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Communication networks and systems for power utility automation – Part 4: System and project management

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COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 4: System and project management

FOREWORD

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IEC 61850-4 edition 2.1 contains the second edition (2011-04) [documents 57/1103/FDIS and 57/1122/RVD] and its amendment 1 (2020-11) [documents 57/2256/FDIS and 57/2271/RVD].

International Standard IEC 61850-4 has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

This edition aligns the document more closely with the other parts of the IEC 61850 series, in addition to enlarging the scope from substation automation systems to all utility automation systems.

A list of all parts of the IEC 61850 series, under the general title: *Communication networks and systems for power utility automation*, can be found on the IEC website.

The committee has decided that the contents of the base publication and its amendment will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
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COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 4: System and project management

1 Scope

This part of IEC 61850 applies to projects associated with processes near automation systems of power utilities (UAS, utility automation system), such as substation automation systems (SAS). It defines the system and project management for UAS with communication between intelligent electronic devices (IEDs) in the substation respective plant and the related system requirements.

The specifications of this part pertain to the system and project management with respect to:

– the engineering process and its supporting tools;
– the life cycle of the overall system and its IEDs;
– the quality assurance beginning with the development stage and ending with discontinuation and decommissioning of the UAS and its IEDs.

The requirements of the system and project management process and of special supporting tools for engineering and testing are described.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60848, *GRAFCET specification language for sequential function charts*

IEC 61082 (all parts), *Preparation of documents used in electrotechnology*

IEC 61175, *Industrial systems, installations and equipment and industrial products – Designation of signals*

IEC 61850-6, *Communication networks and systems for power utility automation – Part 6: Configuration description language for communication in power utility automation systems related to IEDs*

IEC 61850-7 (all parts), *Communication networks and systems for power utility automation – Part 7: Basic communication structure*

IEC 81346 (all parts), *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
supporting tools
those tools that support the user in the engineering, the operation and the management of the UAS and its IEDs

NOTE These tools are usually a part of the UAS.

3.2
engineering tools
tools that support the creation and documentation of the conditions for adapting an automation system to the specific plant (substation) and customer requirements

NOTE Engineering tools are divided into project management, configuration and documentation tools.

3.3
system specification tools
tools used to create a system requirement specification including the relation of system functions to the plant/substation to be managed; especially a tool creating a specification in a formally defined, standardized format for evaluation by other tools

3.4
system configuration tools
tools handling the communication between the IEDs in the system, configuration of issues common for several IEDs, and the logical association of the IED's functions to the process to be controlled and supervised

NOTE See also "system parameters".

3.5
IED configuration tools
tools handling the specific configuration and download of configuration data to a specific IED of a specific type

3.6
expandability
criteria for the efficient extension of an automation system (hardware and functional) by use of the engineering tools

3.7
flexibility
criteria for the fast and efficient implementation of functional changes including hardware

3.8
scalability
criteria for a cost effective system while recognizing various functionalities, various IEDs, substation sizes and substation voltage ranges

3.9
parameters
variables which define the behaviour of functions of the automation system and its IEDs within a given range of values

3.10
system parameters
data which define the interaction of IEDs in the system

NOTE System parameters are especially important in the:

– configuration of the system;
– communication between IEDs;
– marshalling of data between IEDs;
– processing and visualization of data from other IEDs (for example, at the station level).

3.11
IED parameters
parameters defining the behaviour of an IED and its relation to the process

3.12
IED-parameter set
all parameter values and configuration data needed for the definition of the behaviour of the IED and its adaptation to the substation conditions

NOTE Where the IED has to operate autonomously, the parameter-set can be generated without system parameters using an IED-specific parameterization tool. Where the IED is a part of the system, the parameter set may include the IED related or complete set of system parameters, which should be coordinated by a general parameterization tool at the system level.

3.13
UAS-parameter set
all parameter values and configuration data needed for the definition of the behaviour of the overall UAS and its adaptation to the substation conditions

NOTE The parameter set includes the IED-parameter sets of all participating IEDs.

3.14
remote terminal unit (RTU)
used as an outstation in a supervisory control and data acquisition (SCADA) system

NOTE An RTU may act as an interface between the communication network to the SCADA system and the substation equipment. The function of an RTU may reside in one IED or may be distributed.

3.15
UAS product family
different IEDs of one manufacturer with various functionalities and with the ability to perform within utility automation systems

NOTE The IEDs of a product family are unified in relation to the design, the operational handling, the mounting and wiring conditions, and they use common or coordinated supporting tools.

3.16
UAS installation
the concrete instance of a substation automation system consisting of multiple interoperable and connected IEDs of one or more manufacturers

3.17
configuration list
overview of all instances of IEDs and other installed products of a system, their hardware and software versions including the software versions of relevant supporting tools

NOTE The configuration list also contains the configured communication connections and addresses.

3.18
configuration compatibility list
overview of all compatible hardware and software versions of components and IEDs, including the software versions of relevant supporting tools operating together in an UAS-product family

NOTE The configuration compatibility list also contains the supported transmission protocols and protocol versions for communication with other IEDs.

3.19
manufacturer
the producer of IEDs and/or supporting tools

NOTE A manufacturer may be able to deliver an UAS solely by use of his own IEDs and supporting tools (UAS product family).

3.20
system integrator
a turnkey deliverer of UAS installations

NOTE The responsibility of system integration includes the engineering, the delivery and mounting of all participating IEDs, the factory and site acceptance tests and the trial operation. The quality assurance, the maintenance and spare delivery obligations and the warranty are agreed in the contract between the system integrator and the customer. A system integrator may use IEDs from several different manufacturers.

3.21
system life cycle
the term has two specific meanings:

a) for the manufacturer, the time period between the start of the production of a newly developed UAS product family and the discontinuation of support for the relevant IEDs;

b) for the customer, the time period between the commissioning of the system installation and the decommissioning of the last IED of the system installation

3.22
test equipment
all tools and instruments which simulate and verify the input/outputs of the operating environment of the automation system such as switchgear, transformers, network control centres or connected telecommunication units on one side, and the communication channels between the IEDs of the UAS on the other side

3.23
conformance test
verification of data flow on communication channels in accordance with the standard conditions concerning access organization, formats and bit sequences, time synchronization, timing, signal form and level, reaction to errors

NOTE The conformance test can be carried out and certified for the standard or specially described parts of the standard. The conformance test should be carried out by an ISO 9001 certified and by the UCA International User Group Subgroup testing qualified organization.

3.24
system test
validation of correct behaviour of the IEDs and of the overall automation system under various application conditions

NOTE The system test marks the final stage of the development of IEDs as part of a UAS product family.

3.25
type test
verification of correct behaviour of the IEDs of the automation system by use of the system tested software under the environmental test conditions corresponding with the technical data

NOTE This test marks the final stage of the hardware development and is the precondition for the start of the production. This test is carried out with IEDs that have been manufactured through the normal production cycle, and not with prototype HW.

3.26
factory acceptance test
FAT
customer agreed functional tests of the specifically manufactured system or its parts, using the parameter set for the planned application

NOTE This test is typically performed in the factory of the system integrator by the use of process simulating test equipment.

3.27
site acceptance test
SAT
verification of each data and control point and the correct functionality inside the automation system and between the automation system and its operating environment at the whole installed plant by use of the final parameter set

NOTE The SAT is a precondition for the automation system being put into operation.

3.28
system requirements specification
the specification of all requirements including functions, technical quality, and interfaces to the surrounding world

NOTE The requirement specification is typically supplied by the customer.

3.29
system design specification
a description of a system design showing how a system requirement specification is fulfilled with selected products, and how the required functions are implemented on them

NOTE The system design specification is typically provided by the system integrator.

4 Abbreviations

ASDU	application service data unit
CD ROM	compact disc read only memory
CAD	computer aided design
CT	current transformer
FAT	factory acceptance test
HMI	human machine Interface
.icd	IED capability description file
ICT	IED configuration tool
.iid	instantiated IED description file
IED	intelligent electronic device
PE	process environment
RTU	remote terminal unit
SAS	substation automation system
SAT	site acceptance test
SCADA	supervisory control and data acquisition
.scd	substation configuration description file
SCT	system configuration tool
.sed	system exchange description file
.ssd	system specification description file
TE	telecommunication environment
UAS	utility automation system
VT	voltage transformer

5 Engineering requirements

5.1 Overview

The engineering of a utility automation system is based on a system requirement specification, which defines the scope, functions, boundaries and additional restrictions and requirements for the system, and includes:

– the definition of the necessary hardware configuration of the UAS: i.e. the definition of the IEDs and their interfaces with one another and to the environment as shown in Figure 1;

– the adaptation of functionality and signal quantities to the specific operational requirements by use of parameters;

– the documentation of all specific definitions (i.e. parameter set, terminal connections, etc.).

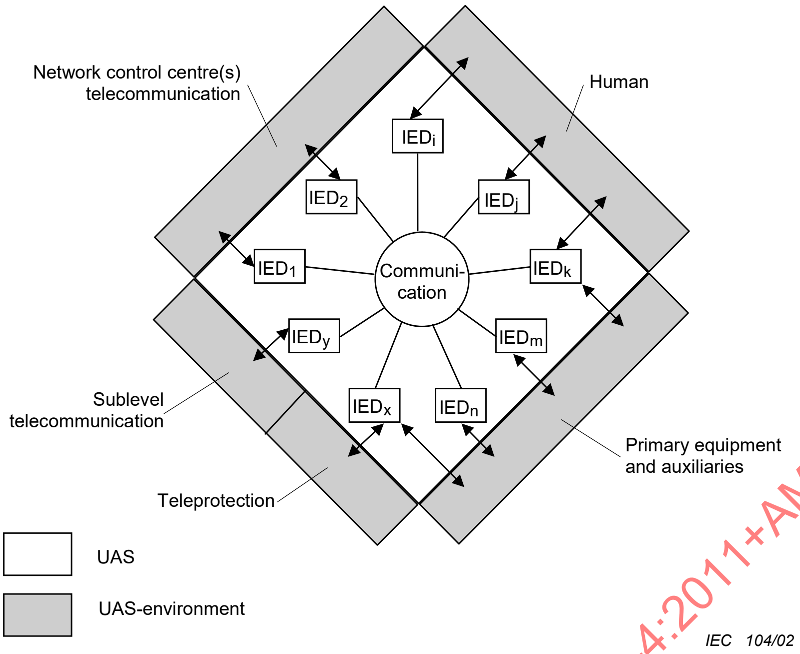

Figure 1 - Structure of the UAS and its environment

As shown in Figure 1, the UAS consists of different IEDs which communicate with each other via communication channels and which execute tasks concerning interactions with the environment of the automation system, such as:

– telecommunication environment (TE);
  - network control centre(s);
  - subordinate systems;
  - teleprotection;
– the human as a local operator;
– process environment (PE) like switchgear, transformer, auxiliaries.

