Secondary technology for advanced substations

Integrated engineering using IEC 61850

Some 20 years after the introduction of the IEC 61850-based communication system, many German energy suppliers are still beginners and are not fully utilizing Ethernet-based communication system in their switchgear systems. However, the majority of energy supply companies (EVU) have been using IEC 61850 for many years.

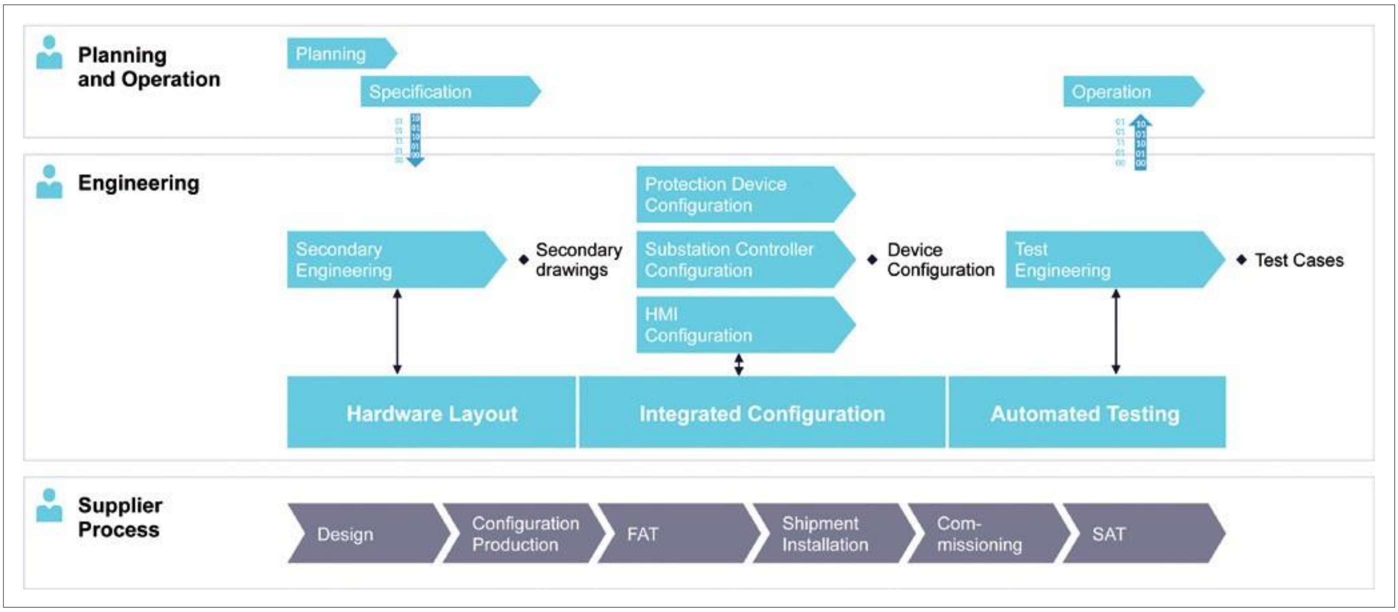

Figure 1. Integrated engineering process

Compared to similar communication standards, IEC 61850 offers broader capabilities for data communication control, redundancy procedures, and quality evaluation. There is greater flexibility. For example, the possibility to supervise the communication, the redundancy mechanism and the higher flexibility given by the standardized Goose communication between the devices., IT security represents a key characteristic. Additionally, the standard is evolving, thus creating new benefits for users. Compared with serial communication according to IEC 60870-5-103, the communication system based on IEC 61850 is considerably more comprehensive and therefore more powerful. Naturally, having more capabilities increases complexity compared with serial protocols, but the benefits for the user clearly outweigh this. The operator learns the system within a few months, creates a new platform in the company, and increasingly benefits from the advantages with each step.

And as mentioned previously, development is ongoing. The process bus is an additional application that has become an inherent part using the same standard. A wide range of protection system manufacturers already offer products and solutions, and



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operators abroad, as well as locally, are implementing the first systems using the IEC 61850-based process bus. It can be expected that the new technologies will become more widespread more quickly than some have predicted.

We recommend that EVUs with more than 100 protection devices that are not yet operating with IEC 61850 take the next step, prepare their personnel, accordingly, implement initial pilot systems and leverage the many advantages. Professional introduction and application require not only the respective hardware and software components and corresponding engineering tools, but also staff training, appropriate consultation as part of the pilot stage, and a step-by-step adaptation of internal company processes consistent with the new communication system.

Major energy companies that operate several thousand protection devices and have already started the transition to IEC 61850 in Germany are expecting improvements and cost reductions based on the following:

- an integrated, interoperable engineering process conforming to the standards
- faster adaptation to new company requirements or external conditions,
- shorter replacement of secondary technology after the end of service life has been reached, etc.

