Centralized AC/DC protection

Opportunities

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About DNV

We deliver world-renowned testing, certification and technical advisory services to the energy value chain including renewables, oil and gas, and energy management.

We are also a world-leading provider of digital solutions for managing risk and improving safety and asset performance for ships, pipelines, processing plants, offshore structures, electric grids, smart cities and more.

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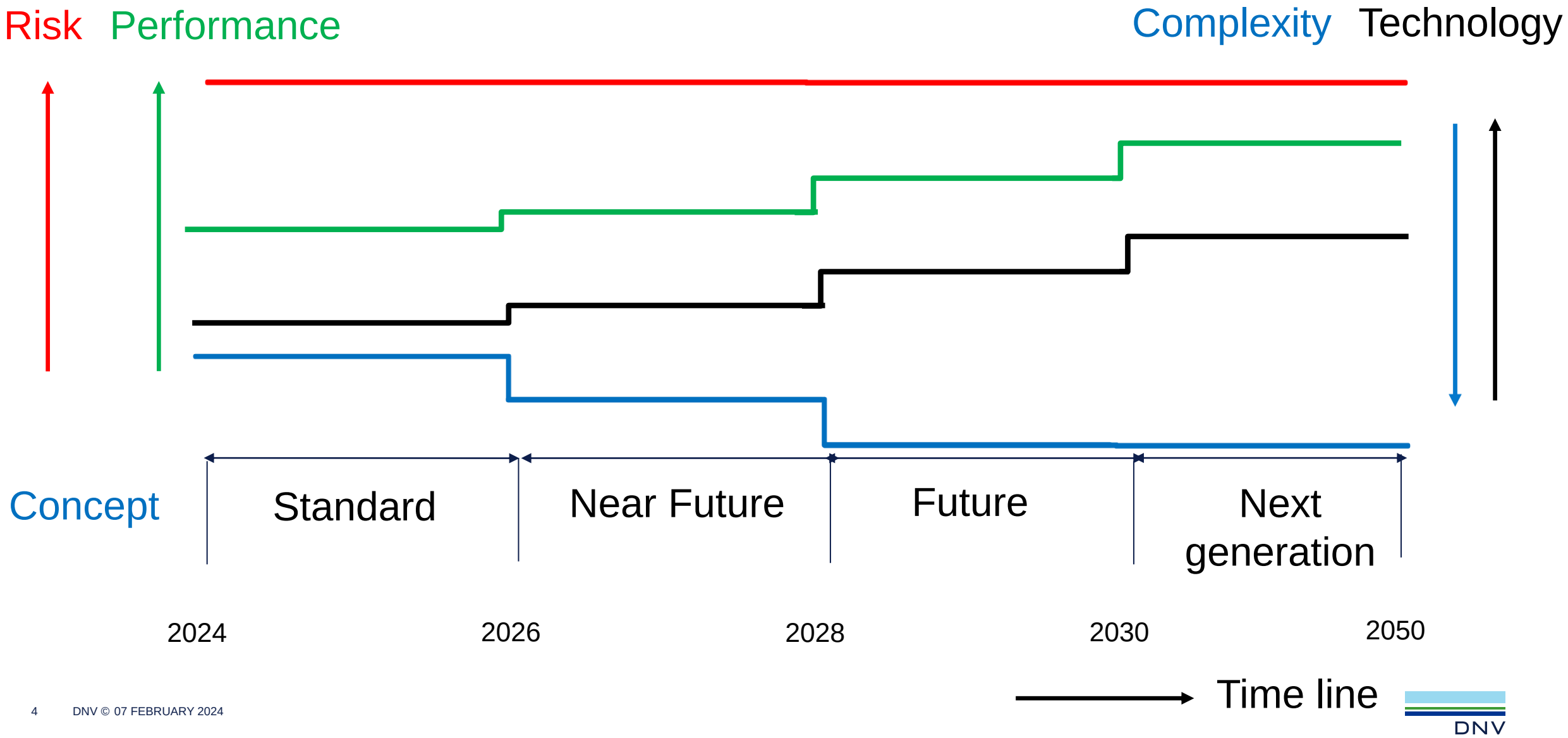
Content

- Considerations
- Protection system
- AC/DC protection challenges
- System test protection
- Outlook future protection
- Wrap up

Considerations 1/1



Considerations 2/2

- New technologies means new organizational skills
- Implementing and support technologies means long term knowledge
  - Engineering and specialism in-house
  - Engineering and specialism outsourced by long term contracts
  - Combination in house /outsourced

- How organisation accept new concepts/technology?
  - If leads to less complex, more effective system
  - Explain and test by giving a demonstration using tools: PowerFactory, Omicron test suite (Relay Sim Test), RT Lab

