WEBINAR

Contribution of the Osmose project to the enhancement of the IEC61850 standard: Improvement of the engineering process and storage data modeling

AGENDA

1. **Introduction**
2. **Engineering process enhancements**
    - Introduction and overview
    - Impact on the standard – IEC61850-6-100
    - Impact on tools
3. **Demonstrator**
    - Setup of R&D nester lab
    - Demonstrator setup
    - Functional testing
4. **Storage modelling exercise, conclusions and recommendations**

1. Introduction:

General scope and the advantage of a standardized model for storage

Christoph Brunner, it4power

OSMOSE work on Interoperability

- Scope: interoperability in the context of IEC 61850, which has three aspects
  - Engineering
  - Data model
  - Communication
- OSMOSE addressed the first two aspects:
  - Engineering
    - Enhance the engineering process described in IEC 61850-6 for better interoperability, but as well higher efficiency
    - A key point was adding formal specification capabilities
  - Data model
    - Verify and enhance the semantic definitions with a focus on storage systems

Why improving IEC 61850 engineering process?

- A standardized semantic model eases:
  - To understand how something works
  - The efficiency of the integration

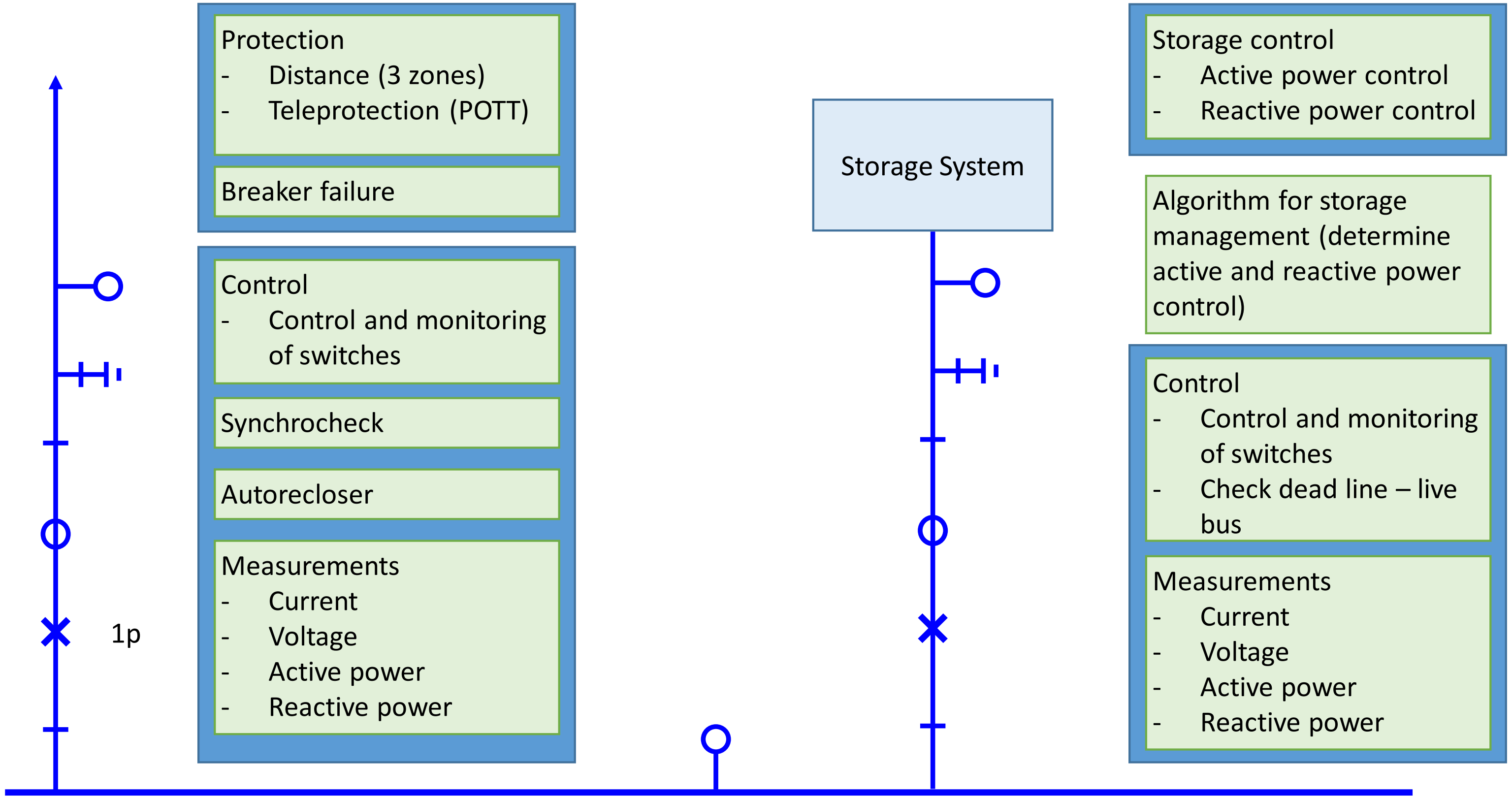
    Example: If a DERMS knows, what data point to use to e.g. set active power, integration is much easier

- Support a fully digitalized specification and design process
  - Template based, to support application standardization within a utility

How to perform these improvements?

- Build a demonstrator as a playground to verify and improve concepts
- For the engineering process:
  - Implement the proposed enhancements in commercially available tools
  - Refine the process based on experience learned with the demonstrator
- For the data model:
  - Model a feeder with typical utility requirements and provide feedback to the standard where data points are not available
  - Define an application for storage to verify the 61850 modeling concepts for DER

The application scenario of the demonstrator



- Include communication between substations for teleprotection

2. Engineering process enhancements

Thomas Sterckx, ELIA Engineering
Jörg Reuter, Helinks
Camille Bloch, Schneider Electric

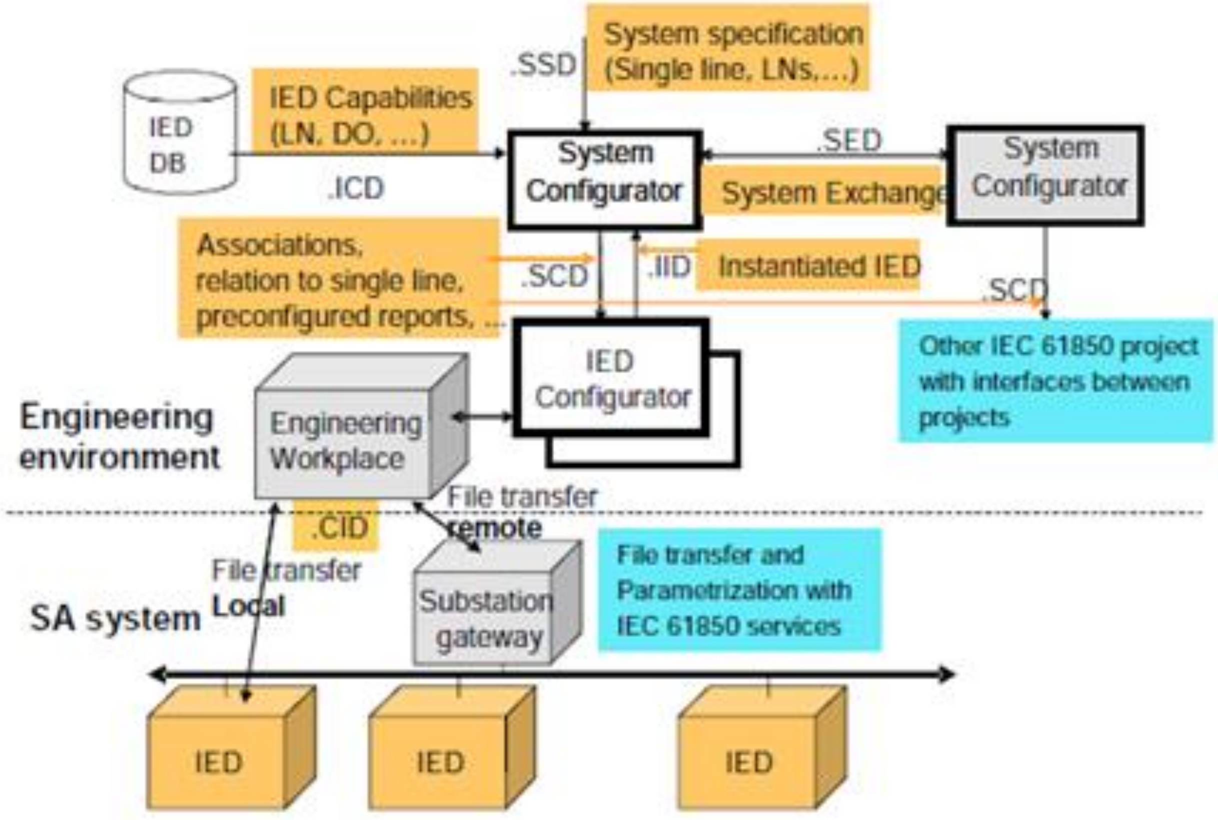
Engineering process| Impact on standardization | Impact on tools

2. Engineering process enhancements

Thomas Sterckx, ELIA Engineering
Jörg Reuter, Helinks
Camille Bloch, Schneider Electric

Engineering process| Impact on standardization | Impact on tools

Engineering process enhancements/ reminder on the process

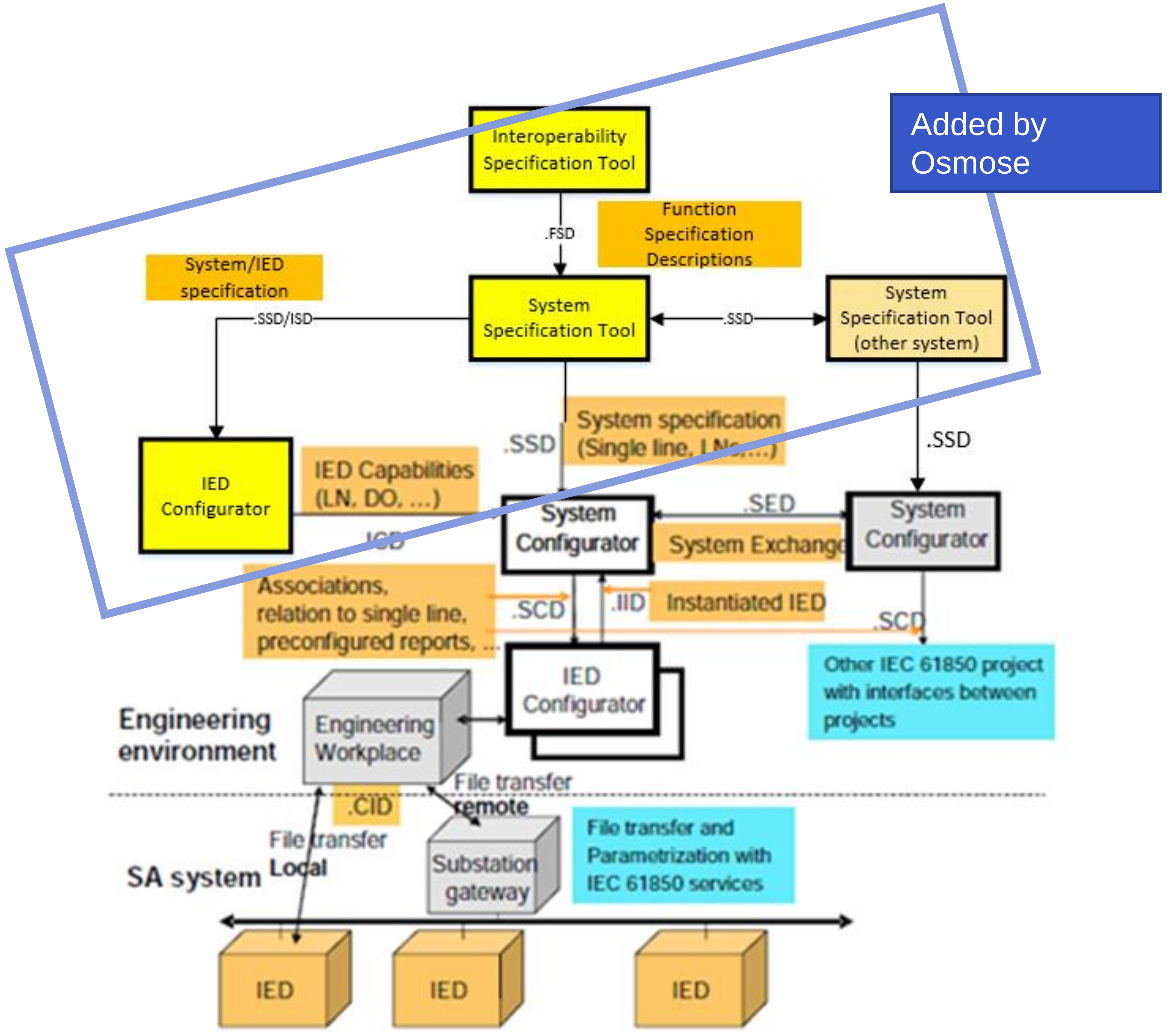


From IEC61850-6

- **Starting point: Engineering process as defined in IEC61850 ed2.1**
- Using SCL as a language for specification and configuration
- Using available IEC61850-6 ed2.1 SCL namespace
  - Existing concept of functions in the SCL substation section
- Starting from engineering tools available on the market

Engineering process enhancements/ reminder on the process

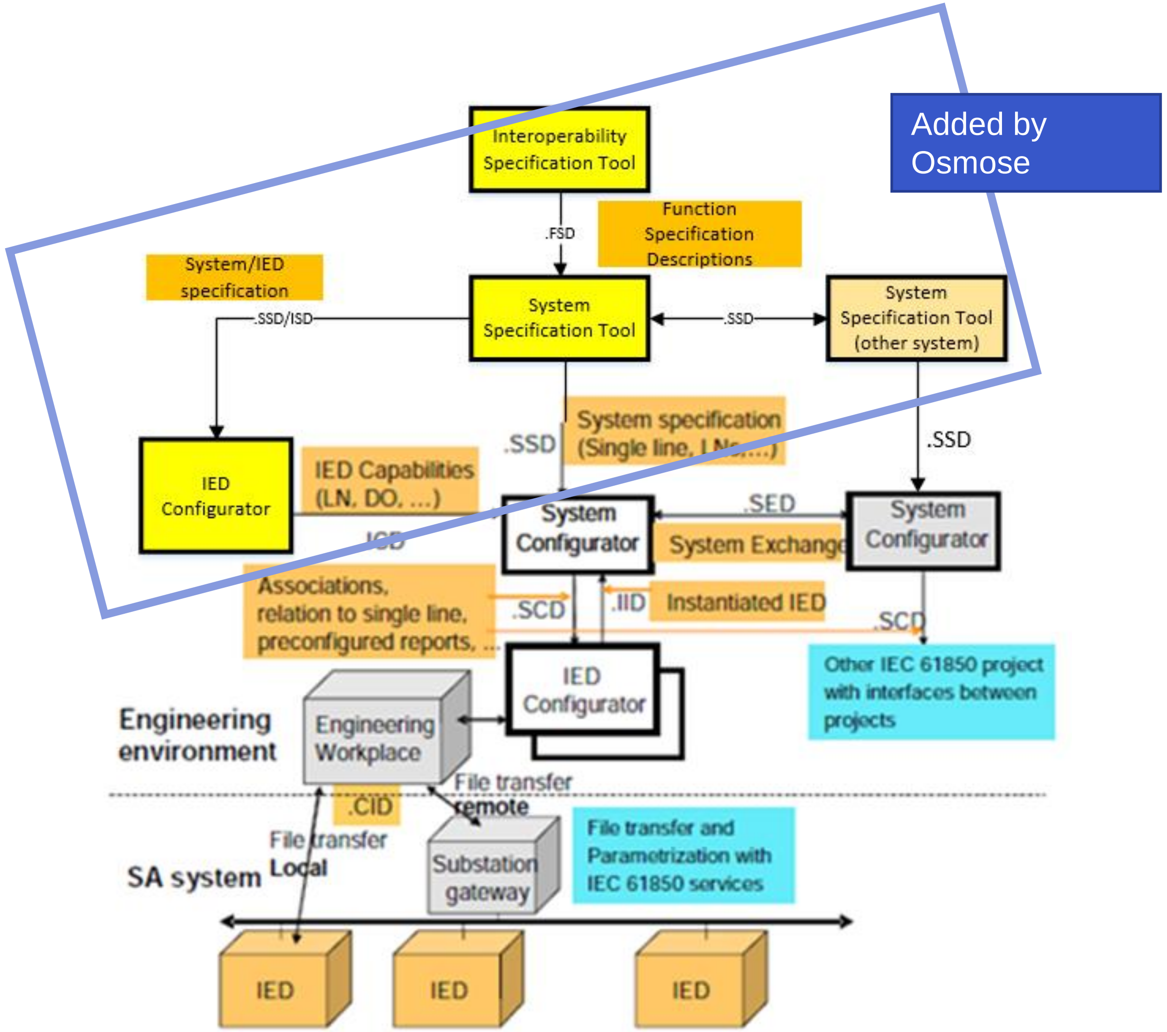
ISGAN
INTERNATIONAL SMART GRID ACTION NETWORK



Enhancing the engineering process

- **Introducing overall engineering process efficiency**
- **Allowing efficient specification management**
  - **How?**
- Extending specification stage
  - Creating system specification including dataflow
    - Vendor independent
    - Physical allocation independent
- Improving interface with IED suppliers
  - Improving interpretation by providing machine readable specification which includes dataflow
  - Allowing flexibility in physical allocation of specified functions
  - Allowing comparison between specification and offered IEDs
- Improving specification management
  - Including traceability of specification in configuration files
  - Allowing comparison between specification and configuration

