A**rbeits**K**reis **952.0.1:

Description of the Engineering Process

Version 1.0

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1. Applications

The workflows in the engineering process differ according to the particular application. The following applications are defined:

- Erecting a new substation
  - Without template
  - Using templates
  - Based on an existing substation (delta engineering)
- Modifications in an existing substation
  - Reduction / expansion by one bay
  - Changing the information scope in one IED (e.g. by modifying one functionality)
  - Replacing an IED with a device from a different manufacturer without change to the functionality
  - Replacing an IED due to changed functional requirements
  - Parameter changes
  - Firmware exchange (functional modification)
  - Firmware exchange (modifications in the area of communication)

2. Actors in the engineering process

Different actors are involved in the engineering process:

- Manufacturers of (e.g.)
  - Protection / bay devices
  - Network components
  - Operator stations
  - Gateways
  - Transformer/resonance controller
  - Tools
- Users (e.g.)
  - Owners / asset management
  - Plant operators
  - Network control center
  - Substation service
- Service providers (e.g.)
  - Planning agency / consulter
  - Assembly companies
  - Service

3. Roles in the engineering process

The actors in the engineering process can take on different roles. The possible roles and the associated tasks are described in the table below:

System engineer for secondary equipment	Translating the guidelines into substation-specific planning Result: Requirement specifications for secondary equipment
Project engineer for secondary equipment	Translating the system requirements into a solution comprising products, protocols etc. Result: Target specification for secondary equipment
System integrator	Logical linking of the devices, routing of the bay-spanning functions, ensuring the communication required for the functions, compilation of the information for test and commissioning
Device parameterizer	Parameterization of the individual devices, integrating functions into the devices
System tester (e.g. commissioning engineer)	Test and release of the entire system, fault diagnostics
Device tester	Test and release of individual system components
Construction engineer	Translating the specifications into wiring
Assembly operator	System assembly (installation and wiring)

4. Tools in the engineering process

Several tools are used in the engineering process. These tools and their tasks are described in the table below:

Tool	Task
System Specification	▪ Defining the primary substation structure (topology as single line) ▪ Defining function-related data objects (acc. to IEC61850) ▪ Creating the system specification file (.ssd file)
Device configuration (manufacturer-specific)	▪ Configuring the device functions (e.g. protection, control and automation functions) ▪ Creating the device model (.icd file) ▪ Importing the system configuration file (.scd file) ▪ Creating the device parameterization file ▪ Loading the device parameterization file into the target device
System configuration	▪ Importing the system specification file (.ssd file) ▪ Importing device models (.icd files) ▪ Configuring communication settings ▪ Configuring communication functions (reporting, GOOSE cross-communication) ▪ Creating the system configuration file (.scd file)
Test	▪ Simulating / stimulating process signals ▪ Simulating / stimulating communication signals ▪ Testing device and system functions and verifying the desired behaviour
Diagnostics	▪ Listening in to / recording the communication traffic ▪ Retrieving and displaying device models (acc. to IEC 61850)
Documentation	Creating and archiving of: ▪ signal lists ▪ interfacing diagrams ▪ function charts ▪ test reports ▪ parameter and configuration files

5. Description of the engineering processes

As described under *Applications*, the engineering processes depend on the particular application case that is the motive for starting the process. It may be necessary to repeat certain process steps, e. g. during the release/revision process or for retroactive adaptations.

Definition of the file extensions according to IEC61850-6:

.scd ➔ Substation Configuration Description
.ssd ➔ Substation Specification Description
.icd ➔ IED Capability Description
.cid ➔ Configured IED Description
.iid ➔ Instantiated IED Description (in IEC61850-6 Edition 2)

Outside the standard, this document differentiates between different versions of the .icd file:

.icd (type 1) ➔ .icd file supplied by the manufacturer which describes the possibilities of the device within the scope of IEC61850 independent of the actual application in the project
.icd (type 2) ➔ .icd (type 1) file tailored to the actual application in the project (equivalent to the .iid file in IEC61850-6 Edition 2)
.icd (type 3) ➔ typed .icd file (used when working with templates) with modelled substation section, IED section and the references between substation LNs and IED LNs. The file extension .scd has to be selected for typed bays consisting of multiple IEDs.