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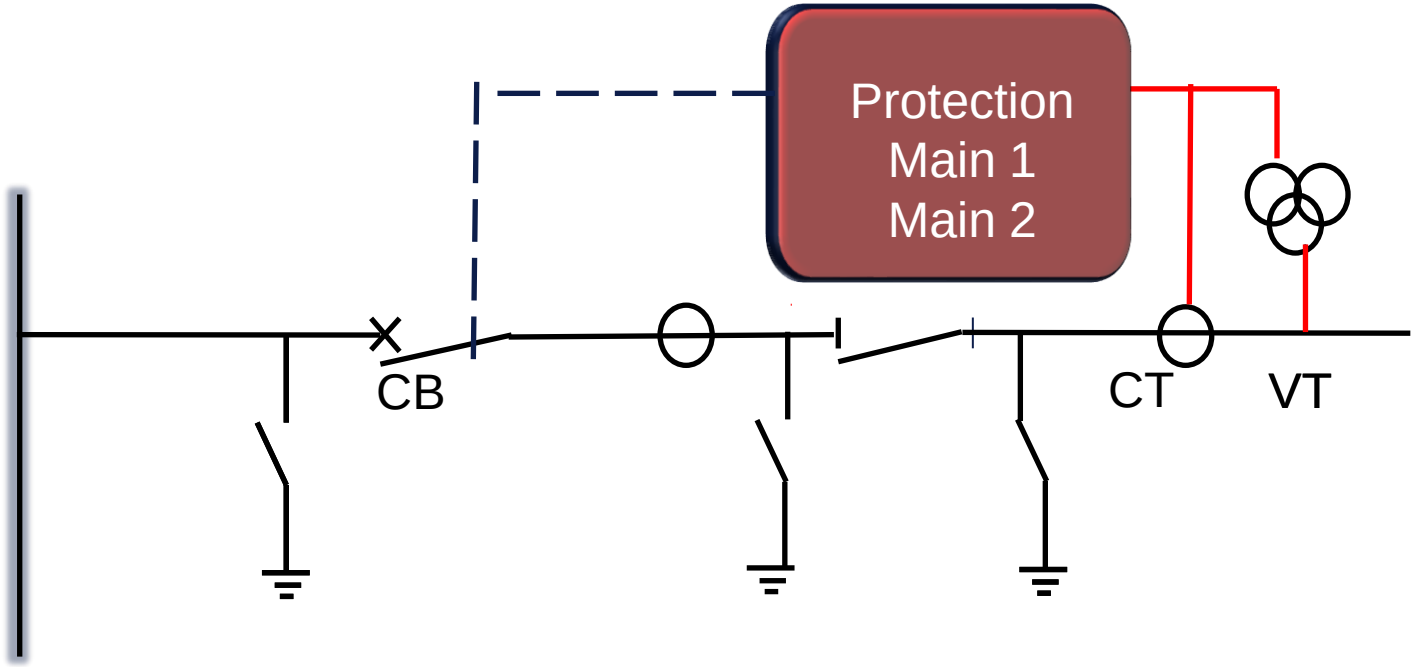
Protection concept

Basic

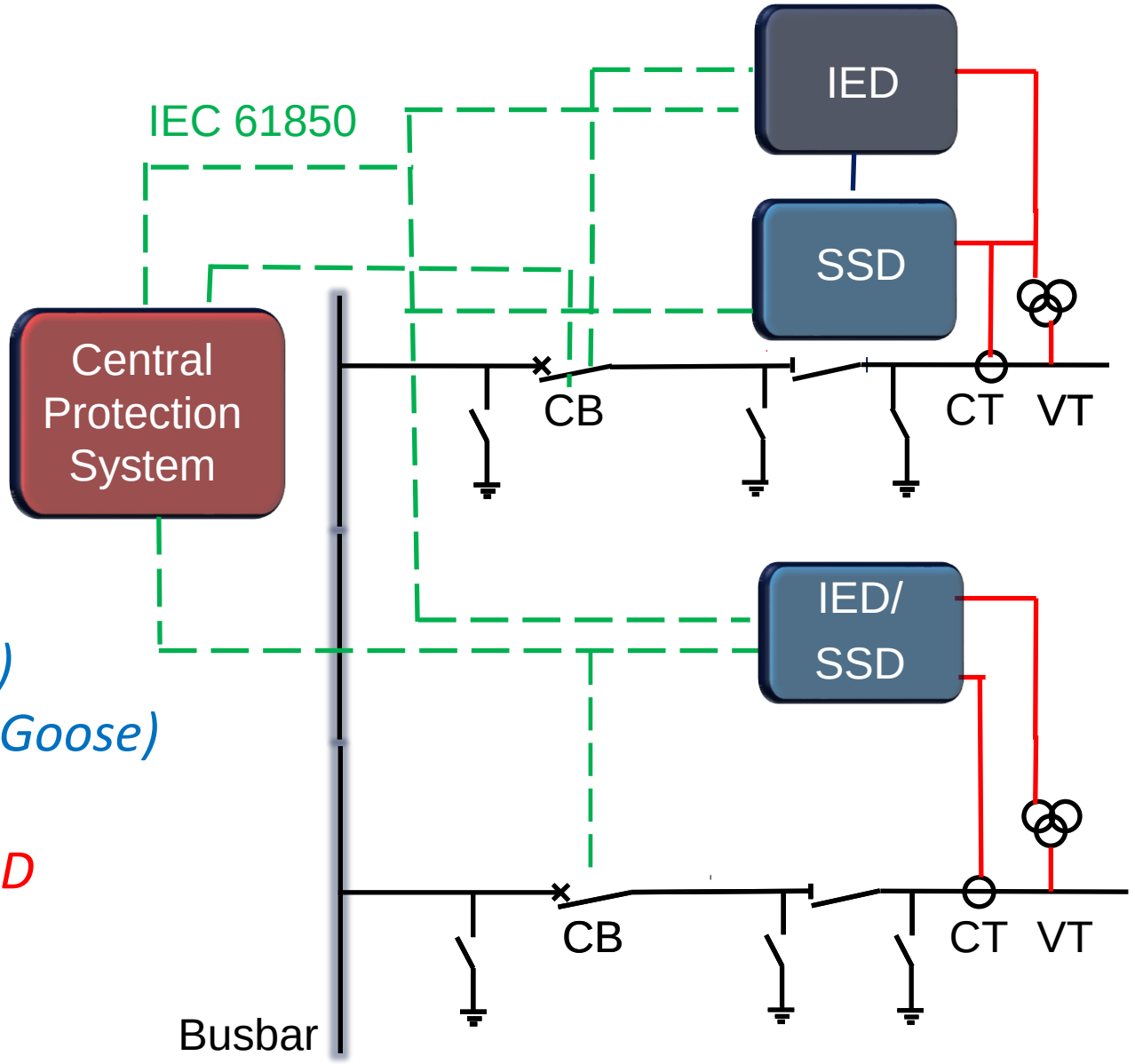
- Current Transformer, CT
- Voltage transformer, VT
- Control/Protection, IED
- Trip circuit
- Circuit Breaker, CB
- Supply