Typical IEDs may be:

– for the telecommunication environment:
  - gateways;
  - converters;
  - RTUs (telecommunication side);
  - protection relays (teleprotection side);
– for the human machine interface (HMI):
  - gateways;
  - personal computers;
  - workstations;
  - other IEDs with integrated HMIs;
– for the process environment (PE):
  - bay control units;
  - protection relays;
  - RTUs (process side);
  - meters;

- autonomous controllers (i.e. voltage controllers);
- transducers;
- digital switchgear interface;
- digital power transformer interface;
- digital VTs and CTs.

5.2 Categories and types of parameters

5.2.1 Classification

Parameters are data, which control and support the operation of:

– hardware configuration (composition of IEDs);
– software of IEDs;
– process environment (primary equipment and auxiliaries);
– HMI with different supporting tools; and
– telecommunication environment

in an automation system and its IEDs in such a way that the operations of the plant and customer specific requirements are fulfilled.

The total set of parameters and configuration data of an UAS is termed the UAS-parameter set. It consists of the used parts of the parameter sets of all participating IEDs.

With respect to handling methods and input procedure, parameter set contents is divided into two categories:

– configuration parameters;
– operating parameters.

With respect to origin and function, the parameters are divided into types:

– system parameters;
– process parameters;
– functional parameters.

In Figure 2, the overview of the parameter structure is given.

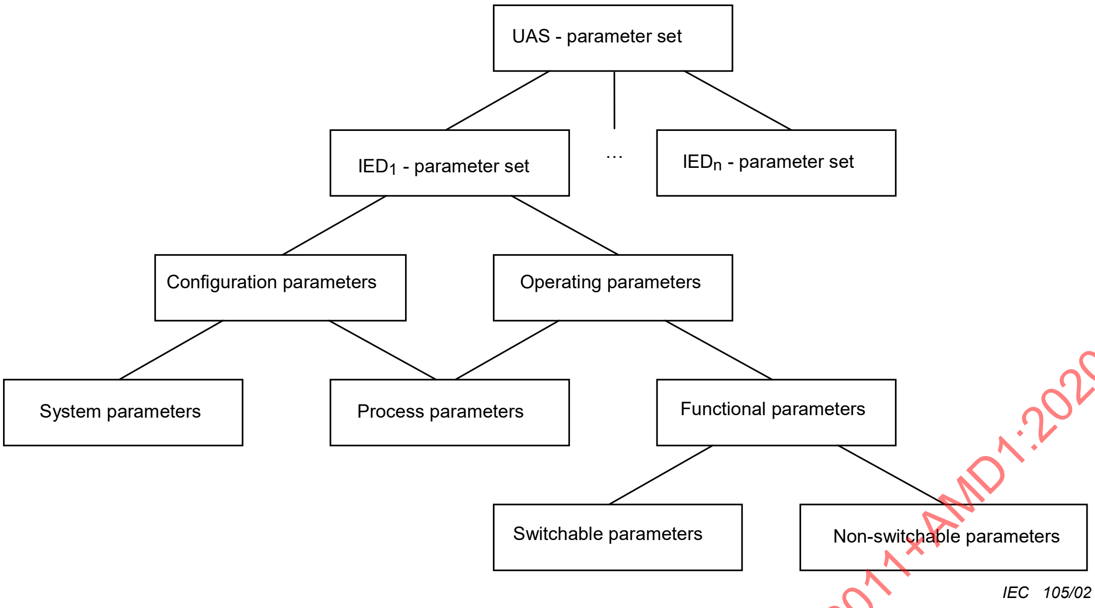

Figure 2 - Structure of UAS and IED parameters

The categories and types of parameters in Figure 2 are described below.

5.2.2 Parameter categories

5.2.2.1 Configuration parameters

The configuration parameters define the global behaviour of the whole UAS and its IEDs. As a rule, they are only assigned a value during the initial parameterization, but they should be updated when extending or functionally changing the UAS.

The generation and modification of the configuration parameters should be carried out off-line, i.e. separately from the operation of the automation system. During the input of configuration parameters, a temporary restriction of the system operation is allowed.

Observe that the term parameter in a more narrow sense means some variables, whose setting defines the wanted behaviour. System and IED configuration needs however often more than just setting of values. If we want to differentiate these different kinds of configuration, we talk about “configuration data” meaning more complex parameterizations, while “configuration parameters” means an adjustment by value setting alone.

The configuration parameters of an IED usually include system and process parameters. Observe that UAS configuration parameters are typically defined at system level. They contain or specify IED related system parameters.

5.2.2.2 Operating parameters

The operating parameters define the behaviour of partial functions of the system. They shall be changeable on-line during the normal operation of the system. The modification is allowed without restricting the system operation and within a framework of ranges of parameter values. Protection functions, as far as combined in IEDs with other functions, shall not be influenced during the parameterization of these functions.

The range and the basic settings of these parameters are determined at the initial parameterization or at a modification stage, separate from the operation of the system. The operating parameters can be put on-line into the system via:

– telecommunication interface;
– HMI;
– integrated service interface of the IEDs.

The operating parameters usually include process and functional parameters, for example limit values, target values, command output times, delay times in switching sequences, etc.

5.2.3 Parameter types

5.2.3.1 System parameters

System parameters consist of configuration data which determines the co-operation of IEDs including the internal structures and procedures of the system in relation to its technological limits and available components.

For example, the system configuration data determines the configuration of hardware components in the system (IEDs and their physical connections), the communication procedure between the IEDs (protocol, baud rate) and the scope of required and available functions in the software of IEDs at the station level.

Additionally, the system configuration data describes data flow relations between functions on different IEDs, for example interlocking, visualization of information in the substation single line diagram and others.

Furthermore, the system configuration data includes the assignment of texts to events at the station level and the determination of data flows in the system, for example to

- HMI (display, event report);
- printer;
- archive;
- telecommunication with network control centre or further substations.

System parameter values should be consistent in all parts of the system and its IEDs. The consistency of the system parameter values should be maintained and validated by a general system configuration and parameterisation tool at the system level.

5.2.3.2 Process parameters

Process parameters describe all types of information that is exchanged between the PE and the UAS.

The process parameters are responsible for qualitative features at the process interface such as command output times, suppression of transient events (filter time), measured value damping (threshold value), and of the process itself, e.g. switch run times.

Furthermore, the process parameters include the assignment of texts to events for visualization at the IED-level.

5.2.3.3 Functional parameters

Functional parameters describe the qualitative and quantitative features of functionality used by the customer. Normally, the functional parameters are changeable on-line.

For example, the functional parameters determine the target values (set points) of controllers, the starting and tripping conditions of protection relays, automatic sequences such as operations after measurement overflow or commands in relation to specific events. The functional parameters are responsible for algorithms of automatic control, protection, blocking and adjustment.

The functional parameters are divided into switchable and non-switchable parameter value groups.

A set of functional parameter values for a group of functional parameters can be resident in an IED in parallel with other sets of functional parameter values. In this case, only one set of these functional parameter values is active at a time. It shall be possible to switch between the sets on-line.

5.3 Engineering tools

5.3.1 Engineering process

The system engineering process creates the conditions for designing and configuring an automation system to the specific plant (e.g. substation) and to the operating philosophy of the customer based on the system requirements specification from the customer.

Within the engineering process, we can distinguish different actor roles:

- The *project requirement engineer* sets up the scope of the project, its boundaries, interfaces, functions and special requirements ranging from needed environmental conditions, reliability and availability requirements up to process related naming and eventual specific address range restrictions or product usage. He defines what he wants to have application wise and how he wants to operate the system (*project requirement specification*). He finally accepts the delivered system.
- The *project design engineer* defines, based on the requirements specification, how the system shall look like; its architecture, requirements on the products needed to fulfil the required functions, how the products should work together. He thus defines the *system design specification*.
- The *manufacturer* supplies the products from which the system is built. If necessary, he supplies a project specific *IED configuration*.
- The *system integrator* builds the system, engineers the interoperation between its components based on the system design specification and the concretely available products from the manufacturers, and integrates the products into a running system. This results in a *system configuration description*.
- The *IED parameterizing engineer* uses the set-up possibilities of the system and device configuration to adjust the process, functional and system parameters of an IED to the project-specific characteristics.
- The *testing and commissioning engineer* tests the system on the basis of the system configuration description, system design and requirements specification and additional documentation, and puts the system into operation.

It can be that the same person or organisation has more than one role, e.g. a manufacturer is also system integrator, or a customer does system integration by himself. This influences the packaging and formal organisation, however not the tasks which have principally to be performed.

The concrete engineering process is dependent also on responsibilities for parts of the system, and how they relate together. Even if a system integrator is also manufacturer, he might have to integrate products from other manufacturers. A customer might want to have a system with interfaces to a system of another customer. Across these organisational interfaces a data exchange in a standardized form should be possible.

A typical project will start with the project requirement engineer creating a project requirement specification that defines the scope of the project, single line diagrams, device ratings and other required data. The aim is to create a set of technical specifications that can be used for tendering and engineering, irrespective of whether design and installation work will be done in-house or by external parties. Beneath general interfacing requirements, this includes also the identification or at least naming rules for primary and secondary equipment, and any communication addresses or addressing schemes needed to interface with other systems of the customer. Further needed redundancy requirements, response times, availability and safety measures have to be stated beneath the environmental, physical and geographical restrictions for the project.

IEC 61850-6 provides a formal means to define the single line diagram with customer's functional names and the intended automation system functionality at the primary equipment identified in the single line description (.ssd, system specification description). This formal description is based on the hierarchical structure of IEC 81346-1, allows however instead of identifications according to IEC 81346-2 also customer specific identifications, and additionally customer specific descriptive text. It further defines a formal way to exchange function and communication related interface descriptions between systems respective between system projects (by means of an .sed, system exchange description).

Based on this requirement specification and its knowledge about existing solutions and products, the project design engineer designs the functional and physical system architecture inclusive communication system to reach the needed response times and reliability, and produces the specifications for the products to be used. The details form a system design specification, which is typically approved by the project requirement engineer, and is then used as a base for the product manufacturer to deliver the needed products with the specified configuration. The resulting system design specification can be supported by a formal description of IEDs, the functions on them, and their relation to the process functionality as defined in IEC 61850-6 (.scd, system configuration description). The system integrator uses this specification to order the fitting products and to build the system from the products. The manufacturer supplied IEDs, before integration into the system, come with a formal description of their functional and communication engineering capability (.icd, IED capability description), which is then used as base to engineer the system configuration.

