ÉNERGIE ÉLECTRIQUE 4.0

MEDEE
Maîtrise Energétique des Entraînements Electriques

COMITE DE SUIVI EE4.0-MEDEE

Présentation de VICORE

10 avril 2026

Données du projet

Nom du projet : VIrtualisation des fonctions de COnduite du Réseau Electrique

Nom du porteur : Frédéric Colas

Partenaires impliqués : SEL, EDF et SPHERA

Laboratoires GE : L2EP

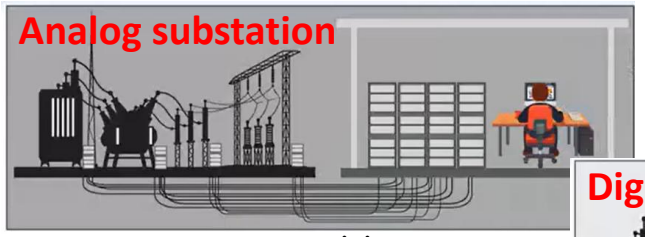
Laboratoires hors GE : -

Autres partenaires :

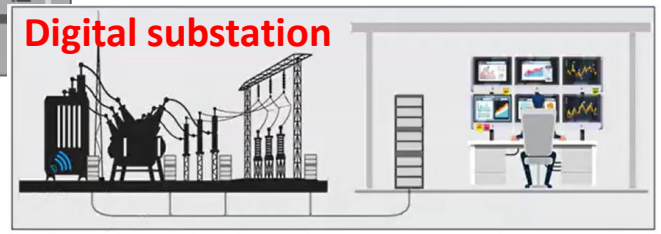
Subventions : 2023 : 172 800€

Introduction

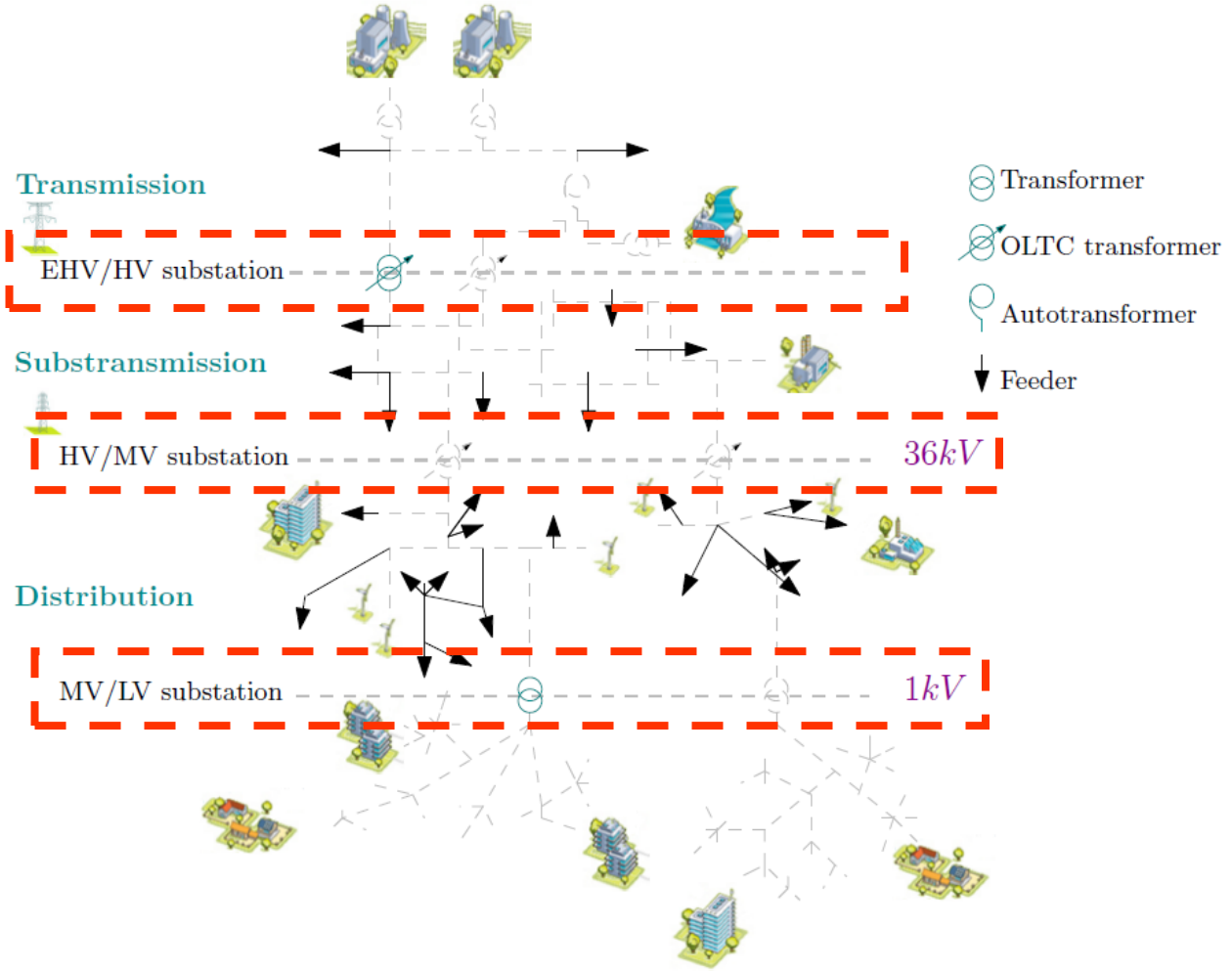
- **The substation is a key element in the operation and control of power systems.**
- **Modern power systems are increasingly based on digital substations, replacing traditional analog infrastructures.**



