following commissioning, for the first time ever, we have immediate access to "**As Operating**" information provided we specify and use a mechanism to create it.

The efficiency of the SCD extends further into the testing processes. Firstly, a scheme can be engineered once, tested and proven and simply copied through to the next system in the full knowledge that the system will work as required without extensive retesting. Indeed new test process can be taken off line even prior to connecting up the actual devices or developed for remote testing, thus streamlining allowing the real focus on what more we want the FAT and SAT to achieve without wasted repetition.

Whilst IEC 61850 does not attempt to standardise the SAS itself, clearly there are benefits in having a consistent approach to the fundamentals of the nomenclature used within the SAS. Many organisations have their own specific dictionary of terms and references which needs to be amended or extended as new items are introduced. In this respect IEC 61346[4] defines a naming convention which is readily recognised worldwide. This has the benefit of eliminating confusion and misinterpretation by anyone inside or outside the organisation to recognise each item of plant and equipment by its name. Of course the change from a private nomenclature domain to an international standard must itself be well managed in the process. But if we want to leave a legacy of efficiency and clarity which leads to increased safety and security of the system and for those who work on these systems in the future, the investment in renaming and retraining is rewarding.

It is therefore a key requirement to seek out new and appropriate tools that provide the process efficiencies of generating the full substation specification and design.

The use of the SCL is therefore the key to efficiency not only in the sense of specifying the SAS engineering today, but as much for any future expansion or modification of the scheme given the increasing resource shortage, an increase in new works and a growing requirement for refurbishment.

f SCD: System Configuration Description – this single file contains the complete equivalent of every wiring diagram for the substation and the settings for every device

[g] ICD: IED Capability Description file – the master XML file of the device capability prior to configuration for a specific application

[h] IID Instantiated IED Description

6 GOOSE

Even just the term GOOSE[i] has attracted a lot of attention as IEC 61850 systems have taken advantage of this capability. Certainly it is possible to deploy devices with IEC 61850 capability without specifically defining GOOSE. Indeed a simple device to device communication can be set up based on a simple directory name somewhere on the IP network, just as you would use a LAN server and directory structure on a PC network. However this is not using the benefit of GOOSE.

GOOSE involves sending individual or combined groups of data on the basis of a certain event or criteria changing. In this respect concepts such as defining a report of CB and isolator status can be a powerful tool in engineering a substation. Once a report is defined which combines all the position, time stamp and quality information for all the CBs and switches in a bay, this report is easily reproduced for every other bay.

Once again, it is a simple matter to establish a system which is GOOSE based. However if there is some thought to the policies of what types and structures of reports are used, the power of repeatable definitions can be obtained. It may be as simple as defining the ancillary data that should go along with a GOOSE message such as the time stamp and quality attributes of the data being transmitted that will enable the rest of the scheme to function correctly.

One of the applications of GOOSE is for the purpose of transmitting the trip command to the circuit breaker. At first glance this could be seen as overkill for a simple process handled by "a few wires" in conventional systems. However these "few wires" end up being many wires with several terminations. Each time a new bay is added, the full physical installation has to be tested even though on paper it is exactly the same as the other bays. Here the benefits of true reusability come to the fore in that a system verified once need only be retested for general operation without the need for extensive 'belling' of the wires and complete operational tests.

In addition to eliminating wires in the yard (especially when combined with IEC 61850 based condition monitoring devices and Merging Units for current and voltage sensors), IEC 61850 provides higher reliability and performance of the flow of information and commands. To date there has only been a few systems deployed making use of trip command capability mainly due to the industry's caution about relying on a communications network for an essential function. This is understandable as the industry is only now coming to a good understanding of the elements of the Ethernet architecture in terms of bandwidth, latency and the number of switches involved, priority policies and the use of virtual LANs to segregate different types of traffic. The first deployments of GOOSE based tripping are already proving faster function to function operating times if the architecture and the policies around using GOOSE have been appropriately engineered.

Hence not only does IEC 61850 aid in the current design process but facilitates the next stage of augmentation of the substation. As we face increasing rates of new developments and refurbishments every 15-20 years, building in processes that enable easier processes in design and commissioning for the future is a important legacy of improving the current design process.

7 Conclusion

In order to obtain the benefits of "More, Faster, Less, Less, Higher, Lower" we need to take a methodical approach to new technology. In as much as we need to understand the technology itself through a variety of references, we need to increase our understanding of how we apply the technology in our environment and to our objectives in the power industry.

We must define appropriate architectures that not only meet the needs of the NER to ensure that every power system fault will be cleared even with something not working, but also an architecture that suits the needs of our organisation in all respects of RAMP. This is a full operational consideration of how do we

[i] GOOSE Generic Object Oriented Substation Event is a message that is transmitted on the basis of a certain event and contain a defined set of data pertinent to that event

access, how do we isolate, how do we test, how well does it perform under the highest of network traffic and indeed how do we handle the priority traffic. All this cannot be determined by a casual consideration of what looks good on a sketch.