Often a part of the system design specification is produced by the project design engineer during the tendering process. This first order system design specification together with the system requirement specification is then the start for the project system design.

The basic engineering process shown in Figure 3 starts with producing the system design specification (system design) based on the tender specification already approved by the project requirements engineer:

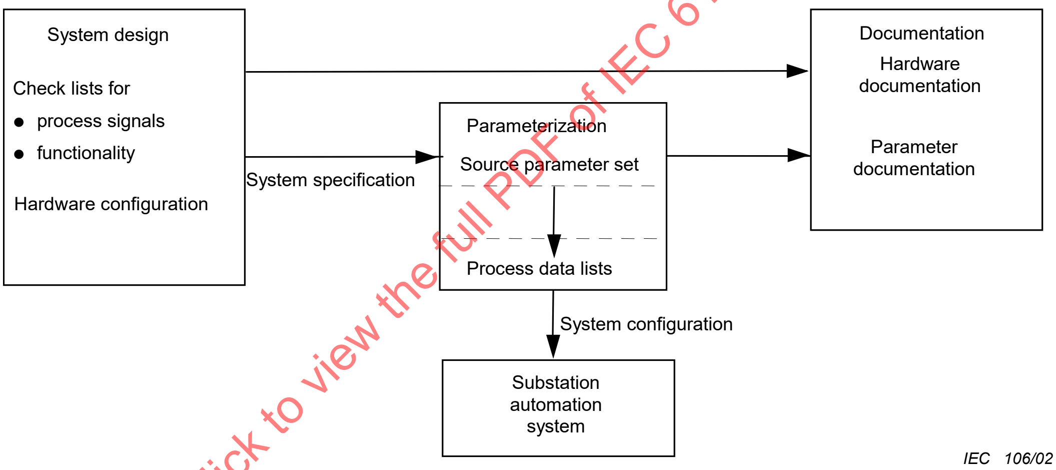

Figure 3 – Engineering tasks and their relationship

System design is the definition of the technological concept to solve the required automation system tasks including the choice of structure, IED type selection and IED basic configuration as well as the determination of interfaces between the IEDs and the PE. The result is the system design specification.

In the configuration process the required system functions will be created or activated within a selected group of IEDs. With that a set of parameters containing system and IED configuration data will be available. Depending on the IEDs capability this can be performed in a pre-engineering phase either by the manufacturer, the IED parameterization engineer or by the project design engineer.

Parameterization, often called detail engineering, is the generation of the parameter set for the UAS. The system configuration data (system parameter set) is produced by the system integrator. The IED configuration data (IED parameter set) is produced by the IED parameterizing engineer.

Documentation is the description of all project and parameterization agreements about the features of the system and its link to the PE according to the required standards.

In practice, engineering tools are useful for efficient handling of the engineering tasks. To better support interoperability between tools of different IEDs and different manufacturers, within this standard conceptually three kinds of tools are envisaged:

– system specification tool: allows specifying the system and device requirements regarding the needed system functional and process capabilities;
– system configuration (system design) tool: allows selection of needed IEDs based on a system (requirements) specification, and defines the communication connections between the IEDs of the system and the logical relations between IED functionality and the primary equipment. Often the system configuration tool includes a system specification tool;
– IED configuration (parameterization) tool: allows making the detailed parameterization of an IED based on a system design and requirement specification beforehand and a system description delivered by the system configuration tool after the system configuration process.

To enable interoperable exchange of engineering data between IED parameterization tools of different manufacturers and the system configuration tool, as well as between different system configuration tools handling different system parts as separate projects, appropriate configuration data exchange formats are defined in IEC 61850-6.

5.3.2 System specification tool

In the project requirement phase a system specification tool allows to describe parts of the process to be controlled at the level of a single line as well as process related names and the required functions to be performed in parts of the process in a formalized way. This formal description can support evaluation of needed products as well as be input to a system configuration tool in the system design phase. Mostly the tool is based on a template data base for the standardized functions and their needed signals and typical parts of the process.

The standard language defined in IEC 61850-6 offers a standardized description of a part of the system requirements specification.

5.3.3 System configuration tool

The system configuration tool offers the choice of components with functional assignments in the design stage of an automation system project. Mostly the tool is based on an IED or solution database and requires as minimal input the required functions and process signals. It provides the first results using, for example, tables and check lists, which have to be agreed upon between project requirements engineer and project design engineer. As a result, the system structure and configuration, including the interfaces to the PE, will be defined. In a second step then the communication connections between the IEDs are configured by the system integrator, so that the intended system functionality is implemented.

The standard SCL language defined in IEC 61850-6 allows configuration data exchange between system configuration tool and IED configuration tool as well as between two different system configuration tools respective projects, and also of the functions and communication capabilities of IEDs, which might be used as external inputs to the system configuration tool for product selection.

It is the intention of this standard to enable IED type and manufacturer independent implementations of this type of tools in that sense, that system configuration tasks can be done independent from the used IEDs, and the engineering result transferred to the IED respective IED tool in a standardized form. For this purpose a system configuration tool shall be able to import IED descriptions and system interface descriptions in SCL and export system configuration descriptions in SCL.

5.3.4 IED configuration tool

The IED configuration tool supports the creation of the consistent IED parameter set for a specific IED within the system. This (set of) tool(s) is mostly manufacturer specific, or even IED type specific. The basic IED function specification as well as all system related configuration data is imported from the system configuration description produced with the system configuration tool. For this purpose an IED configuration tool shall support the import of system configuration descriptions in SCL language as defined in IEC 61850-6. Further IED specific configuration data like implementation of special functions and settings or IED specific parameters are performed with this tool.

The main tasks of the tool are the generation of process data lists based on the IED parameter set and the secure management of the process data lists for the IEDs. The tool must be capable of reading actual parameter values.

Additionally, the tool supports the management, archiving and documentation of the IED parameter set.

Essential components of the tool are shown in Figure 4.

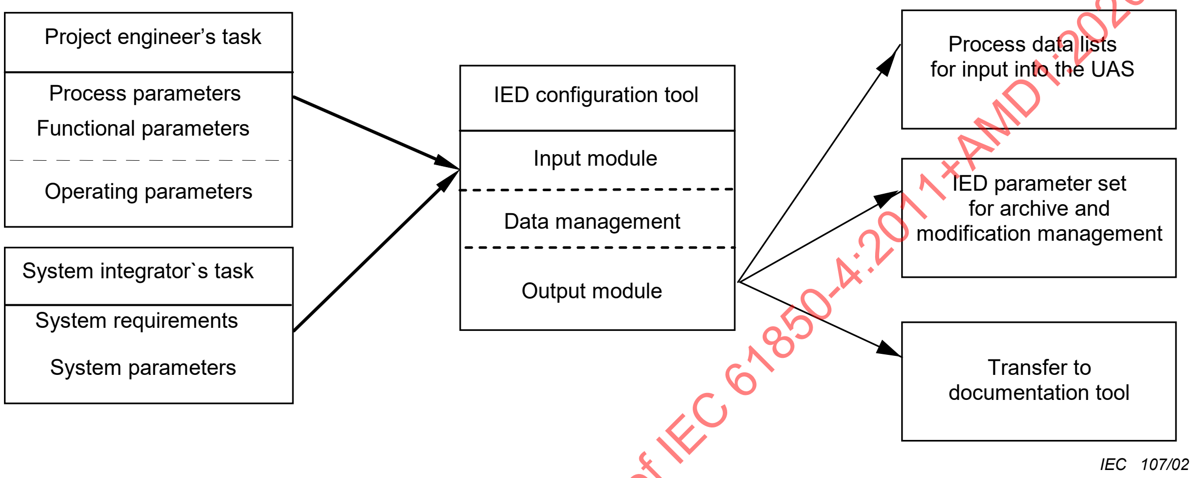

Figure 4 – IED configuration process

The tool's data input module supports the interactive input of parameters as well as the import of the system description as created by means of the system configuration tool. The structure of input data should be technically oriented towards the process architecture, i.e. structured according to the hierarchical approach to substation, voltage level, bay, equipment and function.The repeated input of similar information should be avoided as much as possible by using for example templates of typical solutions or copy functions (for example, copy of switch, bay, busbar sections, etc.).

The entry of a parameter should only be necessary once. The assignment of this parameter to other processes should be carried out automatically in order to guarantee parameter consistency at all times.

The data management module checks the entered parameter values with respect to their consistency and plausibility. Parameters with multiple use will be assigned to the respective processes.

Furthermore, the data management module includes the system information management with respect to the IED parameter set. The system information contains a unique identification of the parameter set, including

- process (e.g. substation or line) identification;
- document identification and version identification;
- parameter set version identification;
- engineer's identification;
- access permission;
- date of creation / modification;
- software releases of the IEDs and the parameterization tool;
- IED instance name in the project.

The data management module generates the process data lists, which are the base for the behaviour of the automation system in accordance with the substation and the customer requirements.

The output module is responsible for the transfer of process data lists to an archive (internal or external) or for the direct input into the system and its IEDs. Additionally, it provides the service to recall and view the source parameters stored in the archive. The output module must provide the source parameters for the documentation tool.

5.3.5 Documentation tool

The documentation tool generates uniform, project specific documentation in accordance with the required standards (IEC 61175, IEC 60848, IEC 81346 series, IEC 61082 series). The documentation consists of:

– hardware documentation for the representation of all external connections between the system components and the PE which are defined in the project design process;
– software documentation in form of (principle) function charts, sequence diagrams, flow charts as needed;
– parameter documentation for the representation of all internal qualitative and quantitative relations, which are agreed in the parameterization process.

The documentation tool should be capable of creating a "revision history", documenting all changes known to the tool itself.

5.3.6 Engineering tool workflow

5.3.6.1 From System specification to project description

Typical use case: one centralised SCT working with several ICT (see Figure 5).