Abbreviations

BAP	Basic Application Profile
CID	Configured IED Description
Goose	Generic Object-Oriented Substation Event
HMI	Human Machine Interface
ICD	IED Configuration Description
IED	Intelligent Electronic Device (Protection and automation devices)
SCD	System Configuration Description
SCF	Substation Configuration File (configuration file for Sitipe)
SCL	System Configuration Description Language (IEC 61850 configuration language)
SCT	System Configuration Tool
SSD	System Specification Description
TR	Technical Report
XML	eXtensible Markup Language (text-based data format)

Improved integration and automation in the engineering process.

The goal of integrated engineering is to standardize and automate the various operation steps required for the secondary engineering of a substation, including the creation of documentation. An essential prerequisite for the standardization and automation is a standardized specification. As a standard, the IEC 61850 data model is an excellent choice for automating energy systems and designing an integrated engineering process for secondary technology.

Figure 1 presents a diagram of the steps for engineering the secondary technology. The essential steps here are the layout of the hardware which is created with a CAD system, the parameterization and configuration of the protection and automation components with programs such as DIGSI and SICAM, the final test of the system, as well as archiving and documentation.

The IEC 61850 data model focuses on the description of communication in the substation and the functions of the protection and automation components. This suggests that the greatest benefit of the integrated engineering process based on the IEC 61850 data model can be leveraged during the parameterization of these components.

Figure 2 shows the current status of an integrated engineering process using the IEC 61850 data model. First, a manufacturer-independent system specification is created using a suitable tool, for instance the Helinks STS System Integrator or similar. Next, the manufacturer-specific typicals are created based on the SSD file generated from the specification in the configuration tool for the IED, such as DIGSI. This is necessary because additional information is required for the respective typicals such as signal attributes or CFC logic. This information extends beyond the IEC 61850 data model in some cases. Then, this manufacturer-specific typical information is linked to the manufacturer-independent information in the system configuration tool and stored.

The next step is system configuration using the instancing process (creating an object in the object-oriented programming technology) for the defined typicals and generation of the system description by creating the SCD file.

Finally, the protection and automation devices are configured and parameterized, i.e., adapted to the specific requirements of the respective switchgear. This is achieved by reading the corresponding SCD file, which has a manufacturer-independent structure in accordance with IEC 61850, into the configuration tools.

