October 2023

R#SPACE
Scope and progress update

01

The path to full IEC 61850 PACS

INTRODUCTION – RTE DIGITAL SUBSTATION PROJECTS - POSTES INTELLIGENTS

SCOPE OF "POSTES INTELLIGENTS PROJECT"

- On site full scale experimentation in **2** substations
- Implementation of enhanced and extended functions
- Monitoring of HV equipment and substation infrastructure
- Implementing the latest technological solutions
  [primary equipment, SAS Information and Communication Technologies]
- **Full IEC 61850 PACS [Station bus, process bus including trip]**
- **Near process SCU, SAMU and MU**
- **Use of LPIT**

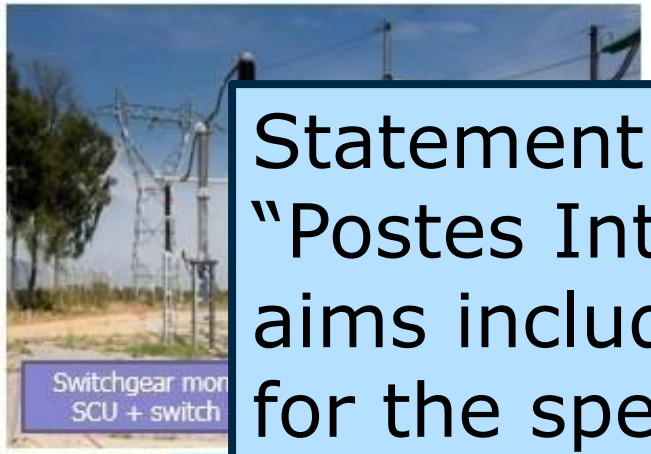
Substantial experience feedback obtained

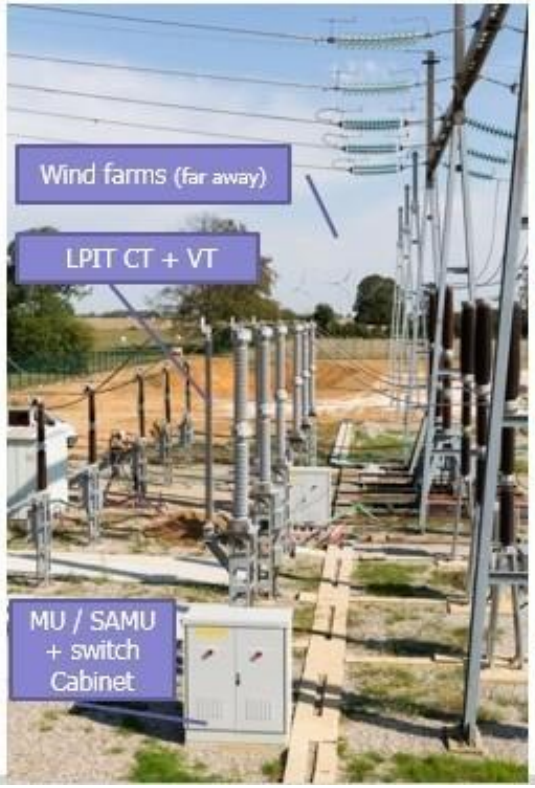
- specification, design and testing of full IEC 61850 PACS,
- testing of functional protection chains including LPIT,
- features related to life-time maintenance,
- HV monitoring- and control functions.

References :

DPSP 2016,
PACW 2016
Tutorial DPSP 2018
CIGRE B5 2018
PAC World Magazine
sept 18

Introduction – Rte Digital Substation Projects - Postes Intelligents





Statement 2018:
"Postes Intelligents" project aims include to generate input for the specification of the next-generation PACS.
This aim has been attained.

What is the next step ?

MAIN DRIVERS FOR RTE TO LAUNCH A NEW GENERATION OF PACS

- Increased insertion of Renewable Energy Sources (RES)
  - implementation of more complex and personalised automatons on substation level
  - traditionally workflow of specifying functions and their development by PACS vendors is not well adapted
- Need to Decrease costs in case of evolutions of substation level functions
  - automatons, HMI, telecontrol gateway or asset management
  - one single development managed directly considered to be more efficient
- Strategic decision of Rte to enhance digital applications throughout all transmission network services and components
- Take advantage of IEC 61850 process bus as a new PACS process interface
- Pave the path for an increased integration of PACS functions and virtualisation
- Increase and improve
  - remote maintenance,
  - administration
  - supervision

