Documentation Requirements Throughout The Lifecycle Of Digital Substation Automation Systems

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The Need for Suitable Documentation

Digital Substation Automation Systems (DSAS) have been in use for well over 20 years and are the basis of most modern substation secondary systems - protection, SCADA, condition monitoring and automation. This "digitalisation" of the secondary systems provides the means to implement higher levels of performance and functionality. There have been many experiences and learnings in deployment of many proprietary DSAS as well as of various Standards related to different parts of the DSAS.

The DSAS involves 'orders of magnitude' more pieces of information being exchanged between devices than traditional wire-based systems. As an example a single protection contact was sufficient to cause a CB trip and initiate all sorts of other functions, albeit via many individual wires and terminations in between the devices. However, DSAS is able to communicate the phases involved, the specific protection elements that operated, time of that occurrence, the primary power system quantities, validity of the messages and even just the health of the device that caused the operation. In addition we are now able to create many more advanced functions leading to power system performance improvement without adding extra wires - just an extra set of messages being sent over the same LAN. As the DSAS shifts from wire-based to increasingly communication-based it becomes more virtual and dynamic than conventional physical solutions, involving the configuration of the various Intelligent Electronic Devices (IEDs) to exchange signals between them over a substation LAN.

Therefore the traditional wiring and device documentation systems are not appropriate, or indeed capable to represent the functions and extensive signals being communicated between the IEDs. As result, various proprietary and "ad-hoc" documentation methods have evolved over the last 20 years to satisfy the project requirements.

As it's main purpose, since it's release over 10 years ago, the IEC 61850 standard has certainly revolutionised the engineering process to configure devices to communicate. It has also been proven to achieve significant reduction in capital and refurbishment costs along with easier engineering and an increase in reliability – Reliable Reusable Engineering (refer CIGRÉ Technical Brochures 246, 329, 540). It is therefore appropriate that, as organisations move to adopt the IEC 61850-engineering process, a large portion of the Technical Brochure focuses on this technology. However, many of the principles apply equally to "legacy" DSAS (Modbus, IEC 60870-5, DNP3 etc) albeit to varying lesser extents.

However as the advanced engineering process for IED configuration and exchange of information between various tools, IEC 61850 does neither address the full scope of the DSAS nor specifically addresses the human-readable documentation requirements. Part 6 defines six structured text files (ICD, CID, IID, SSD, SCD, SED under the so called System Configuration Language - SCL) that are exchanged between the software tools during the engineering process. As millions of lines of text fields, these files are barely readable by humans and as such may fail to convey how it will work being essential to operating and maintenance of the system. The files are essential to the engineering process, but other documentation formats are needed in association with them. These types of documentation need to be linked/integrated with the SCL files to ensure coherency in all respects and at all times to be more than •••

just "as built" documentation but rather the objective of up-to-the-minute As Operating documentation.

The papers, discussions and reports related to Preferential Subject 1 of the 2009 SC B5 Colloquium and Technical Brochure 464 (Maintenance Strategies for Digital Substation Automation Systems) clearly show the need for a clarification on documentation requirements.

Insufficient documentation may lead to misunderstandings between utilities, vendors and contractors in the creation of the DSAS. A complete and clear set of documentation is also required during the lifetime of the systems for maintenance, extension or refurbishments of the system or of parts of the systems.

These evolutions raise the need to completely review the documentation associated to all phases of the life-cycle of DSAS. New documentation systems and formats need to be appropriate for providing the necessary documentation inputs to that phase for humans to do their work, as well as those required as the documentation outputs to be used in subsequent phases.

However, whatever the form chosen, it is also clear that a part of this documentation has to:

- be directly readable by maintenance, engineering and approval staff,
- cover not only all devices of the DSAS but also the design and operation of the whole system,
- include maintenance test procedures,
- be automated to eliminate human rework, manipulation or interpretation.

This Technical Brochure does not attempt to describe the entire suite of documentation for a SAS in general - i.e. traditional "wire-based" system documentation is "well known" and in common use which needs no investigation. Equally the Technical Brochure is not specifically a description of tools - itself a subject of much discussion of what tools are required as the suite of tools for DSAS such as the Preferential Subject at SC B5 Colloquium in 2011.