Protection concept

Centralized

- IEC 61850 standard
- Standard IED protection
  - *Detect and trip-output*
- Smart Sensor Device (SSD)
  - *PMU (Symmetrical components)*
  - *Merging Unit (Sampled Values, Goose)*
- Central Protection System
  - *Communication with IED and SSD*
  - *Higher performance, back-up*



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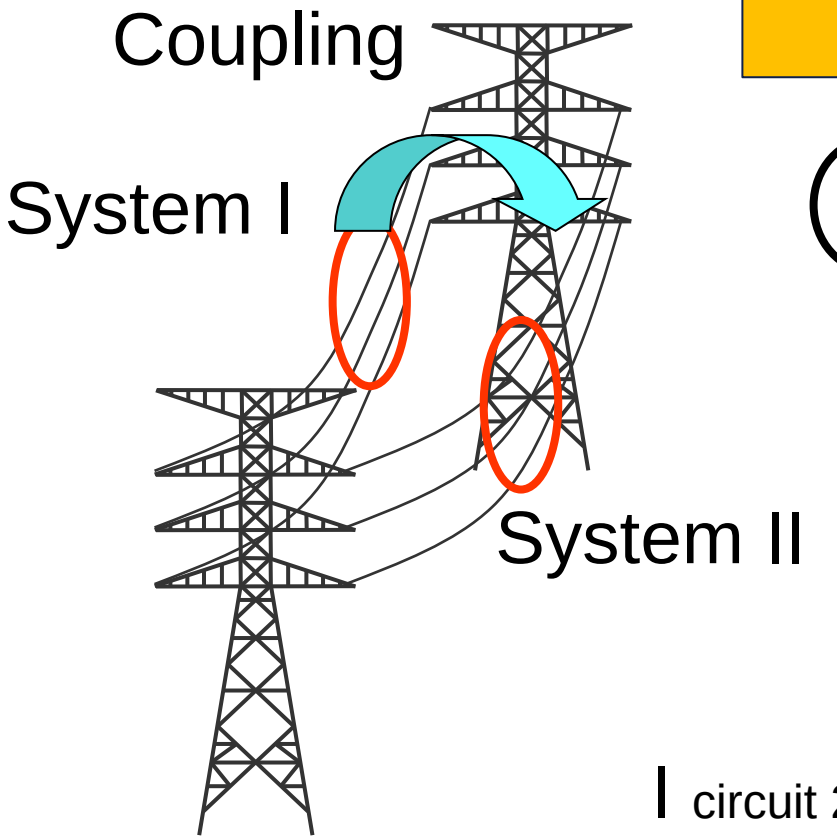
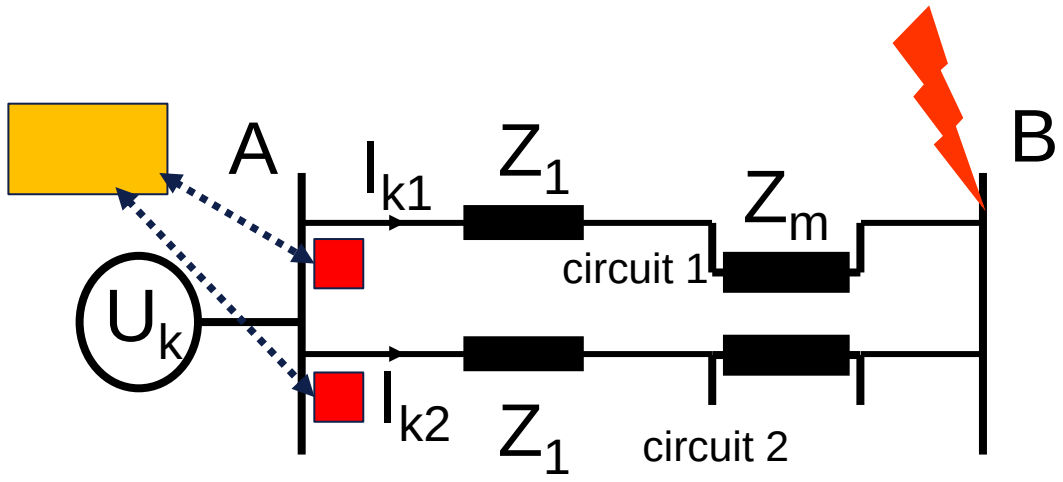
Challenges AC

- Mutual coupling (2-4 circuits)
- Substations with short distance
- DER integration

Challenges AC (Distance protection)