copper wiring



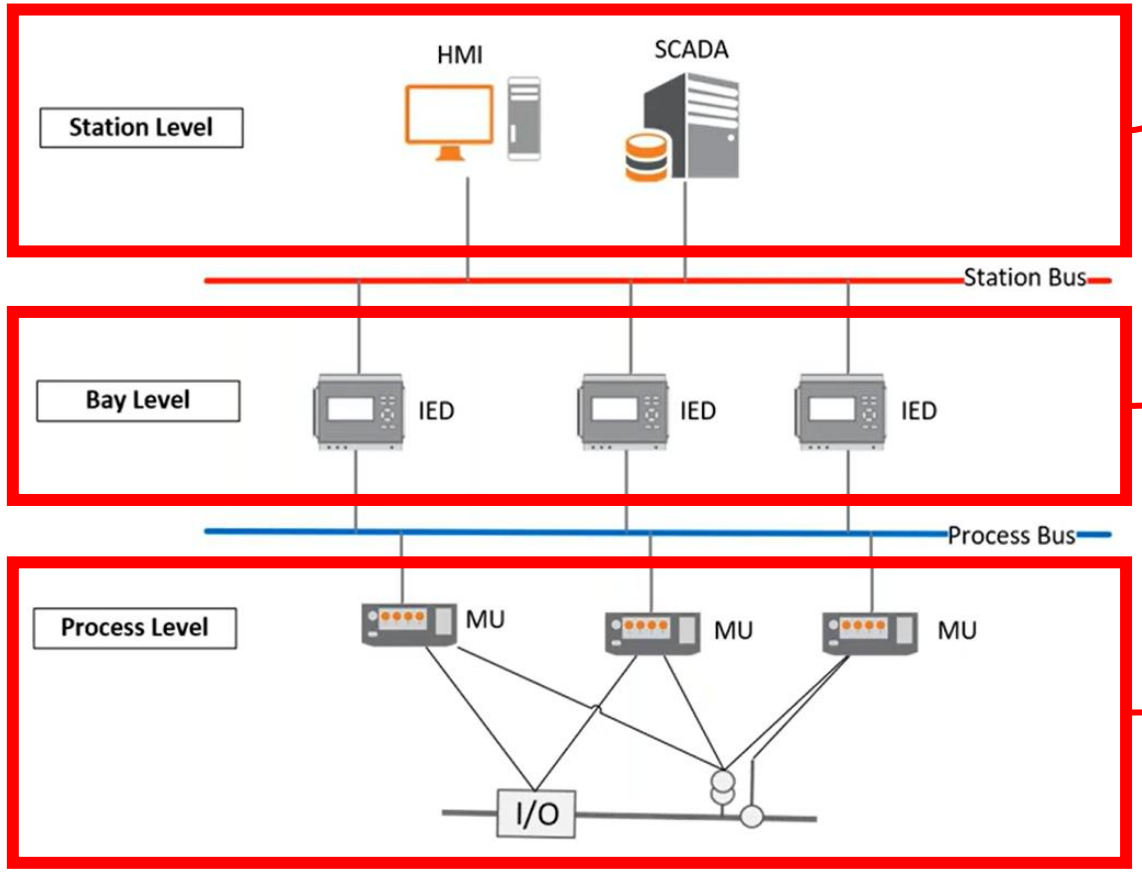
ethernet-based communication



✓ **Virtualization of PAC functions**

✓ **Design of a testbench to validate them**

Digital substation architecture



- Operators to monitor and control
- External communication gateways

- IEDs to monitor and control
- Types of devices at Bay are:
  - Relay
  - Protocol Gateway
  - Remote Telemetry Unit (RTU)
  - Bay Controller Unit (BCU)

- Transducers like CT and VT to measure and digitize current and voltage.
- Conducting equipments like circuit breakers and isolators.

- Vendor-specific solutions
- Heterogeneous communication standards

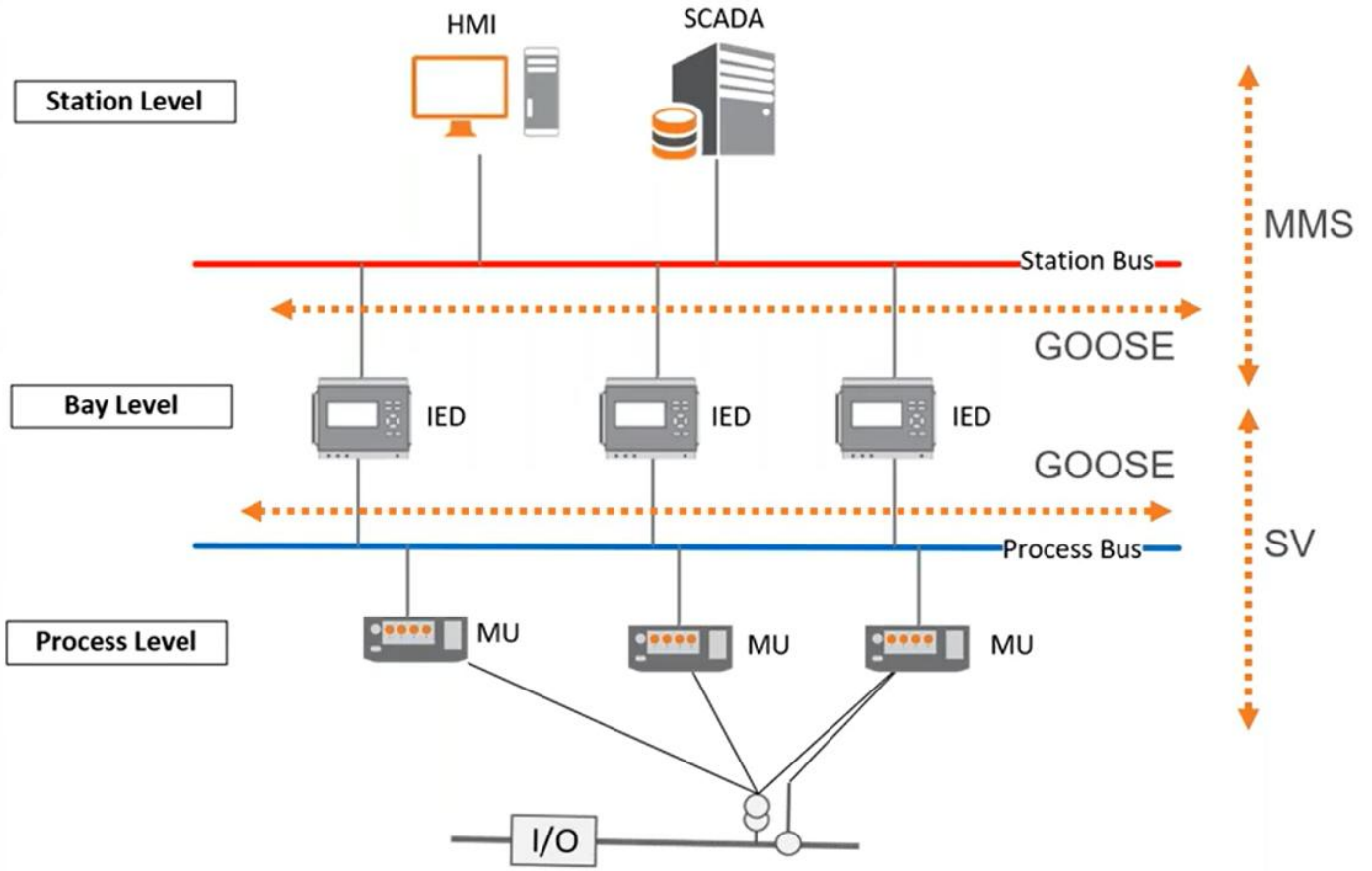
significant challenges:

Lack of interoperability, high integration cost, complexity of system maintenance, and limited long-term scalability

IEC 61850 standard

Enables communication and interoperability in digital substations.

IEC 61850 Communication Protocols



MMS Traffic (Manufacturing Messaging Specification)

- For monitoring substation status
- Unicast
- TCP, Acknowledgment
- Stations bus

GOOSE Traffic (Generic Object-Oriented Substation Events)

- For sending command request
- Multicast
- UDP
- repeated signal
- Station bus/Process bus

SMV Traffic (Sampled Measured Values)

- For transmitting power lines current and voltage values
- Process bus

Protocol	Speed	Pattern	Data volume
SV	< 1 ms	Client-Server	High
GOOSE	< 4 ms	Publisher-Subscriber	Low
MMS	~ 10 -100 ms	Publisher-Subscriber	Vaiable

State of the art

Virtualization of PAC Functions of IEDs

***PAC:** Protection, Automation, Control

Nowadays, virtualization is increasingly used for PAC functions in power systems.