Structure and Content of the TB

The Technical Brochure first of all sets out the general changes to documentation for DSAS. Chapter 2 deals with defining what the general meaning of the term "documentation" involves, from both procedural and Standards perspectives. It then follows the lifecycle stages identified in Chapters 3 - 8. The focus of these Chapters are summarised as follows:

Chapter1 - Introduction

Clearly documentation has been a core requirement of all secondary systems design for many decades. The introduction of digital technologies adds a new dimension to the nature of documentation. No longer is documentation related to drawing of an individual wire from device "A" to device "B", but rather highly detailed information is contained in Datasets, various types of messages and configuration of devices to be able to communicate and the communication network infrastructure itself. Moreover, documentation now needs to reflect the combined primary and secondary system, logical and physical, and be able to be referenced by many different users at many different stages of the lifecycle. Identification of these Users and the Lifecycle itself is therefore the key to embarking on establishing an appropriate engineering process and associated documentation.

Chapter 2 - The Philosophy And Process Of Documentation

Documentation is a widely used term covering many requirements and formats. In the context of creating and operating a Substation Automation System many different people have needs for different types of documentation. Whilst IEC 61850 has certain defined file types for exchange of information between engineering software, these are not really for "human consumption". This chapter includes identification of the relationship between various Standards pertaining to documentation (IEC 61666, IEC 81346, IEC 61082, IEC 60617, IEC 61355, IEC 61175 and IEC 61850). Along with any documentation comes a requirement for suitable governance procedures to maintain the integrity and coherence of the information throughout the life cycle with the objective of establishing "as operating" documentation.

Chapter 3 - Policy, Concept And Standardisation Phase

The long life cycle of a SAS in itself presents a conundrum of being able to integrate new technologies whilst maintaining a consistent set of operational capabilities throughout. This is even more critical in a DSAS with the need over the long life times of the substation to incorporate new equipment into a highly integrated environment whilst not being constrained by the oldest technology. Establishing appropriate standards sets the basis for each subsequent specific implementation.

Chapter 4 - System Design Phase

The design phase reflects the first step of the project execution of a digital substation automation system. This is essentially creating the functional specification of the DSAS created by the Systems Integrator primarily for the Asset Owner to validate the system design. The documentation shows on a high level the structure, functions, devices and how it is intended to be built. The main document of the system design phase is the functional description; this is generally a composite document(s) including, text, diagrams, tables images and other required formats.

Chapter 5 - IED Procurement Specifications

In the past, the IED procurement process has been focused on the performance of the IED and its own •••

functions as "stand alone" devices. However in a SAS, specification documentation and responses must evolve to cater for the detailed datamodels, the communication interaction between the IEDs and indeed the engineering tools become the core criteria to successfully procure the right IEDs for the specific application and engineering process which is not just evident from a simplistic statement of "conformance to the Standard".

Chapter 6 - Implementation - FAT - SAT

This implementation phase has the input from the documentation of the design phase. The implementation phase creates the "as built" documentation of the Digital Substation Automation System. Thereby this chapter describes mainly the documentation of the whole system and the documentation of the tests.

Chapter 7 - Operation Requirements

The DSAS operating manual is a critical component supporting safe operation of the DSAS whilst all the equipment is in service. The importance of the manual cannot be overstated, since the DSAS may include a variety of automated functions that may directly control equipment function.

Chapter 8 - Maintenance Requirements

Maintenance generally involves dealing with some part of the DSAS, perhaps involving testing, whilst the rest of the DSAS remains in service. In the past tests were done by physically disconnecting the wires to the IED, allowing it to be tested in total isolation of the rest of the system, A DSAS however involves all IEDs remaining in constant communication with all the other IEDs and hence physical or "air gap" isolation is not possible. DSAS requires sending additional test messages to the Device Under Test (DUT) whilst the normal messages are still arriving over the LAN. Equally the DUT will be issuing its messages to the LAN and hence all the other IEDs need to be appropriately configured as to how to respond to them. Maintenance documentation is therefore critical on how to set not only the DUT, but also all other IEDs into the right configuration.

The Appendices deal with:

- Definitions, Abbreviations and Symbols
- Links and References
- Sample Contents of Specification Documents
- What Does "Digital" Mean/Not Mean?
- New documentation formats as UML Diagrams and FICS

Conclusion

SC B5 has been at the forefront of providing guidance on the implementation of DSAS with many Technical Brochures providing extensive reference material. However SC B5 has also been concerned about the new documentation requirements and to establish some basis of what new types, format and content of documentation is inherently required because of the change to Digital SAS.

Readers of this Technical Brochure will gain a comprehensive understanding of:

- interrelationship of various documentation Standards;
- the corporate, commercial and technical governance changes that are required with specifically Digital SAS; and
- how specifically Digital SAS documentation evolves and is used by different users in different formats throughout the lifecycle.

It is expected that this 'exposé' of DSAS-specific documentation requirements will lead to more advanced engineering tools that will aid in creation and maintenance of documentation throughout the lifecycle. ■