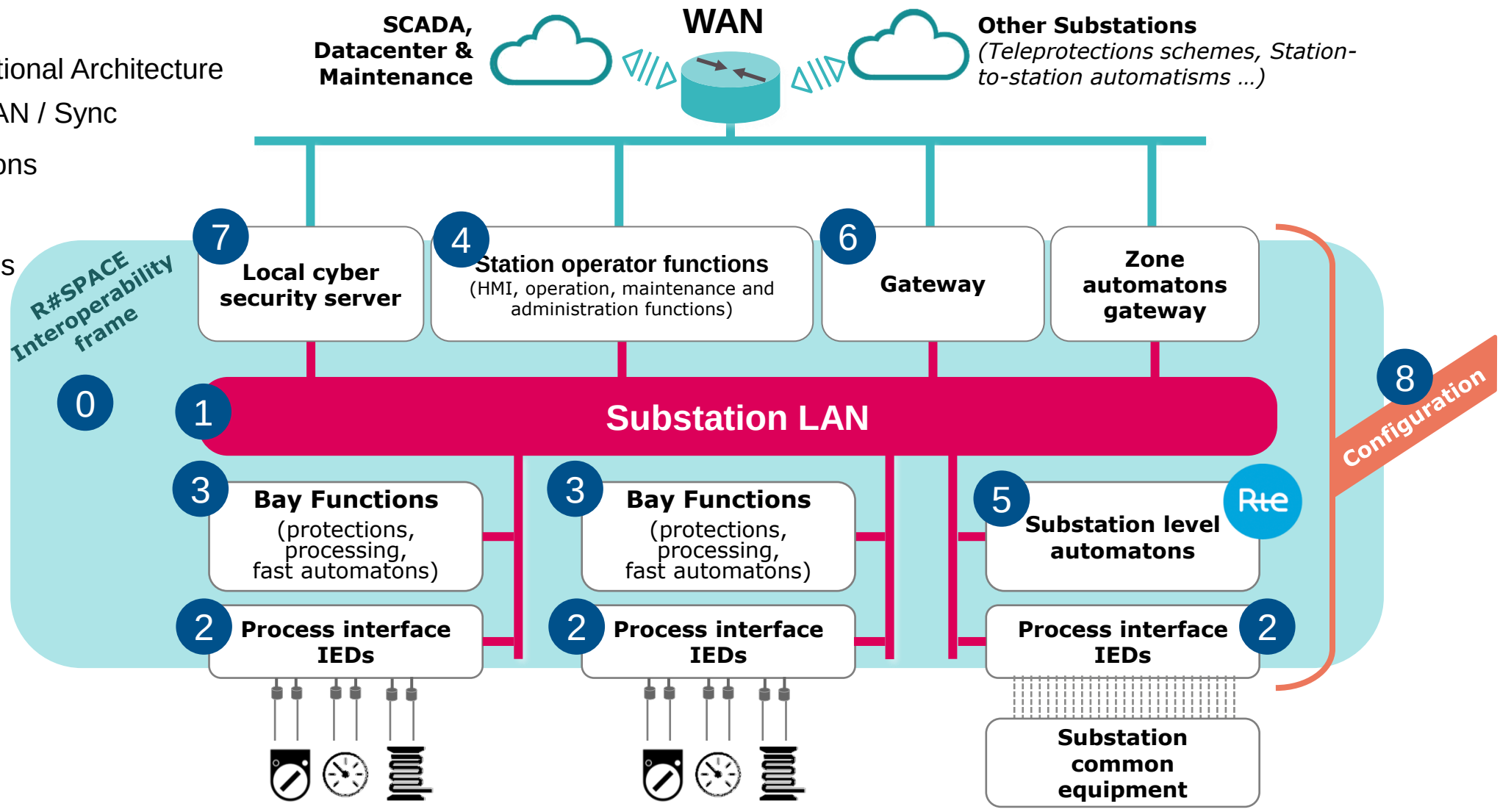
Rte Digital Substation Projet – R#SPACE

Technical Lots

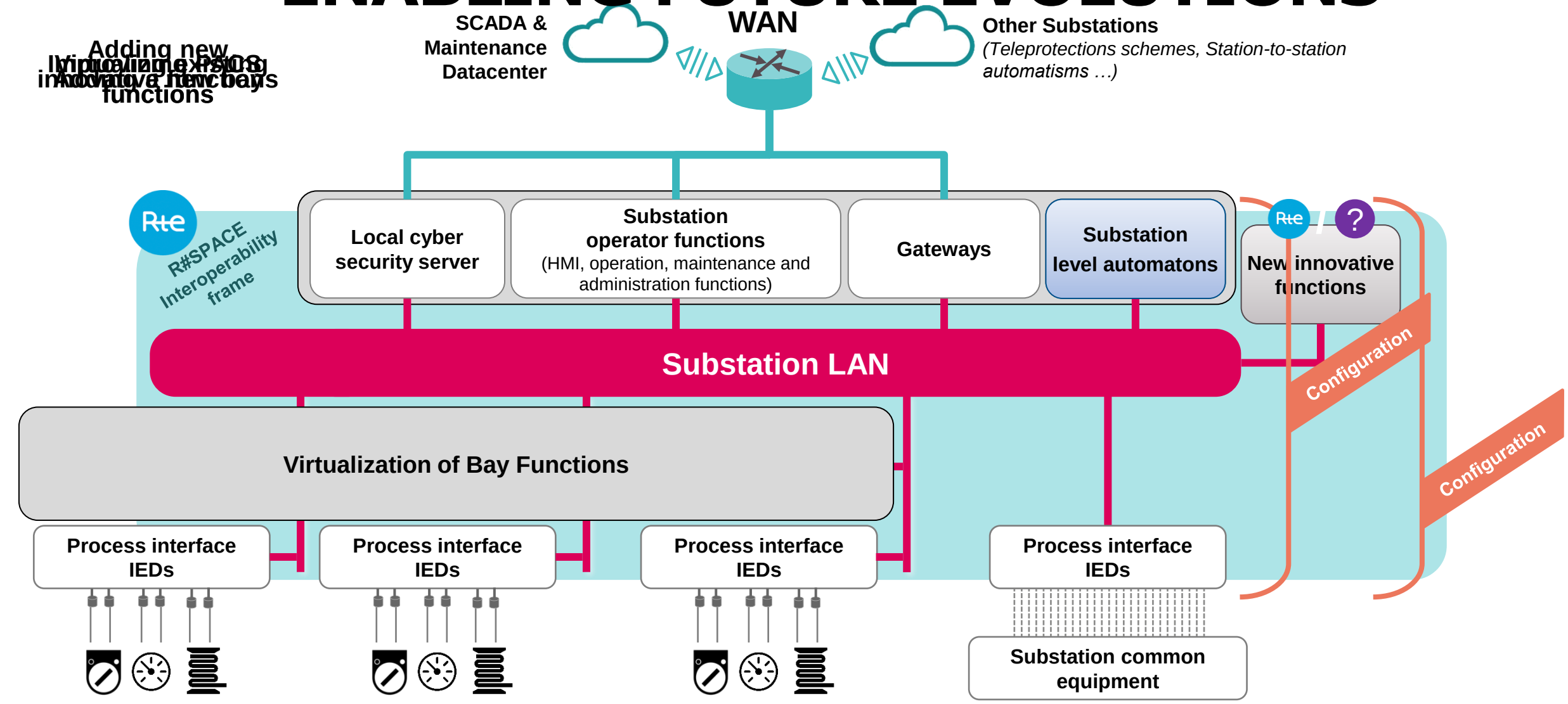
0. IEC 61850 Model / Functional Architecture
1. Physical Architecture / LAN / Sync
2. Process Interface functions
3. Bay Functions
4. Station operator functions
5. Automaton
6. Gateway
7. Cyber security
8. Configuration
9. Tests / Integration
10. System engineering