5.1 Definition of the engineering process steps

5.1.1 Substation specification

Process step	*Input*	*Output*	*Role (acc. to chap. 3)*	*Tool (acc. to chap. 4)*
Develop planning of secondary equipment	- Single-line diagram (as specification from the network planning) - Function requirements - Technical system guidelines - System management concepts	- Requirement specification with the following contents: o Function chart of the secondary system Function chart o Quantified project specifications (information model - process data - connection of network control center) o Function charts (logical diagrams - interlocking, switching authority, protection functions) o Verbal requirements (using IEC 61850 - object types/services, combination devices, availability)	- System engineer for secondary equipment	- Documentation
Creation of the .ssd file	- Requirement specification	- .ssd file	- System engineer for secondary equipment	- System specification - Documentation

5.1.2 Implementation planning - device specifications - target specification

Process step	*Input*	*Output*	*Role (acc. to chap. 3)*	*Tool (acc. to chap. 4)*
Implementation planning / selecting devices	- Requirement specification o Function chart of the secondary system Function chart o Quantified project specifications (information model - process data - connection of network control center) o Function charts (logical diagrams - interlocking, switching authority, protection functions) o Verbal requirements (using IEC 61850 - object types/services, combination devices, availability) - .ssd file	- Target specification with the following contents: o Number and layout of devices o Selected devices (manufacturer and type) o Distribution of the functions among the devices o .icd (type 1) file	- Project engineer for secondary equipment	- Device configuration (manufacturer specific) - Documentation

5.1.3 Implementation planning - system specifications - target specification

Process step	*Input*	*Output*	*Role (acc. to chap. 3)*	*Tool (acc. to chap. 4)*
Determination of the network design	- Function chart of the secondary system Function chart - Selected devices (manufacturer and type) - Verbal requirements	- Network design - Target specification	- Project engineer for secondary equipment	- Documentation
Selecting the network components	- Network design - Function chart of the secondary system Function chart - Verbal requirements - Proof of compatibility of the network components	- Selected network components (manufacturer and type)	- Project engineer for secondary equipment	- Documentation
Determining the system communication	- Requirement specification o Function chart of the secondary system Function chart o Quantified project specifications (information model - process data - connection of network control center) o Function charts (logical diagrams - interlocking, switching authority, protection functions) o Verbal requirements (using IEC 61850 - object types/services, combination devices, availability) - Network design	- System parameters (communication settings) - Selecting the communication services (specifications for reporting and GOOSE)	- Project engineer for secondary equipment	- Documentation

5.1.4 Device configuration

Process step	*Input*	*Output*	*Role (acc. to chap. 3)*	*Tool (acc. to chap. 4)*
Configuration of the device functions	- Requirement specification	- Function-related device parameterization (manufacturer-specific configuration file) -	- Device parameterizer	- Device configuration (manufacturer specific) - Documentation
Creating the .icd (type 2) file	- Requirement specification o Function chart of the secondary system Function chart o Quantified project specifications (information model - process data - connection of network control center) o Function charts (logical diagrams - interlocking, switching authority, protection functions) o Verbal requirements (using IEC 61850 - object types/services, combination devices, availability) - Selected devices (manufacturer and type) - .icd (type 1) file - .ssd file	- .icd (type 2) file	- Device parameterizer	- Device configuration (manufacturer specific) - Documentation
Configuration of the communication functions	- Network design - Selecting the communication services (specifications for reporting and GOOSE)	- Communication-related device configuration	- Device parameterizer	- Device configuration (manufacturer specific) - Documentation