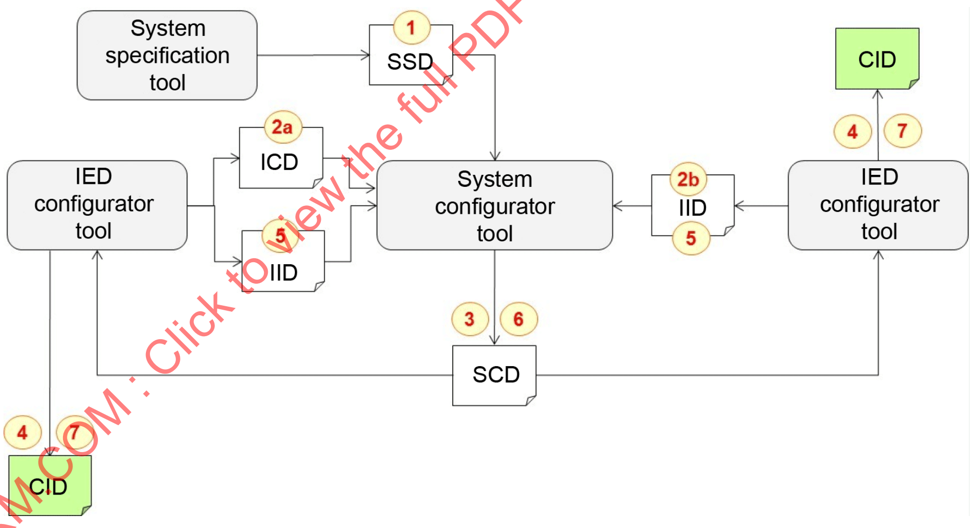

Figure 5 - Engineering workflow steps from system to project

Step 1: System Specification Tool (SST) creates an .ssd file according to part 6.

Step 2a: IED Configurator Tool (ICT) creates an .icd file according to part 6.

Step 2b: ICT creates an .iid file according to part 6.

Step 3: System Configuration Tool (SCT) creates an .scd file, using previous files: .ssd, .icd and/or .iid.

Step 4: This .scd is used by an ICT to finalize configuration and publish a .cid file to its related IED (configuration of dataflow).

The 4th step is the last except if the .scd contents requires modifications from the ICT, which shall be transferred to the SCT in order to publish a updated .scd. Then it is replaced by the step 5 hereafter.

Step 5: ICT updates the IED description based on the further IED configuration needs and on system configuration needs provided by SCT in step 3. The ICT exports to the SCT the updated configuration description via the .iid file.

Step 6: SCT publishes a updated .scd file taking into account information described by previous .iid.

Step 7: ICT publishes the updated .cid file to send to the IED, using the .scd published on step 6.

5.3.6.2 Change of system tool

Use case: considering an SCT A has to be replaced by an SCT B. The context is transferred with an .scd exported from the SCT A.

The creation of the project with SCT A is similar to the previous use case and is assumed to be done before the replacement of SCT A as classical project engineering as shown in Figure 6.

Note: changing an SCT is always on purpose of updating / upgrading the system configuration with features that previous SCT doesn't support.

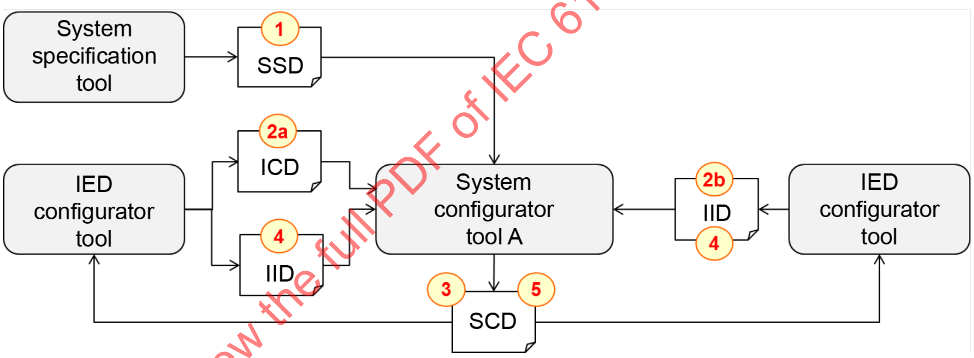

Figure 6 - Change of system tool first stage

Step 1: System Specification Tool (SST) creates an .ssd.

Step 2a: IED Configurator Tool (ICT) creates an .icd.

Step 2b: ICT creates an .iid as a first instantiation.

Step 3: SCT creates an .scd, using previous files: .ssd, .icd and .iid.

Step 4: ICTs create .iid using the .scd issued on step 3.

Step 5: SCT publishes a new .scd taking into account information described by previous .iid.

Hereafter the second stage, the SCT B uses the .scd provided by the SCT A, as shown in Figure 7.

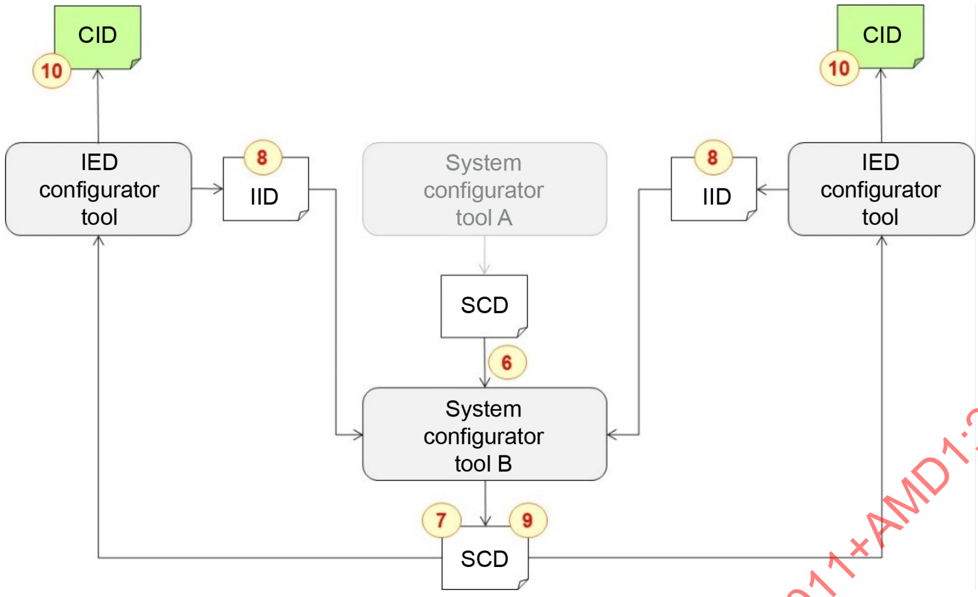

Figure 7 - Change of system tool second stage

Step 6: .scd to be transferred by SCT A to SCT B. Even if that does not appear on the scheme, it is strongly recommended to also transfer the latest version of all .icd files.

Step 7: SCT B updates the .scd, using previous .scd created by SCT A (previous step) if .

Step 8: ICTs create .iid using the .scd issued on step 7.

Step 9: SCT publishes a new .scd.

Step 10: ICTs create .cid using the .scd previously created.

5.3.6.3 Interaction between projects

Use case: considering 2 different configuration projects managed by 2 SCT A and B (The 2 configuration projects may cover one or multiple UAS). One IED (e.g. IED 2) regards both projects. The .cid intended to the IED 2 shall take into account both contexts. The final step, is the publishing of the .cid

Hereafter, the first stage consists of the publishing of the .scd, as shown in Figure 8.

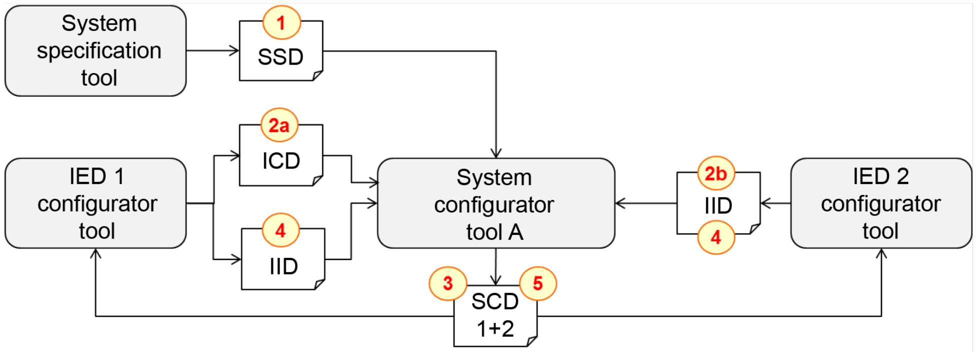

Figure 8 – interaction between projects, first stage

Step 1: System Specification Tool (SST) creates an .ssd.

Step 2a: IED 1 Configurator Tool creates an .icd.

Step 2b: IED 2 Configuration Tool creates an .iid as a first instantiation.

Step 3: SCT creates an .scd 1+2, describing both IED 1 and IED 2 and using previous files: .ssd, .icd and .iid.

Step 4: ICTs create .iid using the .scd issued on step 3.

Step 5: SCT publishes a new .scd 1+2 taking into account information described by previous .iid.

Hereafter, the second stage consists in using part of the .scd 1+2, that is involved in the communication of a second project, as shown in Figure 9.

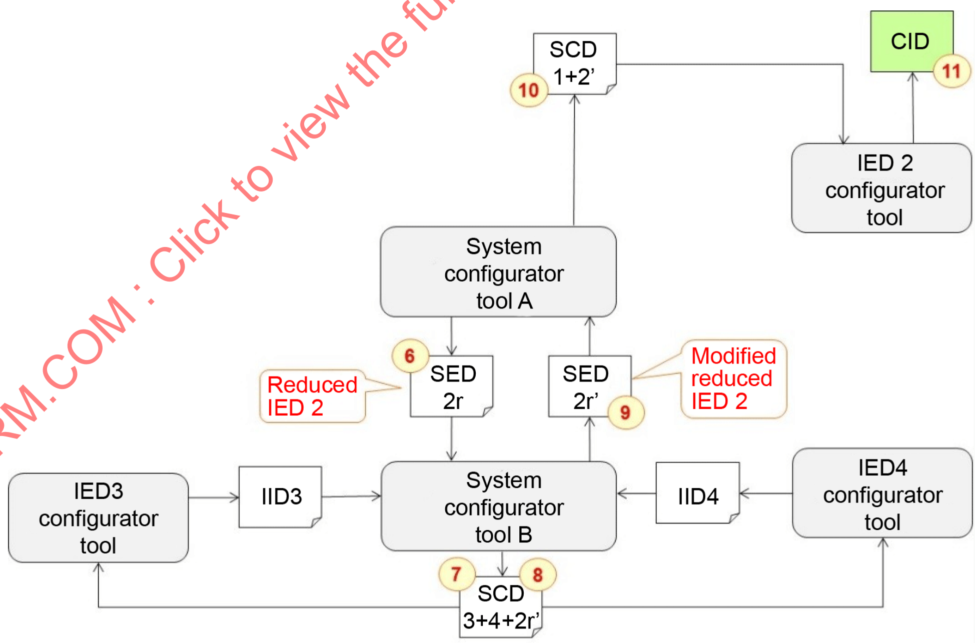

Figure 9 - interaction between projects, second stage

Step 6: SCT A creates an .sed 2r, which gives only required information on the IED 2 needed for the engineering of the second project(that why "reduced IED 2").