Engineering process enhancements/ reminder on the process

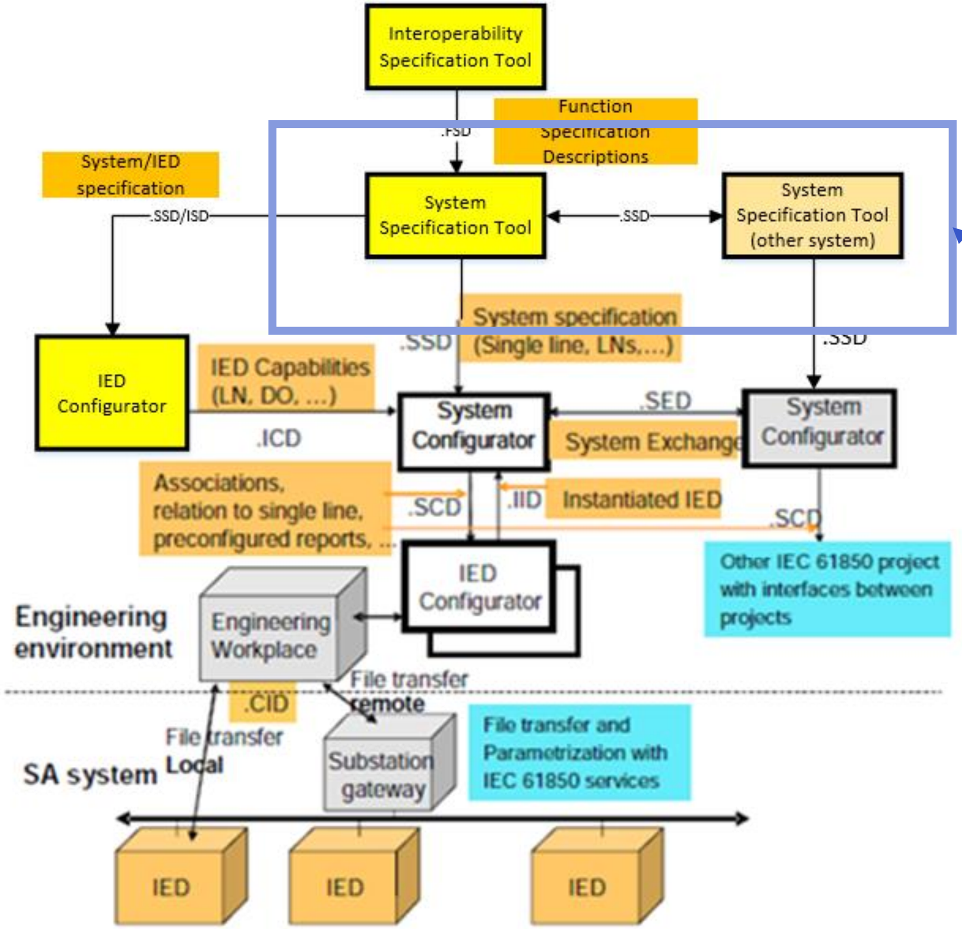


Enhancing the engineering process

- **Introducing overall engineering process efficiency**
- **Allowing efficient specification management**
  - **How?**

- Automating configuration stage
  - Implementing IED dataflow based on specified dataflow between functions
  - Implementing IEDs into the specification based on enhanced IED capability descriptions (.ICD) from IED suppliers

Engineering process enhancements/ reminder on the process



Enhancing the engineering process

- **How?**

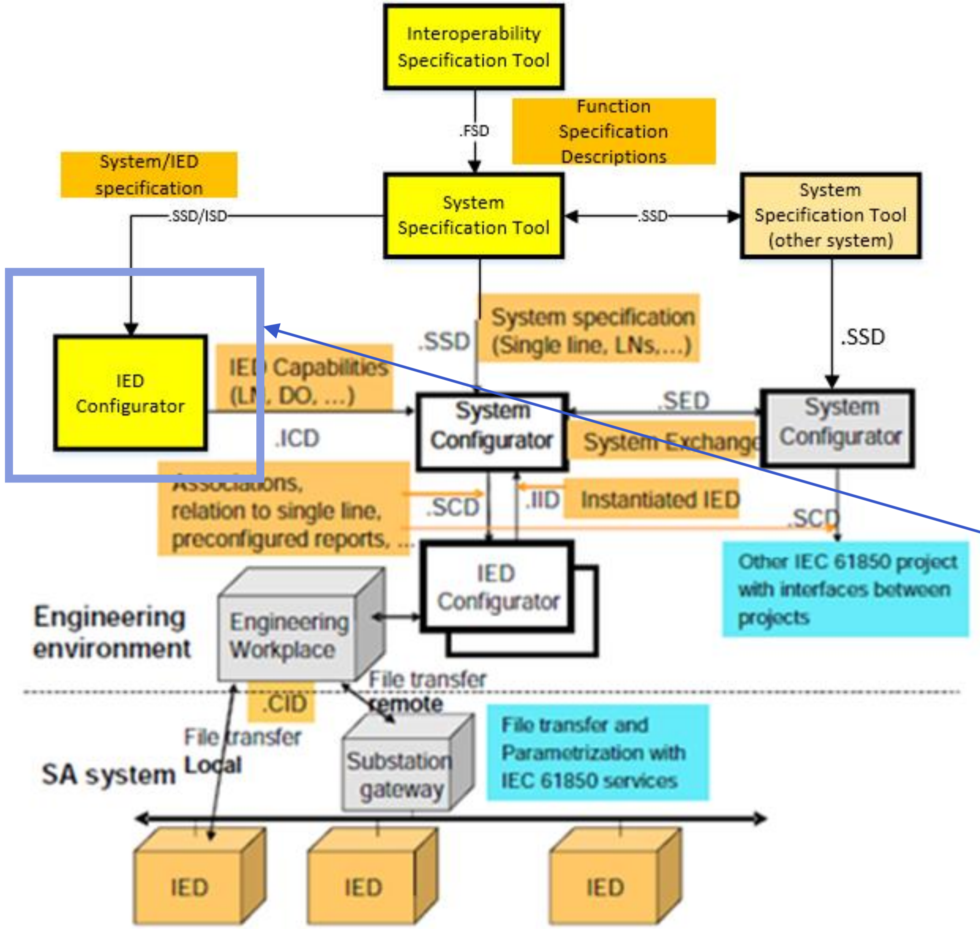
- Extending specification stage

- **How – Specific**

- Extending SCL with elements to allow dataflow definition between (sub)functions
  - Inside substation section of SCL
  - Removing the obligation to allocate functions to IEDs

- Extending the process with ways to define data exchange between 2 system specifications

Engineering process enhancements/ reminder on the process

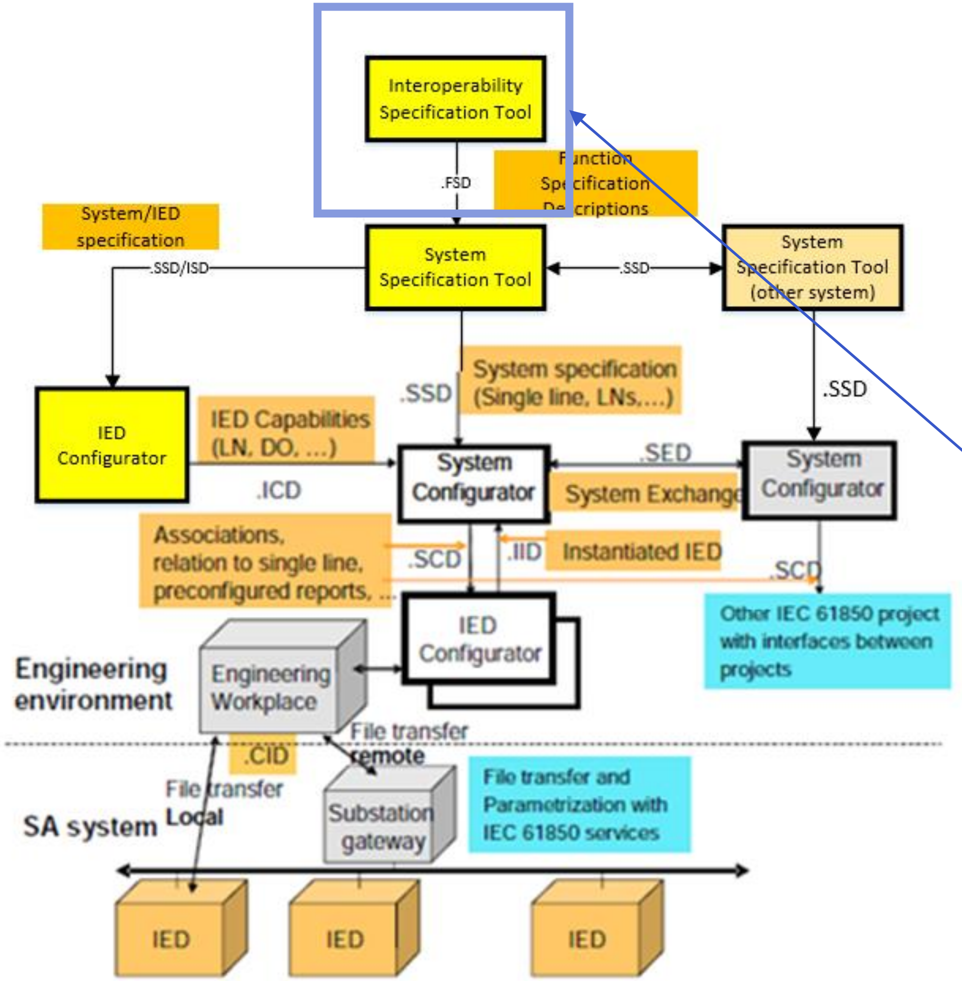


Enhancing the engineering process

- **How?**
- Improving interface with IED suppliers

- **How - Specific**
- Introducing a concept of virtual IEDs for IED specification
- Allowing an IED supplier to select optimal allocation by providing allocation independent specification
- Extending SCL allowing IED suppliers to document specification mapping deviations inside the offered IED capability description (.ICD)
- Providing ways to compare an IED offer to a specification file

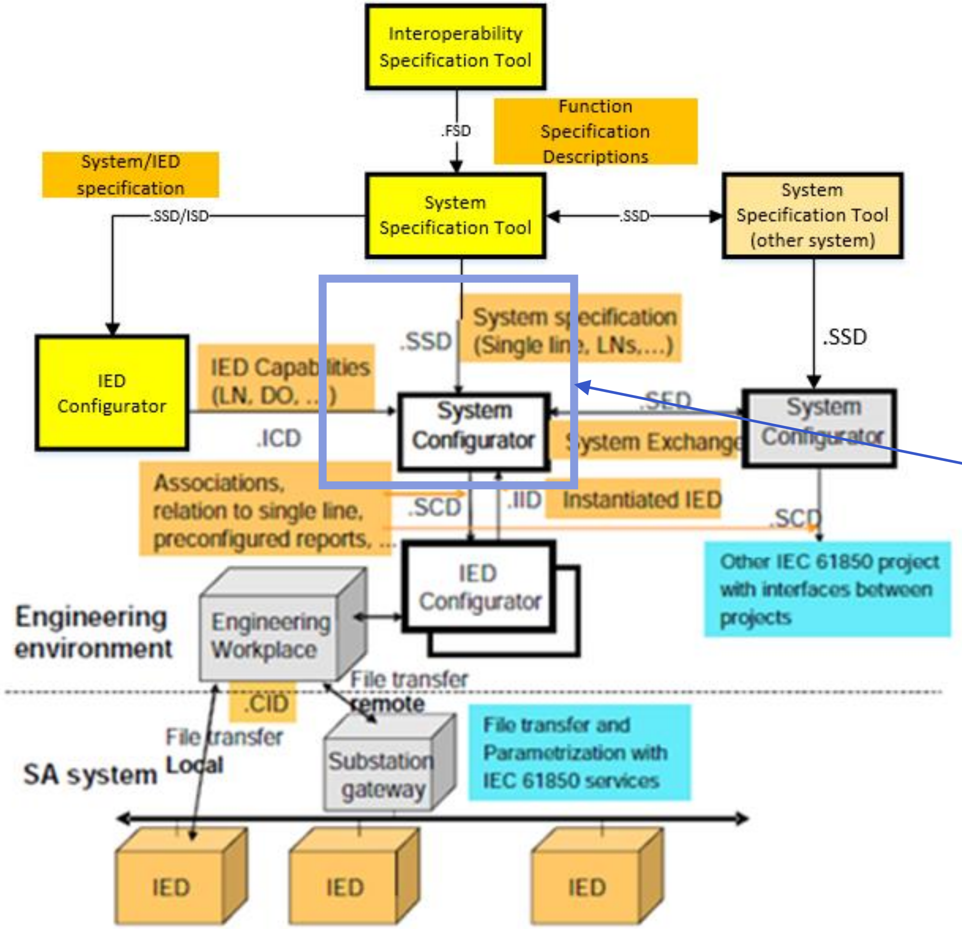
Engineering process enhancements/ reminder on the process



Enhancing the engineering process

- **How?**
- Improving specification management
- **How - Specific**
- Introducing a concept of functions specification descriptions
  - Allowing creation of a user profile containing a function library
- Extending SCL allowing traceability of specification inside configuration files

Engineering process enhancements/ reminder on the process



Enhancing the engineering process

- **How?**
- Automating configuration stage

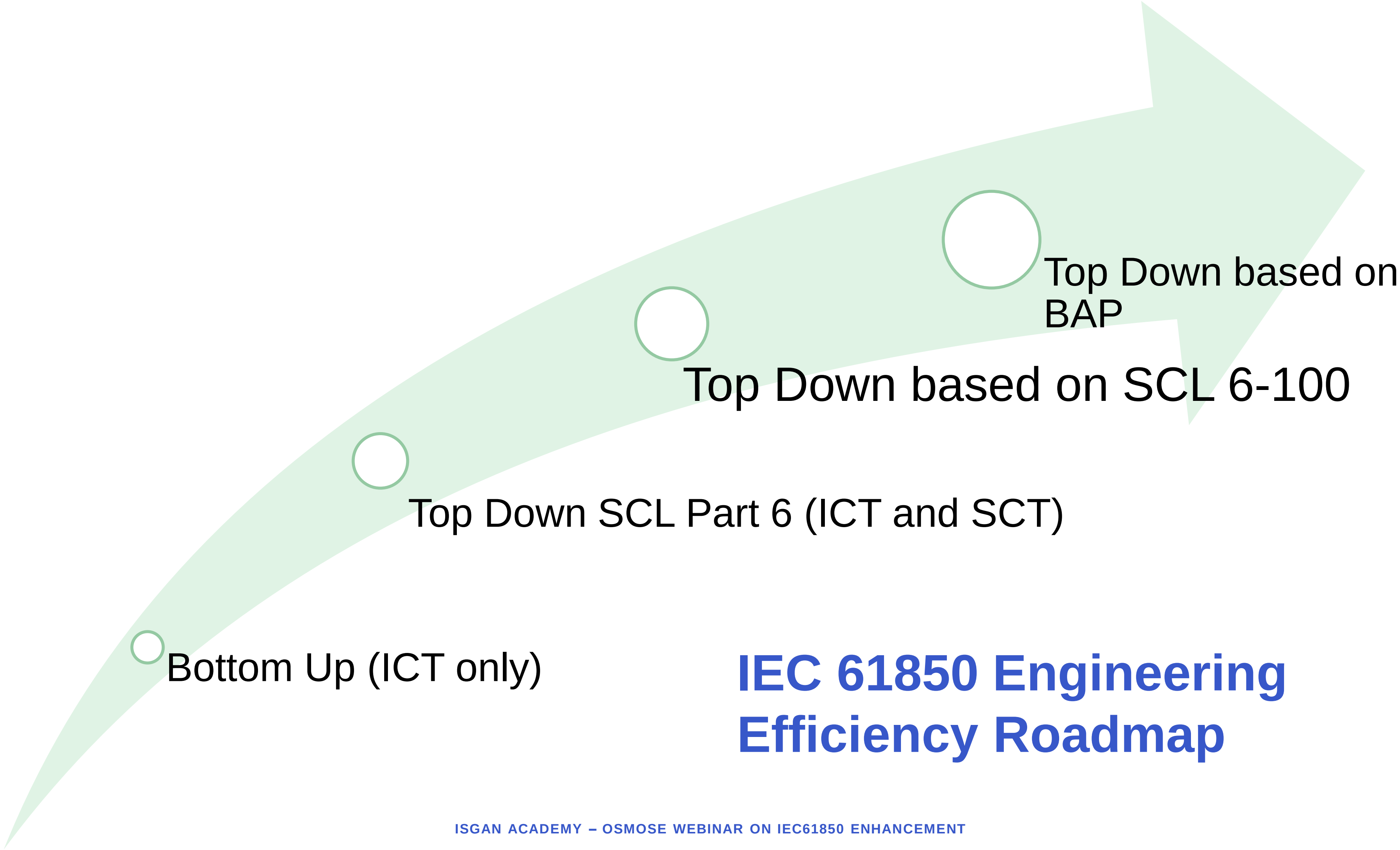
- **How - Specific**
- Dataflow already configured in specification stage
- IED datamodel mapping on specification documented in offered IED capability description (.ICD)

2. Engineering process enhancements

Thomas Sterckx, ELIA Engineering
Jörg Reuter, Helinks
Camille Bloch, Schneider Electric

Engineering process| Impact on standardization | Impact on tools

Engineering process enhancements/ Impact on standardization (IEC61850-6-100)



IEC 61850 Engineering Efficiency Roadmap

Engineering process enhancements/ Impact on standardization (IEC61850-6-100)

What is TR 61850 6-100?

