Question 3.04 What are other experiences to improve the specification, engineering, testing and maintenance to address the challenges in our industry?

In the past two decades, the policy of Rte has been to purchase "turn-key" integrated Protection Automation and Control Systems (PACS) from several vendors, according to a set of specifications. Rte has now launched the R#SPACE project aiming at an industrial rollout of fully digital, IEC 61850 based multi-vendor PACS.

For R#SPACE, the position of Rte is thus that of a system integrator charged with the definition of the interoperability framework of the new PACS, including the configuration, data models and cybersecurity. Regarding the specific constraints and interface requirements for specific tools and databases, Rte develops a proper configuration tool using an open source approach (LFE / ComPAS).

In this context, the configuration is a central element of the PACS, which is directly linked to specification, engineering, testing and maintenance (Figure 1). Several issues related to the IEC 61850 configuration have been identified and addressed by the project. Most of them have been also submitted for discussion or as user-feedback issue to IEC TC 57 WG 10.

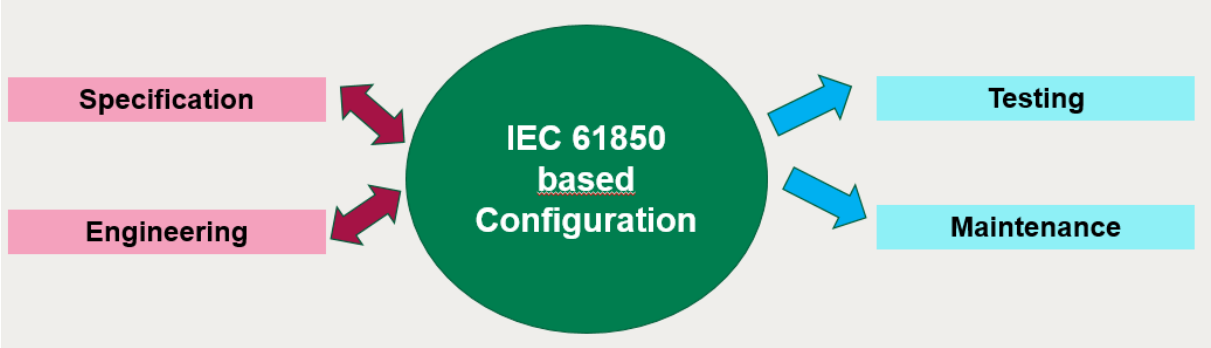

Figure 1 Central Role of IEC 61850 based configuration

Association between IEC 61850 DO and functional specification

Mapping and identification of application inputs is instrumental in order to achieve interoperability of a functional chain which may be composed of several functions, represented as Logical Devices.

Particular attention has to be paid to the description of the functions in order to keep them functionally independent from each other. All signal exchanges have to be defined in the SCD, providing flexibility for the instantiation of PACS functions, and for the instantiation of the associated signal flow. In this aspect, it can be compared to a conventional, wire based relay technology. Each function has so-called application inputs, which are associated to the functional requirements and algorithms. These inputs need to be mapped to the IEC 61850 Data Objects or attributes.

In R#SPACE, this is done using later binding on the base of the “Input/ExtRef” element or the DO “InRef” in the ICD file. The application inputs are mapped by configuration to the Data Objects (DOs) and Data Attributes (DAs) that they have to subscribe and which are published by other functions. A precise syntax for doing this has been defined in order to cover all possible cases, covering multiple inputs, dynamic subscription and handling of redundant SV and GOOSE streams, data type conversion and rules for processing quality and timestamp of the subscribed data. This is described in more detail in [3] and illustrated in Figure 2. It would be beneficial to introduce such a mechanism in the IEC 61850 standards.