Step 7: SCT B creates an .scd 3+4+2r’, using the .sed 2r created by SCT A (previous step) and taking into account its own context.

Step 8: ICTs create .iid using the .scd 3+4+2r’.

Step 9: SCT B creates a new .sed 2r’ taking into account IED 2 in the SCT B context.

Step 10: SCT A creates a new .scd 1+2’ using the .sed 2r’ to integrate dataflow modifications of IED 2 coming from the SCT B.

Step 11: ICTs create .cid using the .scd previously created.

5.4 Flexibility and expandability

Flexibility and expandability of an automation system requires the expandability of the hardware and software configuration of the system. It also depends on the functional and physical architecture and the resulting dependency between functional parts.

The flexible extension of the hardware configuration with additional IEDs or with IEDs of different functionality is the first requirement in order to meet flexibility and expandability of the system.

The flexibility and the expandability also depend on the engineering tools. The most essential engineering tool with respect to the behaviour and maintenance of the automation system is the IED configuration tool and its handling of different parameter sets in relation to the IED. Observe that an IED configuration tool is specific for a manufacturer or even an IED type, and therefore several IED configuration tools might be needed in a project containing IEDs from several manufacturers.

Therefore, functionality, compatibility and expandability of the IED configuration tool are significant for further functional expansion of the system. As a minimum it shall support the compatibility features for different versions of this standard as defined in IEC 61850-6 and in all parts of IEC 61850-7.

The IED configuration tool of a manufacturer shall be backwards compatible, i.e. it shall be possible to parameterize all existing IEDs of the same family supplied by the manufacturer using the most recent parameterization tool.

All configuration tools shall be able to run on commercial hardware with a commercial operating system. They shall be able to support flexible and consistent modification of existing parameter sets with version identification.

The system configuration tool shall provide open interfaces for data exchange with other configuration tools, for example for dispatching centres and tools from other manufacturers. As a minimum it shall support export and import of SCL files as defined in IEC 61850-6.

5.5 Scalability

The system configuration tool should be able to be used for all typical UAS applications. Generally, the UAS systems are designed in such a manner that they can cover the whole range of applications by using a modular device system with respect to

– task (transmission/distribution/power plant/DER/... networks) and voltage range (medium, high or ultra high voltage) of the substation;
– completion level of the application (simple centralized telecontrol unit or integrated substation control, monitoring and protection with distributed artificial intelligence);
– complexity of the functionality (from simple SCADA up to sophisticated automation tasks);
– telecommunication functions (simple telecommunication to one dispatching centre, node functionality with different telecommunication protocols, master in the common mode with integration of other substations).

The system configuration tool should permit scalability in such a way that the configuration task for different application levels can be carried out with a minimum of resources and costs. The lowest level, for example, requires only the input of parameters for a simple telecommunication unit, and on the highest level all available options of the system must be managed.

Furthermore, the system configuration tool should support the engineering rationalization by using, for example, templates, macros and copy functions.

5.6 Automatic project documentation

5.6.1 General

The documentation of an UAS consists of two project specific components (see Figure 10).

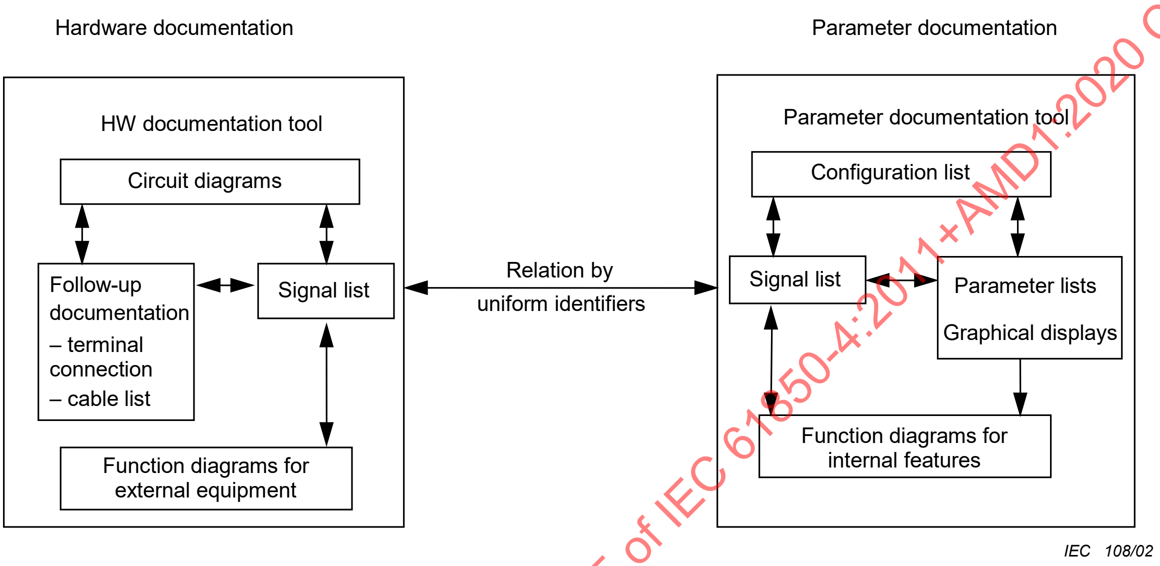

Figure 10 - Project related documentation of UAS

The hardware documentation consists of:

- circuit diagrams for the link between the UAS components and for their connection with the PE;
- signal connection lists;
- function diagrams for external schemes;
- cubicle layouts and wiring / cabling lists.

The system and IED parameter documentation consists of:

- the configuration list;
- signal lists;
- parameter lists;
- communication network addresses;
- graphical representation of all displays and operation menu sequences;
- function diagrams or function descriptions.

The requirement on the engineering tools is that the documentation should be generated as:

a) hardware documentation with the help of the input values of the planning tool on a CAD (or similar) system;

b) parameter documentation using the IED parameter set from the parameterization tool;

c) system configuration documentation using the system parameter set from the system configuration tool as needed.

The interfaces between hardware and parameter documentation are the signal lists, which should have uniform and unique signal identifiers in both documents, preferably based on the semantically standardized identifications defined in other parts of this standard.

The generation of documentation, based on the inputs of the planning and parameterization tool, should ensure the consistency between documentation on one hand and the project check lists, the IED parameter set and process data lists on the other hand.

5.6.2 Hardware documentation

The hardware documentation of the system should be carried out according to the same structure as the documentation of the other substation equipment.

Concerning the identification and the structure of the hardware documentation the use of international standards (for example, IEC 61175, IEC 81346 series) is recommended.

5.6.3 Parameter documentation

5.6.3.1 General

Parameter documentation is typically done in lists and tables, supported by figures showing principle solutions. To get a better overview it is recommended to produce the documentation for typical objects and functions, and then have a higher level list about the object instances of each documented type.

5.6.3.2 Configuration list

The configuration list and the single line diagram of the substation are the starting point for the parameter documentation. The configuration list consists of:

– an overview of IEDs and components of the system with identification of the hardware and software releases;
– identification of the software release of the configuration tool(s);
– identification of the parameter sets according to the requirements in 5.3.4.

The parameter documentation is carried out in different ways for the different parameter types.

5.6.3.3 System parameter documentation

The system parameters to be set onto the IEDs can be taken over as a chosen set from the manufacturer's standard documentation into the project specific documentation. Project specific system parameter sets are generated by the system configuration tool and can also be documented by it.

5.6.3.4 Process parameter documentation

The documentation of process parameters consists of the description of all signals at the system border, and details their further management and marshalling inside the system. The following description documents are typically included in the process parameter documentation set:

– signal lists are the base for the further process parameter lists. The signal lists give the overview of all analogue and binary signals and their assignment to the inputs and outputs of the IEDs of the system and to the specific parts of the documentation;
– telecontrol mapping lists determine the assignment of individual signals to the addresses of the telecontrol protocol;
– message texts can be defined by the customer and assigned to the binary signals for representation in different reports;
– characteristic curves can be assigned to the analogue values;
– HMI lists describe the presentation features of signals on displays and printers;
– archiving lists cover all information about values of which signals have been archived under which conditions and with which attributes;

– acquisition lists include all information about qualitative attributes of signal acquisition such as filter times of binary inputs or command times.

5.6.3.5 Functional parameter documentation

The functional parameters should be documented as parameter lists and graphically as function diagrams.

To provide greater clarity, and in accordance with the rules of circuit diagrams, the function diagrams should be structured as follows:

– control (automatic single and double commands, group commands, switching sequences);
– position indication (assignment to commands, parallel work of transformers, voltage definition for busbar section);
– event/alarm indication (group information, automatic operation);
– interlocking;
– measurement linking (overflow, bimetal);
– algorithms for closed loop control;
– protection.

The operation sequences and the structure and symbols of the overview and detail displays should be documented graphically.

The number and type of report lists and protocols should be documented as a parameter list.

Requirements concerning the design and the structure of the function diagrams are defined in international and national standards (for example, IEC 61082 series).

5.6.3.6 Operating parameter documentation

The operating parameters should be documented as a parameter list with their ranges of values and basic settings. The values changed by the customer are documented in the operations report.

5.6.4 Requirements of the documentation tool

The input of the documentation tool is the IED parameter set, which is created with the parameterization tool. The parameter documentation tool produces the complete parameter documentation as a book with automatic generation of a table of contents.

The parameter documentation tool should be able to generate partial documentation according to different sorting criteria with practical benefit, for example:

– reference lists for telecontrol information;
– message lists, sorted by IED addresses;
– function diagrams for interlocking.

All changes of parameters must be flagged in the documentation. The parameter documentation tool should be able to support the requirements with respect to such modification services.

5.7 Standard documentation

The standard documentation is the description of the device and the functions of one IED or the UAS product family of a manufacturer which is universally valid and which is not changed for purposes of specific projects (refer to CIGRE - TB628 - *Documentation requirements throughout the lifecycle of Digital Substation Automation Systems – B5-39*).

As a general rule, the standard documentation includes:

– equipment description;
– instruction and maintenance manual;
– system concept description;

– description of functions;
– operating instructions;
– instruction for service programs;
– fault detection and maintenance instruction;
– user manual for the engineering tools.