IEC 61850 SCL Files	• serve to exchange specification and configuration information for IEC 61850 based Automation and Protection Systems.
TR-IEC 61850 6-100	• is a Technical Report prepared by WG10. It extends the SCL scheme (IEC 61850 part 6) with new XML elements. • The extensions concern mostly the Process/Substation section of SCL • These extensions allow to describe the PAC-System in a device and implementation independent way.

Engineering process enhancements/ Impact on standardization (IEC61850-6-100)

Overview on 6-100

Substation/Process Section Extension

Virtual IED

References between SCL Files

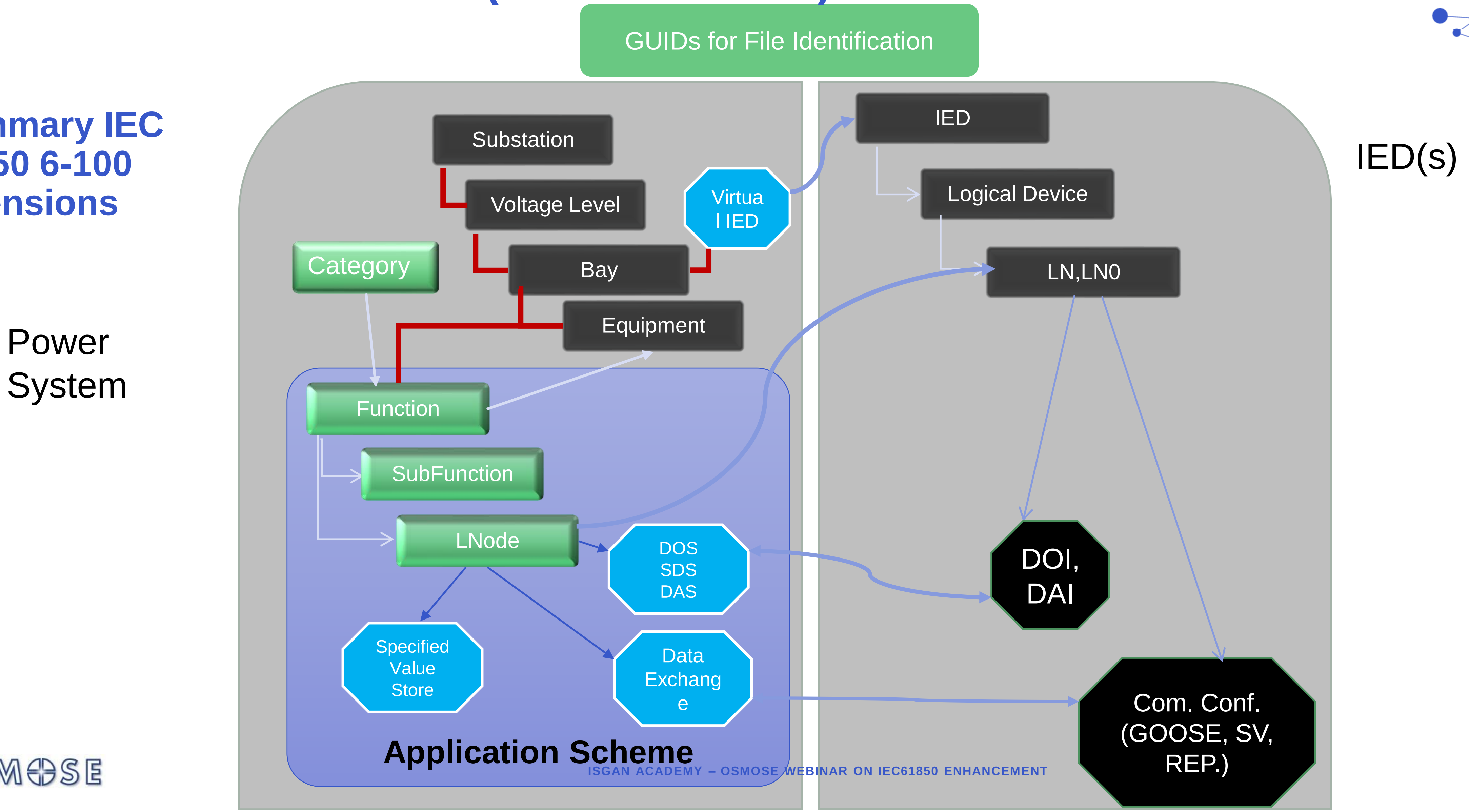
Engineering process enhancements/ Impact on standardization (IEC61850-6-100)

Substation/Process Section: New Concepts in IEC 61850 6-100

	SCL - IEC 61850 6	Extension - IEC 61850 6-100
Specification Tracking	The SCD file has no information about the original Specification.	The SCD file keeps track of originally specified LNodes and Data Objects.
Data Instance Information	The SSD File has no instance information for the Data Objects.	The SSD file supports information on Data Object and Data Attribute Level.(e.g. HMI Texts, DNP3 Addresses)
Data Flow Information	The SSD File (without Virtual IEDs) has no information about the data exchange. Application Schemes cannot be specified.	The SSD file contains information about the data exchanged between Functions and LNodes. It is not limited to IEC 61850 protocols.
Relationship	Functions are only related to their hierarchical parent.	Functions can have multiple references to any Power System Resource and can be categorized.
	Application Schemes cannot be expressed.	Combining Data Flow and Function Relations allows describing Automation and Protection Schemes.
Virtual IEDs	Not supported	Reuses current IED model for specification of an IED Different interpretation of the Service Section

Engineering process enhancements/ Impact on standardization (IEC61850-6-100)

Summary IEC 61850 6-100 extensions

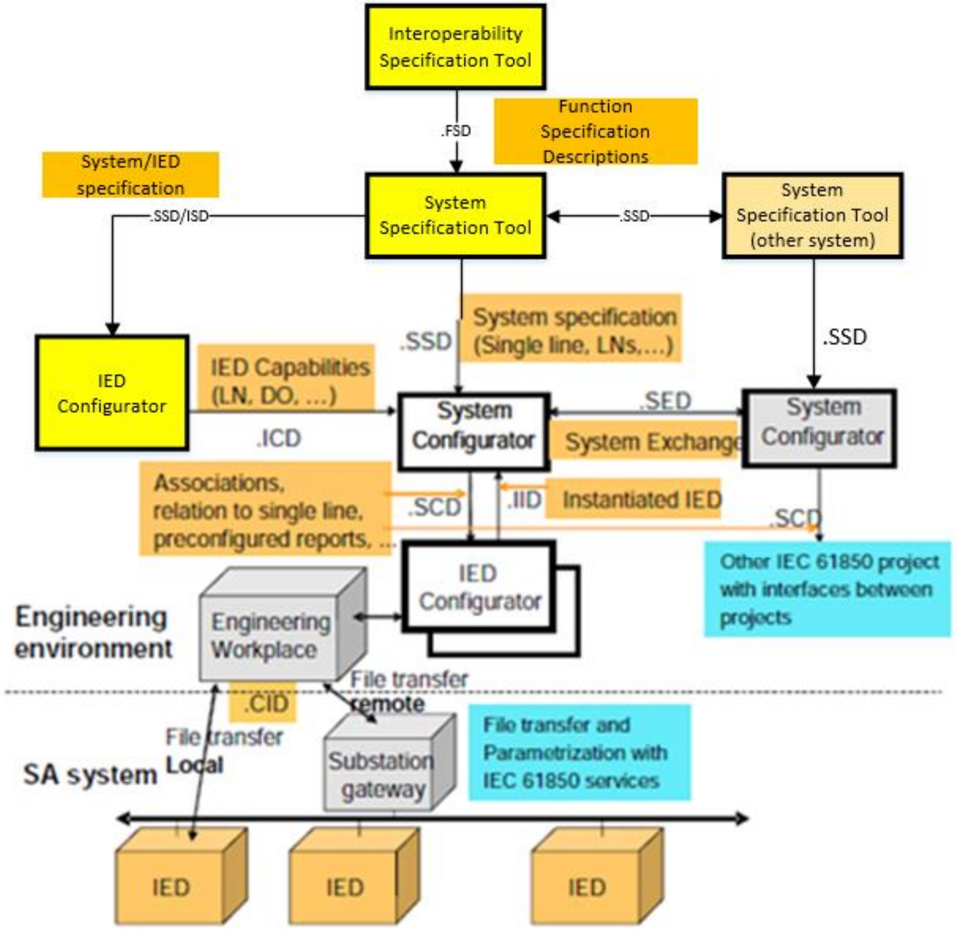


2. Engineering process enhancements

Thomas Sterckx, ELIA Engineering
Camille Bloch, Schneider Electric
Jörg Reuter, Helinks

Engineering process| Impact on standardization | Impact on tools

Engineering process enhancements/ Impact on tools

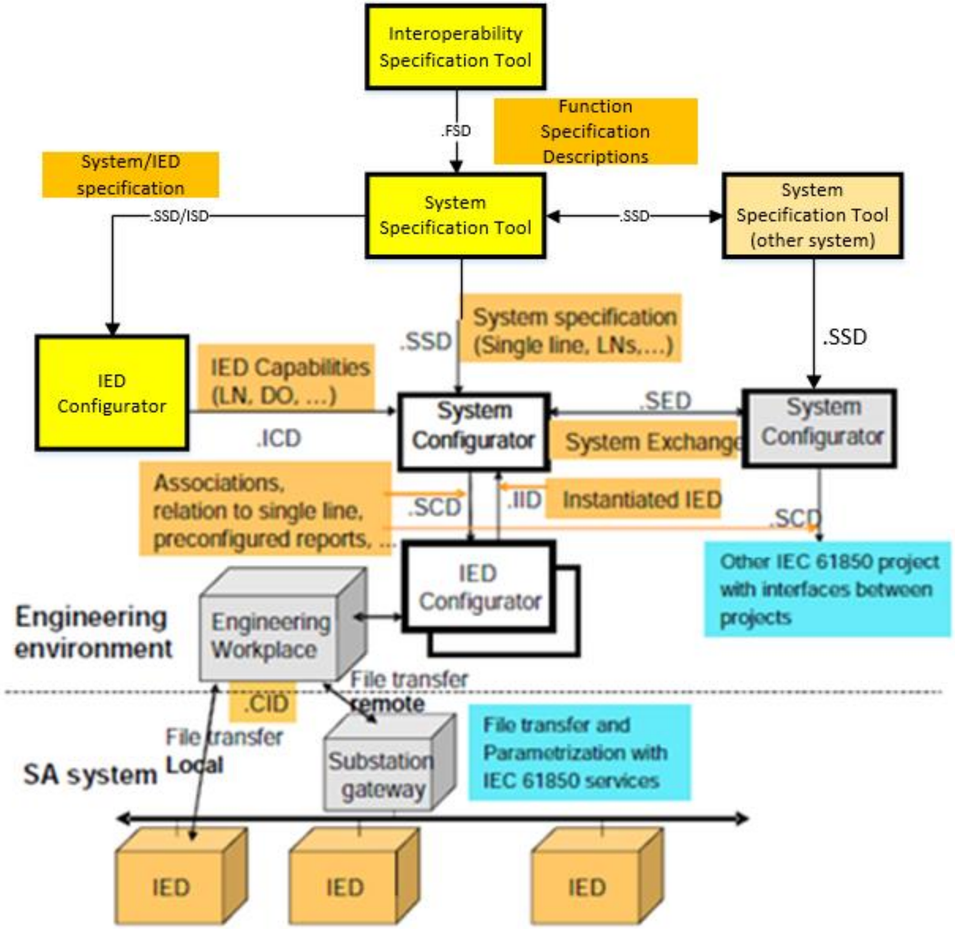


- **New tool role: System Specification Tool (SST)**
- To support creation of a vendor independent specification with IEC 61850-6-100
- Can be provided by system configuration tool
- Have to support FSD/SSD on import and SSD/ISD on export

- **Impacts on IED Configuration Tools (ICT)**
- Shall support ISD/SSD import
- Shall create extended ICD, with description of the implemented process

- **Impacts on System Configuration Tools (SCT)**
- Shall support SSD import with IEC 61850-6-100
- Shall support extended ICD to help user in implementation of the device
- Shall understand IEC 61850-6-100 extension to help user in creation of the dataflow between real devices based on specification of data exchange in SSD

Engineering process enhancements/ Impact on tools



Demonstration of tools based on the project exercise Teleprotection

- **SST demonstration**
- Will present how to create a specification of a system
- Demonstrated with Schneider Electric system tool EPAS-E

- **SCT demonstration**
- Will present how to use an SSD to create project and implement with real device
- Demonstrated with Helinks STS system tool