Definition: the process of creating a software-based version of something instead of using a dedicated physical version.

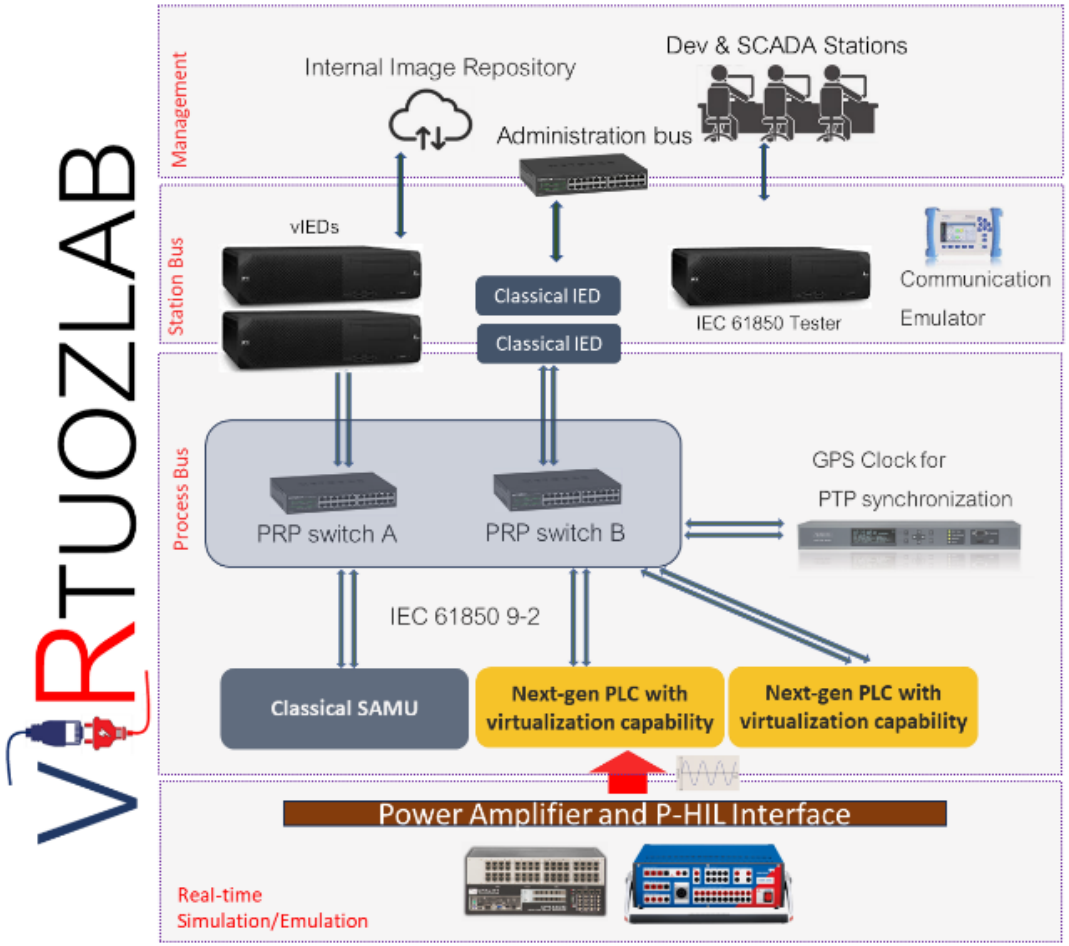
Why virtualization?

- Increased flexibility (software-based functions instead of fixed hardware)
- Reduced costs (less reliance on physical IEDs)
- Improved scalability (easy system expansion and modification)
- Simplified maintenance (remote updates and monitoring)
- Integration with modern technologies (Cloud and Edge computing)

Need for advanced validation platforms capable of emulating realistic network behaviour while supporting modern digital communication standards

State of the art

Recent studies have investigated vIED implementations and IEC 61850-based simulation environments.



Setup of the VirtuozLab platform

CIRED 2025 Conference
16 – 19 June 2025
Paper 890

VIRTUOZLAB: AN ADVANCED TESTING PLATFORM FOR VIRTUAL IED AND PAC FUNCTIONS

Van-Hoa Nguyen, David Ramsey, Houda Abil , Thierry Coste, Rémi Thomas*

EDF R&D, EDF Lab Paris Saclay, Palaiseau, France
**Corresponding author: david.ramsey-herrera@edf.fr*