5.1.5 System configuration

Process step	*Input*	*Output*	*Role (acc. to chap. 3)*	*Tool (acc. to chap. 4)*
Linking the substation section with the IED section (functional naming) Parameterizing the system configuration including routing of information	- System parameters (communication settings) - Network design - .icd (type 2) files - .ssd file	- .scd file	- System integrator	- System configuration - Documentation
Compilation of the information for test and commissioning	- .scd file - Project-related additional information (e.g. message addresses for connection of network control center) - Wiring manual/circuit diagrams	- Test specifications/lists or .scd file with additional test information	- System integrator	- System configuration - Documentation

5.1.6 Final device parameterization

Process step	*Input*	*Output*	*Role (acc. to chap. 3)*	*Tool (acc. to chap. 4)*
Merging the device parameterization	- Function-related device parameterization - Communication-related device parameterization - .scd file	- Manufacturer-specific device parameterization file - Optionally .cid file	- Device parameterizer	- Device configuration (manufacturer specific) - Documentation
Loading the device parameterization into the devices	- Specific device parameterization file	- Completely parameterized devices	- Device parameterizer Alternatively: - System tester	- Device configuration (manufacturer specific) - Documentation

5.1.7 Installation

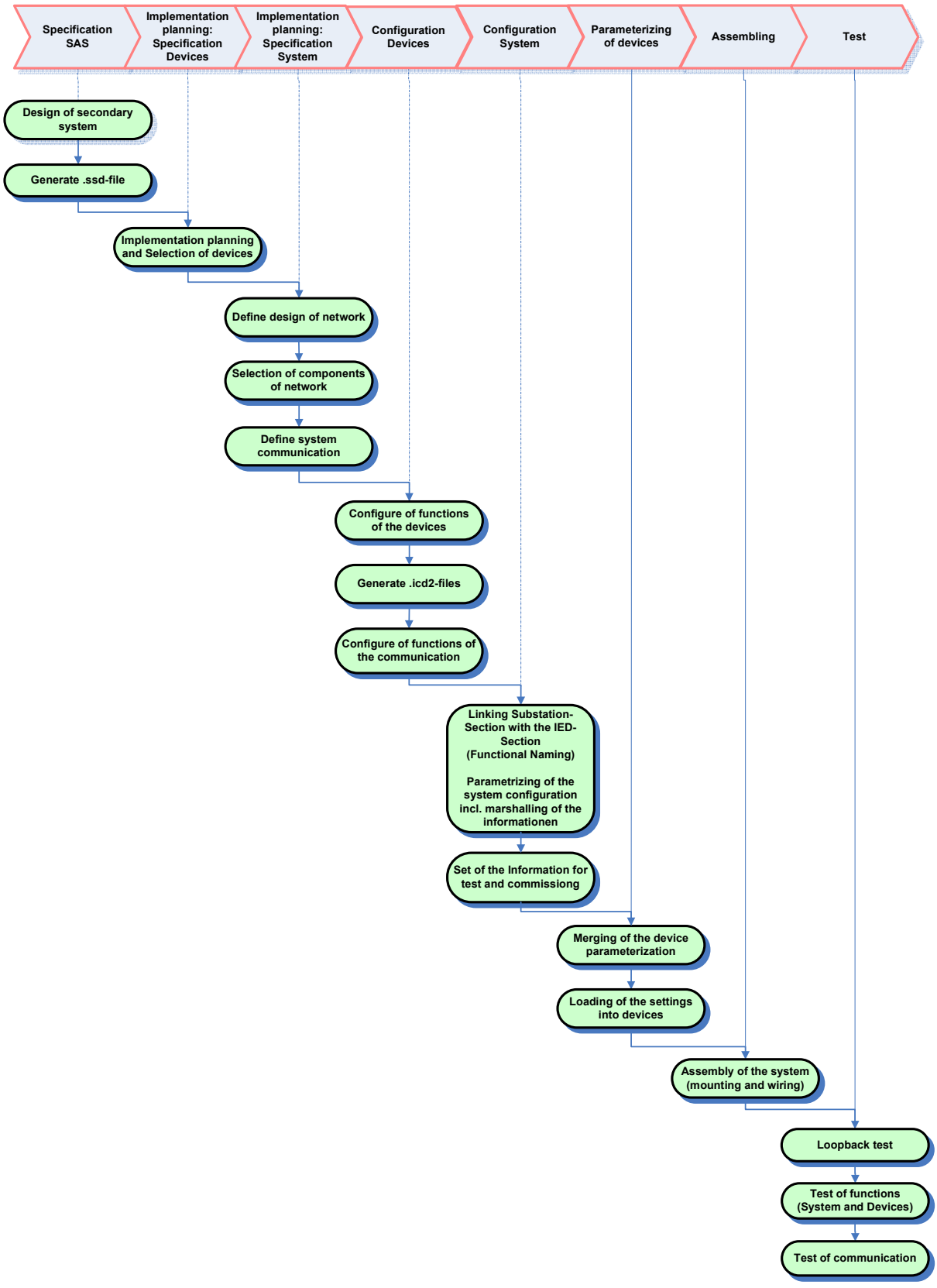
Process step	*Input*	*Output*	*Role (acc. to chap. 3)*	*Tool (acc. to chap. 4)*
System assembly (installation and wiring)	- Completely parameterized devices - Network design - Wiring manual/circuit diagrams	- Functional overall system	- Assembly operator	- Documentation