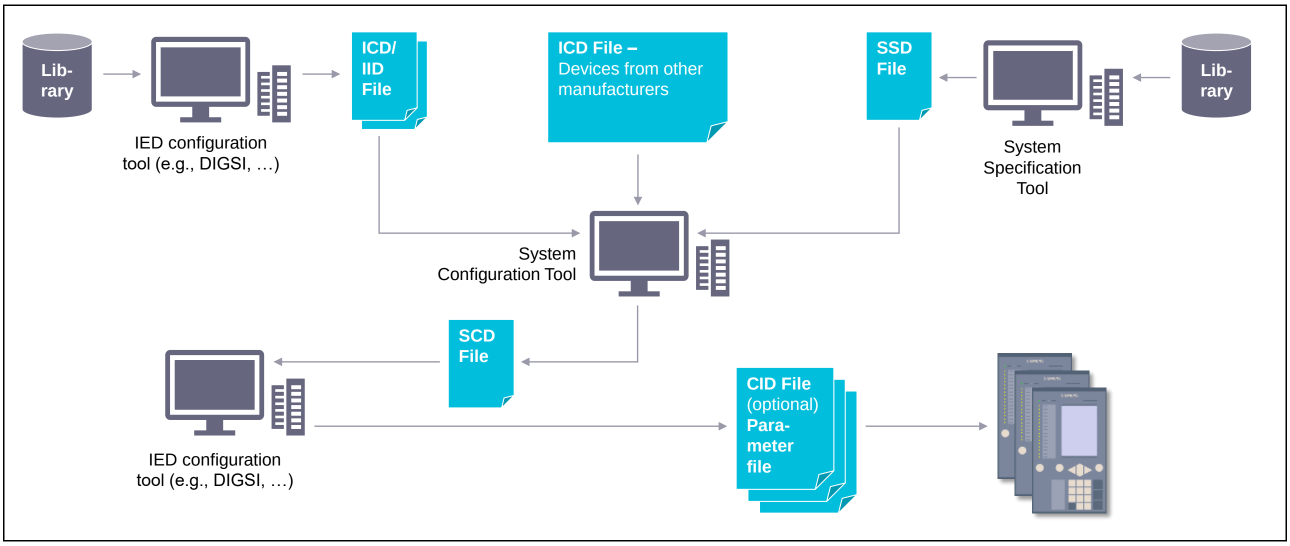

Figure 2. Engineering process in accordance with IEC 61850

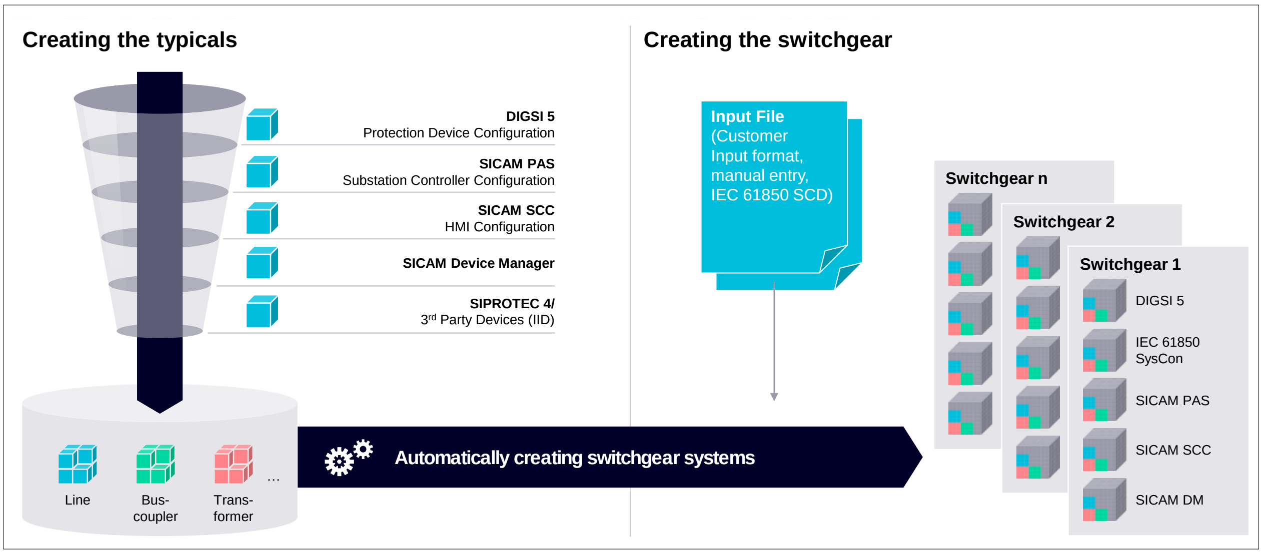

Figure 3. Central approach for the integrated engineering process

Where are we today?

For integrated IEC 61850-based engineering, all tools involved must have interoperable interfaces for the exchange of SCL files. At Siemens, tools such as DIGSI, SICAM PAS, SICAM Device Manager, and SICAM SCC offer maximum interoperability, as has been shown in many projects by the trouble-free interaction with IEDs or third-party tools.

For predefined typicals, it is possible to automatically create and configure the IEDs, the station control system, and the station HMI based on descriptions standardized according to IEC 61850 (SCD, SSD, etc.).

This procedure is already being used today by several network operators. For this application, the high interoperability of the tools is absolutely necessary in order to map the system specification by a third-party manufacturer in a consistent system and IED configuration based on typicals.

Function parameterizations that are not yet standardized by IEC 61850 today, such as signal attributes, CFC logic, HMI, and communication mapping to serial or control center protocols, are typically generated in addition to the SCL files and provided separately.

SITIPE IC software provides an option for integrated system engineering. Furthermore, SITIPE IC allows the user to uniformly archive data and create data versions and data records. The solution is also based on previously created typicals.

Figure 3 shows a diagram of the integrated engineering process based on the centralized approach. Note that in the last step the data are transferred in parallel to the DIGSI, SICAM PAS, and SICAM SCC configuration tools by importing the SCD file one time; the configurations are created automatically. SITIPE software also offers the ability to automate functions that go beyond the scope of IEC 61850 information, e.g., IEC 60870-5-103.

The benefit of SITIPE is, in addition to the archiving and recording of data previously noted, the elimination of manual signal list and communication parameter translation into the different manufacturer-specific tools. As a result, the manual engineering effort involved is reduced, while at the same time resulting in higher quality results.

Figure 4 shows a practical example in which the conventional engineering process was changed to the integrated engineering solution. By reading the substation configuration file (SCF) containing the IEC 61850 information, the parameterizations for the protection devices, the station control system, and the HMI are created automatically. In comparison to the conventional engineering process where parameterizations are performed sequentially, the time needed to engineer the transmission system operator's switchgear systems was reduced significantly. Automatically creating the configurations prevented incorrect parameterizations, which typically occur during manual engineering.

In addition to the considerable optimizations achieved during the initial creation of the substation, the described procedure can also be used to expand or adapt the automation configuration of the substation. If new signals are required in a switchgear or if existing signals have to be changed, the integrated engineering process is used in the same way and the signals are automatically created or changed in the engineering tools.