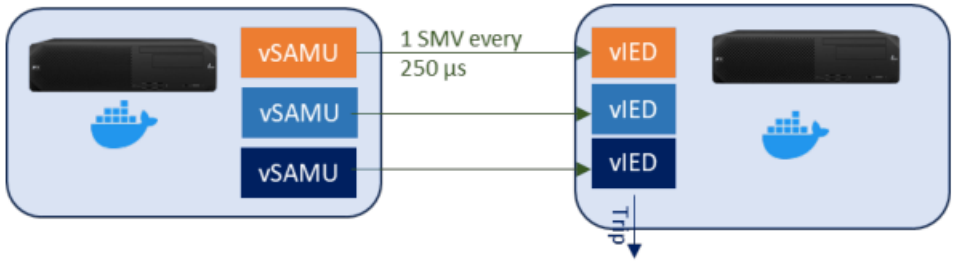


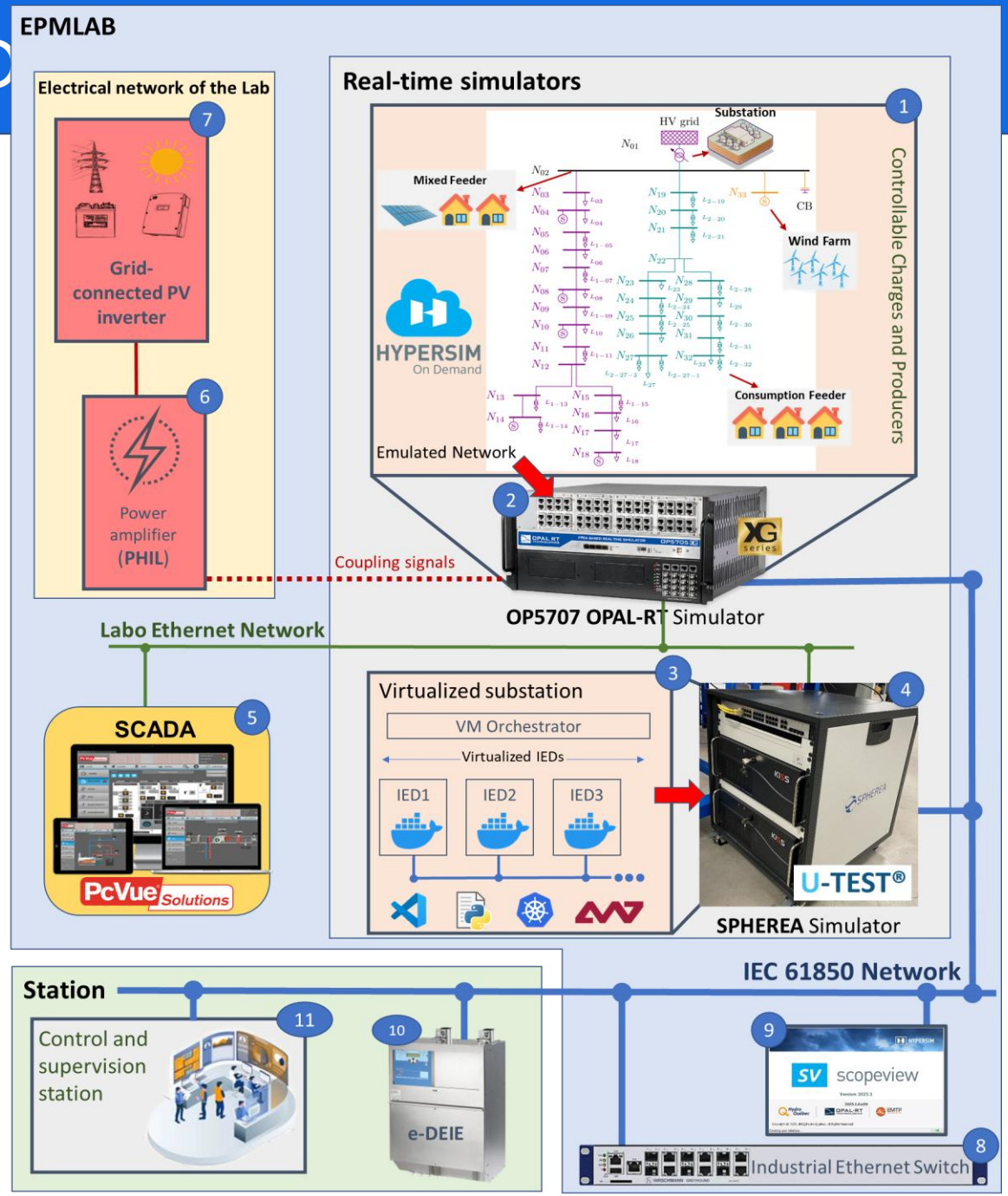
Fig. 6 : Test setup in Virtuozlab for the considered use-case

Lack of integration between power system and vPAC functions; software-based signal generation

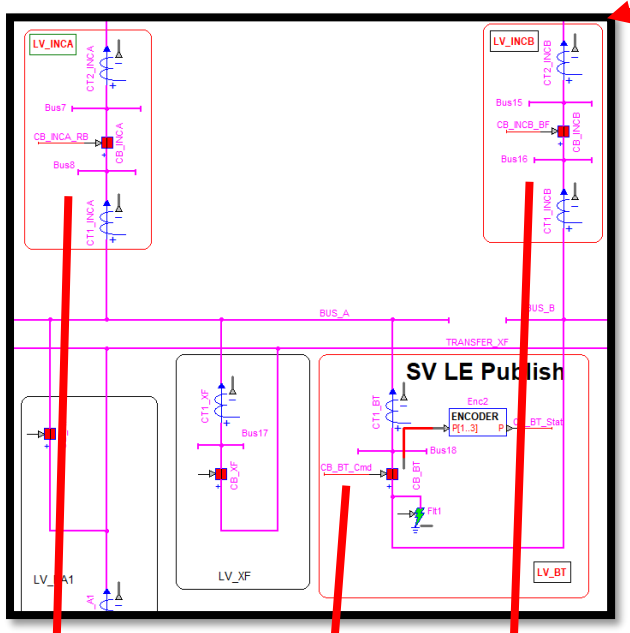
Features of the testb

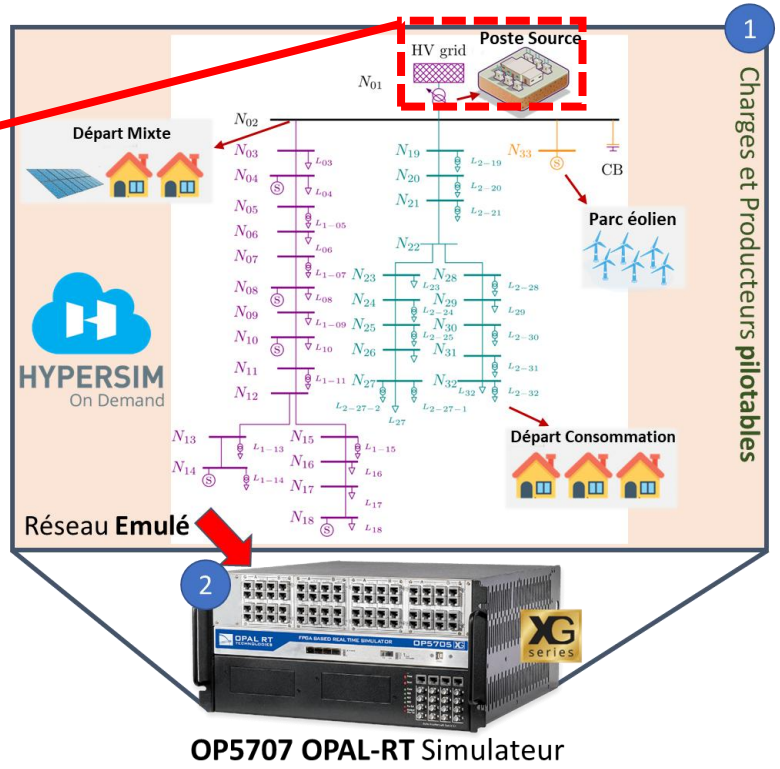
Features of the testbench:

- **Use of two real-time simulators**
- **Containerization of IEDs**
- **Real-time distribution network**
- **Simple and user-friendly platform**
- **PHIL capability**
- **Real IED testing platform**
- **Connectivity with other platforms**