5.1.8 Test (factory acceptance test / commissioning test)

Process step	*Input*	*Output*	*Role (acc. to chap. 3)*	*Tool (acc. to chap. 4)*
Bit test	- Wiring manual/circuit diagrams - Quantified project specifications (information model - process data - connection of network control center) - .scd file	- Test protocol of bit test	- System tester	- Test - Diagnostics - Documentation
Function test (system and devices)	- Function charts (logical diagrams - interlocking, switching authority, protection functions) - Verbal requirements (using IEC 61850 - object types/services, combination devices, availability)	- Test protocol of function test	- System tester - Device tester	- Test - Diagnostics - Documentation
Communication test (availability and performance)	- Network design - Verbal requirements (using IEC 61850 - object types/services, combination devices, availability) - .scd file	- Test protocol of communication test	- System tester	- Test - Diagnostics - Documentation

5.2 Engineering process for a new substation (without template)

The following diagram shows the engineering process steps described in section 5.1 over time.



5.3 Engineering process for a new substation (using templates)

The engineering process according to IEC61850 supports the use of templates. If templates are available, some of the process steps described in chapter 5.1 can be omitted or input for the individual process steps is already available and does not have to be worked out anymore.

5.3.1 Template types

Template type	*Template description*	*Output*
1a Definition of bay types	- Template with the complete device-independent specification of a bay type (e.g. for the bay type of a 400/110-kV transformer bay with bay-specific properties) consisting of configured substation section and specified data objects in the DataTypeTemplate section.	- .ssd files for bay types
1b Definition of substation types	- Template with the complete device-independent specification of a substation type (e.g. for the substation type of a 110-kV submaster station with specific properties) consisting of configured substation section and specified data objects in the DataTypeTemplate section	- .ssd files for substation types
2 Definition of bay types with one IED (with defined device selection)	- Template of a bay type consisting of a manufacturer-independent substation model and a manufacturer-specific device model including the links between product naming and functional naming, e.g. 20-kV line bay with combined bay controller and protection device.	- .icd (type 3) file for devices of a bay type
3 Definition of bay types with more than one IED (with defined device selection)	- Template of a bay type consisting of a manufacturer-independent substation model and several manufacturer-specific device models including the links between product naming and functional naming, e.g. a 400-kV line bay with main and backup protection device and bay controller	- scd. file for device of defined bay types
4 Definition of substation types with more than one IED (with defined device selection)	- Template containing the complete configuration of a voltage level of a substation type consisting of the associated substation model and manufacturer-specific device models including the links between product naming and functional naming	- .scd file for devices of defined substation types

5.3.2 Using templates in tools

The illustration below shows the possible relations between templates, description files and tools in a template-supported engineering process.