Impact on tools
2. System Configuration Tool + Demo

Jörg Reuter, Helinks

Engineering process enhancements/ Impact on tools

System Configuration Tool + Demo

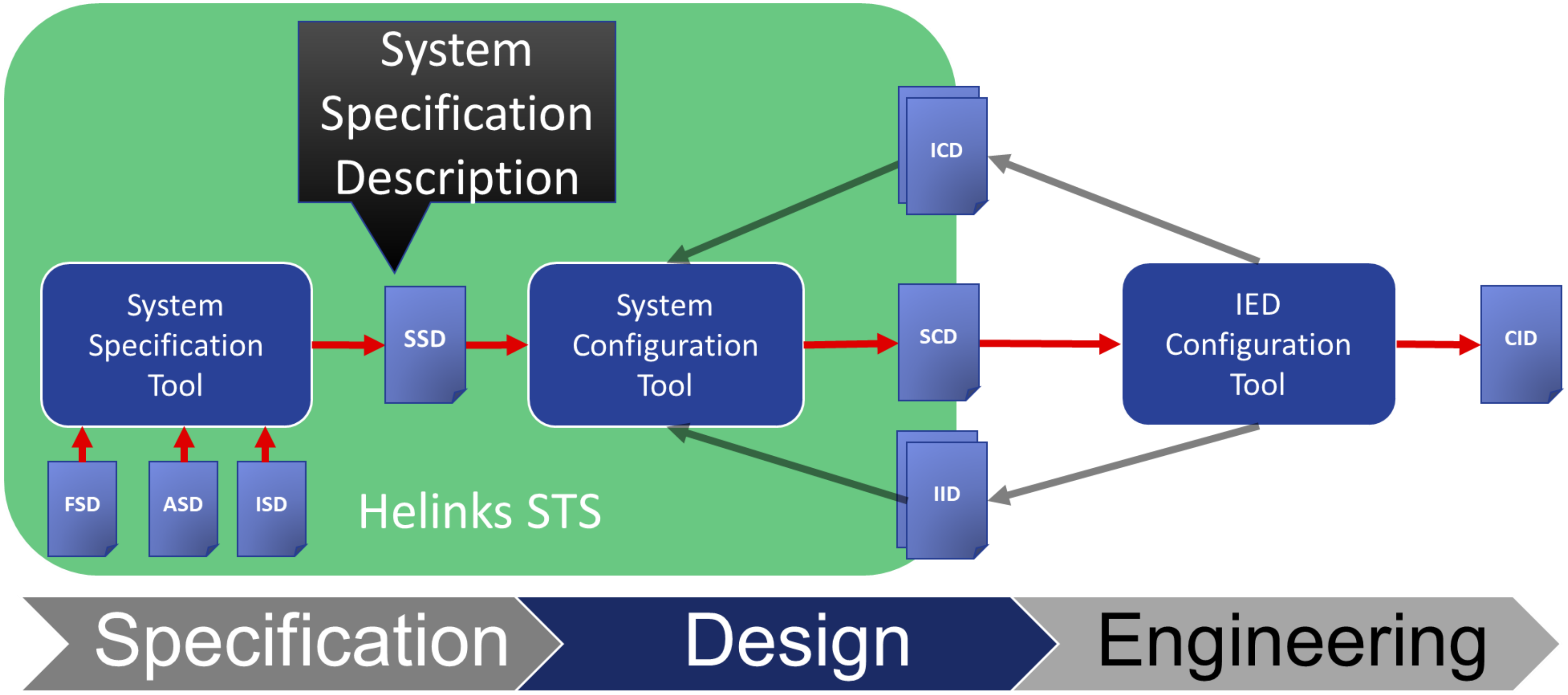
System Tools For IEC 61850

HELINKS

ISGAN

INTERNATIONAL SMART GRID ACTION NETWORK

Osmose IEC 61850 Top Down Process

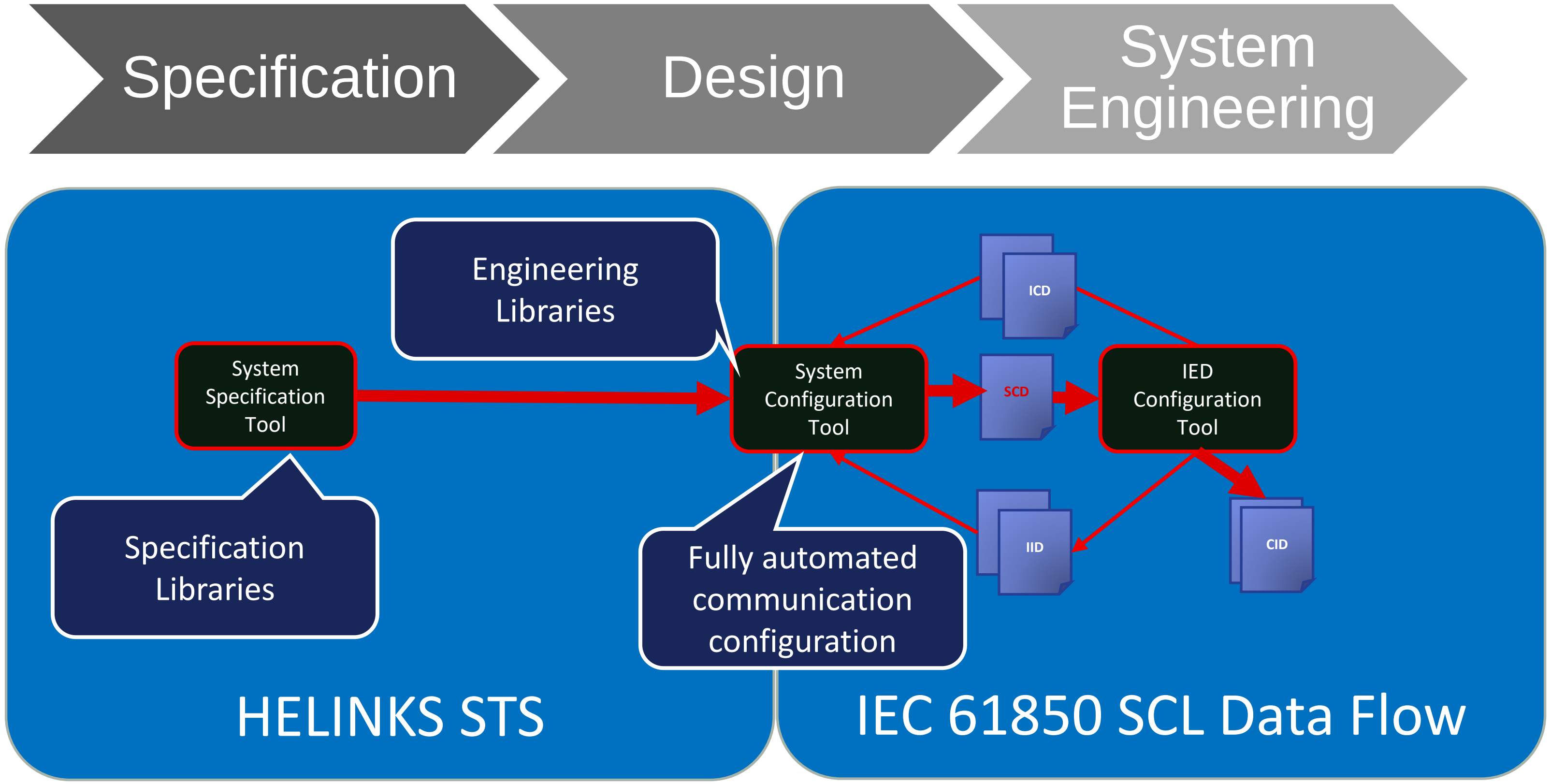


OSMOSE

Engineering process enhancements/ Impact on tools

System Configuration Tool + Demo

Engineering Efficiency



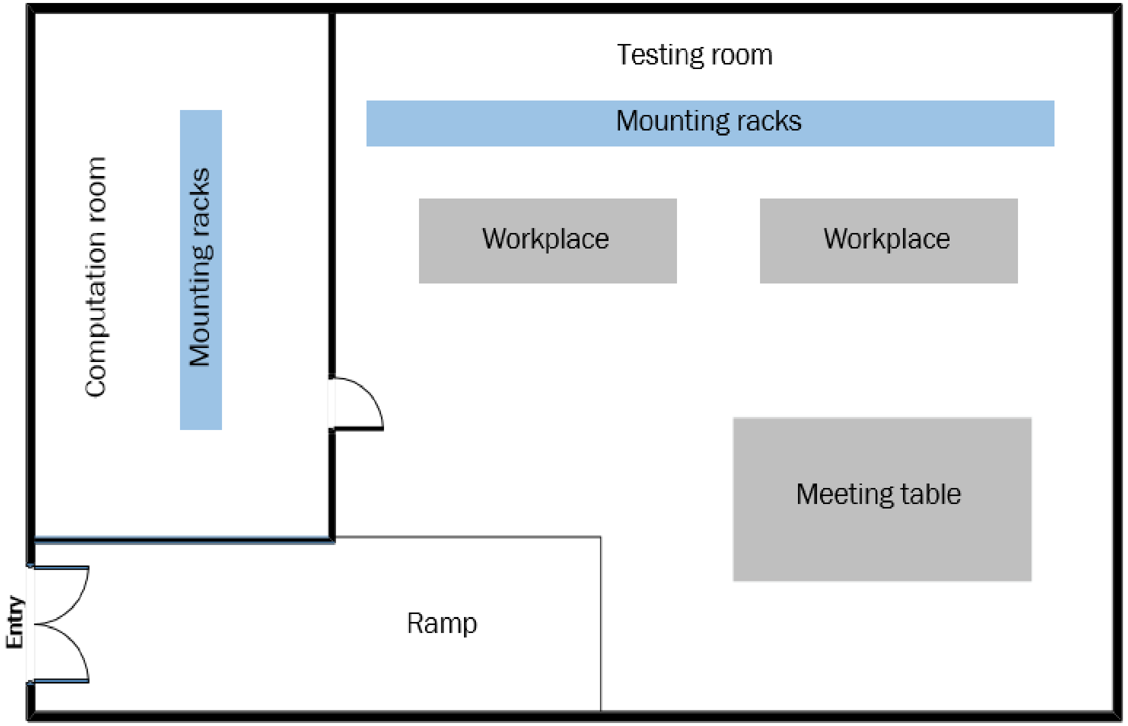
- Specification is created just by drawing the Single Line !
- Drop IED's into the project. STS automatically allocates Logical Nodes and Signals.
- Communication configuration is fully automated.

3. Demonstrator

João Saragoça, R&D Nester

Setup of R&D Nester laboratory | Setup of Demonstrator | Functional testing

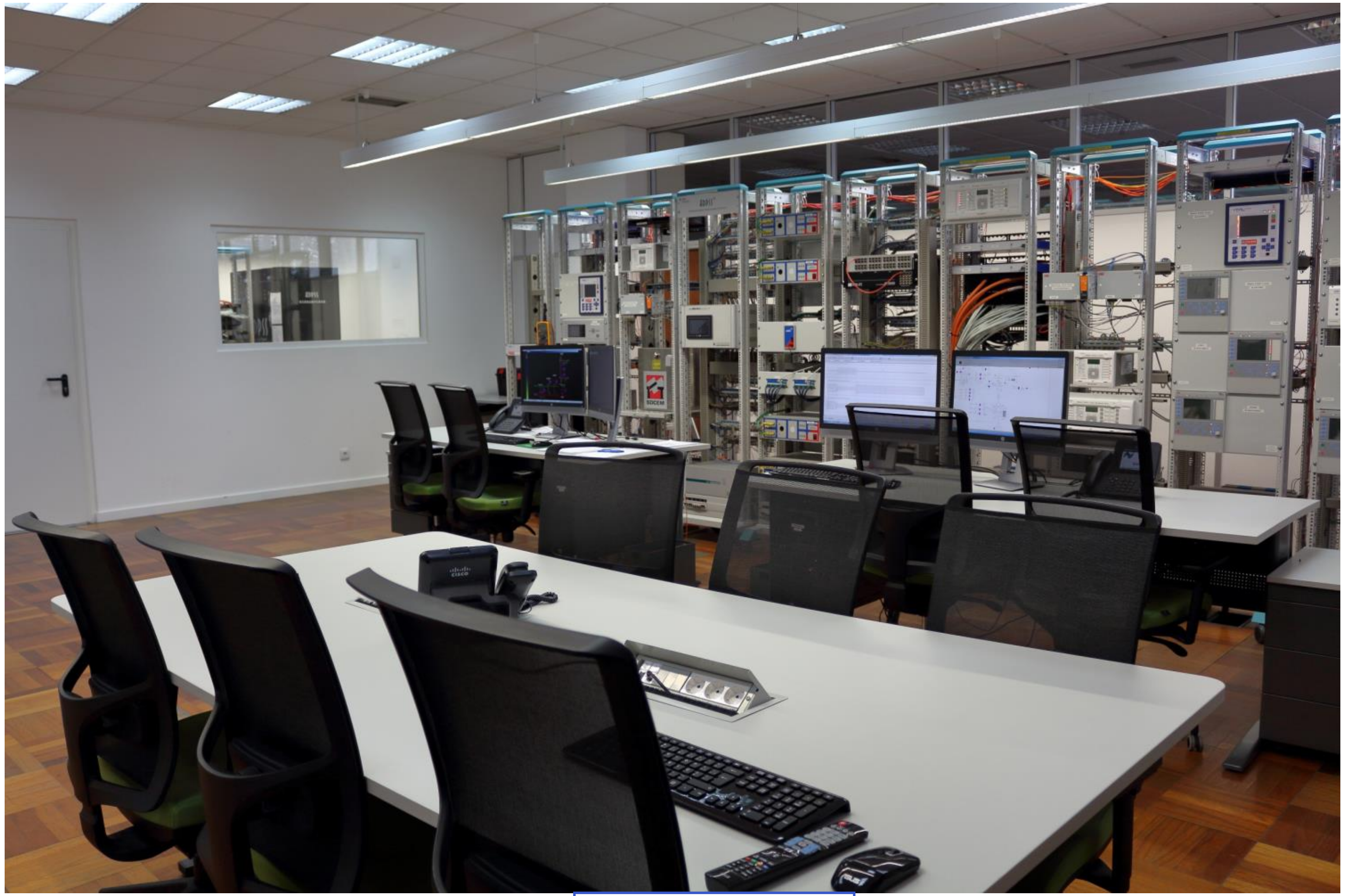
Demonstrator/ Setup of R&D Nester laboratory



Laboratory layout

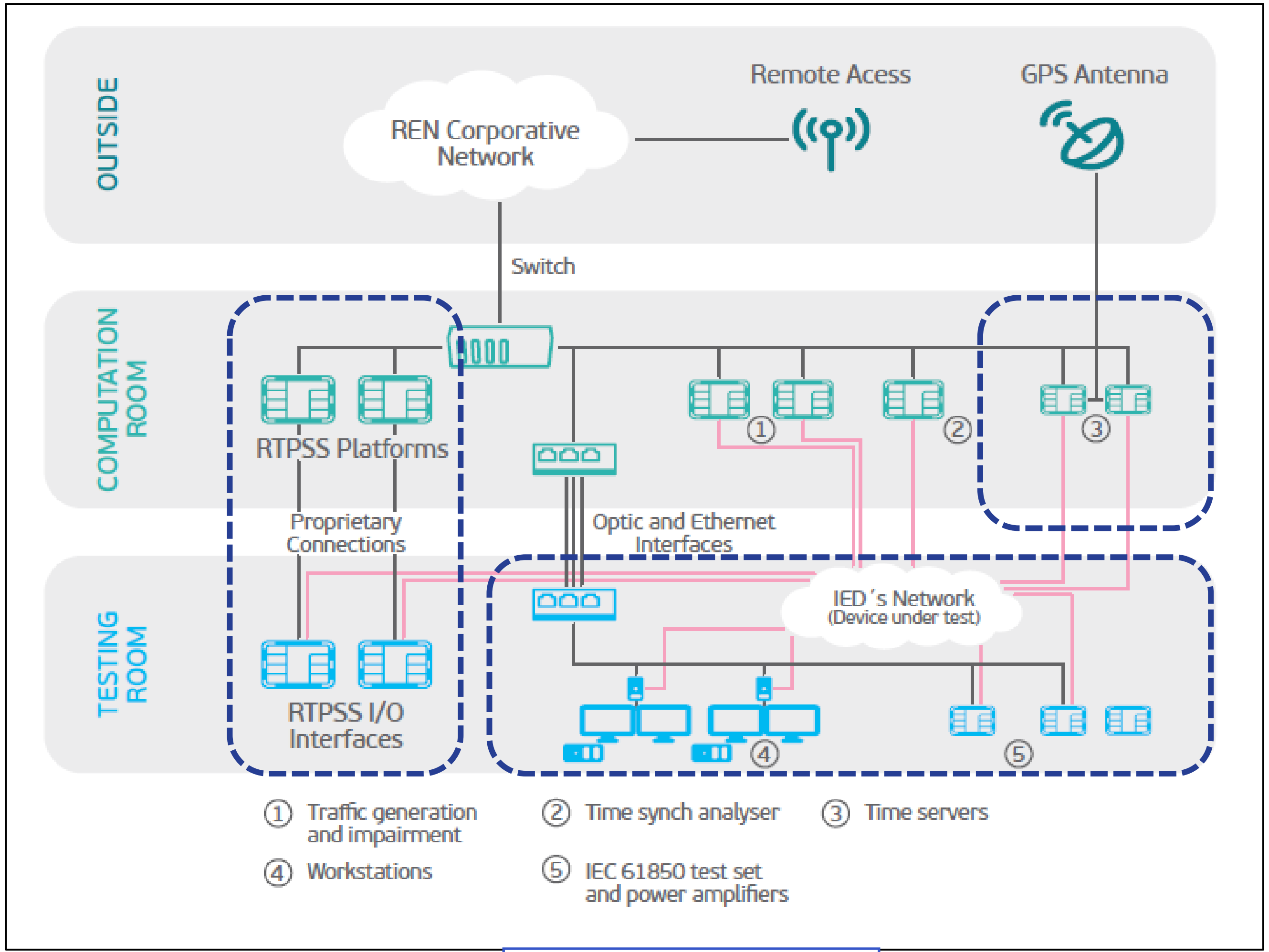
- Separated in two rooms:
  - Computation room: noisy equipment or that needs to be in air conditioned room
  - Testing room: where researchers are working, normally where the DUT (Device(s) Under Test) are