AC mutual coupling





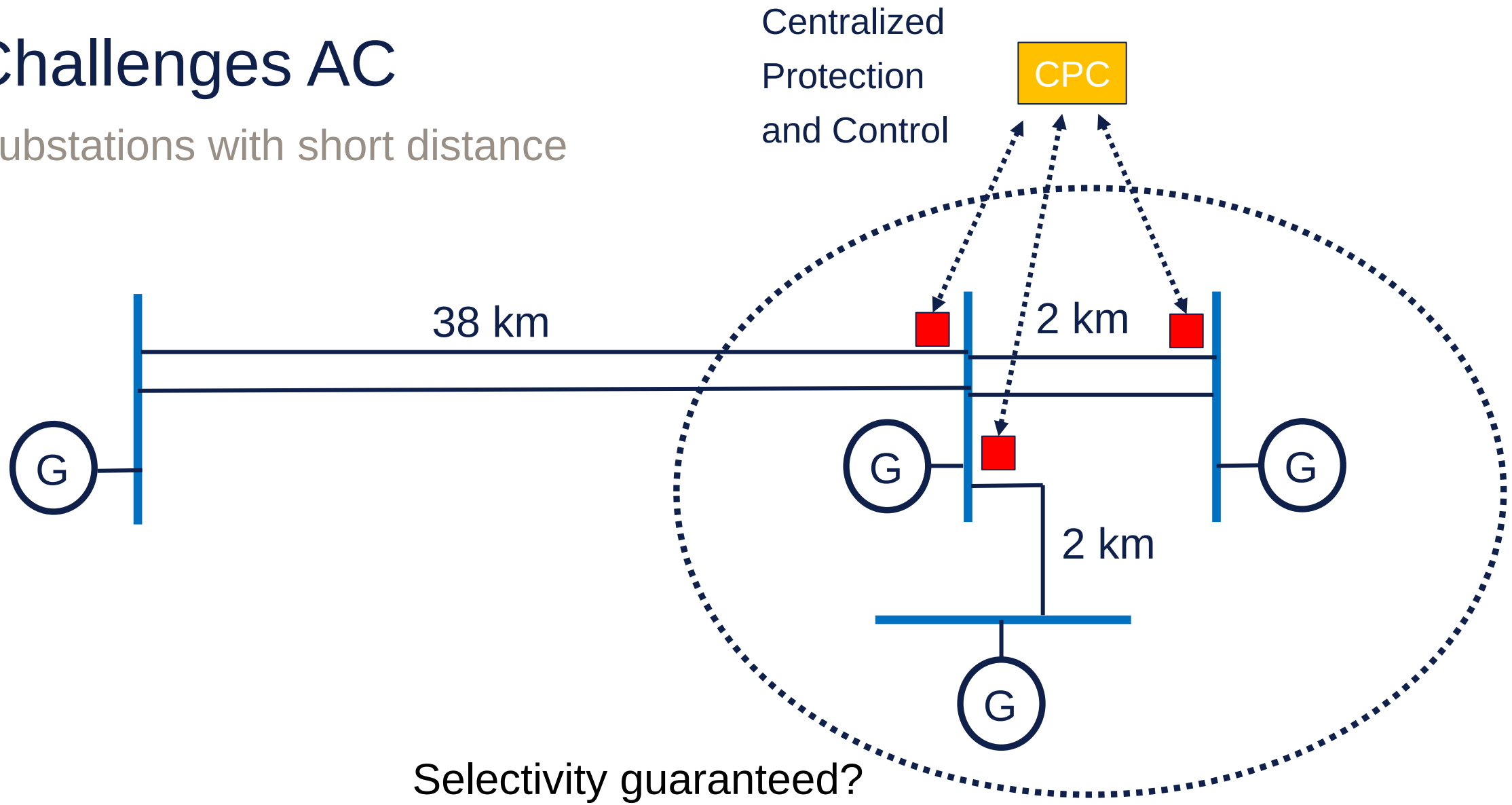
$$U_k = I_{k1} \bullet Z_1 + I_{k2} \bullet Z_m$$

$$U_k = I_{k2} \bullet Z_1 + I_{k1} \bullet Z_m$$

I circuit 2	$I_{k2} = I_{k1}$	$I_{k2} = 0$	$I_{k2} = - I_{k1} Z_m / Z_1$
Z measured	$Z_1 + Z_m$	Z_1	$Z_1 - Z_m^2 / Z_1$