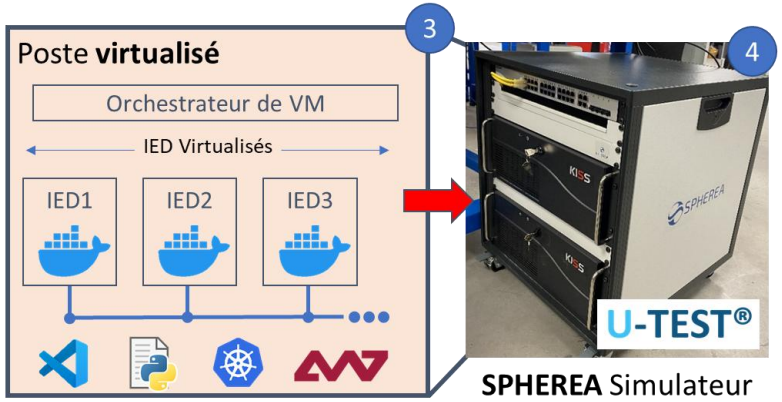


Implementation details

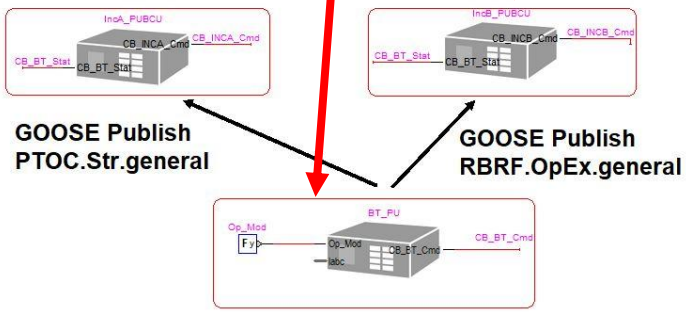




OP5707 OPAL-RT Simulateur



SPHEREA Simulateur



GOOSE Publish
PTOC.Str.general

GOOSE Publish
RBRF.OpEx.general

3 Mus (1 per zone)

SV publisher (sender)

Goose subscriber (receiver)

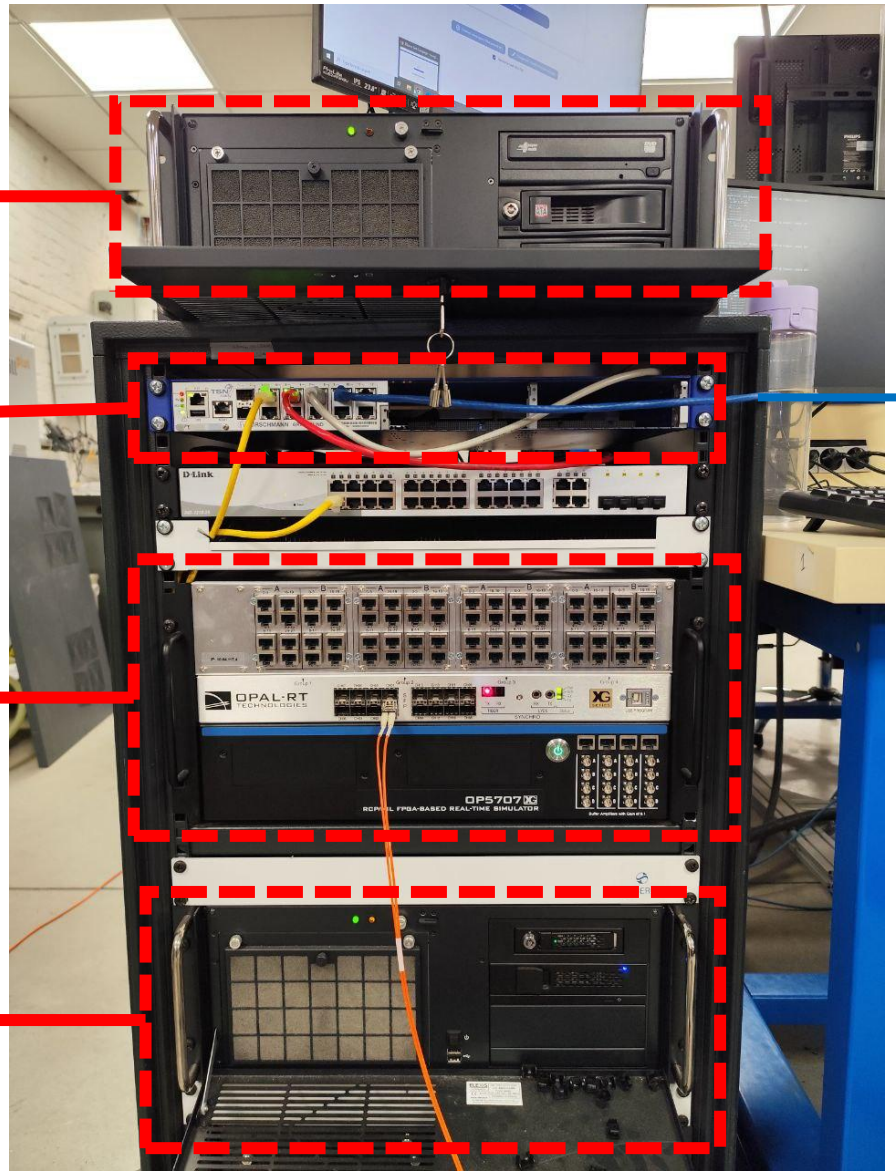
3 IEDs (1 per zone)