Demonstrator/ Setup of R&D Nester laboratory



Testing room

Demonstrator/ Setup of R&D Nester laboratory

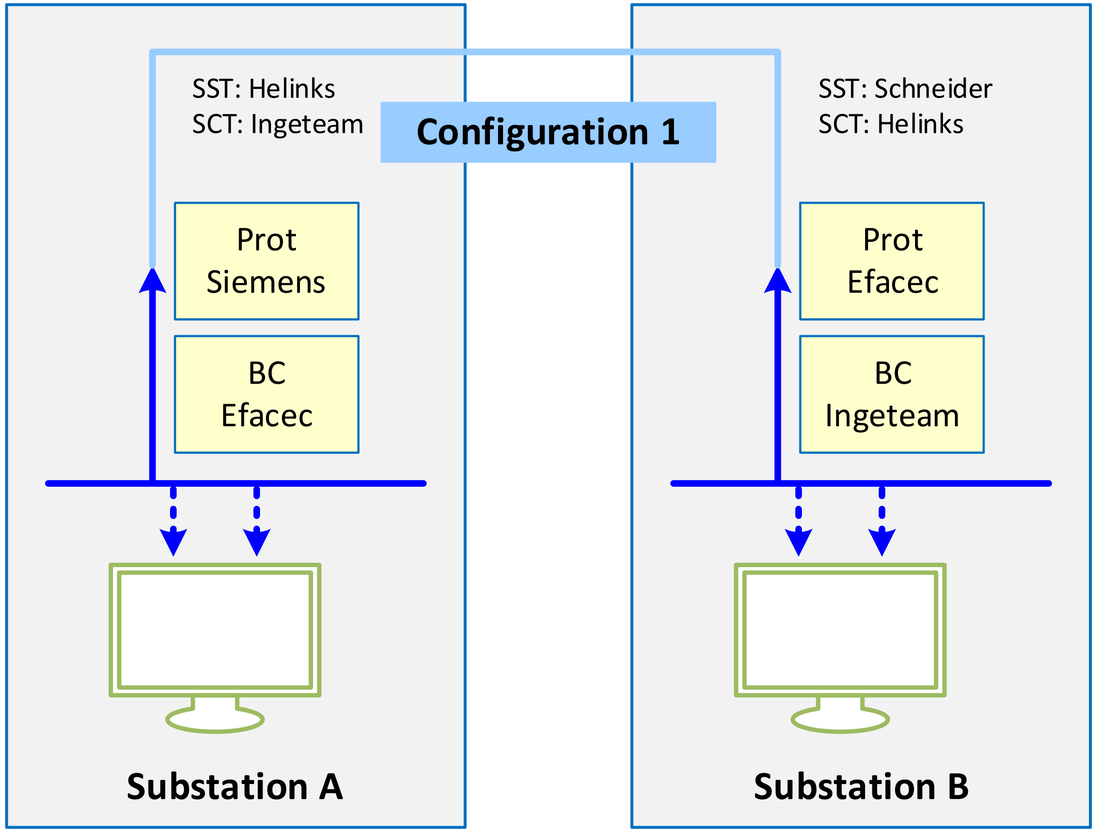


Laboratory Architecture

Used for the OSMOSE T7.1 demonstrator:

- RTPSS platform
- Power amplifiers
- IED provided by partners (Siemens, Efacec, Ingeteam)
- Workstations (with testing software)
- Time server

Demonstrator/ Setup of demonstrator



Setup of demonstrator

- 2 substations (A and B)
- 1 line bay per substation
  - Line from A to B
- 2 IED per bay
  - BC – Bay Control Unit
  - PROT – Bay Protection Unit
  - 3 different vendors
- different combinations of SST/SCT per substation
  - SST – System Specification Tool
  - SCT – System Configuration Tool
  - 3 different vendors

Demonstrator/ Setup of demonstrator

SS/A

PROT

BC

SS/B

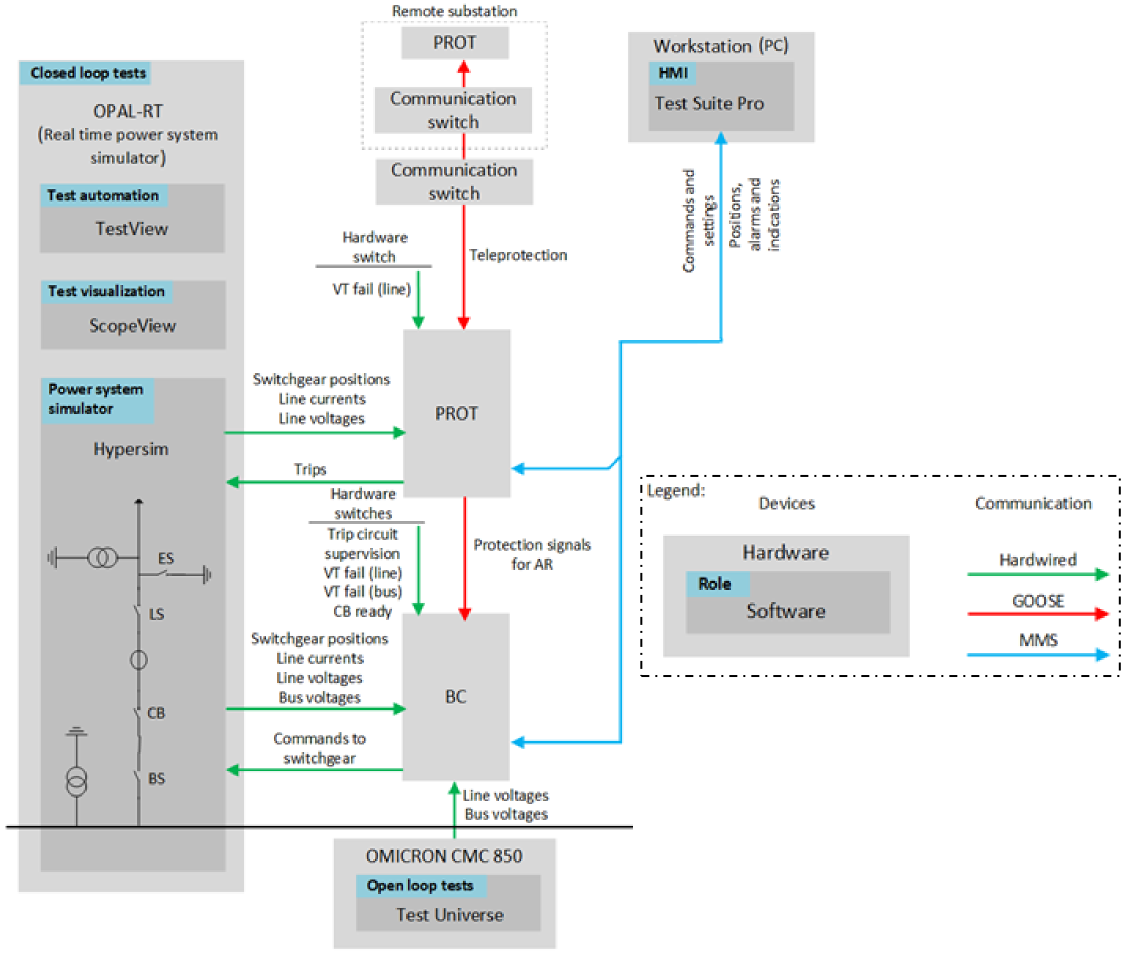
PROT

BC

Mounting racks for SS/A (left) and SS/B (right)

- 2 substations (A and B)
- 1 line bay per substation
  - Line from A to B
- 2 IED per bay
  - BC – Bay Control Unit
  - PROT – Bay Protection Unit
  - 3 different vendors

Demonstrator/ Setup of demonstrator



Detail of demonstrator setup – 1 substation

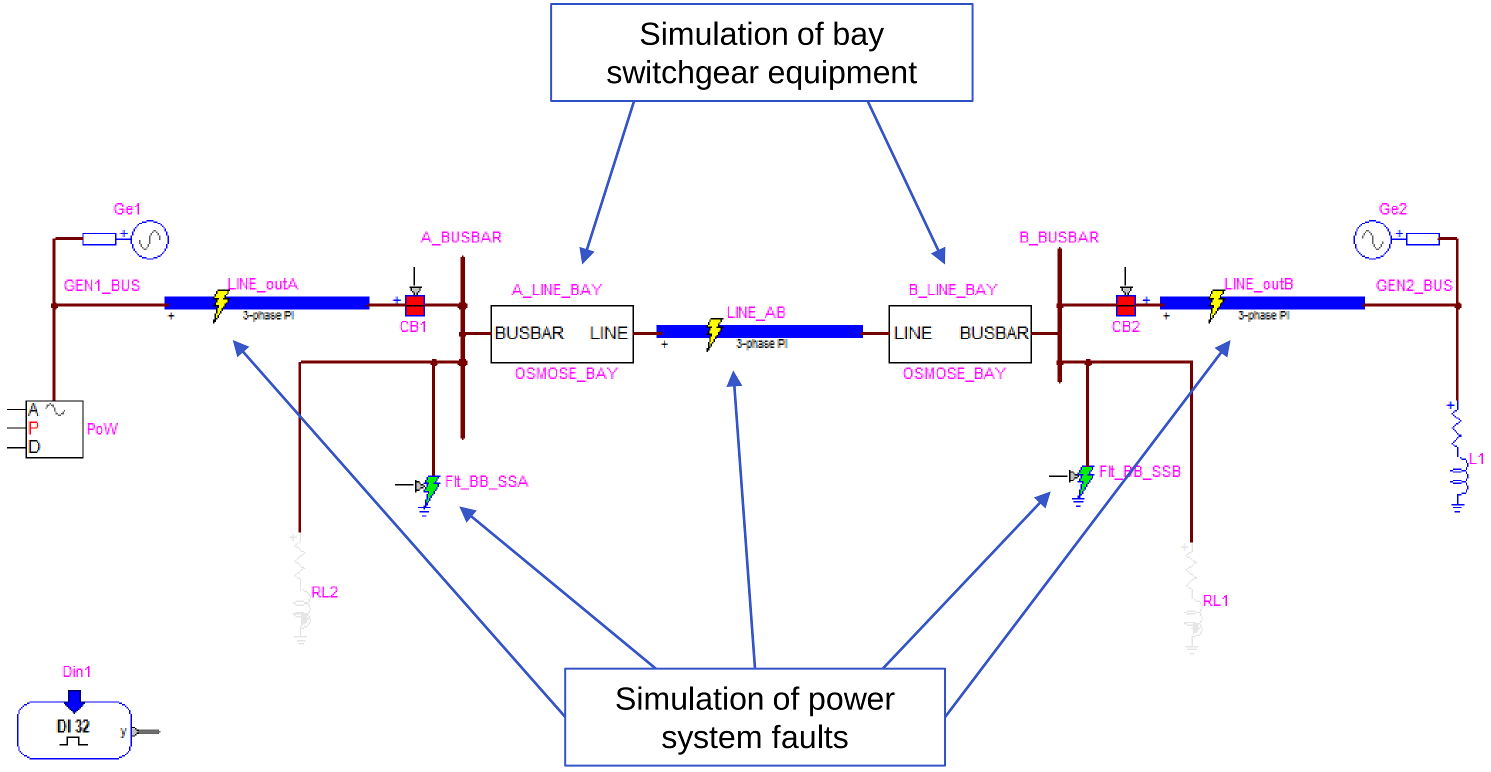
Detail of demonstrator setup

- Process signals (hardwired) and simulated by the RTPSS (Real Time Power System Simulator):
  - Analogue (currents & voltages)
  - Digital signals (substation equipment signals, e.g. CB status)
- Communication between IED (for Teleprotection, Auto Reclose functions) is through GOOSE
- Communication between IED and HMI is through MMS
- Most tests done with RTPSS: exception is Synchrocheck function

Demonstrator/ Setup of demonstrator

OSMOSE Project

A_LINE_BAY and B_LINE_BAY are subcirtuits of type OSMOSE_BAY created for OSMOSE which represent the bay equipments (switchgear) and associated control logic - has trips and controls from IEDs as inputs and switchgear positions (doublepoint) as outputs

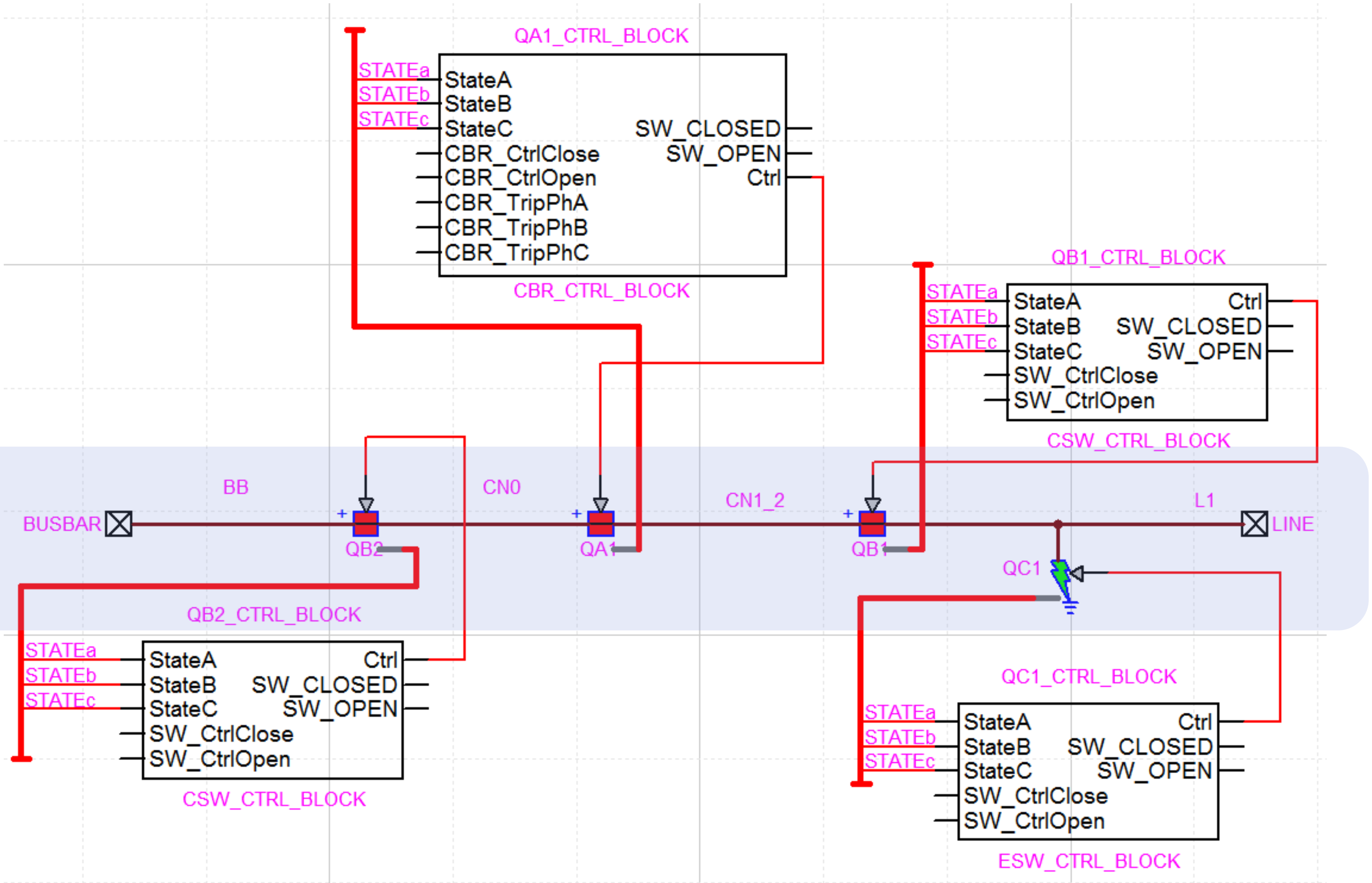


RTPSS model for HIL simulations

RTPSS model for HIL (Hardware in the loop) simulation

- Power system:
  - 2 generators,
  - 3 lines
  - 1 load
  - switch and fault elements
- 2 substation bays: simulation of switchgear and respective control logic
  - Outputs (RTPSS → IED):
    - switchgear position (double point: open & close)
    - line currents and voltages
    - bus voltage
  - Inputs (RTPSS ← IED):
    - trips (1 per phase),
    - controls (open, close)

Demonstrator/ Setup of demonstrator



RTPSS model for HIL simulations – bay switchgear

RTPSS model for HIL (Hardware in the loop) simulation – bay switchgear

- Q50: Circuit breaker
- QB1: line insulator switch
- QB2: bus insulator switch
- QC1: line earth switch