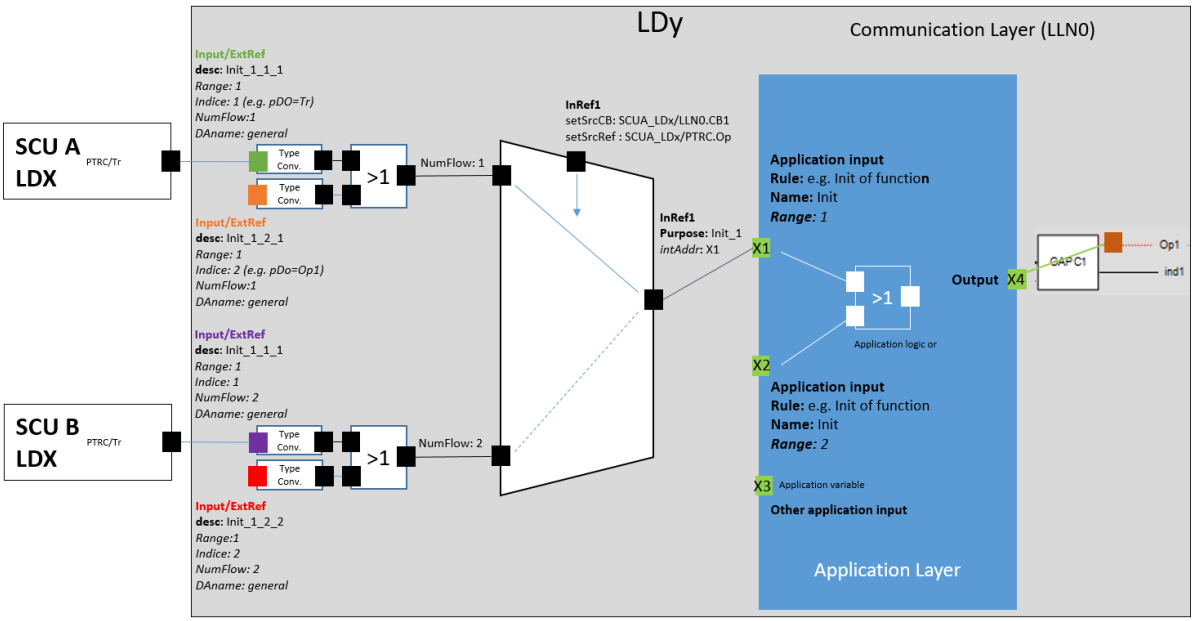

Figure 2 Principle of association of subscribed data to application inputs

Settings

Protection settings are treated as "parameters" by IEC 61850 and described by Data Objects. For some functions, the settings provided in the relevant IEC 61850 Logical Nodes were not sufficient to describe the generic settings used by Rte. This was in particular the case for numerous time delay settings used in protection and automation functions. The following cases can be distinguished [4]:

1. More settings of a given type than defined in the LNs used in the model of the function are required. In this case, additional LN can be instantiated in addition to the LN required for the functional model.
2. Settings of a given type are required but not defined in IEC 61850 for the relevant LN. In this case, several different approaches are possible, including the use of a LN with generic settings or the use of an additional LN including the setting but normally not required to model the function (see Table 1).

Table 1 IEC 61850 Data Objects used in LSET (sample) [4]

Data Object Name	CDC	Explication	M-O-C nds/ds
OpDITmms	ING	Instance of Operate Delay Time	Omulti/ Omuti
DlTmms	ING	Instance of Delay Time	Omulti/ Omulti
StrVal	ASG	Instance of threshold	Omulti/ Omulti
OnOff	SPG	Instance of Boolean parameter	Omulti/ Omulti
SetNb	ING	Instance of integer parameter	O/O
SetMod	ENG	Activation / Deactivation by parameter (on, off)	O/O
SetPhNum	ENG	Phase (ph0, ph3, ph4, ph7, ph8, ph11, neutral)	O/O
SetRef	ORG	IEC 61850 object reference	Omulti/ Omulti
VRtg	ASG	Rated Voltage	O/O
ARtg	ASG	Rated Current	O/O
HzRtg	ASG	Rated Frequency	O/O

Association of terminals to the IEC 61850 Data objects for the Binary I/O

A Binary I/O IED (BIOI) is used as process interface for HV equipment (circuit breaker, disconnectors, etc.) and other physical devices which are non-communicating in IEC 61850. This requires the description of the association of IEC 61850 Data Objects with a terminal (and vice-versa). This information should be included in the configuration, and thus in the SCD file.

In order to ensure the flexibility of the use of terminals, the functional Data Objects (e.g. PTRC.Tr representing protection trips) are linked to Data Objects that model the binary outputs. This is based on proprietary Logical Nodes introduced in the R#SPACE SCD : LPDI for wired inputs and LPDO for wired outputs [4] (based on IEC TC 57 W10 Technical Report 90-29 in progress).

To associate enumerated Data Objects to binary I/O, mapping tables are specified for each Data Object (DO) type (DPC, ENUM, etc.) and are implemented at application level. An example of such a mapping table is given in Table 2.

Table 2 Mapping of DO to binary output contact [4]

DA Type	DO Type	DO Value(s) leading to contact **opening**	DO Value(s) leading to contact **closure**	DO Value(s) leading to contact **opening**	DO Value(s) leading to contact **closure**
		OutMod = Active High		OutMod = Active Low	
Boolean	any	false	true	true	false
DPC	Pos	**off** / inter-mediate state / bad-State	**on**	**on** / inter-mediate state / bad-State	**off**

In addition to this, other identified issues include:

- Need to use phasors, requiring a precise specification of their elaboration.
- Capacity of IEDs regarding the number of subscribed or published datasets
- Need of extensions of several LN or DO

[1] X. Michaut, N. Soupaseum, V. Leitloff: "Design constraints and choices for the LAN in RTE's R#SPACE system" Paper B5-216 CIGRE Session 48 Paris 2020

[2] T. Michel, V. Leitloff, JM. Boisset, X. Michaut, J. Brengarth, S. Germain: "R#SPACE – Rte's new approach towards fully digital Protection Automation and Control Systems" PAC World Conference 2021 Paper PW034

[3] V. Leitloff, X. Michaut , F. Fousseret , G. Duverbecq, T. Machkour, D. Fontenay, T. Michel, S. Mamodaly, C. Zanabria, J. Brengarth: "Process Bus Implementation in Rte's R#SPACE PACS" 41. CIGRE International Symposium Ljubljana 2021 –Paper 1136

[4] V. Leitloff, F. Fousseret, G. Duverbecq, T Machkour, Y. Leloup, G. Baron, T.Michel: "Interoperability challenges for a digitally interfaced functional protection chain" Paper 0023 DPSP 2022 Newcastle, UK, March 2022

[5] M. Merley, V. Leitloff, X. Michaut, T. Machkour, A. Padoan, D. Fontenay, S. Mamodaly, P. Perrin: "Test and Integration approach for Rte's R#SPACE Protection Automation and Control System" Paper PW47- PAC World Conference June 2022 – Prague, CZ