SV subscriber

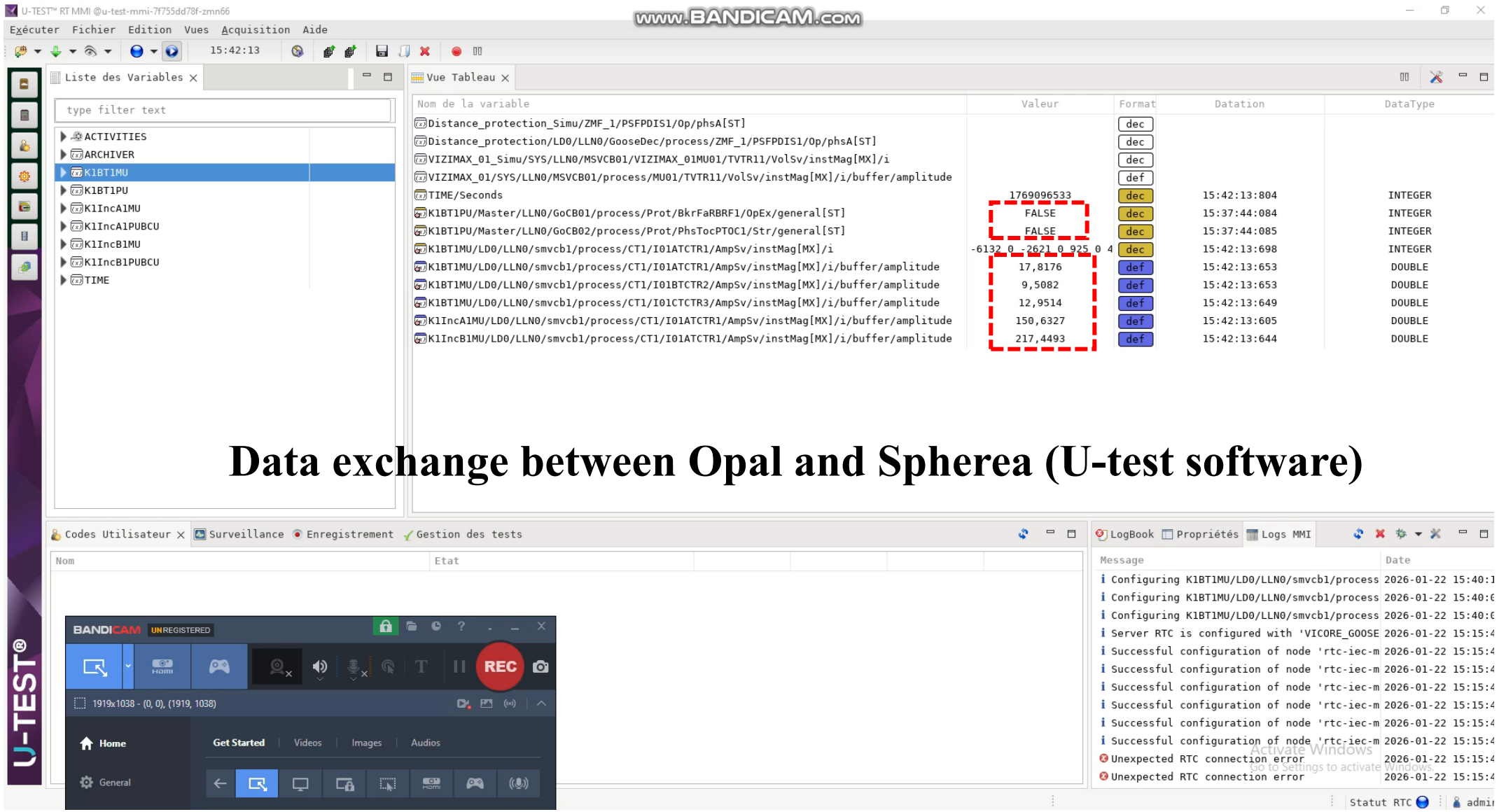
Goose publisher

Goose subscriber

Implemented Platform



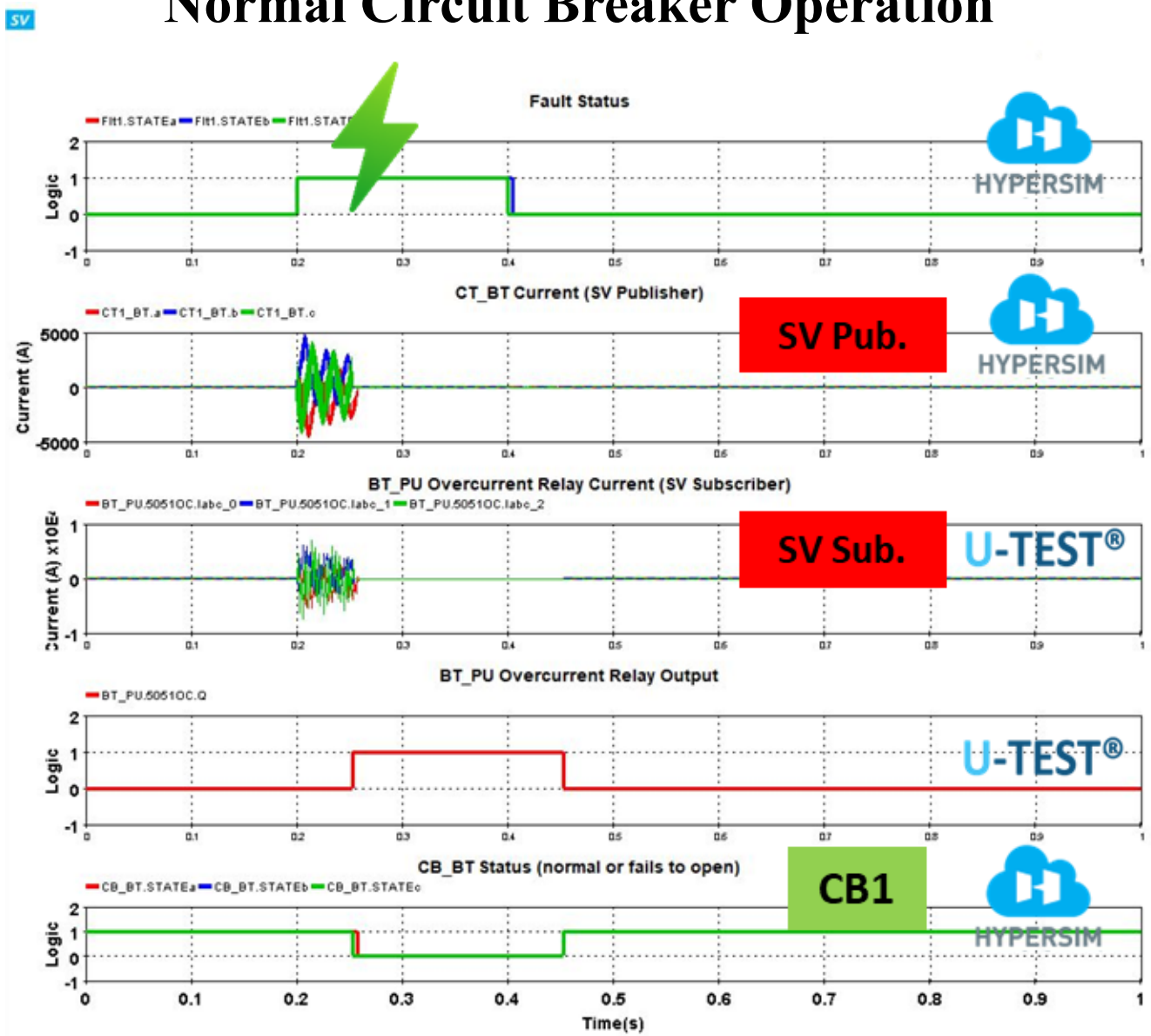
U-test software

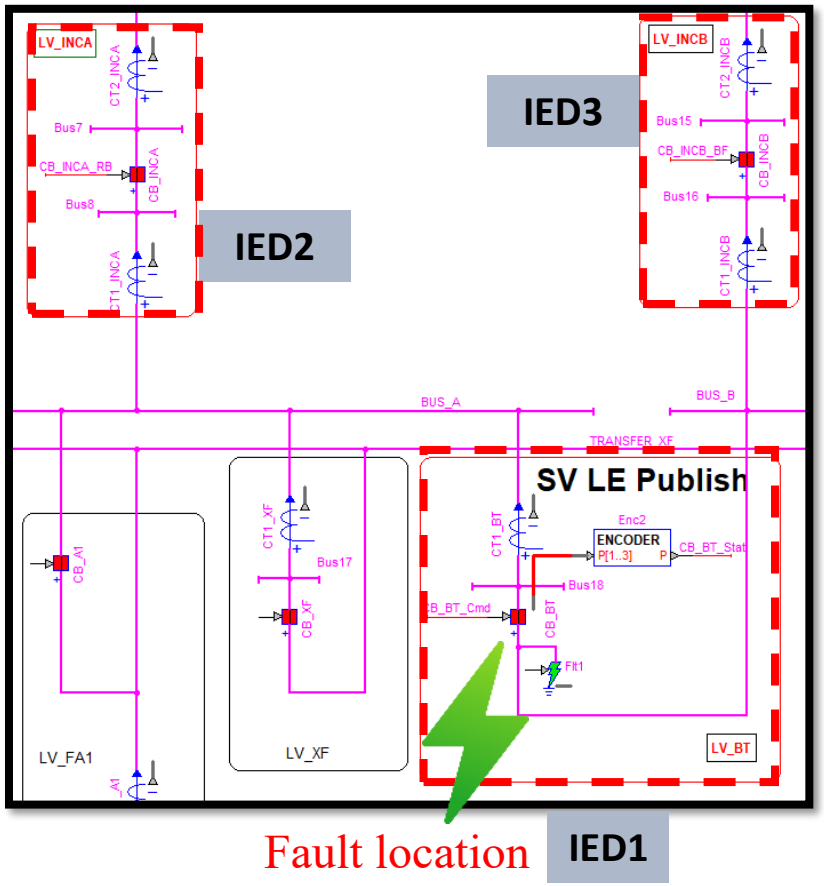


Data exchange between Opal and Spherea (U-test software)