Non Technical Lots

11. Procurement
12. Project management
14. Maintenance Process
15. Human resources



R#SPACE - A MODULAR ARCHITECTURE ENABLING FUTURE EVOLUTIONS



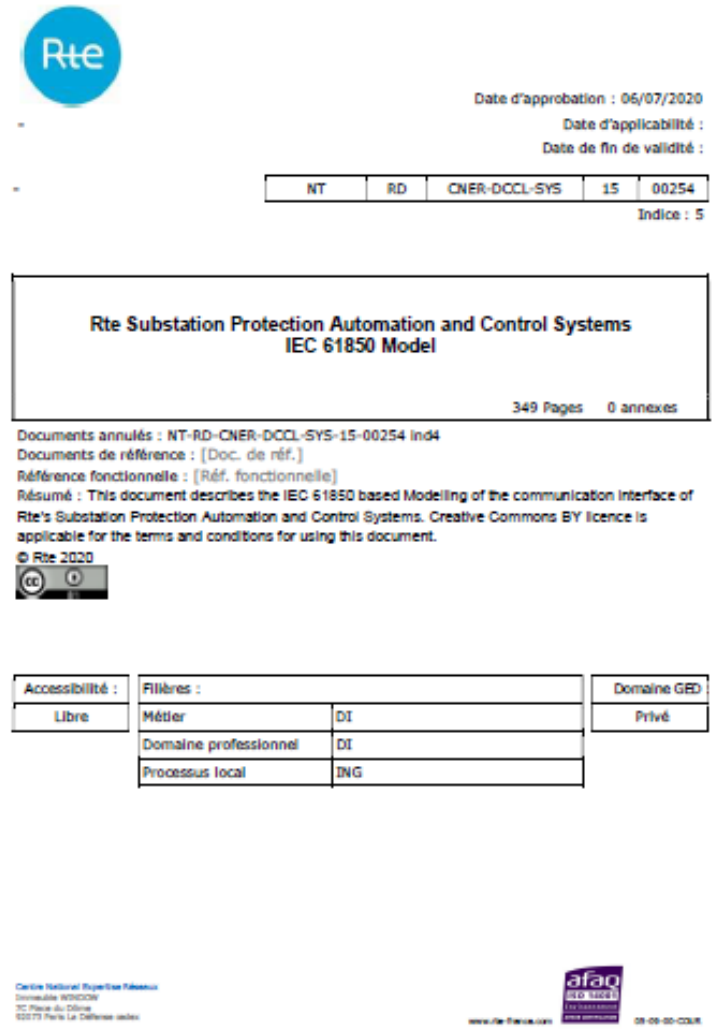
02

Rte Interoperability framework

IEC 61850 based function modelling
State of the Art and Consequences

- **No method proposed (IEC or UCA) to obtain a IEC 61850 data model starting from a functional specification**
- **Method developed by Rte**
  - Based on Rte PACS functional specifications
  - Take into account signal reference list to describes PACS input/output
  - strictly follow the rules described in the standard fascicules

6th version of the document written in English publicly available



Date d'approbation : 06/07/2020
Date d'applicabilité :
Date de fin de validité :

NT	RD	CNER-DCCL-SYS	15	00254

Indice : 5

Rte Substation Protection Automation and Control Systems
IEC 61850 Model

349 Pages 0 annexes

Documents annulés : NT-RD-CNER-DCCL-SYS-15-00254 Ind4
Documents de référence : [Doc. de réf.]
Référence fonctionnelle : [Réf. fonctionnelle]
Résumé : This document describes the IEC 61850 based Modelling of the communication interface of Rte's Substation Protection Automation and Control Systems. Creative Commons BY licence is applicable for the terms and conditions for using this document.
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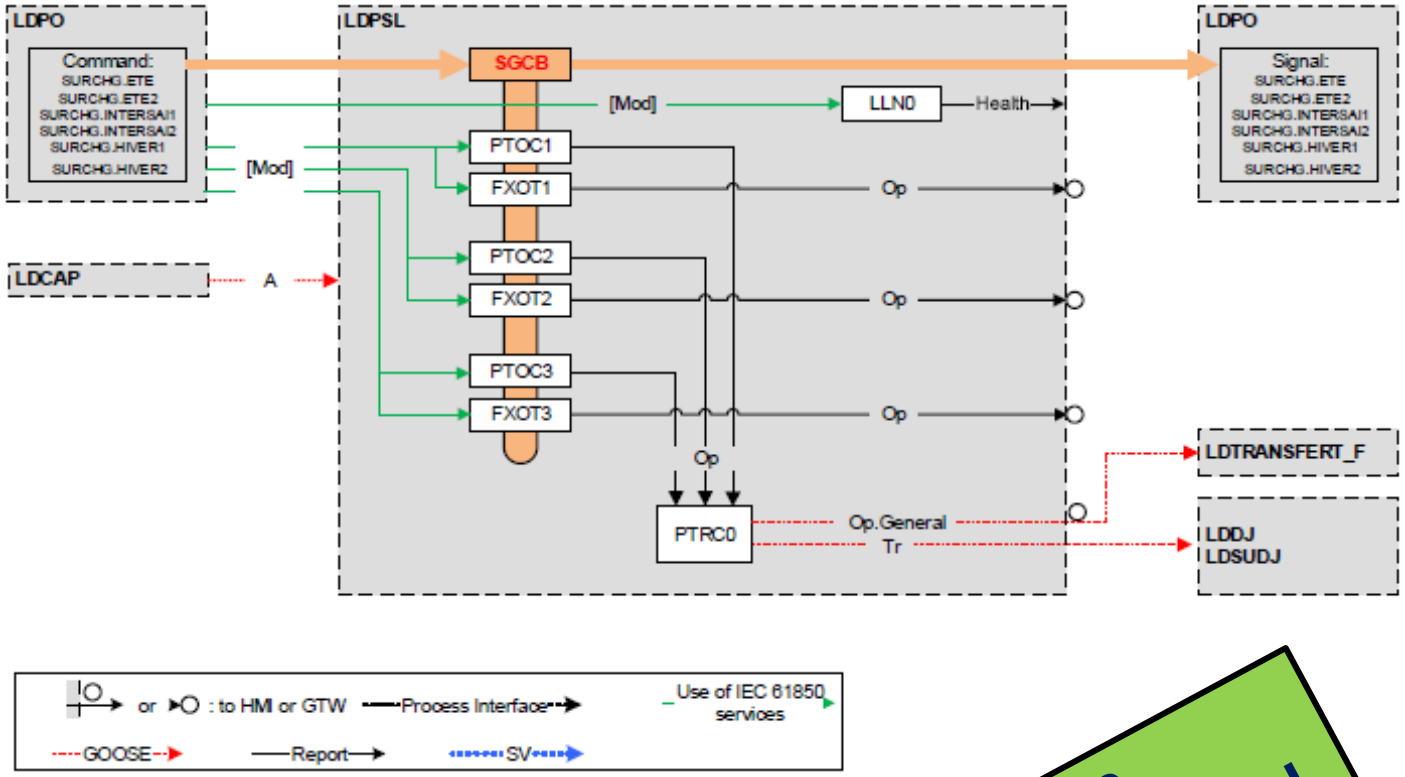
Libre	Métier	DI	Privé
	Domaine professionnel	DI	
	Processus local	ING	

Example: Overload function – Static & Dynamic Description

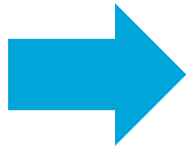
Line overload protection LD (LDPSL)				
LN	**DO**	**CDC**	**FCS name**	**Comments**
LLN0	Health	ENS	DF.PSL/DF.PSC	
	Beh	ENS	PSL/PSC	Signal "Function activated/deactivated"
	Mod	ENC	PSL/PSC	Command to activate / deactivate the function(ES/HS)
	The SGCB mechanism is used to manage the 6 regimes of the PSL (Signals: SUR.ETE, SUR.ETE2, SUR.SAI1, SUR.SAI2, SUR.HIV1, SUR.HIV2 ; **TC** : ETE.TC, ETE2.TC, SAI1.TC, SAI2.TC, HIV1.TC, HIV2.TC)			
FXOT*	Beh	ENS		
	Mod	ENC		Command to inhibit threshold* (when set to off)
	Op	ACT.general	AL.SUR.*	Decision to issue an alarm following the detection of overload and the expiration of the alarm threshold (* = 1, 5, 10, 20 or 60 depending on the threshold and configuration)
	StrVal	ASG.SetMag	n.a.	IS* current threshold (same value as for PTOC) The value is managed by the SGCB and varies with the regimes.
	OpDlTmms	ING.SetVal	n.a.	Alarm delay Ta* The value is managed by the SGCB and but does not vary with the regimes.
PTOC*	Beh	ENS		
	Mod	ENC		Command to inhibt threshold* (when set to off)
	Str	ACD.general	n.a.	Overload detection (* = 1, 2 or 3 depending on the threshold)
	Op	ACT.general	n.a.	Circuit-breaker trip order sent to the PTRC
	StrVal	ASG.SetMag	n.a.	Current threshold IS* The value is managed by the SGCB and varies with the regimes.
	OpDlTmms	ING.SetVal	n.a.	Alarm ltime delay Td* The value is managed by the SGCB and but does not vary with the regimes.
PTRC0	Tr	ACT.general	n.a.	Trip order to XCBR
	Op	ACT.general	DT.SURCHARGE	Tripping decision of 3 phases