A sample library comprises templates of different types:

- Bay and substation templates of type 1; these are created, used and managed using the system specification tool.
- Bay and substation templates of types 2 to 4; these are created, used and managed using the system configuration tool.

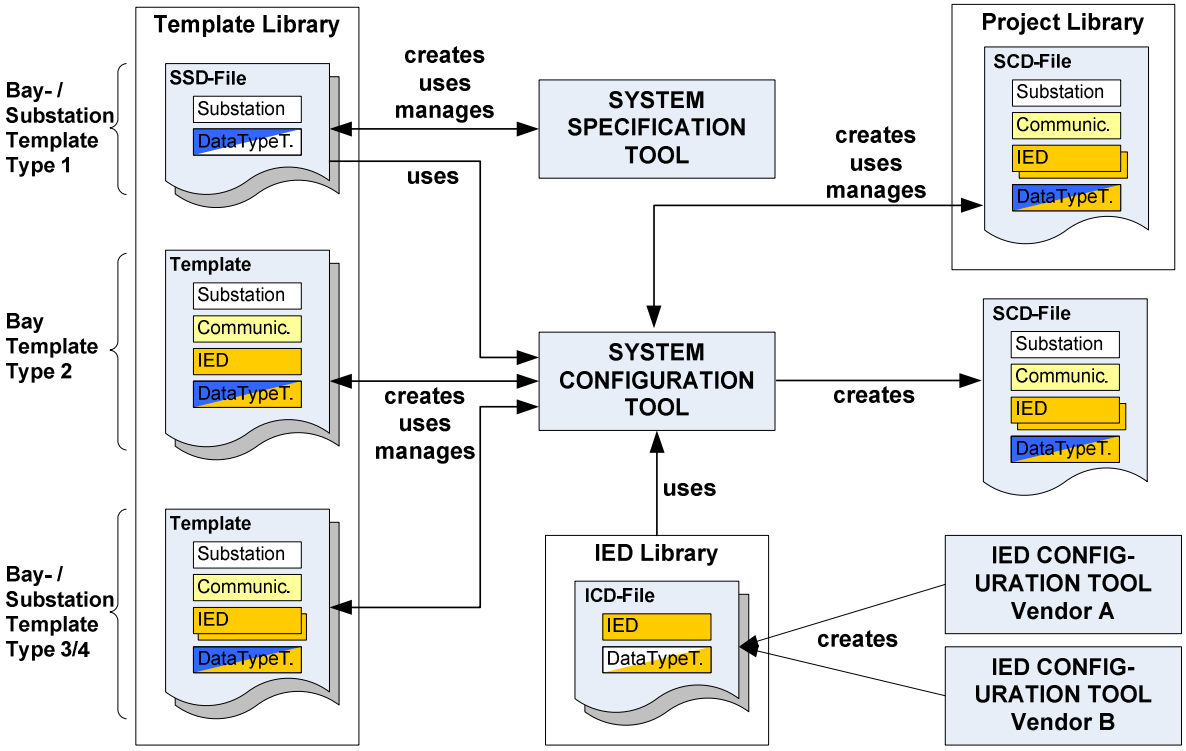
A device IED library serves to compile the device descriptions in the form of ICD files which are provided by the IED configuration tools.

A project library can be used to file system configuration descriptions in the form of SCD files created, used and managed by the system configuration tool.