Example 1

Normal Circuit Breaker Operation

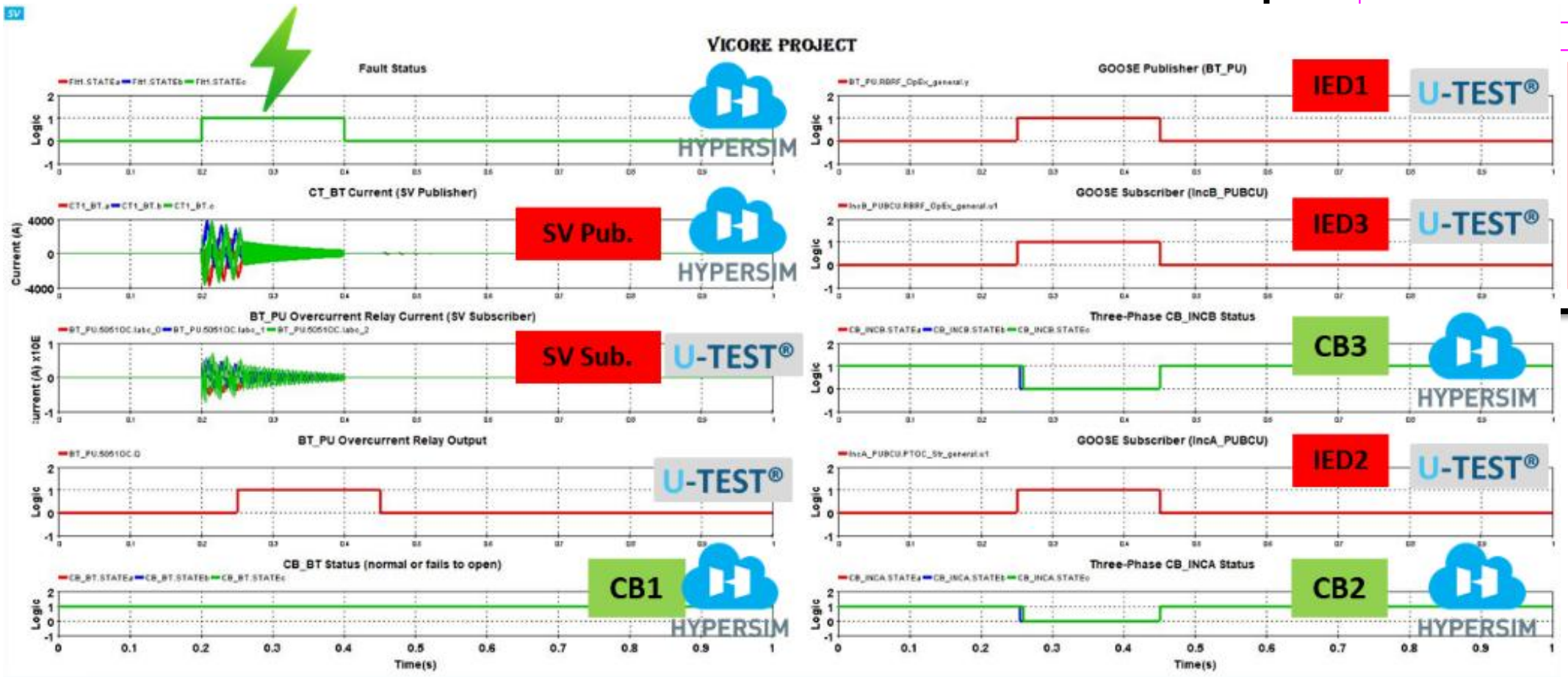


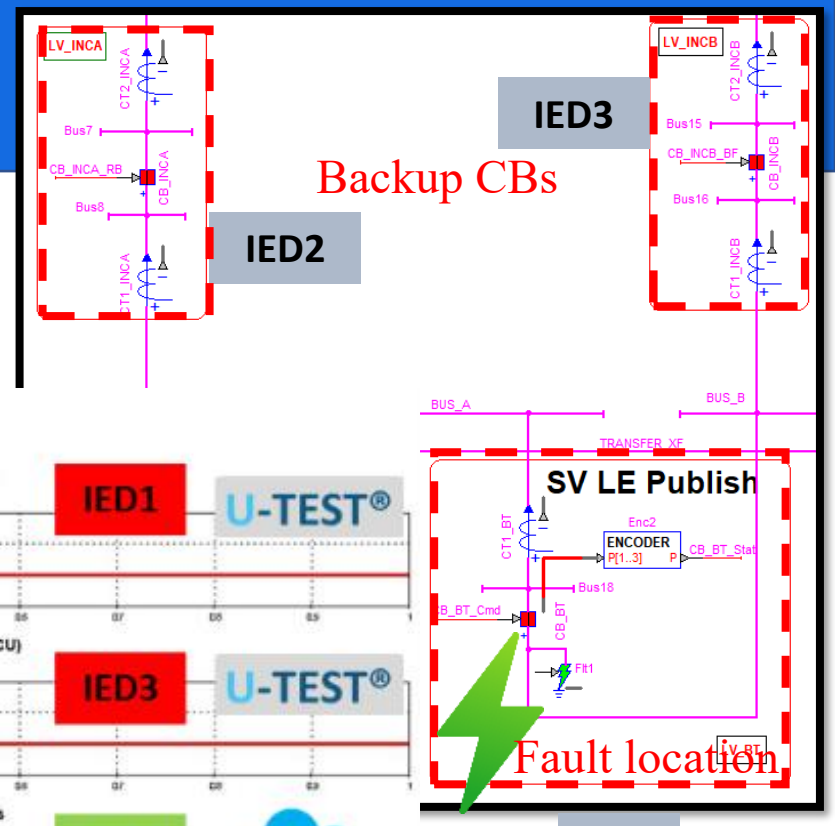


CB1 operates correctly upon receiving the GOOSE tripping signal.