Version #6 issued in English and publicly available

Issues & Questions

- Application
  - Semantic definition sometimes too restricted (XCBR)
  - Limited or restricted DOs functionalities (*Str without delay, Op without direction…*)
  - Missing possibility to group different kinds of signal
- Missing use cases
  - live-live recloser mode
  - remote desabling of recloser function case
  - Semantics describing dynamic substation topology
  - Physiclal I/O Monitoring
  - Shortcomings in available settings
- Method
  - Creating new LN preferred to adding new DO into an existing LN



LDGRP

The values of DO RecCycMod are indicated in the table below:

RecCycMod	1	2	3	4	5	6	7
RT criteria	REB	RVB	RVL	RVB+L	REB+RVB	REB+RVL	all

11.1 LTED - Topologic

The following table lists the elements mentioned above:

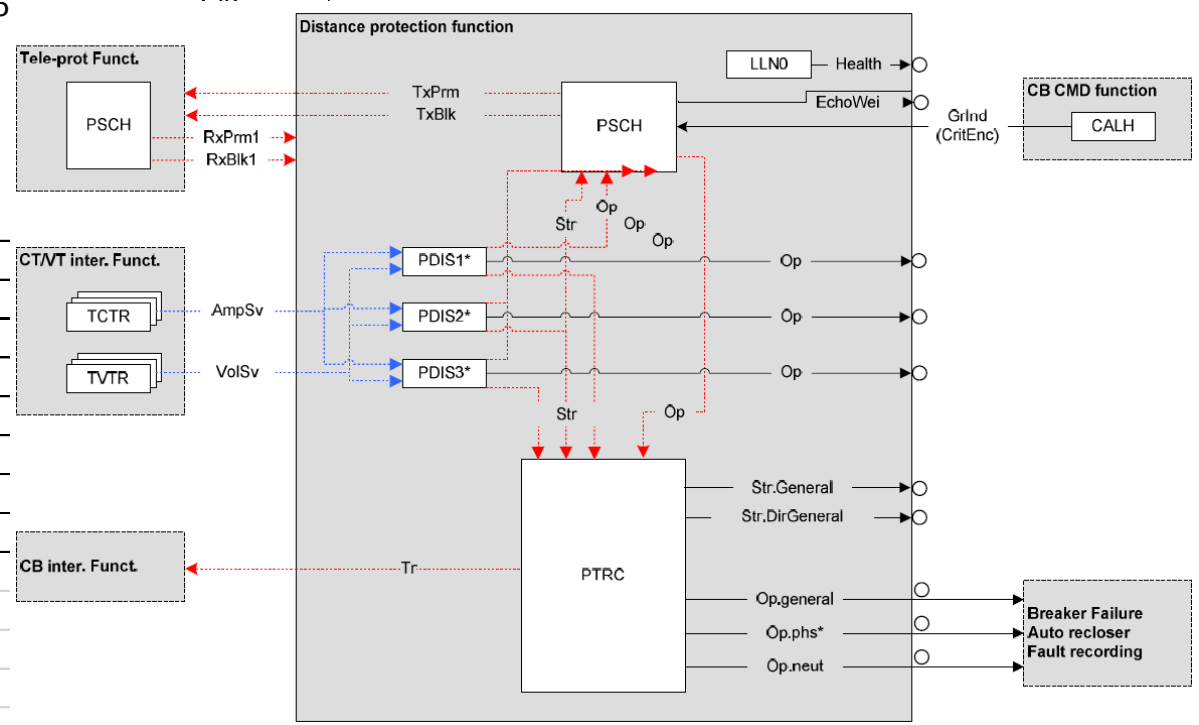
LTED				
Data object name	**Common data class**	**T**	**Explanation**	**M-O-C nds/ds**
Descriptions				
NamPlt	LPL		inherited from: DomainLN	O / na
Status information				
Beh	ENS (BehaviourModeKind)		inherited from: DomainLN	M / na
Health	ENS (HealthKind)		inherited from: DomainLN	O / na
VolLevelDes	ENS		Voltage Level (1..9)	O
VolLevel	ENS		Voltage Level (<45kV, 45kV, 63kV, 90kV, 150kV, 225kV, 400kV, 750kV, DC)	O
TopoObj	ENS		Topological Element Type (busbar, feeder, coupling, "omnibus", power transformer)	O
TopoObjNum	INS		Topological Element Reference (1..n)	O
FeederTyp	ENS		Topological Element Reference - Feeder (line, Power Transformer, Coil, Capacity, FACTS)	O
SectNum	INS		Topological Element Subset Reference - Busbar Section (1..n)	O
SubSectNum	INS		Topological Element Subset Reference - Busbar Subsection (1..m)	O