We must define, learn and apply new tools and processes that provide a basis for better start to finish engineering as well as enabling easier re-engineering for future augmentations, replacements and refurbishments. As much as we invest in new devices with this wonderful new technology, it is essential that we undertake the change management in our organisation to obtain new tools, develop new quality and verification processes, adopt new testing techniques and create a new documentation management framework. In other words apart from looking at the nuances of a Logical Node and GOOSE messages, we have to invest in all the human based processes surrounding their use. We cannot allow ourselves to be robbed of the benefit of dramatically reducing manual effort and the benefits SCL brings in reusability and automation in the engineering process.

We must also take time to define the policies surrounding how the system operates in order to cater for all the requirements of the system and those who use it. The complete engineering cycle must cover concept development through to specification, implementation, commissioning augmentation and replacement for everyone involved over the 50 years or more.

Hence specifying a solution to be IEC 61850 compliant and based on GOOSE messaging is only part of what the community and companies are demanding of us. We have to be more efficient not only just using the latest technology to do the clever bits, but also in the processes to engineer the system at the outset, eliminate wasted repetitive testing of the same thing and manage the design throughout the life of the substation encompassing several system refurbishments, replacements and augmentations.

IEC 61850 is the opportunity to create a platform for innovation if a complete approach to the engineering process is used.

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4. IEC 61346 Industrial systems, installations and equipment and industrial products - Structuring principles and reference designations
5. IEC 61400 Wind farm applications
6. CIGRE Australia: http://cigre.org.au/
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9. CIGRE Technical Brochure 329 Guidelines for Specification and Evaluation of Substation Automation Systems
10. CIGRE Technical Brochure Functional Testing of IEC 61850 Based Systems (to be published 2009)
11. Australian National Electricity Rules http://www.aemc.gov.au/rules.php
12. More, Faster, Less, Less - Maunsell & UTInnovation – R Hughes, M Janssen SEAPAC 2009

13. Definitions of **interoperability** on the Web:
    - The ability of information systems to operate in conjunction with each other encompassing communication protocols, hardware software, application, and data compatibility layers.. www.ichnet.org/glossary.htm
    - the ability of one computer system to control another, even though the two systems are made by different manufacturers. www.sunrise-comp.co.uk/glossary.html
    - This refers to the ability of a system or a product to work with other systems or products without special effort on the part of the customer. ... www.michigandtv.com/glossary
    - The ability of any two computers that are interconnected to understand each other and perform mutually supportive tasks such as client/server computing www.nitrd.gov/pubs/bluebooks/1995/section.5.html

14. Definitions of redundancy on the Web:
    - Backup components used to ensure uninterrupted operation of a system in case of a failure. parabel-labs.com/docs/glossary/
    - A systematic approach to eliminating single points-of-failure in a network or data storage system. www.ucla.cyberstuff.net/glossary_digital_media.htm
    - A secondary system of backup equipment that performs similarly to a primary system, thereby preventing network downtime and system outages. www.the-saudi.net/vsat/vsat-glossary.htm
    - repetition of messages to reduce the probability of errors in transmission, the attribute of being superfluous and unneeded; a system design that duplicates components to provide alternatives in case one component fails, repetition of an act needlessly wordnet.princeton.edu/perl/webwn
    - Redundancy in engineering is the duplication of critical s of a system with the intention of increasing reliability of the system, usually in the case of a backup or fail-safe. en.wikipedia.org/wiki/Redundancy_(engineering)

15. Definitions of **sufficient** on the Web:
    - to provide comfort and meet obligations; an adequate quantity; a quantity that is large enough to achieve a purpose; wordnet.princeton.edu/perl/webwn
    - of a quantity that can fulfill a need or requirement but without being abundant; " wordnet.princeton.edu/perl/webwn

16. Definitions of **ensure** on the Web:
    - guarantee: make certain of something; be careful or certain to do something; wordnet.princeton.edu/perl/webwn

9 Biography

Rodney Hughes has more than twenty five years in the international power industry with a wide range of expertise in the strategic direction of substation, power system and telecommunication design. He graduated from Sydney University in 1980 and joined AREVA (then GEC) Protection & Control as a Protection Applications Engineer. In 1985 he was appointed as General Manager for the Protection & Control business in Australia through to 1998 during which time he was responsible for introducing several generations of AREVA’s technology to the market changing from electromechanical to static to digital to numeric and communicating systems. Rod moved to France as AREVA’s (then ALSTOM) HV Protection Product Director in charge of the R&D, marketing and production for distance and bus bar protection for the world market. In 2001 he moved back to Australia as the Protection & Telecommunications Manager for ElectraNet, the 275kV and 132kV transmission utility in South Australia and was subsequently appointed as the Plant Strategy & Technology Manager in 2003. He is now the Technical Director for Maunsell AECOM Power & Energy with responsibilities for developing IEC 61850 based expertise and applications. He has served on CIGRE Australia's Panel B5 since 1985 and was appointed as Convener in 2003. He has contributed as editor to the publication of Technical Brochure 326 on IEC 61850 implementation.

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