The standard documentation should complete the project specific documentation for each installed system.

5.8 System integrator's support

In most cases, the engineering tasks are included in the system integrator's offer for the UAS project.

In all cases, however, the system integrator has to offer the engineering tools needed for system maintenance and appropriate customer training for the use of these tools so that the customer may maintain and expand the system installation.

The system integrator should support this process with consultative services, training and regular information regarding updates and extended functionality of the system installation and the engineering tools.

5.9 System testing and engineering

Functional testing of the system, especially for maintenance testing, but also during FAT and SAT, requires the preparation of the system configuration to support testing.
The testing concept must be defined by the user at an early stage of the project, since this comes with additional requirements impacting the system design and configuration, see IEC 61850-10-3.

6 System life cycle

6.1 Requirements of product versions

The life cycles of an UAS and its IEDs are subject to differences of the manufacturer's and the customer's point of view, as shown in Figure 11:

– the manufacturer's product life cycle contains the period between the start of production and the discontinuation of the UAS product family;
– the customer's system life cycle contains the period between the site commissioning of the first system installation, often based on several UAS product families, and the decommissioning of the latest system installation. The system installation may be carried out by a system integrator who is different from the product manufacturer.

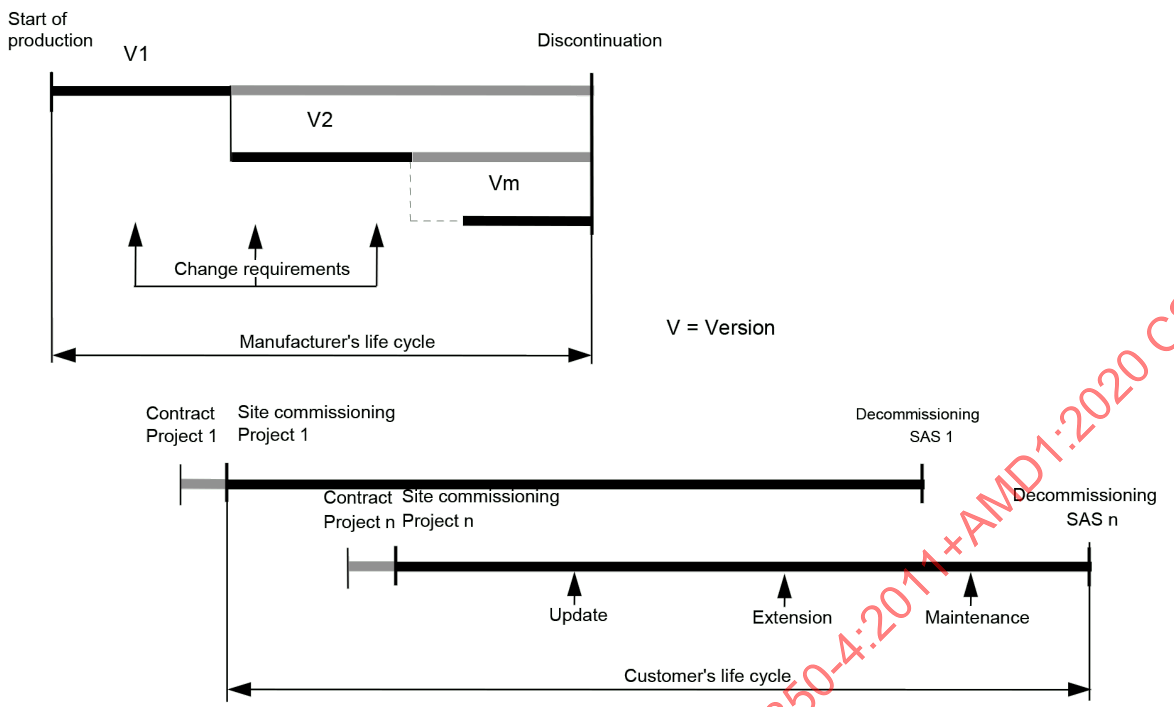

Figure 11 - Two meanings of the system life cycle

During the life cycle of the UAS and its IEDs, a number of changes and extensions are required for various reasons:

– functional improvements and extensions;
– technology changes in the hardware;
– correction of recognized problems.

These changes can lead updating IED versions of hardware, software or even engineering tools. Different use cases are identified and developed later (ref. backward compatibility).

Whatever the use case, the manufacturer is obliged to provide identification of the IED versions (software, firmware, hardware, configuration, revision):

– in the case of IED software or the supporting tools software, the version information is available in a self identifying manner (for example, on display or PC);
– for the hardware, the version information is available at IED level (either physically or by tool);
– if the functionality has changed or a function has been removed, a new configuration compatibility list shall be distributed.

The co-ordination of the manufacturer's and the customer's life cycles requires that new versions of the IEDs with identical model numbers shall comply with the following rules.

a) The hardware shall be compatible. All interfaces must perform the same function in the same places. The sizes of the boards and the devices must be identical.
b) The functional changes from the previous version of the product software shall be declared. This includes any impact on IEC 61850 interface of the device. This information will help the customer knowing the impact on their IEC 61850 system using this device.
c) The supporting tools shall be downward compatible, which means that the new version of the supporting tool shall serve all existing versions of the same product family.

The manufacturer has to inform the customer about all of the functional changes and extensions that are carried out between the last production release and most recent production release.

From an UAS system maintenance perspective identical or backwards compatible products are preferred for replacement of failed parts. In case that functionally but not engineering wise compatible products are used in this case, a re-engineering of a part of the UAS might be necessary.

6.2 Announcement of product discontinuation

The manufacturer is to inform all customers of the product discontinuation in time to ensure that the customers have the option to order spare products or to prepare extensions.

In the case where the product discontinuation will be carried out without a subsequent functionally compatible product, the required notice shall be published in a defined period in advance.

In the case where a subsequent functionally compatible product will follow, the notice may be published in a shorter period in advance. An overlap for delivery of both products for a minimum period is required (an example is given in Annex A).

6.3 Support after discontinuation

During the customer's life cycle of a system and its IEDs, a number of changes, extensions and maintenance issues will occur. The manufacturer is obliged to support this process after the discontinuation of the UAS product family and its compatible IEDs according to the agreement between system integrator respective customer and manufacturer. The following examples could be used for such agreements:

– special customer agreement for further supply with a minimum annual order with special agreed prices and delivery conditions in an agreed time period;
– supply of the same or compatible IEDs (from the point of view of functionality, mounting and wiring) for extensions under specific delivery conditions for an agreed time period;
– supply of spare parts and repair service under specific delivery conditions for an extended time period;
– administration, maintenance and delivery of all supplied versions of the IED software and the service tool software in accordance with the agreed delivery conditions by the manufacturer. The maintenance of parameter sets is the responsibility of the customers;
– support in the integration of new products using adaptive interfaces.

An example for the corresponding time conditions is shown in Annex B.

The above requirements concerning the "system life cycle" exclude the use of commercially available computing products (for example, PCs, CD ROMs).

In the case where the manufacturer and the system integrator are different, the support after discontinuation shall be agreed in relevant contracts.

6.4 Backward compatibility

6.4.1 General

As mentioned in 6.3, the life cycle of an UAS and its IEDs involve several changes. These may come from:

- the manufacturer for including improvements, new functionalities and-or bugs correction;
- the customer for taking into account extensions or new requirements;
- the new edition of the standard.

This chapter deals with replacement or extension whatever the component is provided by the same or a different manufacturer. It scrutinizes, through four use cases, taking into account what is standardize in the actual IEC 61850 SCL configuration process what can be the encountered issues.

Considering the system is operated, the utilities point of view is highlighted.

Note 1: If the backward compatibility is not possible following standard advice, a mitigation plan shall be supplied by the manufacturer.

Note 2: If for any reason, the backward compatibility of the standard itself must be broken, the mitigation solutions has to be handled by the SCT as described in Part 6 annex I.

Note 3: It is understood that Edition 1 is a special case not considered here. The discussion is about future Editions/Implementations.

6.4.2 Components

- **New IED**: replaces an IED for any reason or is an extension of an existing system;
- **Clients**: IEDs which are only client or subscriber of the new IED, which means the communication between station and bay level (ref. to 61850-5: IF1 and IF6) or between bay and process level (ref. to 61850-5: IF4 and IF5);
- **Interacting IEDs**: IEDs which are server or publisher for the new IED. Typically means the communication at the bay level, within the bay or between bays (ref. to 61850-5: IF3 and IF8).
- **Other IEDs**: every IEDs, which do not have any relation with the new IED.
- **Configuration Tools**: means SCT (System Configuration Tool) possibly ICT (IED Configuration Tool).

6.4.3 Use cases

Four use cases are identified:

No new functionalities required

1. Replacement of one IED with one coming from the same manufacturer (UC1);
2. Replacement of one IED with one coming from a different manufacturer (UC2);
3. Extension with addition of one IED into an existing system (UC3);

New functionalities required

4. Extension of the system with new functionalities (UC4).

Note : in the following sections, to avoid designating some particular editions of IED 61850 devices (e.g. Ed1 system with an added Ed 2 device), the Ed n and Ed n+m designations will be used to cover all possibilities (eg ED 2 system with added Ed 3 device, or even Ed3 system with Ed 5 device ect). What matter here is Ed n+m has later edition than Ed n.

6.4.4 Impacts

6.4.4.1 General

Depending on whether it is a new release (i.e. interoperability TISSUES has been implemented) or a new version/revision (i.e. new edition of the standard), the three following possible impacts are studied for each components previously listed:

- changing or modifying the configuration, which means creating an updated .scd.scd file and potentially a new .cid;
- upgrading the firmware of IED(s);
- upgrading the SCT and, other ICT.

The table, shown in Figure 12, is used to detail which impact is acceptable and which is not:

	IEC 61850 Configuration impact (which part of the .scd shall be updated)	Upgrade Firmware of device	Upgrade IEC 61850 configuration Tool (upgrade of ICT for devices / upgrade of SCT for entire system)
New IED		NA *	NA**
Client (s)			
Interacting IEDs		y	
Other IEDs			
Entire 61850 System	NA***	NA****	x

Figure 12 - Template table of acceptable impacts

- * a new IED don't need firmware upgrade as it is new
- ** a new IED comes with a new ICT already upgraded
- *** entire system configuration update (all IEDs) is covered by selecting all the others in this column (New IED + Client(s) + Interacting IEDs + Other IEDs)
- **** entire system firmware upgrade (all IEDs) is covered by selecting all the others in this column (Client(s) + Interacting IEDs + Other IEDs)
- Selected case (: dark blue filling) means needed. If any, "x" is a number that refers to an explanation.
- Partially selected case (: light blue filling) means needed under certain condition. If any, "y" is a number that refers to an explanation.
- Non-selected case (blank) means there shall be no impact (e.g An IED not concerned by new features shall not be affected).