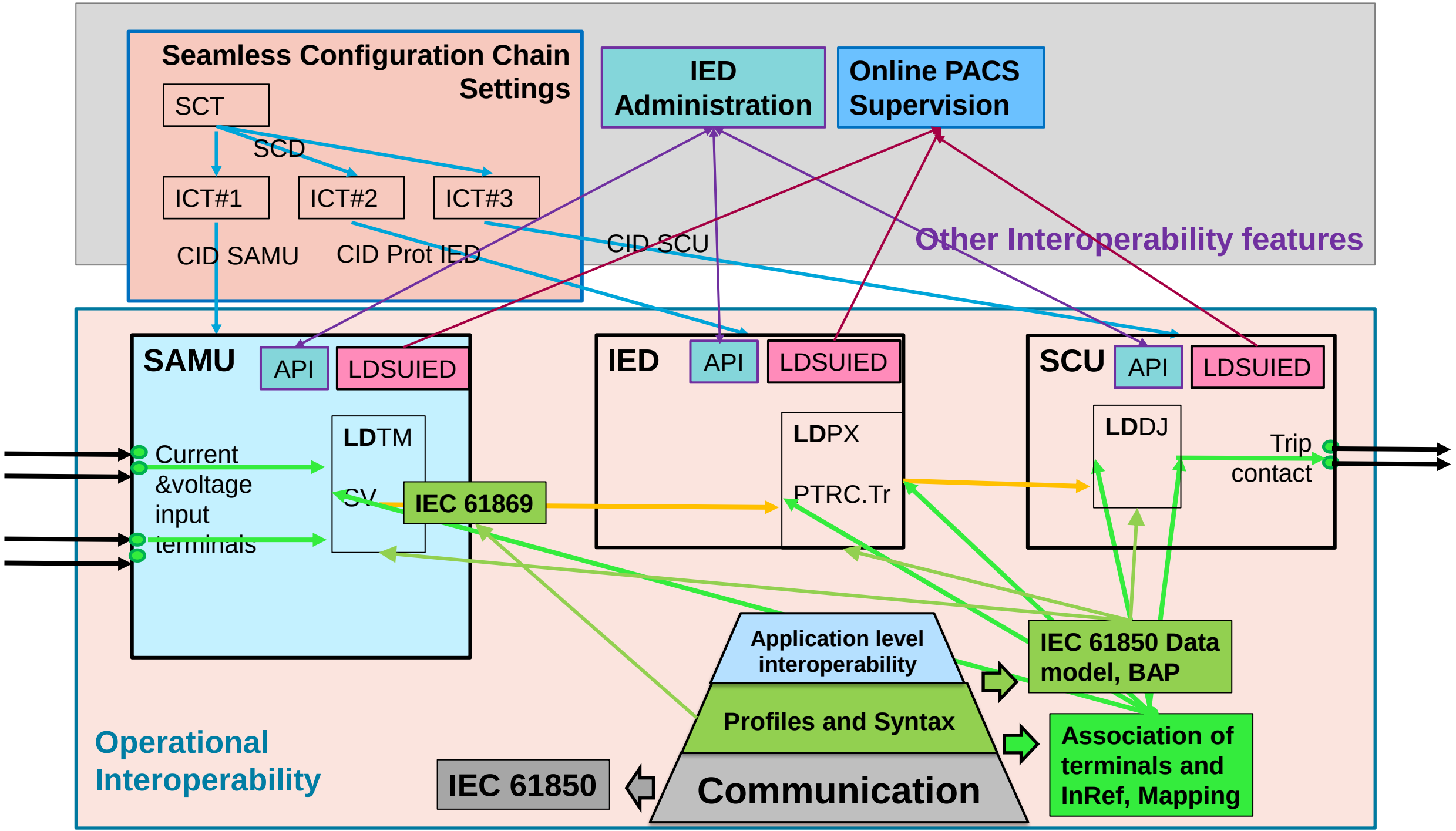
Profile &Functional Interoperability
– Data Model & Basic Application Profile for quality

		QUALITY											
		Detailed Quality										SOURCE	
		INVALID			QUESTIONNABLE								
Input	Input Type	Overflow *)	Faillure	Other (not associated to detailed quality)	Oscillatory **)	BadReference *)	OutOfRange *)	OldData	Inconsistent	Inaccurate *)	Other (not associated to detailed quality)	PROCESS	SUBSITUTED

		Non Applicable
		Nominal Processing of Input
		Ignore Input
		Function blocked or degraded operation
R		Identifier replicated to output
*)		Only applicable for SV or MV
**)		Only applicable for DO representing wired binary inputs
A		Generate Alarm

Pro

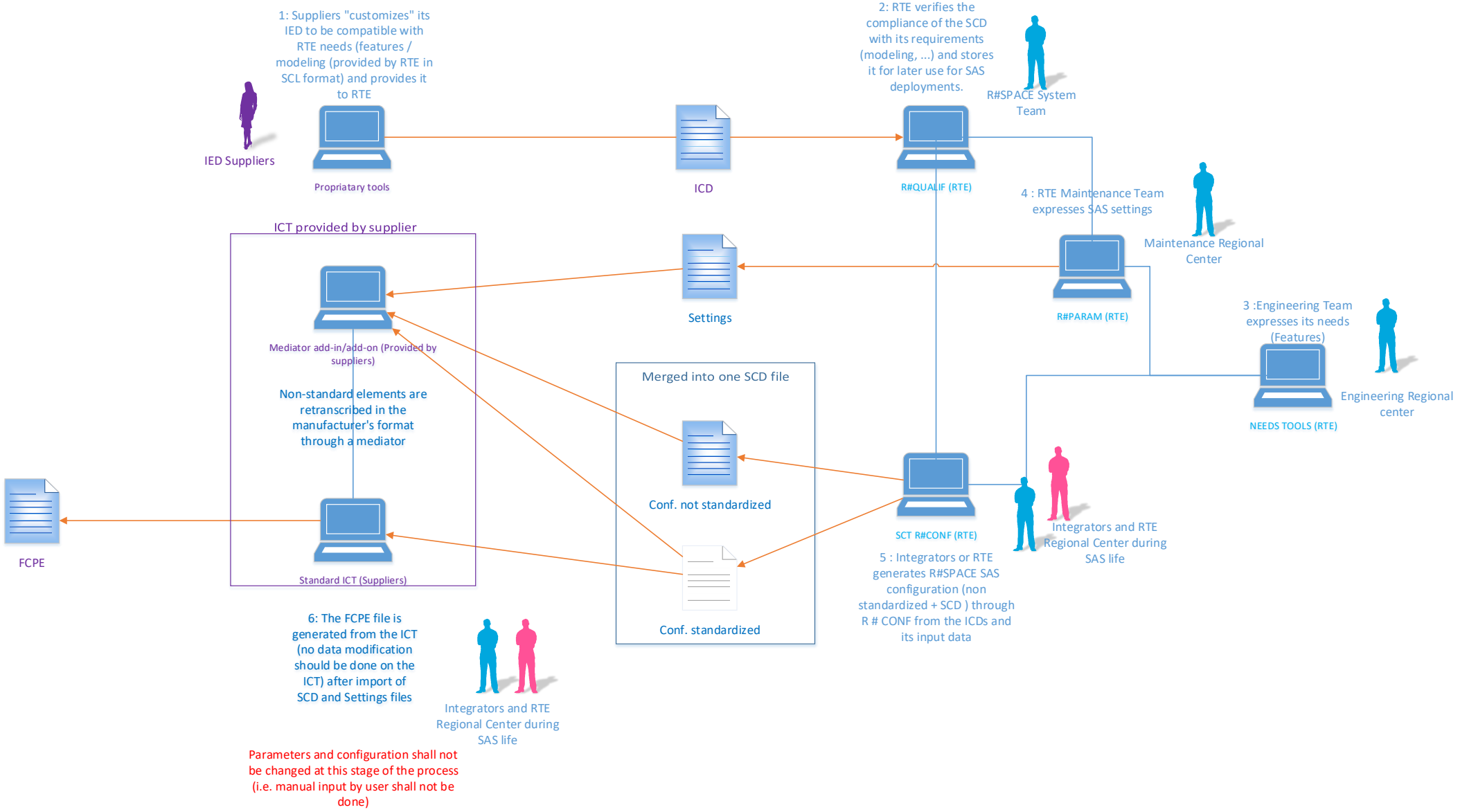



Seamless Configuration Chain Settings
SCT
SCD
ICT#1
ICT#2
ICT#3
CID SAMU
CID Prot IED
CID SCU
IED Administration
Online PACS Supervision
Other Interoperability features
SAMU
API
LDSUIED
LDTM
SV
Current &voltage input terminals
IEC 61869
IED
API
LDSUIED
LDPX
PTRC.Tr
SCU
API
LDSUIED
LDDJ
Trip contact
Application level interoperability
Profiles and Syntax
Communication
IEC 61850
IEC 61850 Data model, BAP
Association of terminals and InRef, Mapping
Operational Interoperability