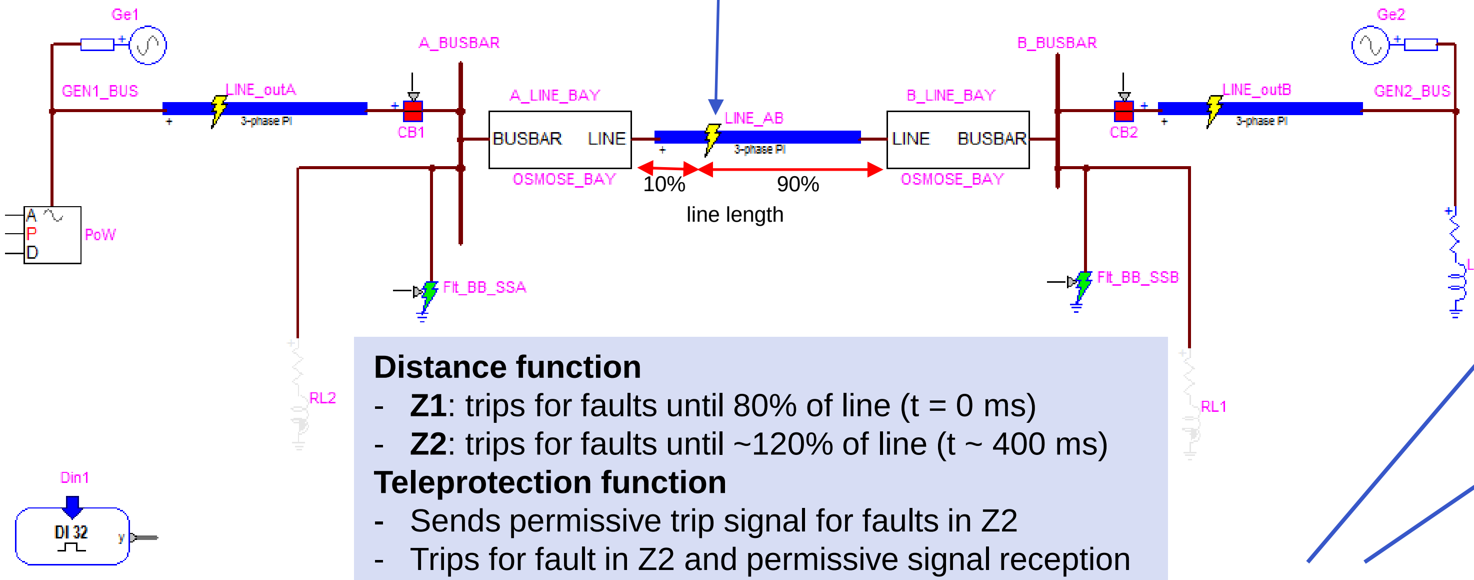
Demonstrator/ functional testing

Test execution

OSMOSE Project

A_LINE_BAY and B_LINE_BAY are subcirtuits of type OSMOSE_BAY created for OSMOSE which represent the bay equipments (switchgear) and associated control logic - has trips and controls from IEDs as inputs and switchgear positions (doublepoint) as outputs

Line fault simulation (1)



Distance function

- **Z1**: trips for faults until 80% of line (t = 0 ms)
- **Z2**: trips for faults until ~120% of line (t ~ 400 ms)

Teleprotection function

- Sends permissive trip signal for faults in Z2
- Trips for fault in Z2 and permissive signal reception

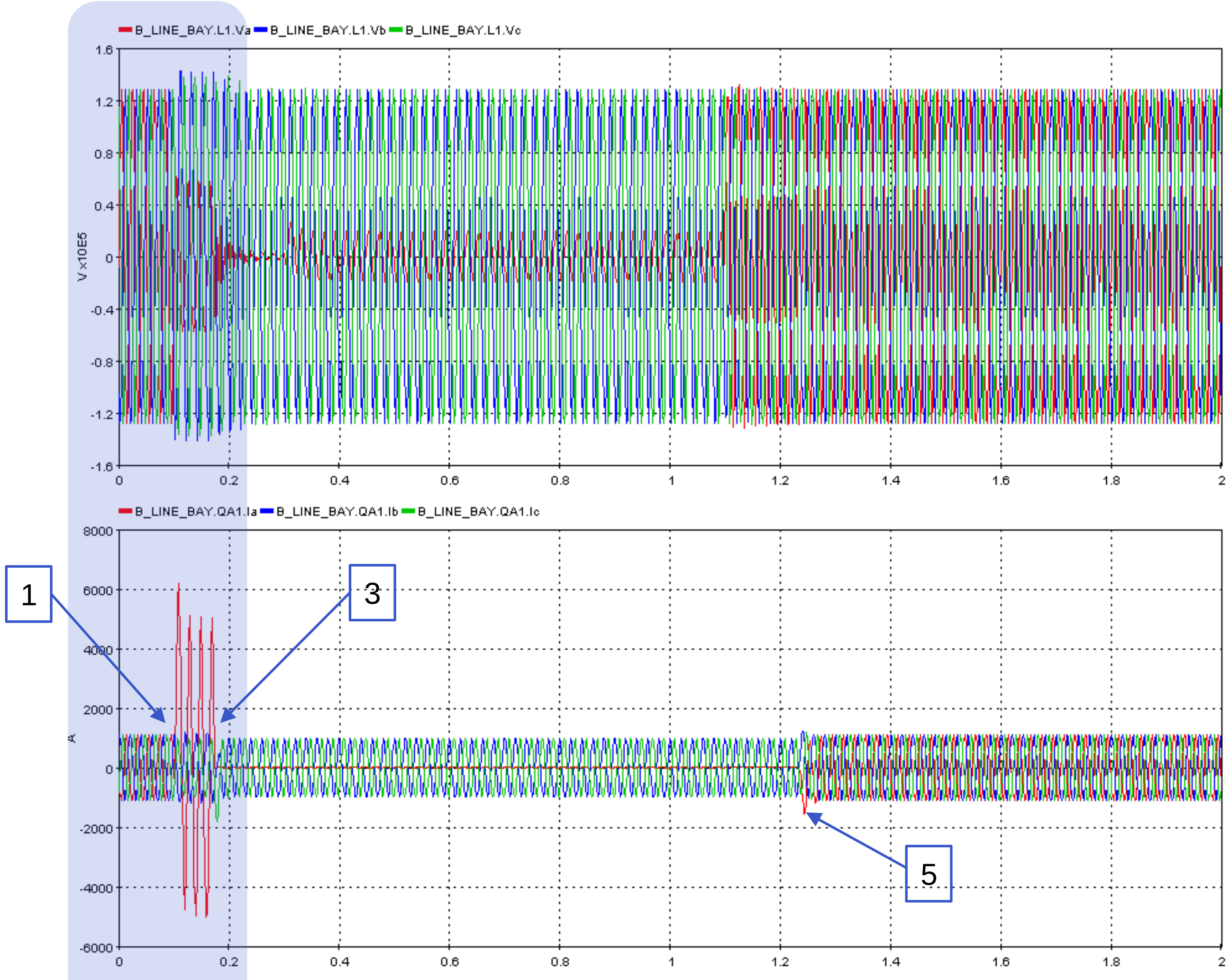
RTPSS model for HIL simulations

GOOSE communication

Example: test of trip by teleprotection function by PROT of SS/B

1. Simulation of fault in line at 90% of line length away from substation B
2. Distance function of PROT detects fault in:
   a) Z1 in substation A
      i. trips CB
      ii. sends TP signal to PROT of substation B
   b) Z2 in substation B
      i. trip delay ~ 400 ms
3. PROT of substation B receives TP signal
   a) Trips CB
   b) sends trip information to IED BC
4. BC receives trip signal initiates Auto reclose function
5. Auto reclose function issues close command to CB after DeadTime

Demonstrator/ functional testing



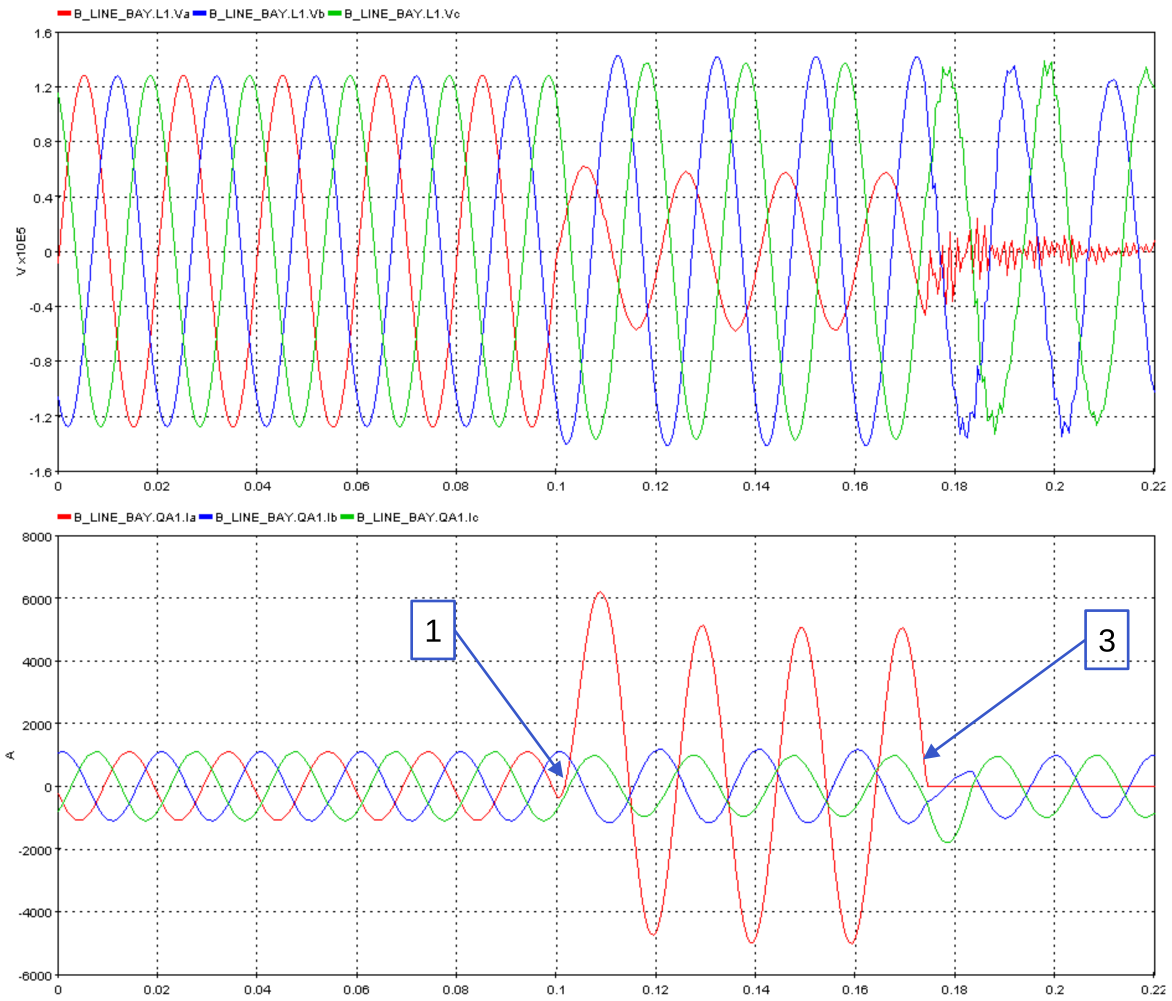
HIL simulation – Line voltages and currents at substation B

Example: test of trip by <u>teleprotection</u> function by PROT of SS/B

1. **Simulation of fault (phs A) in line at 90% of line length away from substation B**
2. Distance function of PROT detects fault in:
   a) Z1 in substation A
      i. trips CB
      ii. *sends TP signal to PROT of substation B*
   b) Z2 in substation B
      i. trip delay ~ 400 ms
3. **PROT of substation B receives TP signal**
   a) Trips CB
   b) sends trip information to IED BC
4. BC receives trip signal initiates Auto reclose function
5. **Auto reclose function issues close command to CB after DeadTime**

Demonstrator/ functional testing

ISGAN
INTERNATIONAL SMART GRID ACTION NETWORK

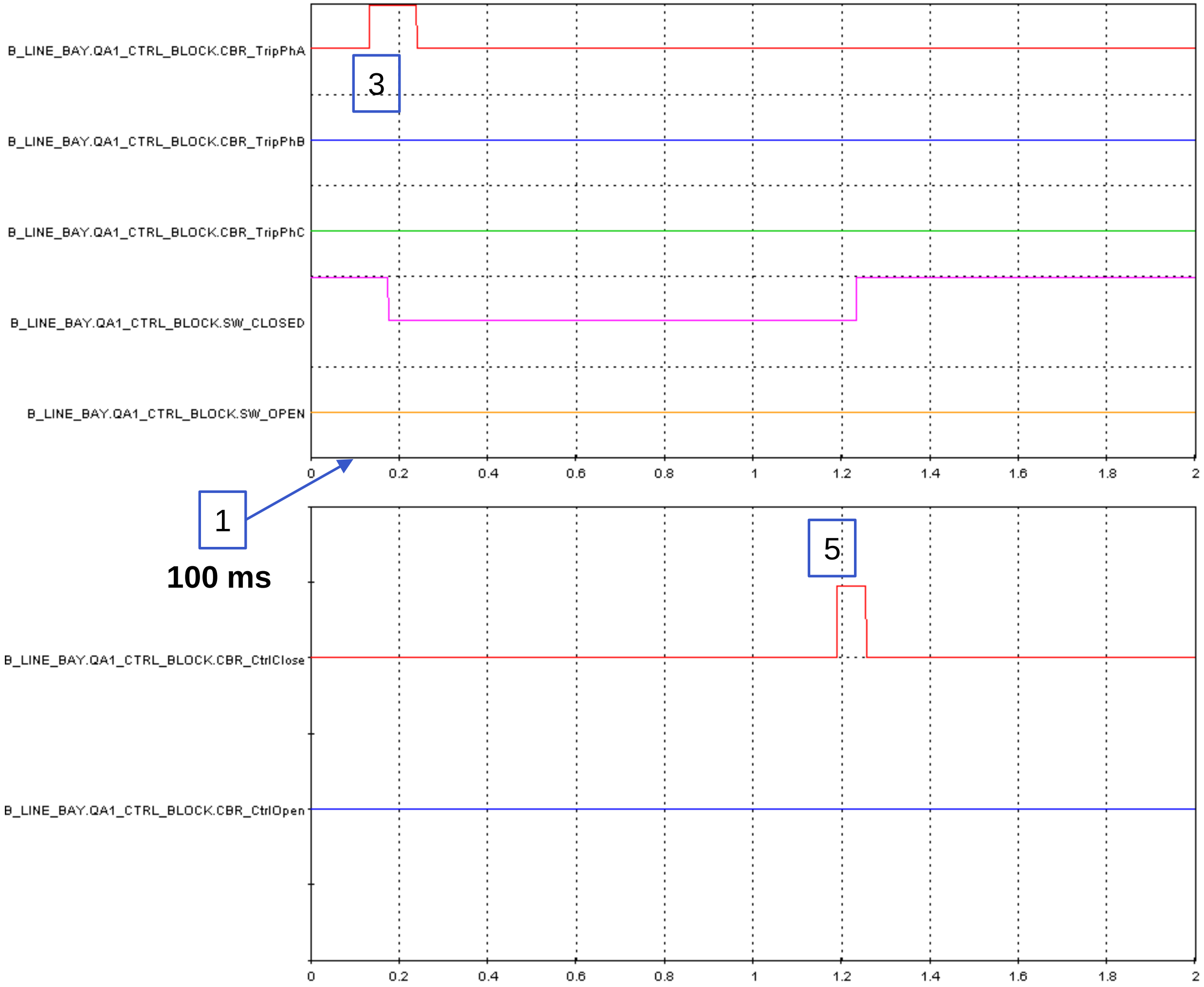


HIL simulation – Line voltages and currents at substation B

Example: test of trip by <u>teleprotection</u> function by PROT of SS/B

1. **Simulation of fault (phs A) in line at 90% of line length away from substation B**
2. Distance function of PROT detects fault in:
   a) Z1 in substation A
      i. trips CB
      ii. sends TP signal to PROT of substation B
   b) Z2 in substation B
      i. trip delay ~ 400 ms
3. **PROT of substation B receives TP signal**
   a) Trips CB
   b) sends trip information to IED BC
4. BC receives trip signal initiates Auto reclose function
5. **Auto reclose function issues close command to CB after DeadTime**