A system configuration description for a concrete substation project can be created using the system configuration tool in the following ways:

- Modelling the entire substation by combining bay templates of type 1a or taking over a substation template of type 1b, subsequently adding device descriptions and linking the device description to the substation specification, adjusting the system configuration to project-specific requirements
- Modelling the entire substation by combining bay templates of type 2/3 or taking over a substation template of type 4, adjusting the system configuration to project-specific requirements
- Taking over a system configuration description from the project library, adjusting the system configuration to project-specific requirements

A system configuration description created in this way is passed on to the manufacturer-specific IED configuration tools for device parameterization.



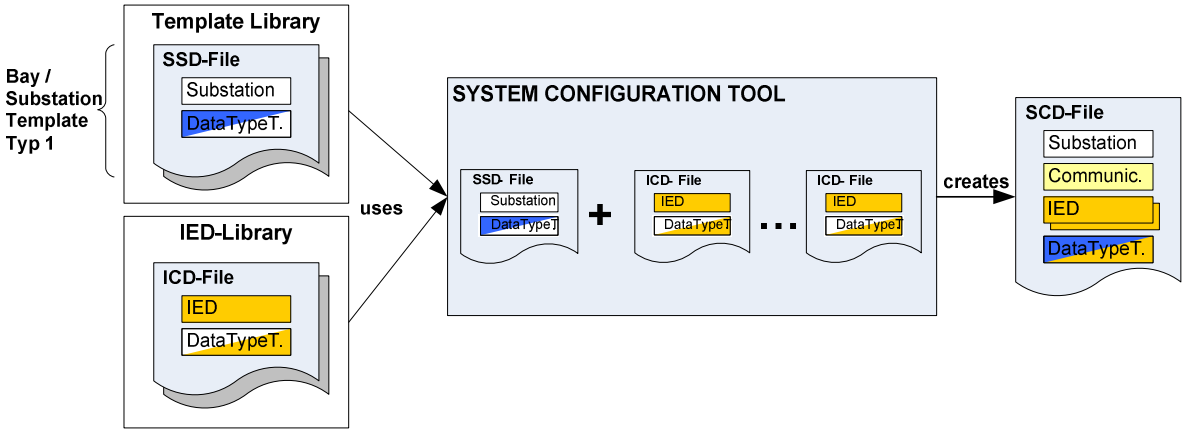
5.3.3 Saving potentials when using templates

The use of templates allows savings to be made in the engineering process. The following table describes the potential savings in each process step.

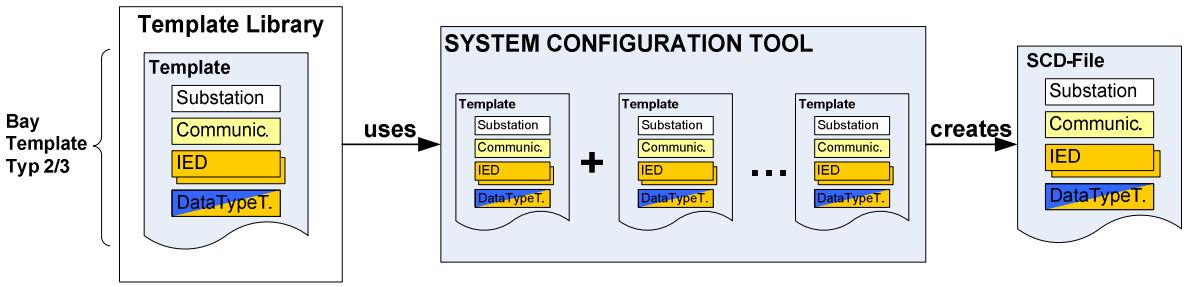
		Template type 1a	Template type 1b	Template type 2	Template type 3	Template type 4
5.1.1 Substation specification	Develop secondary planning	average	high	average	average	high
	Creating the .ssd file	average	high	average	average	high
5.1.2 Implementation planning - specification of devices - target specification	Implementation planning / selecting the devices			average	average	high
5.1.3 Implementation planning - specification of the system - target specification	Determining the network design					high
	Selecting network components					high
	Determining the system communication					high
5.1.4 Device configuration	Configuration of the device functions			high	high	high
	Creating the .icd (type 2) file			high	high	high
	Configuration of the communication functions			average	average	high
5.1.5 System configuration	Linking substation section with IED section (Funct. Naming)			high	high	high
	Parameterisation of the system configuration incl. routing of information			high	high	high
	Compilation of the information for test and commissioning	average	average	high	high	high
5.1.6 Final device parameterisation	Merging the device parameterisation					
	Loading the device parameterisation into the devices					
5.1.7 Assembly	Installing the system (installation and wiring)					
5.1.8 Test (factory acceptance test / commissioning test)	Bit test					
	Function test (system and devices)					
	Communication test					