6.4.4.2 First use case (UC1)

Replacement of one IED with a new one coming from the same vendor, with equal behaviour, without any impact on system configuration, as shown in Figure 13.

In that case, the vendor shall be able to provide a way to configure the new IED (especially the data model) that mirror the older device configuration (event if the new device support newer edition of the IEC 61850 standard)

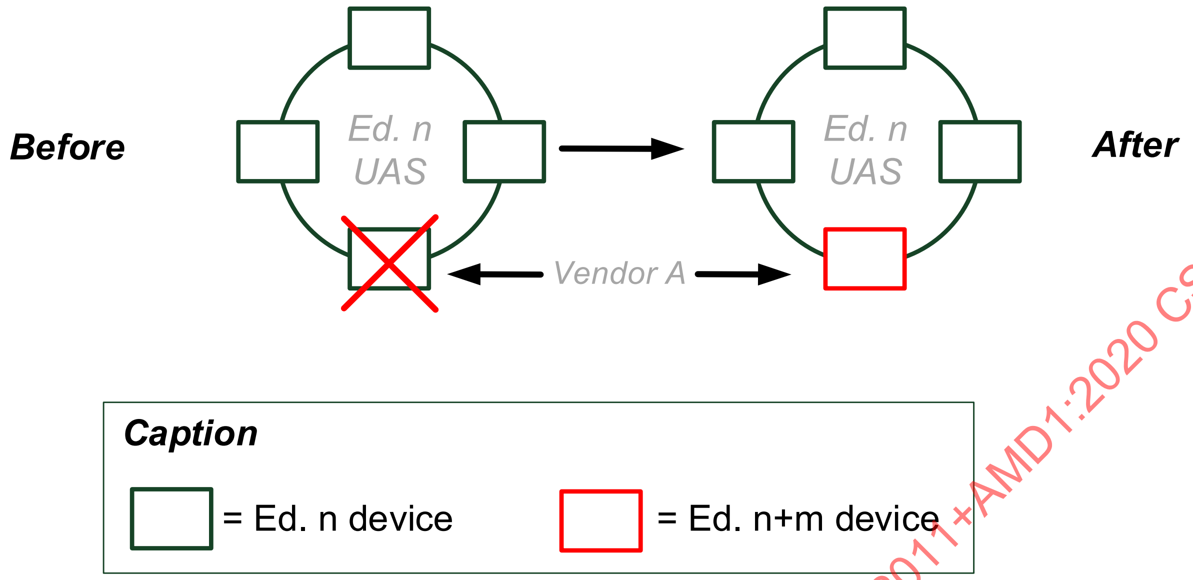

Figure 13 : Backward compatibility first use case

	Before	After
UAS Version	Ed.n	Ed.n
Event	Device failure from vendor A.	Replacement with one device with the same behaviour.
IED IEC 61850 Edition supported	Ed.n	Ed.n+m* configured and acting like an Ed.n
Vendor	A	A
Clarification	New functionalities not required.	
Requirements	The new IED can be integrated without a need for re-engineering (e.g. no bug correction or no Interop issues correction needed), it is required that the Ed.n .scd file can be used to load the new IED with no impact on the system, i.e.: • No impact on other IEDs • No impact on ICTs • No impact on SCT	

*you have to change a device in a system in IEC 61850 edition n (all IEDs are edition n), your new device can be a newer edition of IEC 61850: that's what n+m means
Example: Edition 1 system where you add an edition 2.1 device.

	IEC 61850 Configuration impact	Upgrade Firmware of device	Upgrade IEC 61850 configuration Tool
New IED		NA	NA
Client (s)			
Interacting IEDs			
Other IEDs			
Entire 61850 System	NA	NA	

No impact is accepted.

6.4.4.3 Second use case (UC2)

Replacement of one IED with a new one coming from a different or same vendor, with equal behaviour, with impact on system configuration, as shown in Figure 14.

We assume in the use case that the new IED has a different data model than the older device. In order to support the same data flow (i.e make the system behave as previously), the system configuration shall be updated.

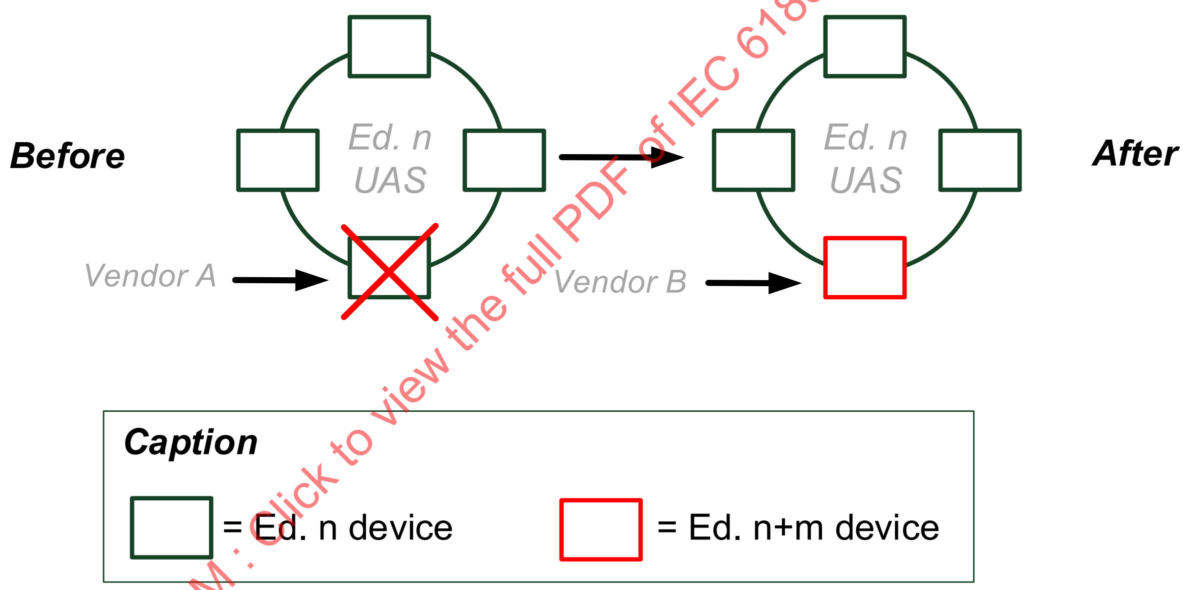

Figure 14 : Backward compatibility second use case

	Before	After
UAS Version	Ed.n	Ed.n
Event	Device failure from vendor A.	Replacement with one device with the same behaviour.
IED	Ed.n	Ed.n+m*
Vendor	A	B
Clarification	New functionalities not required.	
Requirements	A new ICT is required for creating a new configuration to download. The more flexible the new IED is, the more similar the data model will look like. Changes to clients (CBs, Datasets) are to be expected.	

*Example: Edition 1 system where you add an edition 2.1 device.

Expectations

	IEC 61850 Configuration impact	Upgrade Firmware of device	Upgrade IEC 61850 configuration Tool
New IED	2	NA	NA
Client (s)	2		
Interacting IEDs	2		
Other IEDs			
Entire 61850 System	NA	NA	1

(1) As the new Data model is not the same and has more information, the .scd must be updated and, for this, a new version of SCT is required to manage the new IEC 61850 edition of the new IED. The SCT shall provide configuration files in both editions. Refer to IEC 61850-6 Ed2.1 Annex I for detailed workflow.

(2) As the data model changed, the FCDA of new device's DataSet are different for FCDA of older device that imply update of Extref in other devices

6.4.4.4 Third use case (UC3)

Extension with addition of one IED into an existing system to support new UAS functionality, as shown in Figure 15.

The added IED will have to exchange information with clients and maybe other IEDs. A new .scd will be needed.

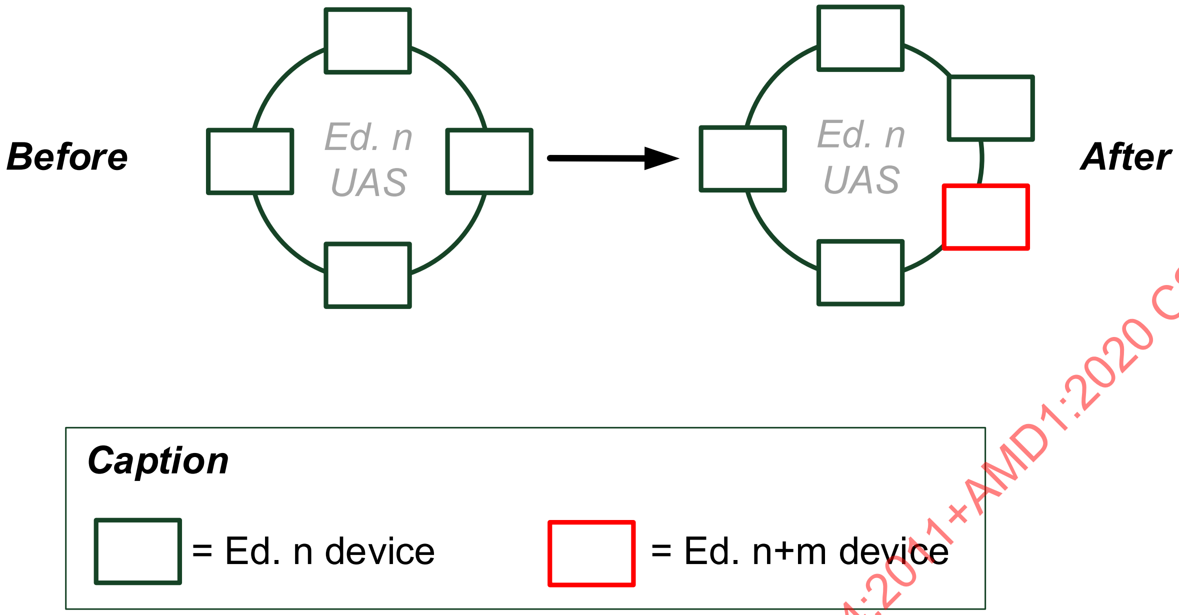

Figure 15 : Backward compatibility third use case

	Before	After
UAS Version	Ed.n	Ed.n
Event	Need new UAS functionality	Addition of a device.
IED		Ed. n+m
Vendor		A or B
Clarification	New functionalities defined in Ed. n+m **are not required** within the system.	
Requirements	A new ICT(or new ICT version) will be introduced for the new IED.	