Example 2

CB Failure and Backup Protection

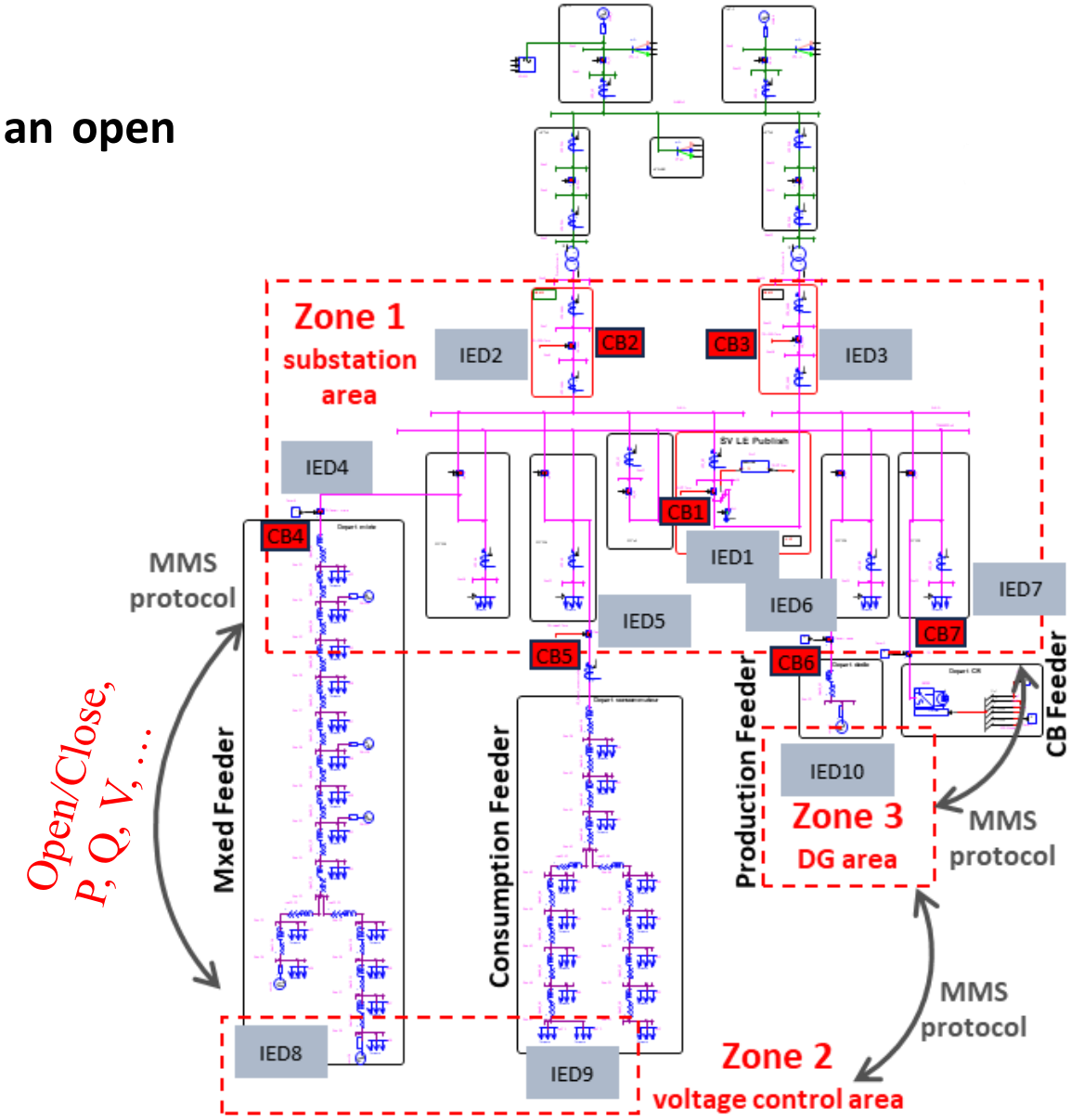




Next steps

VICORE was a preparatory project for building an open platform and more advanced control laws.
Here, the focus was on protection.

- **Multiple protection and control zones**
- **MMS communication is used for inter-zone data exchange where strict latency constraints are not required.**



Outcomes

CIRED 2026 Brussels Workshop
9-10 June 2026
Paper 1408

VICORE: A HYBRID REAL-TIME TEST PLATFORM FOR PAC FUNCTIONS USING VIRTUALIZED IEDS IN POWER DISTRIBUTION NETWORK

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[2]EDF R&D, EDF Lab Paris Saclay, Palaiseau, France
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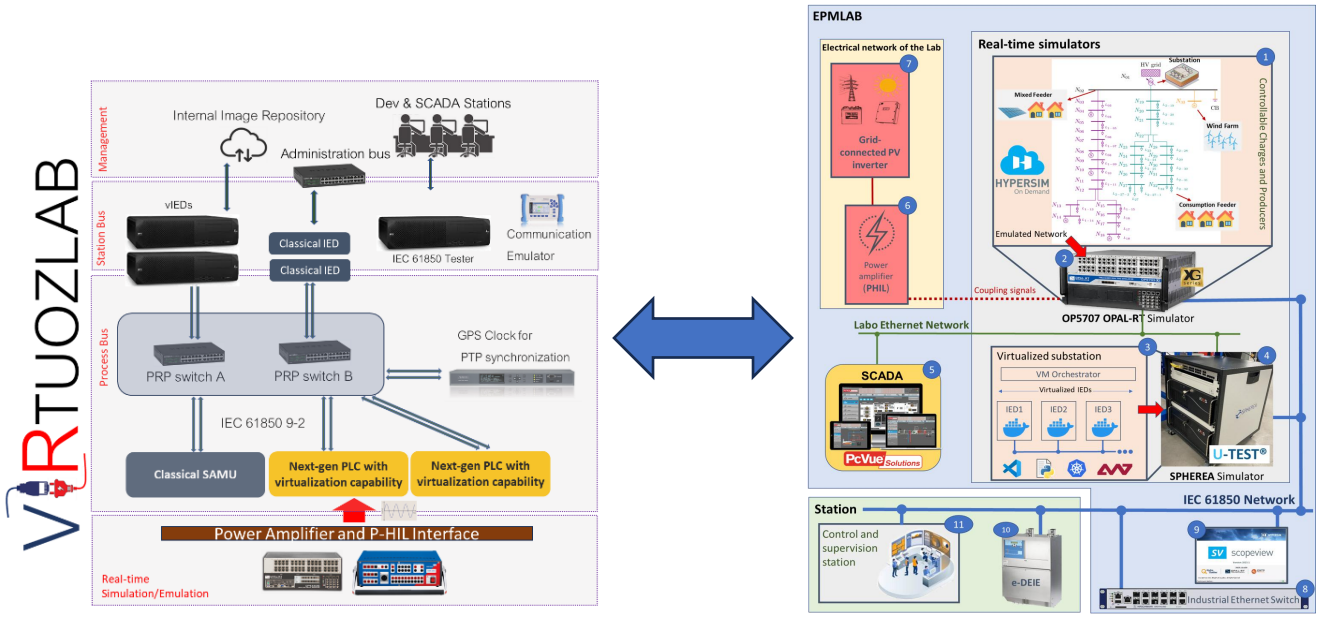

VIPIFLEX Project

Advanced solution for congestion management in distribution networks

EDF Project

Direct collaboration with EDF for advanced control of substations

Merci pour votre attention

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