Annotations [1]:

Templates enable the user to efficiently create a concrete specification and configuration of a substation automation system. The following examples present two possible approaches to obtain a complete system configuration based on different template types.



In the first example, the type 1 template with a device-independent specification of a substation type (e.g. 110-kV H configuration) presents the starting point for the configuration. After importing suitable device descriptions, the user links the functional substation model with the corresponding objects of the device models. This could be accomplished automatically by the system configuration tool by using previously defined association rules. Concrete substation designations, network addresses or cross-communication settings have yet to be assigned. Users could be supported here by intelligent functions of the system configuration tool which ensure the consistency of the settings.



In the second example, the type 2 or 3 bay templates are used each consisting of a bay-specific substation model and one or more manufacturer-specific device models linked with it. By compiling the corresponding bay templates required for modelling the entire substation, the user creates the entire substation and device model. Substation designations and communication settings may yet have to be adjusted but can largely be specified by the templates.

In the first example, the user can reduce the effort for the specification. In addition to that, the linking between substation model and device model becomes dispensable in the second example. The approach taken in the second example is certainly one of the most effective ways of carrying out the specification and configuration according to IEC 61850.

Potentials for reducing the engineering effort for test and commissioning can be achieved by using templates that contain information relevant for the device and system test in addition to the operation-specific information. Such information, e.g. the communication relations, telecontrol addresses, terminal information etc. can form the basis for creating e.g. test lists for the bit test of the substation, or directly updating test tools.

5.4 Engineering process for modifying an existing substation

The engineering process for modifications in an existing substation differs from that of a new substation in so far as only selected process steps are completed. Or only individual tasks within the process steps have to be carried out.

The following table describes the tasks in the individual process steps for modifications in an existing substation.

The following modifications were considered:

- Reduction / expansion by one bay
- Changing the information scope in one IED (e.g. by modifying one functionality)
- Replacing an IED with a device from a different manufacturer without change of the functionality
- Replacing an IED due to changed functional requirements
- Parameter changes
- Firmware exchange (functional modification)
- Firmware exchange (change in the area of communication)

		Expansion by one bay	Reduction by one bay	Changing the information scope in one IED (e.g. by modifying one functionality)	Replacing an IED with a device from a different manufacturer without change to the functionality IEDs are interface-compatible		Replacing an IED due to changed functional requirements	Parameter changes	Firmware change (functional modification)	Firmware change (change in the area of communication)
Marginal conditions:		Expansion by one by with identical structure, functions, device selection as already exists in the substation			IEDs with identical behaviour at the communication interface	IEDs with different behaviour at the communication interface	Changing protection settings or process value parameters (scaling, command termination delay, difference position supervision, ...)		Firmware replaced due to a function-related modification	Firmware replaced due to a communication-related modification
5.1.1	Substation specification	Work out planning of secondary equipment	Take over from existing bay type	Reduce specification if necessary	Adjust the requirement specification	- - -	- - -	Adjust the requirement specification	- - -	- - -	- - -
		Creation of the .ssd file	Adjust the .ssd file by adding a bay	Adjust the .ssd file by removing a bay	Expanding the .ssd file	- - -	- - -	Adjusting the .ssd file	- - -	- - -	- - -
5.1.2	Implementation planning - device specifications - target specification	Implementation planning / device selection	Adjusting the target specification only where the added bay is concerned (only quantities and scopes not functions)	Adjusting the target specification only where the reduced bay is concerned (only quantities and scopes not functions)	Adjusting the target specification only as concerns the added information scope	Select devices	Select devices	execute	- - -	- - -	- - -