Expectations

	IEC 61850 Configuration impact	Upgrade Firmware of device	Upgrade IEC 61850 configuration Tool
New IED	2	NA	NA
Client (s)	2		
Interacting IEDs	2		
Other IEDs			
Entire 61850 System	NA	NA	1

(1) The .scd must be updated and, for this, a new version of SCT is needed in order to support new IEC 61850 edition of the new device. The SCT shall provide configuration files in both editions. Refer to IEC 61850-6 Ed2.1 Annex I for detailed workflow.

(2) The configuration of each IED communicating with the new one needs to be updated.

6.4.4.5 Fourth use case (UC4)

Extension of the system possibly with new UAS functionalities requiring new IEC 61850 edition, as shown in Figure 16.

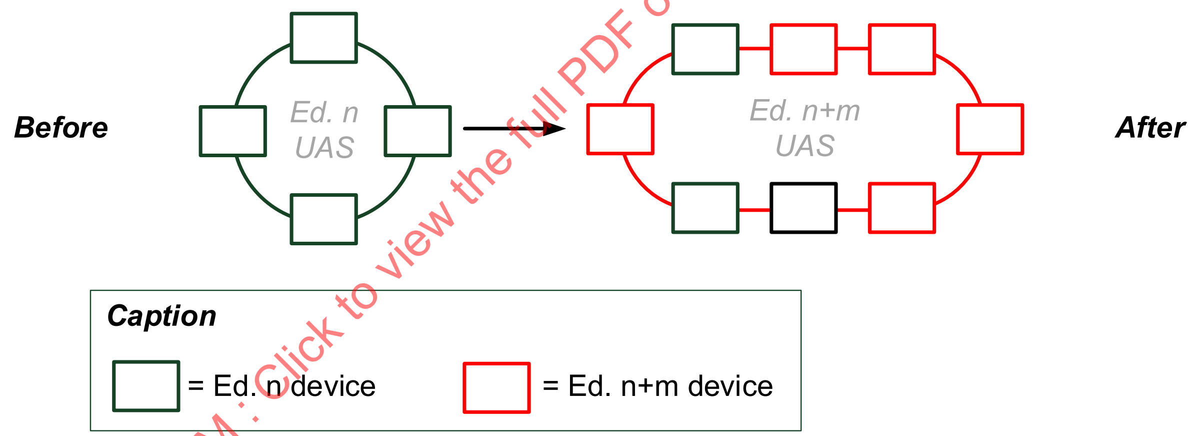

Figure 16 : Backward compatibility fourth use case

	Before	After
UAS Version	Ed.n	Ed.n+m
Event	Primary System extension need UAS Extension	New IEDs added to support UAS Extension
IEDs	Ed.n only	Mixed system Ed.n and Ed.n+m
Vendor	any	
Clarification	New functionalities defined in Ed. n+m **are required** within the system.	

Requirements	If new extension (new IED as well) comes from another vendor, a new ICT could be required for creating a new configuration to download. The more flexible is the new IED, the more similar the data model will look like. If not, changes to clients (CBs, Datasets) are to be expected.

Expectations

	IEC 61850 Configuration impact	Upgrade Firmware of device	Upgrade IEC 61850 configuration Tool
New IED	2	NA	NA
Client (s)	2	3	3
Interacting IEDs	2	3	3
Other IEDs			
Entire 61850 System	NA	NA	**1**

(1) The .scd must be updated and, for this, a new version of SCT is needed in order to support new IEC 61850 edition of the new device. The SCT shall provide configuration files in both editions. Refer to IEC 61850-6 Ed2.1 Annex I for detailed workflow.

(2) For all interacting IEDs and clients, the configuration must be updated.

(3) Firmware and ICT upgrade are needed if interacting IEDs or Clients of previous edition of the standard need to interface with new features of edition n+m. In this case this particular device will upgrade to Ed. n+m.

7 Quality assurance

7.1 Division of responsibility

7.1.1 General

The quality assurance of a system is a common task of the system integrator/manufacturer and of the customer with different areas of responsibility. If two or more parties are involved, then the responsibilities of each party shall be defined at the time of procurement.

7.1.2 Responsibility of the manufacturer and system integrator

7.1.2.1 Quality system

The manufacturer and the system integrator should establish and maintain a quality system in accordance with ISO 9001.

The stages of quality assurance as a responsibility of the manufacturer and system integrator are shown in Figure 17.

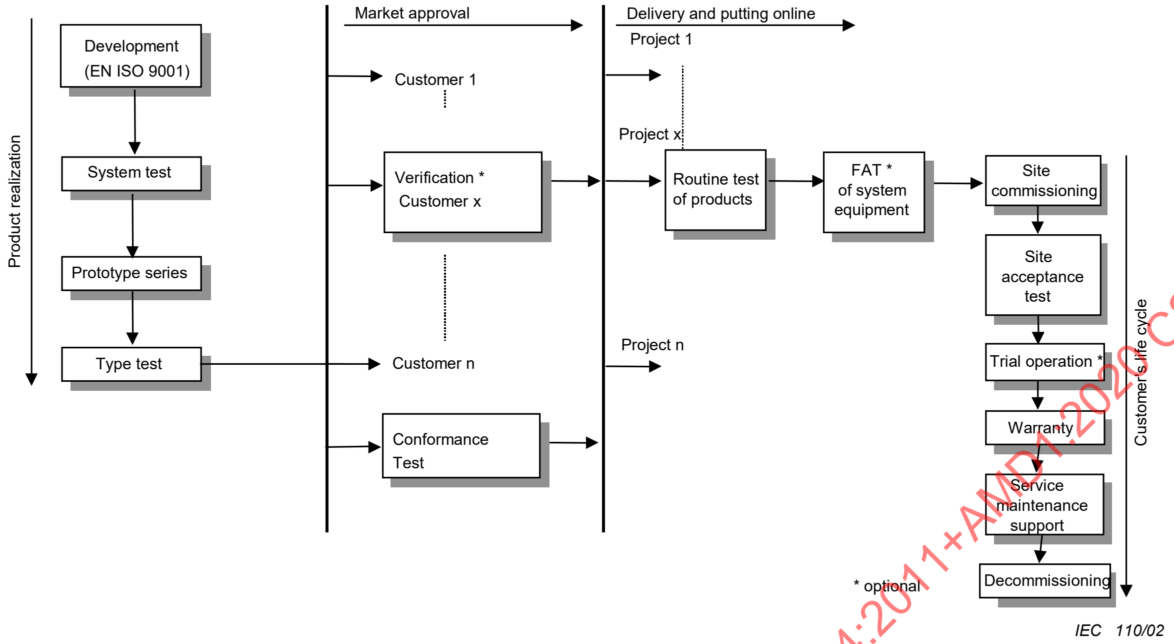

Figure 17 - Stages of quality assurance – Responsibility of manufacturer and system integrator

7.1.2.2 Test responsibilities

The manufacturer is responsible for the correct handling of type tests and system tests of his individual products. Type tests and system tests are preconditions for starting the regular delivery.

All IEDs have to pass device specific routine tests defined by the manufacturer to ensure quality before the products are handed over for delivery.

Customer specific verifications and approvals may be required according to the customer's philosophy and shall be negotiated between the system integrator and the customer. These might be done by the customer at product level as well as at system level.

The system integrator is obliged to prepare and carry out these special investigations with individual products and the overall system. Furthermore, the system integrator is obliged to prove the fulfilment of the technical requirements, including performance criteria. An IED conformance test reduces here the risk for the system integrator.

When introducing a system, the system integrator is responsible for ensuring that all functions are jointly tested by the representatives of the system integrator and the customer during the optional factory acceptance test (FAT) and the mandatory site acceptance test (SAT) with the specific configuration and parameter set of the customer. Observe that before these tests appropriate integration and commissioning phases take place, which are in the responsibility of the system integrator. The successful finishing of the FAT (if required) is the precondition for the equipment delivery and the further site acceptance test at the customer's premises. FAT and SAT, as well as their contents, shall be negotiated between the customer and the system integrator.

The commissioning of the system on site before the SAT is normally the responsibility of the system integrator. Commissioning is followed by a trial operation phase (for example, one month). The length of this phase and the conditions to be met, e.g. trial operation before or after SAT, should be negotiated between the customer and the system integrator.

It is the responsibility of the manufacturer to maintain a quality assurance process, by which any product related errors found during project tests will go back into the next product version. The handling of new versions is described in 6.1.

7.1.2.3 Warranty and after sales service

After the site commissioning, the warranty begins in accordance with the agreed conditions for

– the hardware;
– the engineering;
– the software.

Any faults of a product type detected during the warranty phase that may also appear in other projects shall be communicated to the respective system integrators and customers. It is the responsibility of the customer to decide if a new version of the product shall be installed or not.

After the warranty, the system integrator or the manufacturer should provide after sales service:

– the supply of spare parts for an agreed period;
– the support in diagnosing failures;
– the mandatory provision of urgent information to the customers about malfunctions;
– the correction of detected software errors and hardware defects;
– the offer and introduction of software updates.

7.1.2.4 Diagnostic

The manufacturer should develop and offer special diagnostic tools for

– failure definition inside or outside the system;
– failure localization inside the system and the individual IED's.

The diagnostic tools should be designed to be used remotely, if appropriate.

The technical documentation of the system and its individual products shall include the recommended preventive maintenance (e.g. batteries, capacitors, etc.).

7.1.3 Responsibility of the customer

The customer is responsible for ensuring that the relevant environmental and operating conditions of the system satisfy the conditions described in the technical documentation of the system and its individual products.

The customer has to carry out preventive maintenance for service or exchange of maintainable parts in accordance with the instructions of the manufacturer.

The inspection and regular check of individual products and their inter-related function (e.g. protection relay and circuit breaker) will be necessary from time to time in accordance with the recommendations of the manufacturer or the customer's standards organization (IEE, VDEW, IEEE, etc.).

Corrective maintenance should be carried out immediately after detection of defects, to obtain the highest possible availability.

The customer should define the requirements for the project at the tender stage, latest at an early stage of the engineering process.
The definition could include

- the system specification (functional, network, safety and security)
- requirements for the used IEDs and network equipment
- Communication requirements
- requirements to test and prove the system during FAT, SAT and maintenance
- the concept intended for maintenance testing

Those requirements could be expressed by mean of an .ssd file.