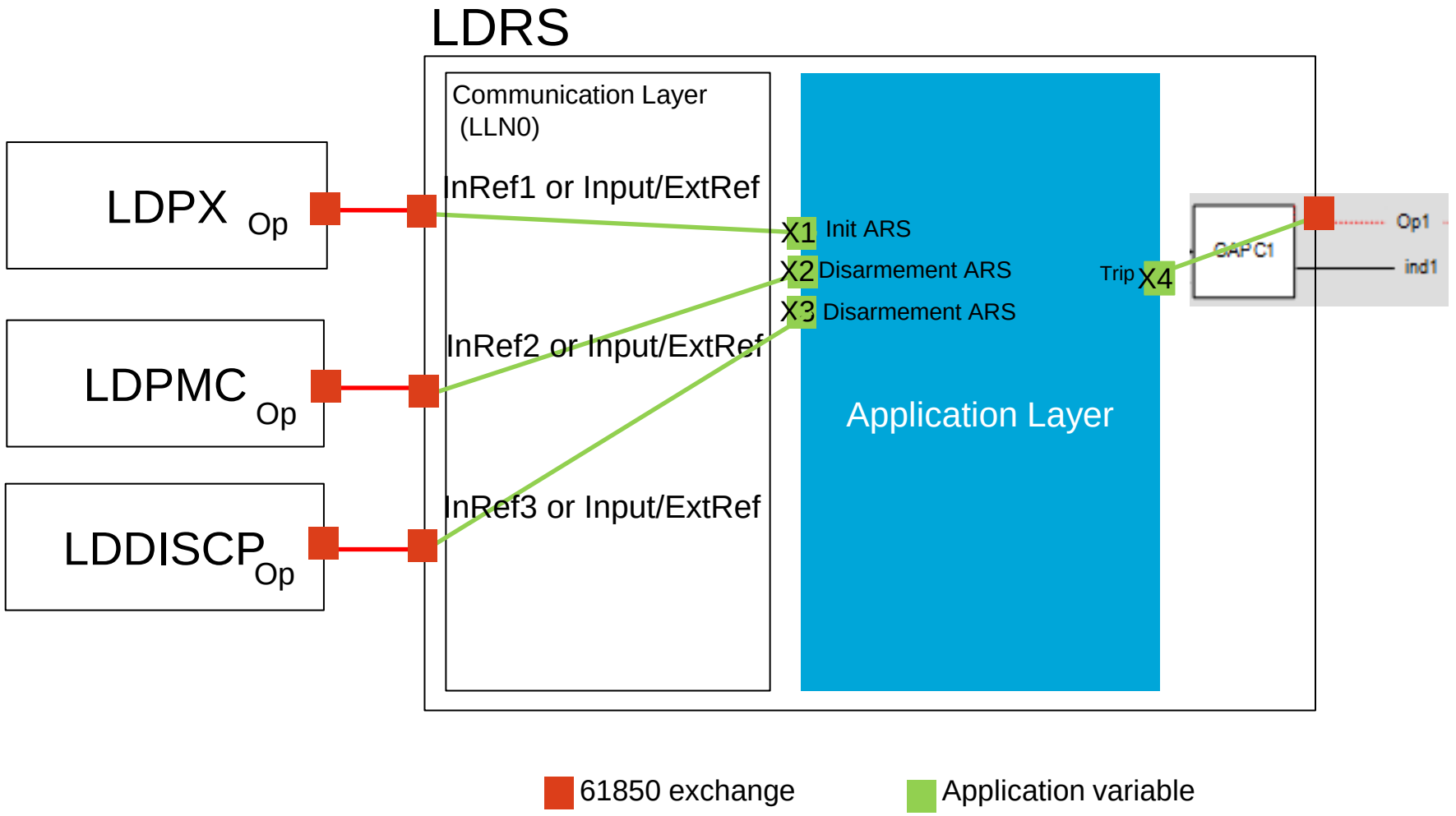
03

Configuration process and tools

Configuration Process



Focus on Later Binding

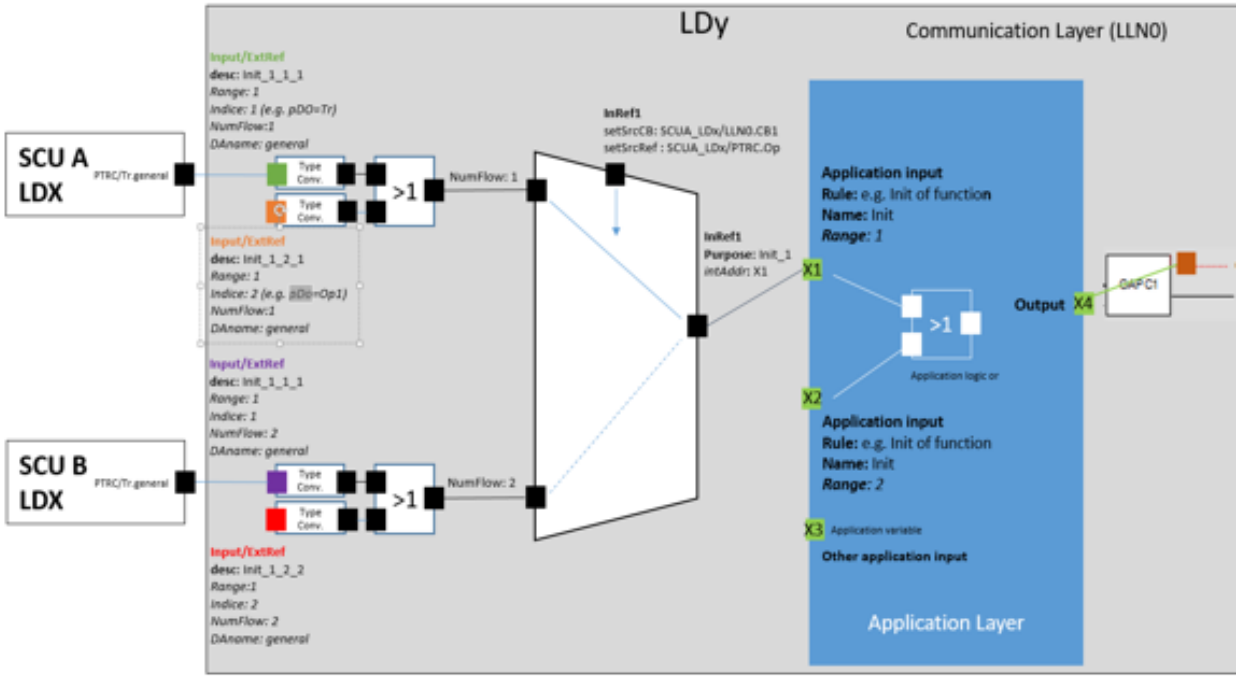


- The LD exposes its entries as InRefx ou ExtRef
- Purpose (InRef) and Desc (Input/ExtRef) contains the name of the application signal as defined by RTE in its requirements
- We can now map what we want on an application input
- The mapping can be dynamic by using InRef instead of Input/ExtRef