Demonstrator/ functional testing



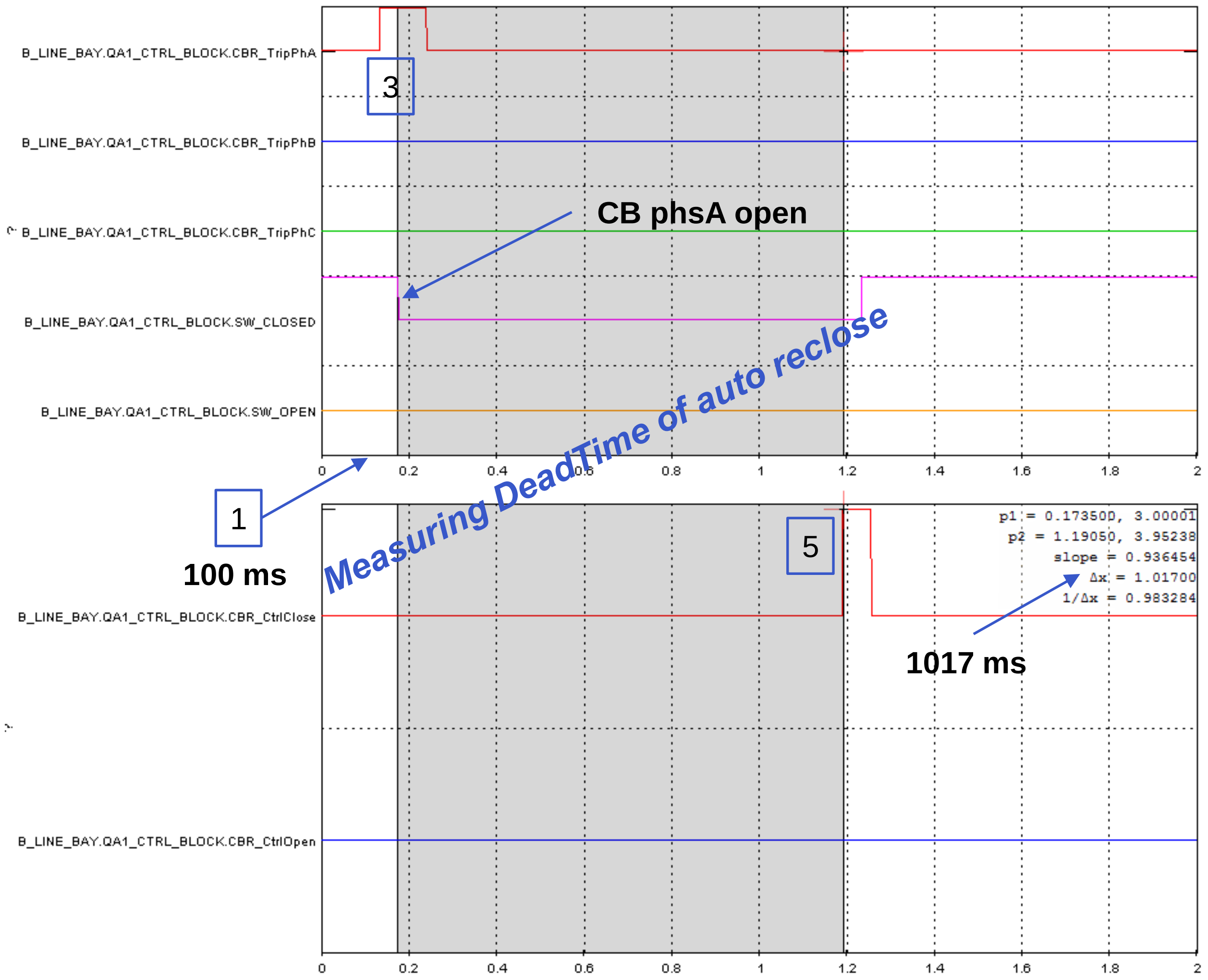
HIL simulation – Digital inputs and outputs of CB

Example: test of trip by <u>teleprotection</u> function by PROT of SS/B

1. **Simulation of fault (phs A) in line at 90% of line length away from substation B**
2. Distance function of PROT detects fault in:
   a) Z1 in substation A
      i. trips CB
      ii. *sends TP signal to PROT of substation B*
   b) Z2 in substation B
      i. trip delay ~ 400 ms
3. **PROT of substation B receives TP signal**
   a) **Trips CB**
   b) *sends trip information to IED BC*
4. BC receives trip signal initiates Auto reclose function
5. **Auto reclose function issues close command to CB after DeadTime**

Demonstrator/ functional testing

ISGAN
INTERNATIONAL SMART GRID ACTION NETWORK



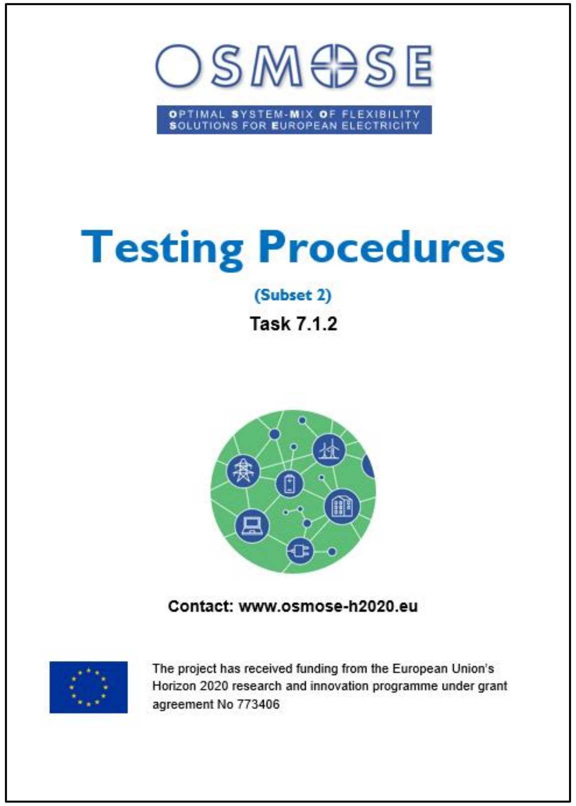
HIL simulation – Digital inputs and outputs of CB

Example: test of trip by <u>teleprotection</u> function by PROT of SS/B

1. **Simulation of fault (phs A) in line at 90% of line length away from substation B**
2. Distance function of PROT detects fault in:
   a) Z1 in substation A
      i. trips CB
      ii. sends TP signal to PROT of substation B
   b) Z2 in substation B
      i. trip delay ~ 400 ms
3. **PROT of substation B receives TP signal**
   a) Trips CB
   b) sends trip information to IED BC
4. BC receives trip signal initiates Auto reclose function
5. **Auto reclose function issues close command to CB after DeadTime**

Demonstrator/ functional testing

Test documentation



Test report document cover and table of contents

Table of content

Documentation of results

- Tests documented in test report
  - 1 test report for substation A
  - 1 test report for substation B
- Tests executed belonging to subset 2
  - Distance
  - SOTF
  - Teleprotection
  - Synchrocheck
  - Autoreclose

Note: the "Test Procedures" document will not be part of the public deliverable

Demonstrator/ functional testing

Test documentation

4.2.2.1 Test case 1 - POTT scheme

Test #	Test description	Expected result	Result	Verdict
1	Simulate a zone 2 fault, PhA to ground.	The trip is issued in less than 35 ms. (T1+Ta+Ttp)	33.0	OK
2	Simulate a zone 2 fault, PhB to ground.	The trip is issued in less than 35 ms. (T1+Ta+Ttp)	34.5	OK
3	Simulate a zone 2 fault, PhC to ground.	The trip is issued in less than 35 ms. (T1+Ta+Ttp)	33.0	OK
4	Simulate a zone 2 fault, PhA to PhB.	The trip is issued in less than 35 ms. (T1+Ta+Ttp)	39.5 ms	OK
5	Simulate a zone 2 fault, PhB to PhC.	The trip is issued in less than 35 ms. (T1+Ta+Ttp)	32.5 ms	OK
6	Simulate a zone 2 fault, PhC to PhA.	The trip is issued in less than 35 ms. (T1+Ta+Ttp)	39.5 ms	OK

Test report document – teleprotection function tests

Documentation of results

- Example for Substation B
  - Teleprotection function tests:
    - single phase fault/trip
    - phase to phase fault / 3ph trip
    - Result: trip time (trip signal - output contact of IED)

Demonstrator/ functional testing

Test documentation

6.2.2.1 Test case 1 – zone 1 dead time

Test #	Test description	Expected result	Result	Verdict
1	Simulate a **zone 1** fault, **PhA to ground.**	The dead time of the AR is 1 s	1.0 s	OK
2	Simulate a **zone 1** fault, **PhB to ground.**	The dead time of the AR is 1 s	1.0 s	OK
3	Simulate a **zone 1** fault, **PhC to ground.**	The dead time of the AR is 1 s	1.0 s	OK
4	Simulate a **zone 1** fault, **PhA to PhB.**	The dead time of the AR is 10 s	10.0 s	OK
5	Simulate a **zone 1** fault, **PhB to PhC.**	The dead time of the AR is 10 s	10.0 s	OK
6	Simulate a **zone 1** fault, **PhC to PhA.**	The dead time of the AR is 10 s	10.0 s	OK

Test report document – Autoreclose function tests

Documentation of results

- Example for Substation B
  - Autoreclose function tests:
    - single phase fault/trip
    - phase to phase fault / 3ph trip
    - Result: time between fault is cleared and reclose order is issue

4. Storage modelling exercise conclusions and recommendations

Christoph Brunner, it4power

How to model a DER?

- Depends on the information user…
- DER management system
  - is not interested in the technology specific details
  - Needs to know generic characteristics and where to apply setpoints
- DER owner
  - Interested in technology specific details e.g. for asset management

→ Model of a DER as a resource has two parts: Generic model and technology specific model

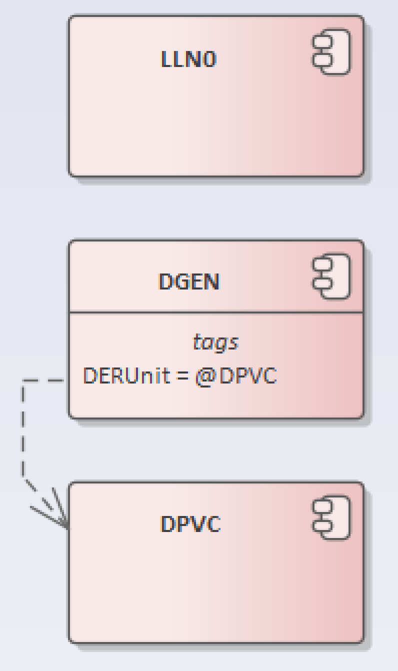
DER Resource

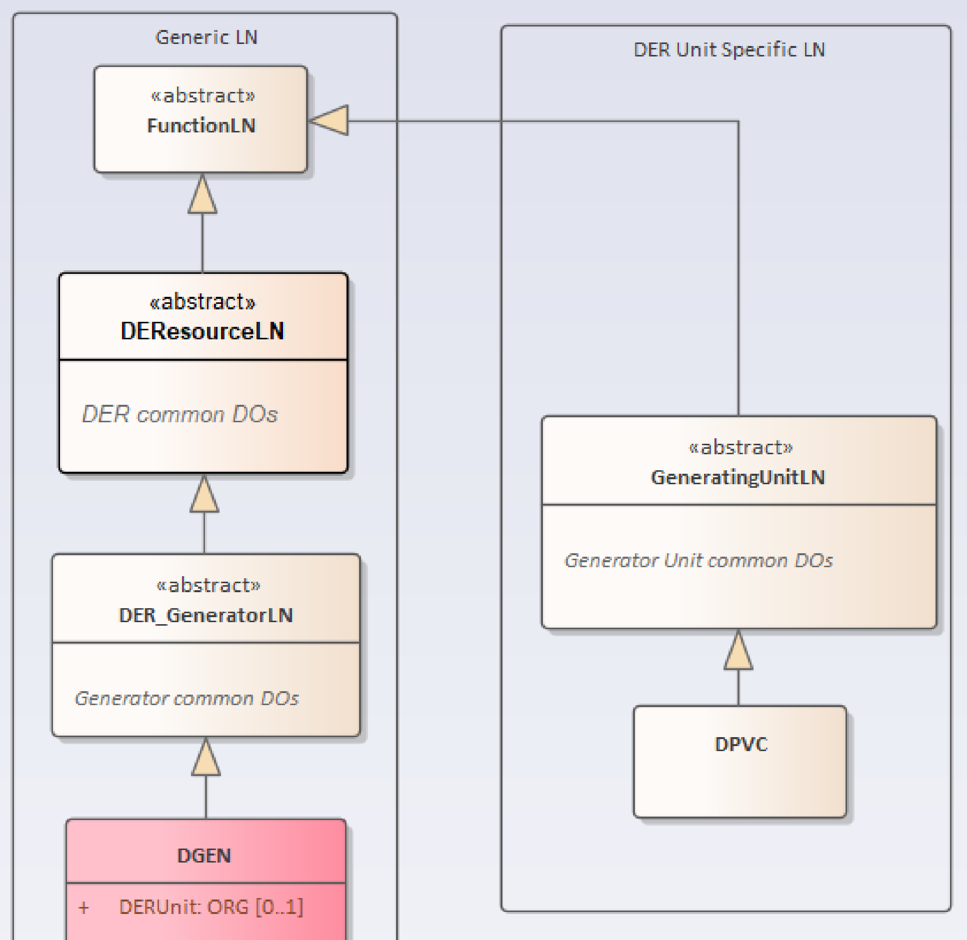
- May be single DER or recursively aggregated DERs
- Describes aspects of the electrical resource – possibly aggregated
  - Capabilities (ratings)
  - Settings
  - Status
- Can be
  - Generator DGEN
  - Load DLOD
  - Storage DSTO
- If the resource is a single DER, it refers to the technology specific LN of that DER

Example of DER Resource – PV

- Model consists of
  - A generic part (**DGEN**)
  - A technology specific part (e.g. **DPVC**)