Since an initial effort is involved in creating the typicals and introducing an integrated engineering process, it is important to note that the savings that can be achieved stand in relation to the number of switchgear systems to be processed each year. In other words, the more switchgear systems that

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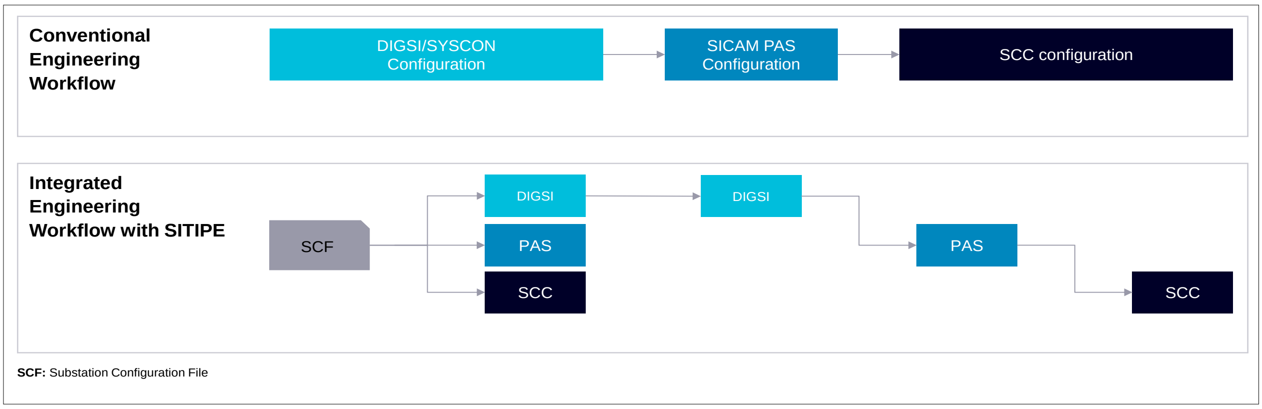

Figure 4. Example of the transformation of a transport network operator's engineering process

are created automatically with the previously created typicals, the greater the total time saved. Therefore, before introducing an integrated engineering process, it is necessary to evaluate the repeat rate that can be achieved and use this information as a basis to decide how much time it will take for this the one-time effort to pay off.

It should generally be noted that introducing integrated engineering cannot be regarded as an isolated process but goes hand in hand with the standardization of the switchgear system engineering as a whole. The higher the standardization of the switchgear systems, the lower variance in typicals and the higher the repeat rate for system engineering.

Further standardization steps

The prerequisites and further improvements of a comprehensive and integrated engineering process in accordance with IEC 61850 are developed in the international standardization division of IEC TC57 WG10 (»Power systems IED communication and associated data models« work group). This includes mainly the following standardization documents:

- IEC TR 61850-6-100 is a guideline for function-oriented modeling of a substation specification with SCL according to IEC 61850. It also leads to a recommendation of extended XML rules for data structures of SCL files (SCL schema). The goal of function-oriented modeling is to make the complete specification of the station automation system, including the data structures and function relations required for device modeling, manufacturer-independent. This technical report (TR) has been available as a draft since the summer of 2020. After incorporation of a number of comments from community of experts, the likely publication date will be in 2021.
- IEC TR 61850-7-6 is a technical report for the definition of Basic Application Profiles (BAP). BAP is an IEC 61850 application profile used as a basic module for engineering. An application can be an individual protection application in which several protection devices are involved. The »Reverse interlocking« application is a popular example. All possible basic applications of the protection and control systems can be formally described as BAP in templates (tables, drawings, text). IEC TR 61850-7-6 is under development in Edition 2 of the technical report and adds the SCL component to the BAP concept. Here, the BAP applications are configured using the SCL tools; in other words, they are created so they are machine-readable according to SCL and saved in libraries for further processing. The SCL BAP can be used to describe the signal flow from source devices to receiving devices independently of the manufacturer. Similar to a Lego approach, the goal is to use the different BAP modules during the specification for a complete system configuration. A first draft is to be presented to the experts in 2021.

Therefore, the two standardization documents complement each other with the goal of creating further cornerstones for an efficient engineering process.

The goal of further IEC 61850 standardization projects is to standardize IEC 61850-conforming engineering in the area of role-based access rights, logic programming within and between devices, configuration of HMI including text descriptors, as well as machine-readable secondary engineering documentation, e.g., linking the physical terminal to the logic IEC61850 signal.

The coming years will be characterized by a close cooperation of the representatives from the standard committees, the developers from the manufacturers of secondary engineering equipment, and their operators. This is the only sufficiently fast and practical way to achieve a further milestone in terms of the standardization and reduction of effort involved in the engineering process.

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