Challenges AC

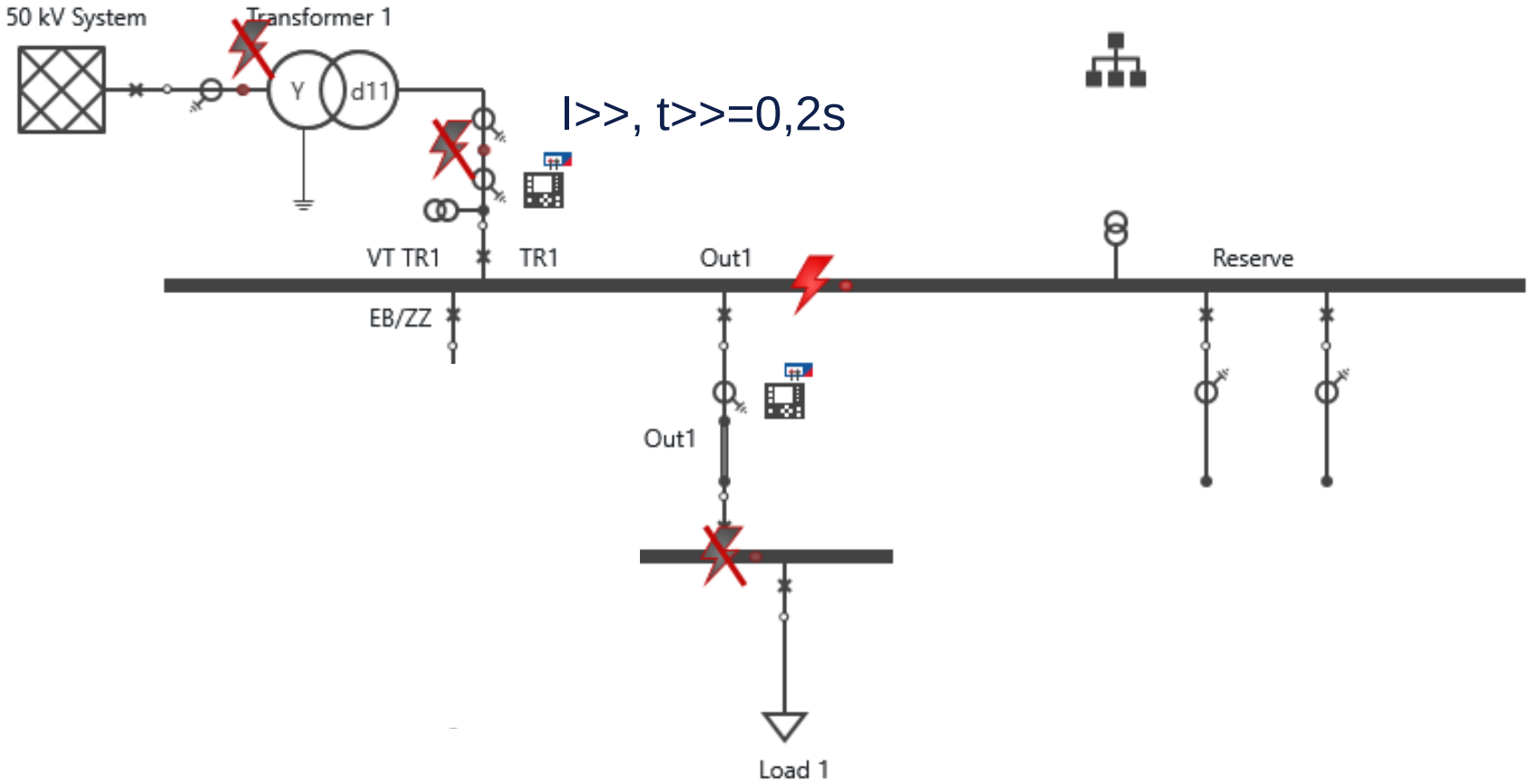
Substations with short distance



Selectivity guaranteed?