Focus on Later Binding

Mapping and identification of application inputs

- Use of Later Binding (Input/ExtRef based on syntax in **desc** or **purpose** attribute)
- Capacity to map application inputs to several DOs /DAs
- Dynamic subscription of GOOSE and SV using "**setSrcCB**" and "**setSrcRef**" of InRef
- Data Type conversion at application level



Focus on Interoperability – Association of DO with binary I/O

- Description of the association of IEC 61850 Data Objects with I/O terminals in SCL file required for Binary I/O IED (BIOI) **[discussed in WG 10]**
- Functional Data Objects linked to Data Objects that model the binary outputs. [**LDPI / LDPO attached to IED management function]**
  - Description of the terminals and their configurations
  - threshold voltages for high / low,
  - input mode (active High or Low).
- Mapping tables between Data Object (DO) type (DPC, ENUM, etc.) and input / output.
- Flexible mapping between the functional Logical Devices and the LPD(I/O)

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

Mapping of DO to Binary Output for **Pos**

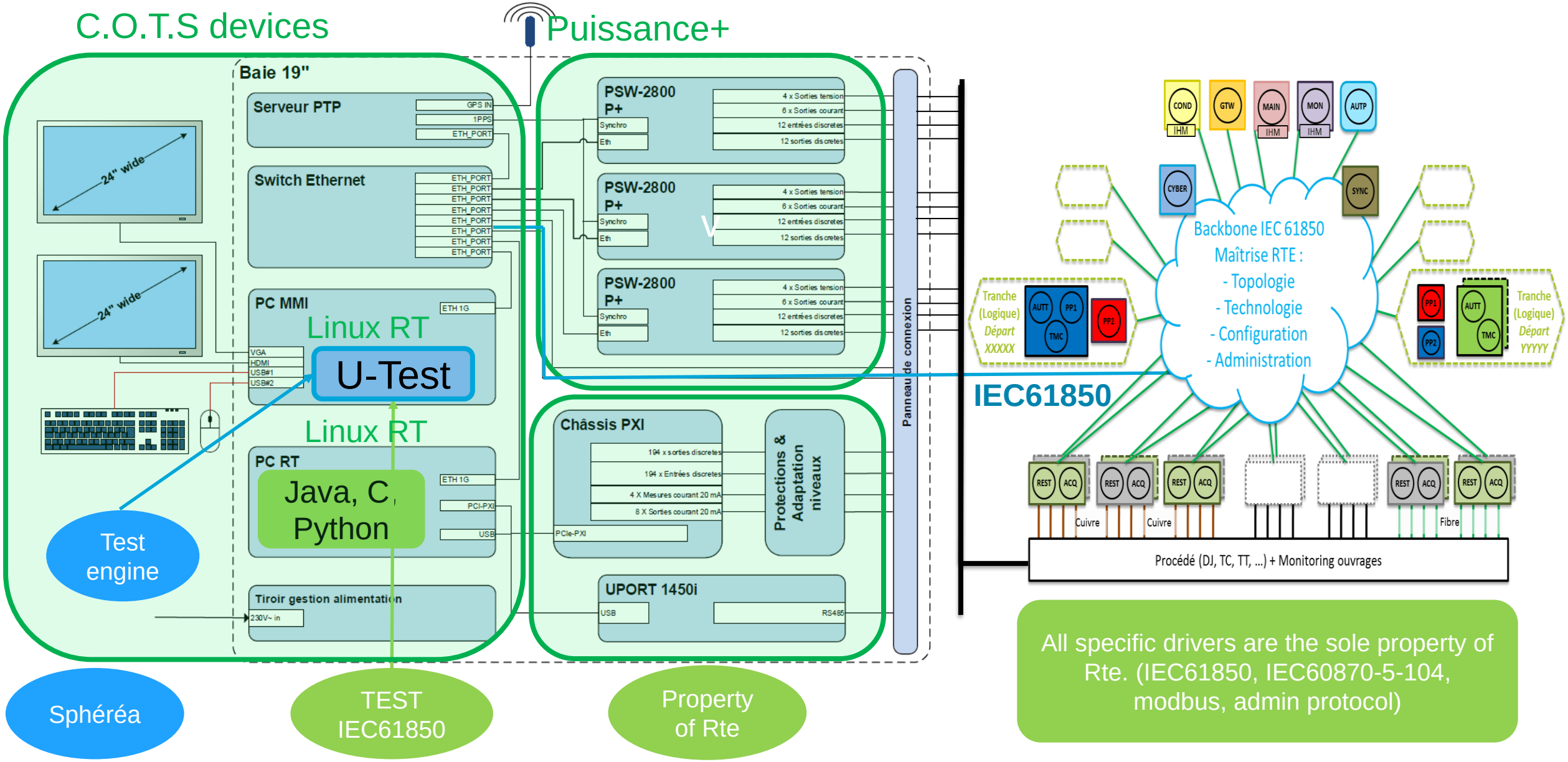
LPDI.Ind of first input	LPDI.Ind of second input	Value of DPC Pos
false	false	intermediate-state
true	false	off
false	true	on
true	true	bad-state