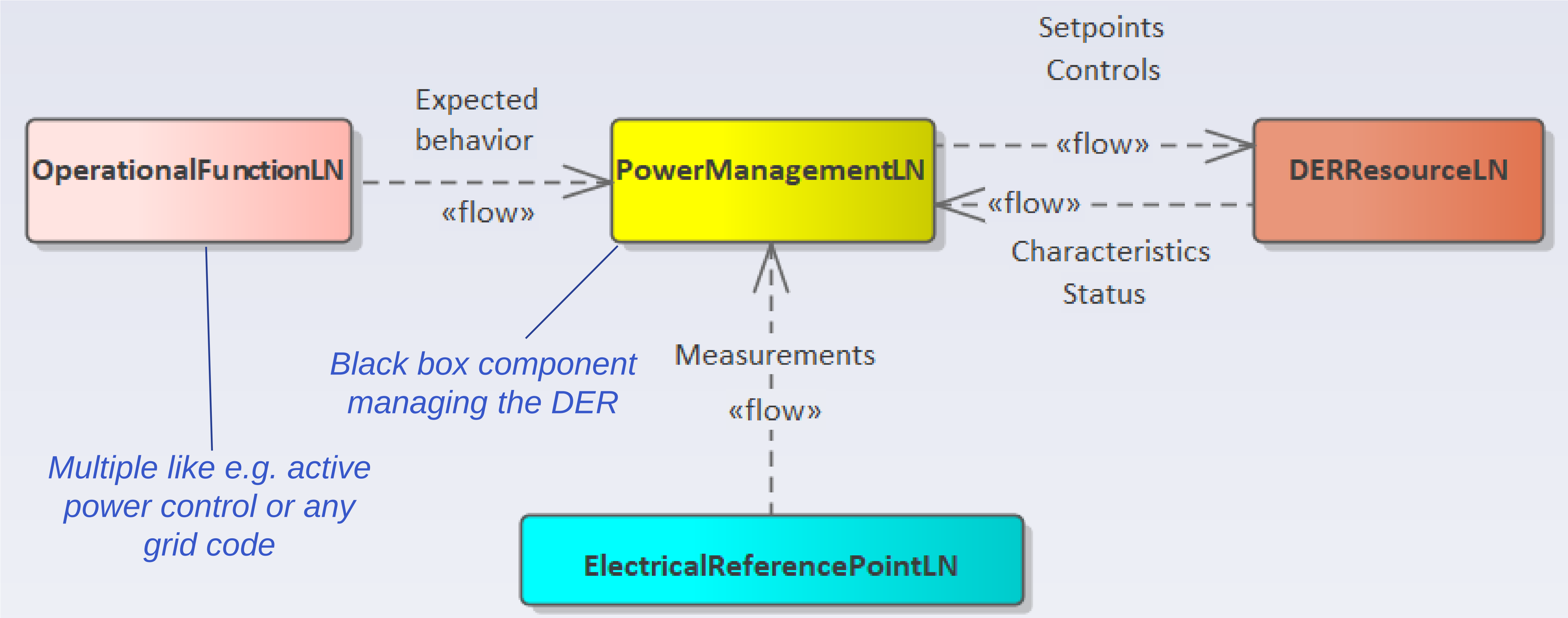
Instance in a Logical Device





Class Model

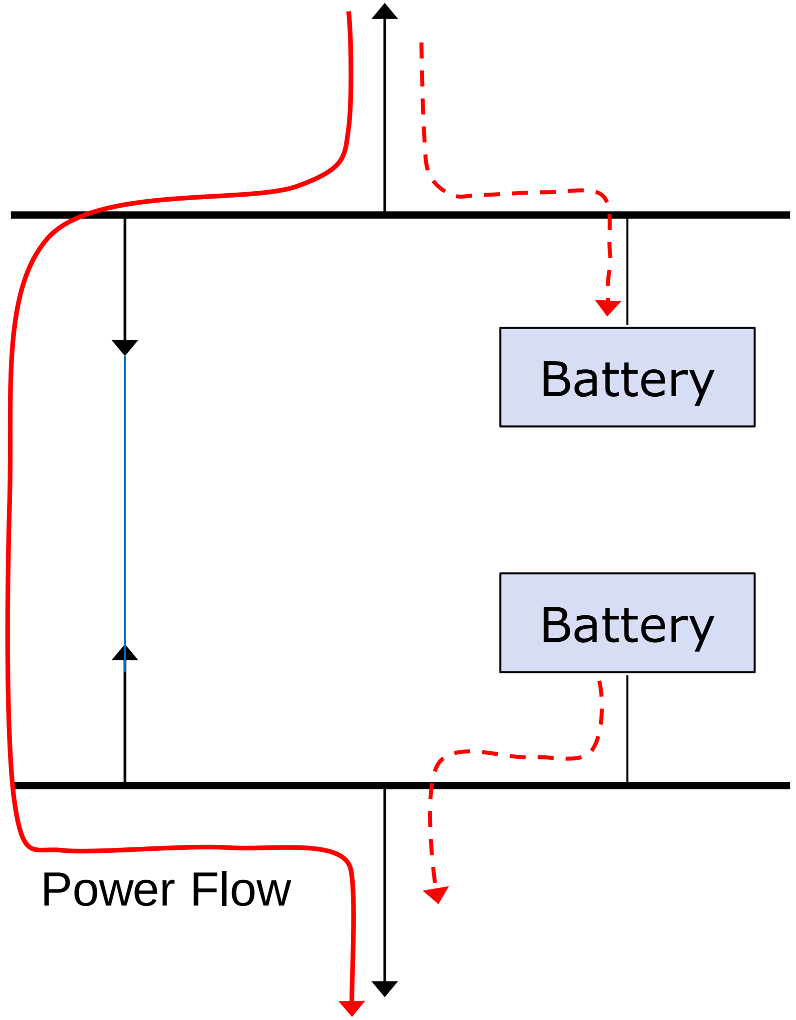
Components of the DER model



Battery Application of OSMOSE

- An additional goal of OSMOSE was, to verify the IEC 61850-7-420 models for Distributed Energy Resources

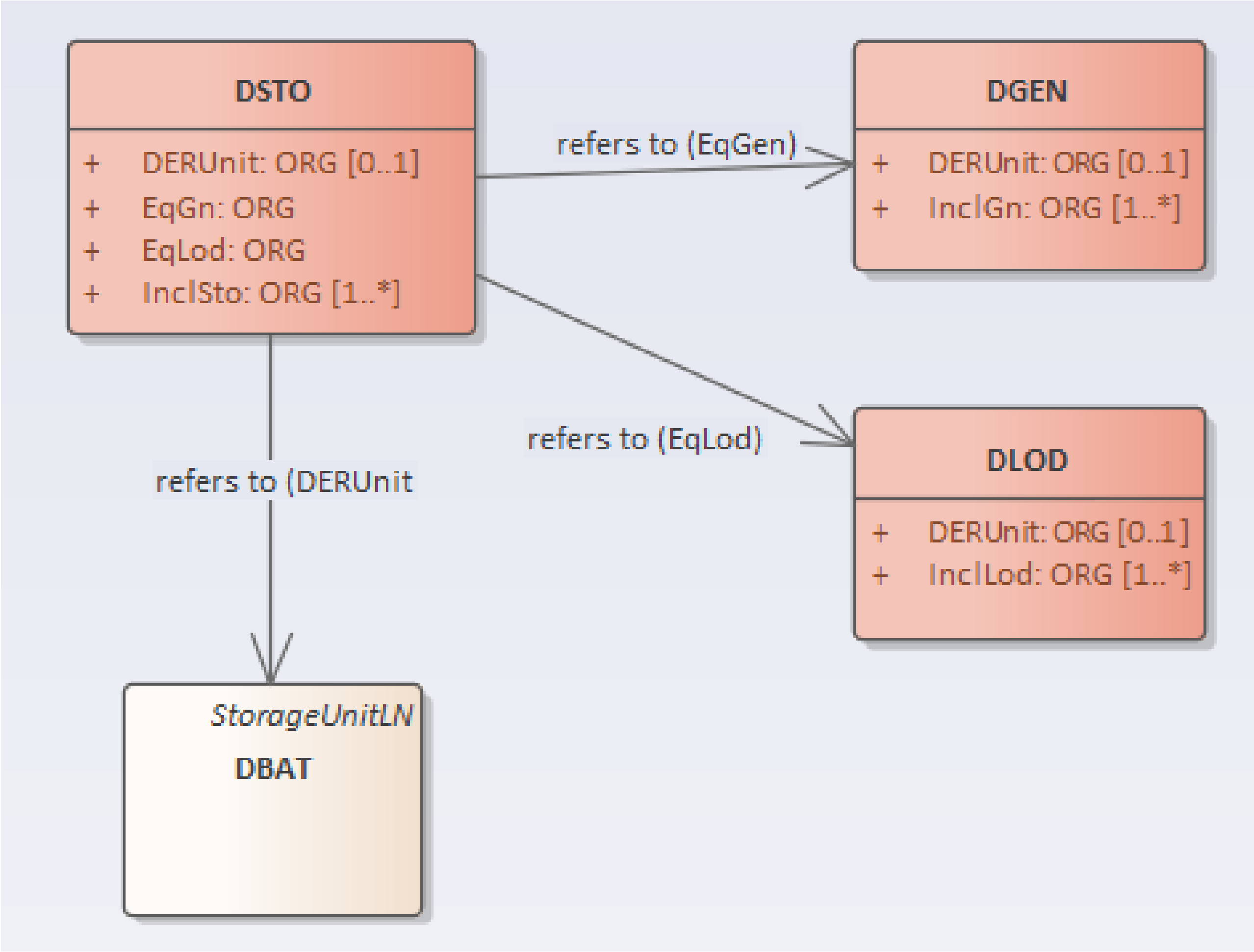
- Use case: Use a battery to prevent overload on a power line



The DER resource model for the battery

- Generic characteristics of storage as Generator and Load are expressed with **DGEN** / **DLOD**

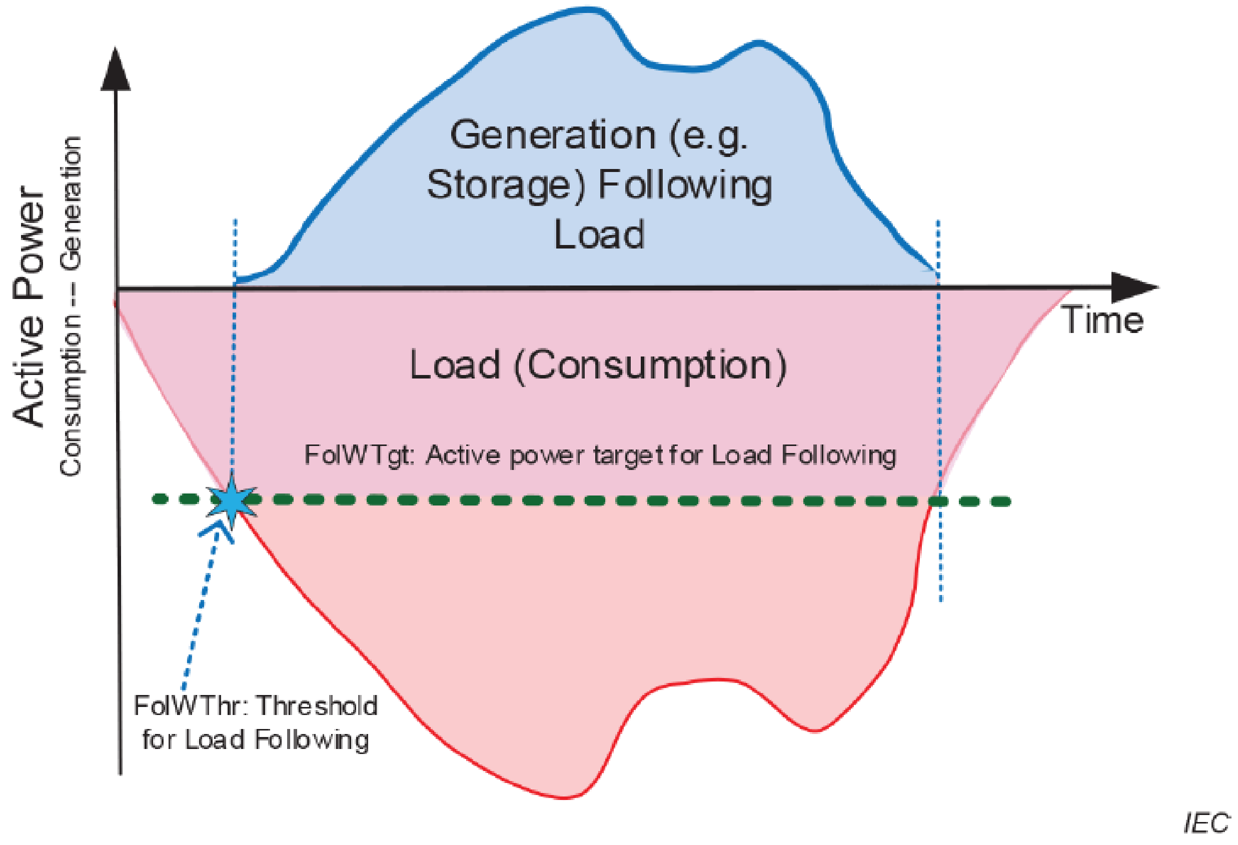
- Specifics of the DER unit (battery) is expressed with **DBAT**



The operational functions to be used

- Load following function (**DWFL**) to determine the power to be produced by the battery

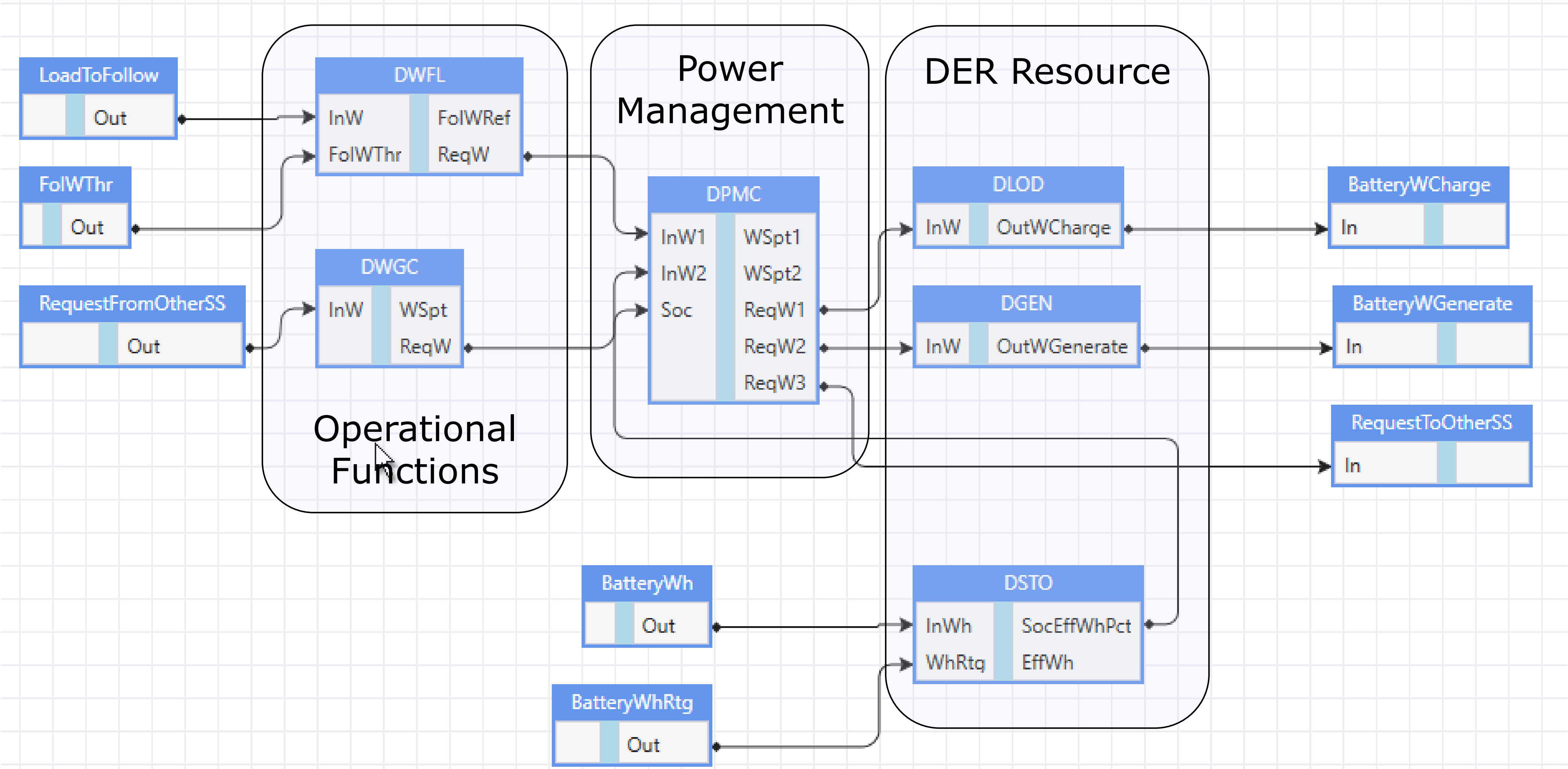
- Active power control (**DWGC**) to execute the request from the battery at the opposite line end



Simulating the Application

- The battery controller and the battery itself were simulated using DTM from Triangle Microworks
- With DTM it is possible, to simulate a complete system or parts of the system
- If the system uses IEC 61850, it is configured through the SCD file
- For functional simulation, a library supports a default behavior for logical nodes
- Custom applications can be described in 61131 function block diagram and structured text

Simulating the Application



Simulating the Application

- The battery controller application is specified as a function block diagram for simulation using the 61850 LNs as function blocks
- The behavior of the individual LNs are specified with structured text
- An additional 61131 program is used to simulate the battery

```
FUNCTION_BLOCK DWFL
// This implementation is doing load following (not generation following)
// That means, the threshold is a negative value (load), also the input value will be negative when the power flow is towards the line

VAR_INPUT
// Measurement to follow
InW : REAL;
// Settings
FolWThr : REAL;
END_VAR

VAR_OUTPUT
FolWRef : REAL;      //Reflects the input value of the load to follow
ReqW : REAL;         //Active power requested by the function
END_VAR

FolWRef := InW;
IF InW < FolWThr THEN
    ReqW := -(InW - FolWThr);
ELSE
    ReqW := 0;
END_IF;

END_FUNCTION_BLOCK
```

Conclusions

- The application could be modeled with the LNs and DOs defined in IEC61850-7-420, Ed 2
- The models of 61850-7-420 are rather comprehensive; in some cases, there is redundancy in the information models
  - In DSTO, state of charge (SoC) can be expressed in Wh or in percentage
  - In DSTO, instead of expressing SoC, energy available for discharging and energy capacity to be stored can be provided
  - In DGEN, there are ratings for active power, reactive power and apparent power

→ *Profiling for specific applications may be recommended*

Key takeways

- Engineering process
  - With the OSMOSE demonstrator, it was possible to provide feedback to IEC TC57 WG10 to extend the standard such that formal specification can be supported
  - Those extensions improve efficiency of the process
  - The extensions could be validated in the demonstrator
  - The extensions have been implemented as prototypes commercial tools – this will help market introduction

- Modelling DER and storage
  - The models defined by Ed 2 of IEC 61850-7-420 could be verified with a practical example
  - It could as well be demonstrated, how SCL files can be used to simulate the behaviour of a system

OSMOSE Final Conference
Paris/ online
24 March

Thanks for your attention

Yves Marie Bourien, CEA: yves-marie.bourien@cea.fr

Christoph Brunner, it4power: christoph.brunner@it4power.com

Thomas Sterckx, ELIA Engineering: Thomas.Sterckx@elia-engineering.com

Jörg Reuter, Helinks jr@helinks.com

Camille Bloch, Schneider Electric: camille.bloch@se.com

João Saragoça, R&D Nester: joao.saragoca@rdnester.com

The OSMOSE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773406