			Expansion by one bay	Reduction by one bay	Changing the information scope in one IED (e.g. by modifying one functionality)	Replacing an IED with a device from a different manufacturer without change to the functionality IEDs are interface-compatible		Replacing an IED due to changed functional requirements	Parameter changes	Firmware change (functional modification)	Firmware change (change in the area of communication)
5.1.3	Implementation planning - system specifications - target specification	Determination of the network design	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
		Selection of the network components	Expansion when reaching system limits if necessary	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
		Determining the system communication	Take over	- - -	- - -	- - -	- - -	- - -	- - -	- - -	if required

5.1.4	Device configuration	Configuration of the device functions	Take over	- - -	execute	execute	execute	execute	execute	if required	if required
		Creating the .icd2 file	Take over	- - -	execute	execute	execute	execute	- - -	- - -	if required
		Configuration of the communication functions	Take over	- - -	Adjust datasets if necessary	execute	execute	execute	- - -	- - -	if required

			Expansion by one bay	Reduction by one bay	Changing the information scope in one IED (e.g. by modifying one functionality)	Replacing an IED with a device from a different manufacturer without change to the functionality IEDs are interface-compatible		Replacing an IED due to changed functional requirements	Parameter changes	Firmware change (functional modification)	Firmware change (change in the area of communication)
5.1.5	System configuration	Linking the substation section with the IED section (functional naming)	Add link for bay	Remove entries for bay	Adjust links for data objects	take over	adjust	Adjust links for data objects	- - -	- - -	if required
		Parameterizing the system configuration including routing of information	Adjust IED-related parameterization Ensure consistency	Adjust IED-related parameterization Ensure consistency	Adjust IED-related parameterization Ensure consistency	Ensure consistency after replacement	Adjust IED-related parameterization Ensure consistency	Adjust IED-related parameterization Ensure consistency	- - -	- - -	if required
		Compilation of the information for test and commissioning	work in	Remove entries for bay and all associated relations	Add entries for this modification and all associated relations	Take hardware interfacing into account	Add entries for IED and all associated relations	Add entries for IED and all associated relations	- - -	Add entries for this modification and all associated relations	Add entries for this modification and all associated relations
5.1.6	Final device parameterization	Merging the device parameterization	Take over and adjust to bay specification	- - -	execute	execute	execute	execute	execute	if required	if required
		Loading the device parameterization into the devices	execute	- - -	execute	execute	execute	execute	execute	if required	if required
5.1.7	Installation	System assembly (installation and wiring)	Installation	Disassembly	Adjust if necessary	exchange	exchange	exchange	- - -	- - -	- - -

			Expansion by one bay	Reduction by one bay	Changing the information scope in one IED (e.g. by modifying one functionality)	Replacing an IED with a device from a different manufacturer without change to the functionality IEDs are interface-compatible		Replacing an IED due to changed functional requirements	Parameter changes	Firmware change (functional modification)	Firmware change (change in the area of communication)
5.1.8	Test (factory acceptance test / commissioning test)	Bit test	execute	- - -	execute	execute	execute	execute	- - -	if required	execute
		Function test (system and devices)	Device functions and cross-bay functions	Cross-bay functions	Device functions and cross-bay functions	Device functions	Device functions and cross-bay functions	Device functions and cross-bay functions	Device functions	Device functions	execute
		Communication test	execute	execute	execute	execute	execute	execute	- - -	- - -	if required

6. Literature

[1] Dawidczak, H. ; Englert, H.; „Functional Naming in IEC 61850 – Prinzip und Anwendungen“, ew, Jg. 107 (2008), H. 1-2, S.66-70.