Mapping of Binary Input to DO **Pos**

04

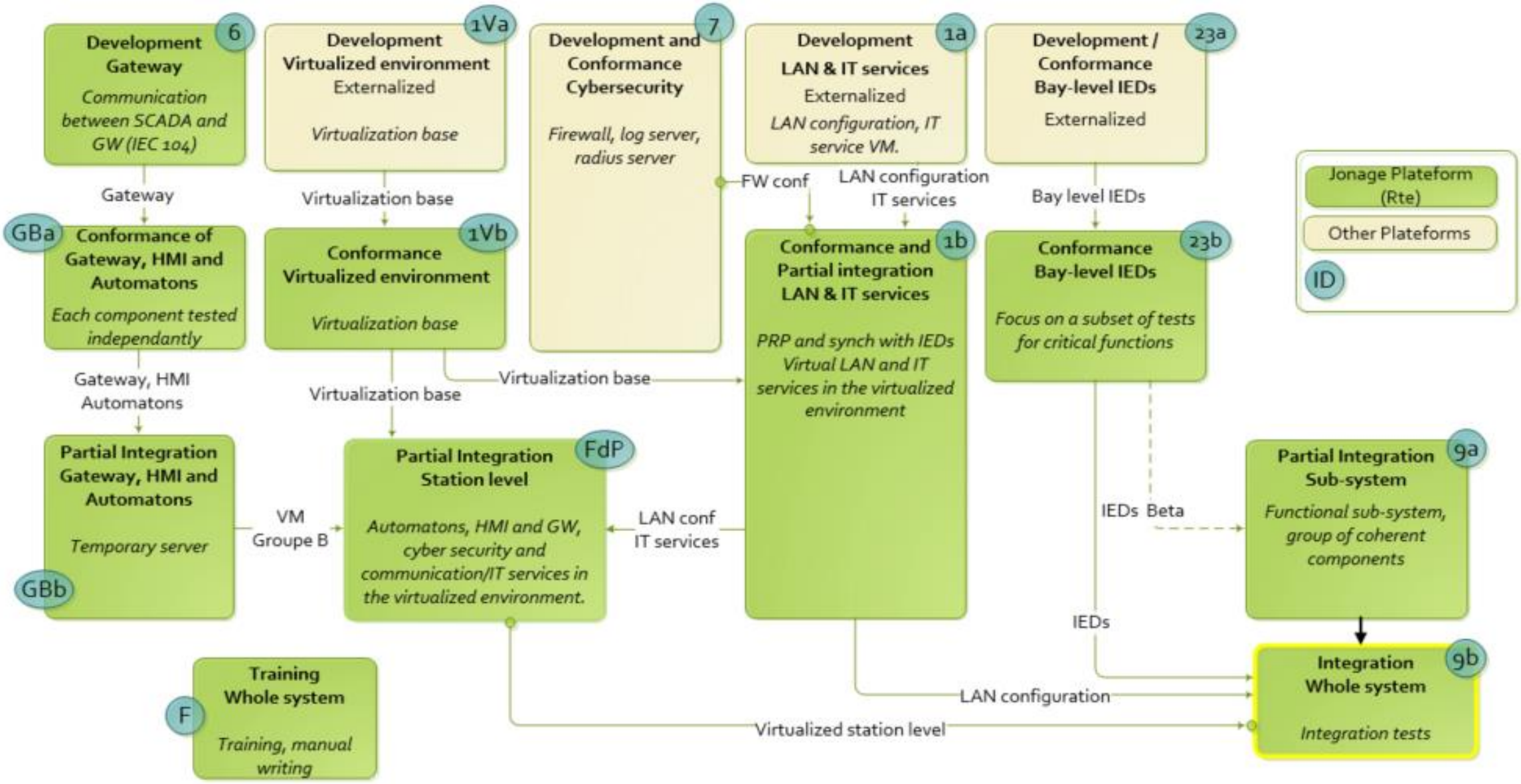
Test System

System Integration Platform (Rte and System Integrator)



All specific drivers are the sole property of Rte. (IEC61850, IEC60870-5-104, modbus, admin protocol)

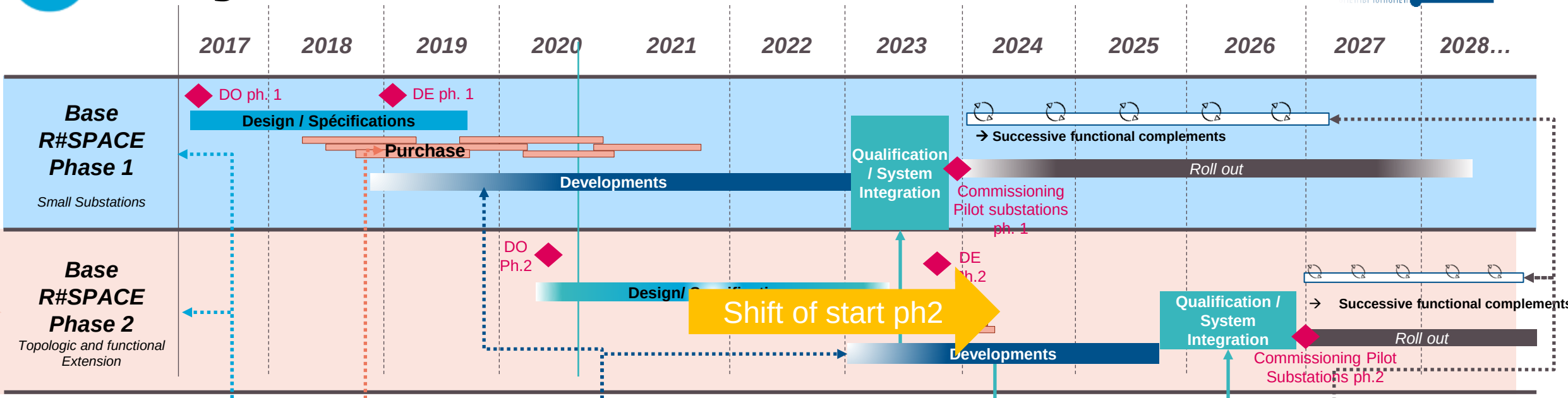
Unitary and pre-integration test platforms



05

Project Progress

Project schedule



Definition of schedule to confirm feasibility of a multi component interoperable DSAS for small substations with RES injections.

Developments in the framework of external contracts and within Rte (function with high added value)

Separated Qualification of each component, then system integration

Successive extension of scope (iterative / agile)

Phase 2 : adaptation for big substations and extension of scope of virtualization

Multiple tenders : subdivision in components.
Aim: identify best suppliers for each component

Project schedule – Pilot substation

- 63 kV, 1 busbar, 2 feeders, 2 HV/MV transformers
- Availability of qualified components (IED, PIU, HMI, GW, AUT, NW) for integration tests after qualification: > march 2023
  - Frequent updates due to corrections of errors in several components
  - Difficulty to configure all components with the same SCD file due to evolutions and error corrections in the different ICT and SCT
  - Issues and shortcomings of the test system of the integration platform
- Availability of first PACS and training platform: > May 2023
  - Additional test capacities
  - Enables parallel testing
  - Several issues detected and addressed during integration and FAT
- SAT > sept 2023
- Commissioning of first PACS planned for October 2023
  - Beginning of October: Put on hold after detection of instabilities in two components

Selected issues from pilot substation

Virtual Infrastructure

- Specific competence required to set up and configurate the Virtual Infrastructure and to implement the virtualised components

Communication network

- Several changes of configuration of switches, mainly due to limitations of components discovered during integration or cyber security constraints
- Separate access points for administration and operational network need to be specified
- Set up of access for remote configuration between substation and maintenance centers

IED

- Need to have valid SCD files for component qualification tests: schedule, responsibilities for updates, procedures in case of errors need to be clarified
- Issues with the interoperability of interlock check and voltage control for recloser
- Delayed validation of Distance Protection function:
    - June 2023: decision to use of qualified distance protection adding IEDs to the pilot PACS

Selected issues from pilot substation

GW

- Problems related to the correct filtering of commands if bay command status in not telecontrol

Endurance / Stress tests

- Need to perform in early stage stress tests to identify unexpected behavior.
  Example : blocking of digital input of SCU when power off / power on of the IED.
- Need to confirm the stability of the PACS over several weeks, with supervision of all events
  Examples :
  - ✓ occurrences of loss of IEC 104 service of the GW after 1 month of operation,
  - ✓ management of log of IEDs (no FIFO implemented),
  - ✓ unexpected variation of digital input of SCU.

Next step : Industrial deployment Phase 1

2024

- 2 substations scheduled for 2024 with more functions and higher number of feeders
- Complete qualification of all components
- Integration of IEDs interfaced by IEC 61850
  - Teleaction for distance protection
  - Protection IEDs
  - Optical underground line fault identification system
- Development of engineering HMI associated to SCT
- Deployment of data repositories and remote access

> 2025

- Gradual increase of number of deployed R#SPACE PACS

Questions ?