Challenges AC

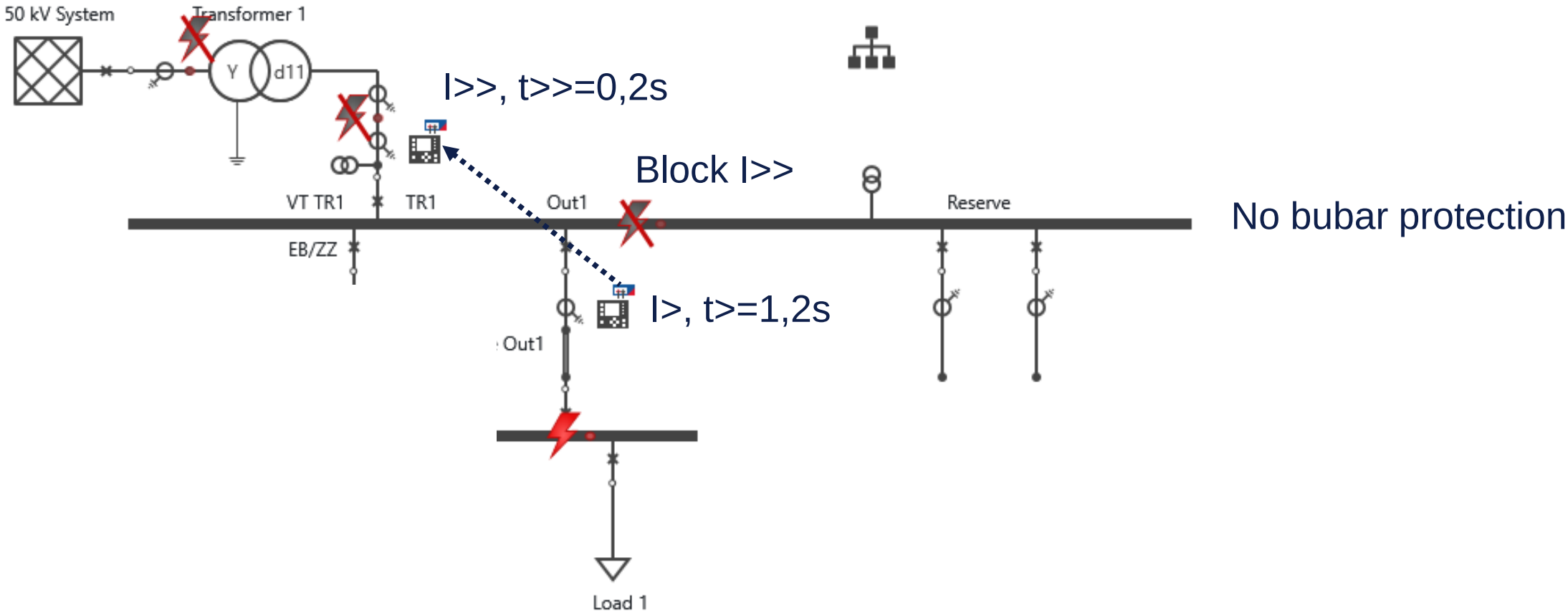
AC DER infeed Distribution grid



No bubar protection

Challenges AC

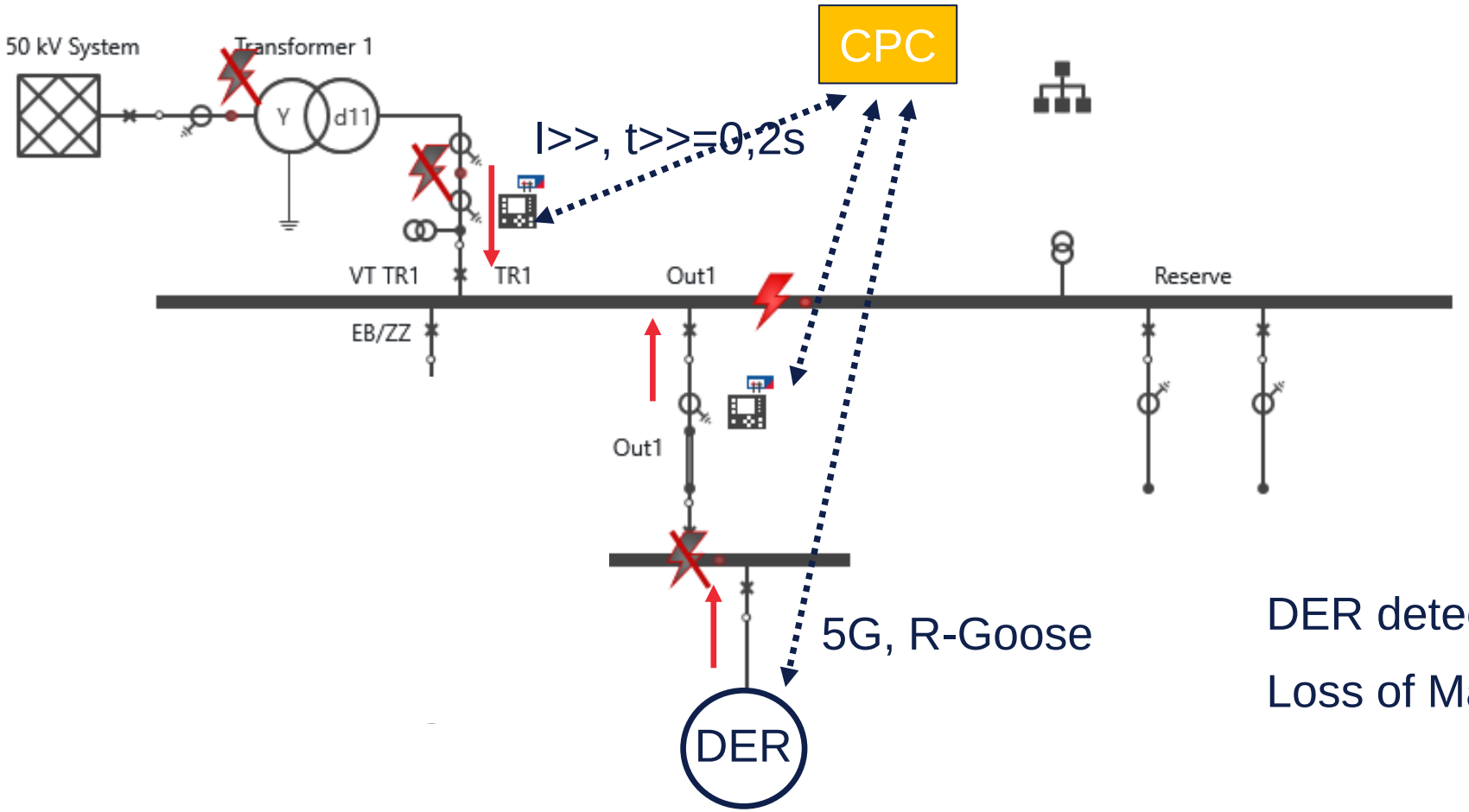
AC DER infeed Distribution grid



No bubar protection

Challenges AC

AC DER infeed



DER detected?

Loss of Main?

Challenges DC

DC full selecticity

Kees Koreman chairman JWG B4/B5.59 Webinar 15 November 2018

Challenges DC

DC full selecticitive fault clearing strategy

- Each branch in the HVDC grid is a separate protection zone
- The faulted branch is isolated from the other zones by HVDC circuit breakers in the faulted branch
- The faulted branch is immediately identified

Challenges DC

DC full selecticitive fault clearing strategy

Rate-of-Change:

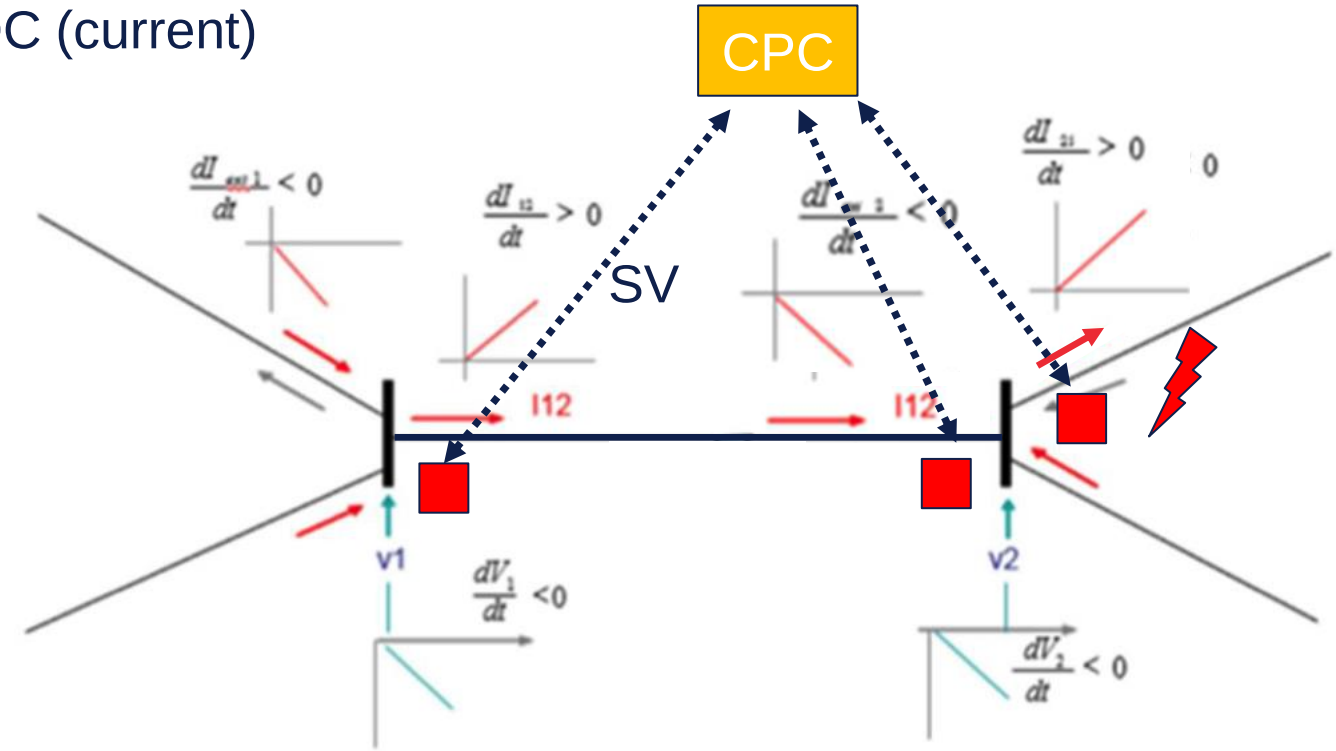
Combining ROCOV (Voltage) and ROCOC (current)

Calculation of

- ROCOV in the connection point
- ROCOC in the connections

Sign of ROCOV and ROCOC

- Different indicates the faulted section
- Equal indicates fault outside zone



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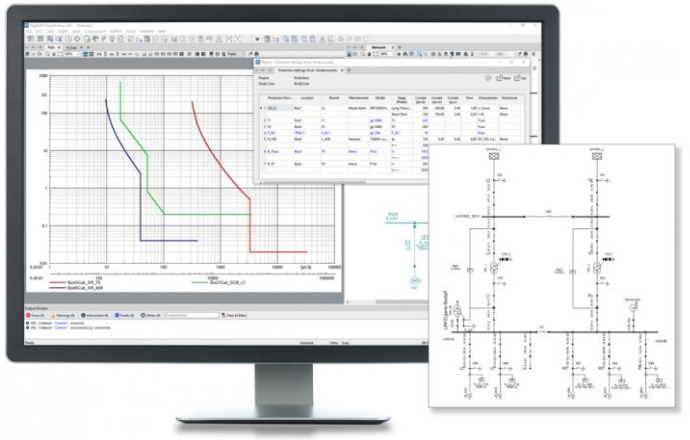
System test concept IEC 61850

Relay Sim Test (Omicron)

Simulated currents and voltages

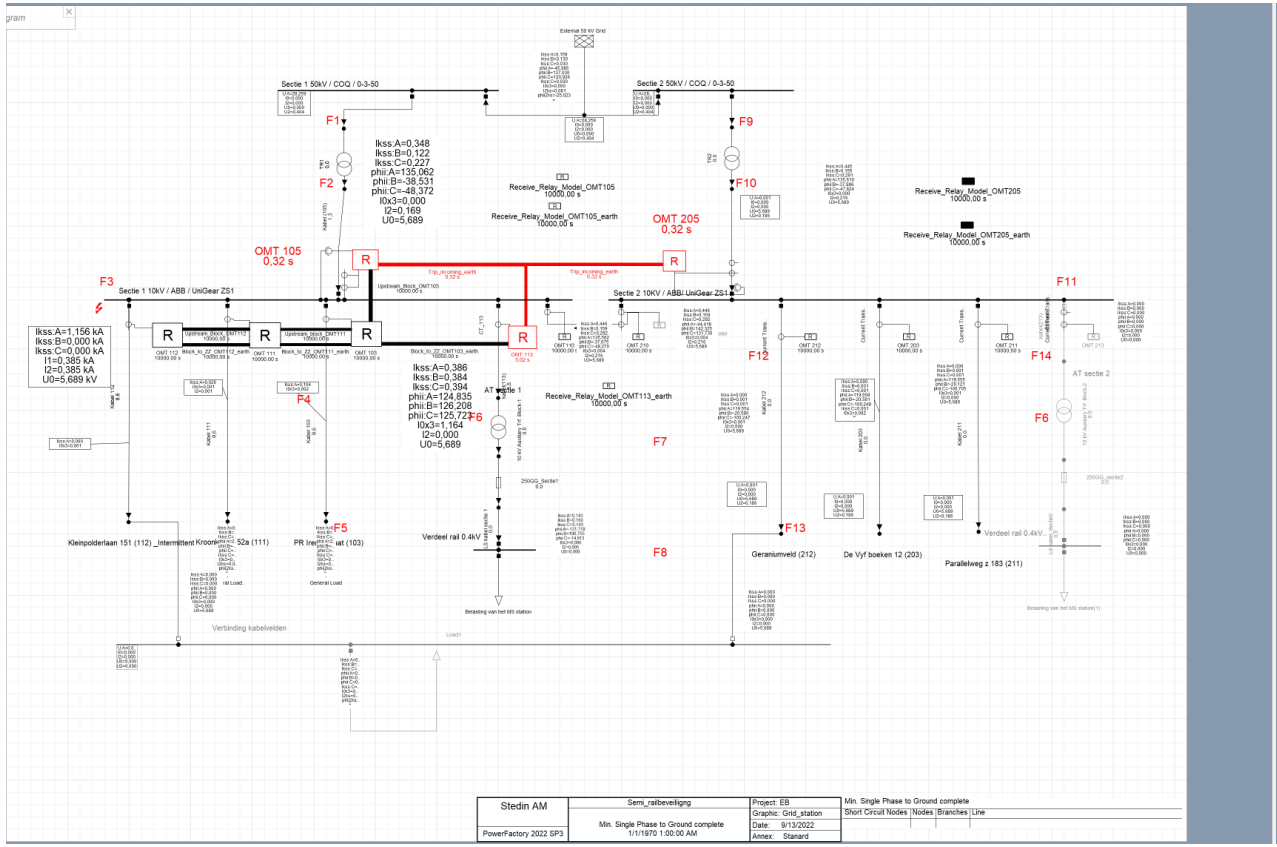
Comtrade files

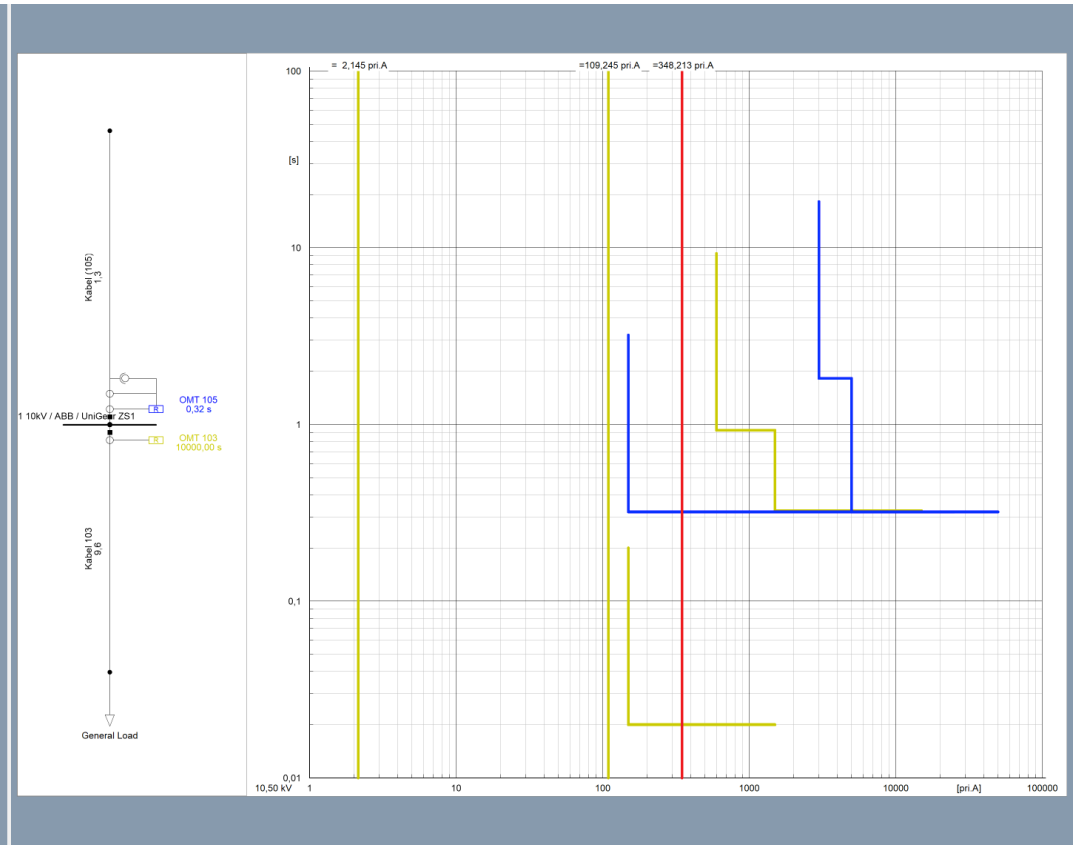


PowerFactory (DIgSILENT)
Test Universal (Omicron)

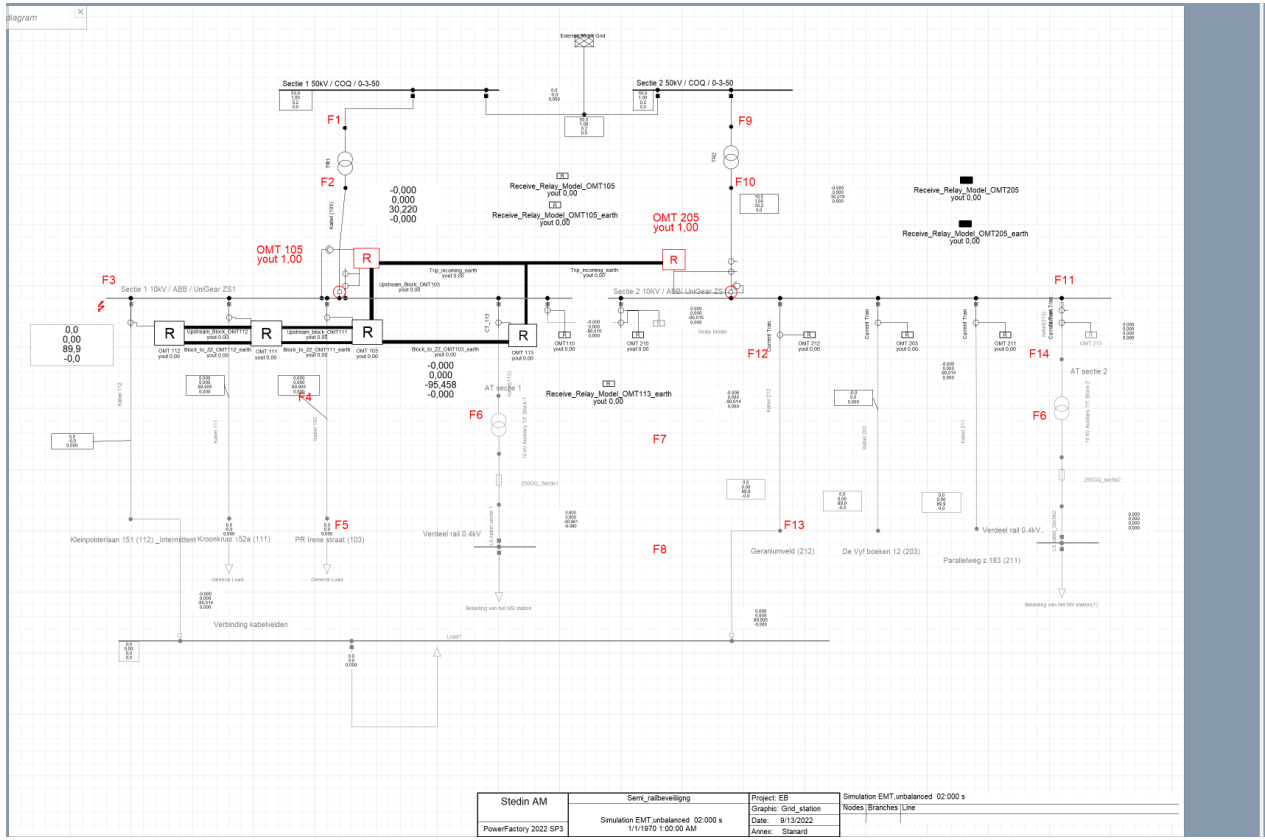
Analogue currents and voltages, Sampled Values, Goose messages

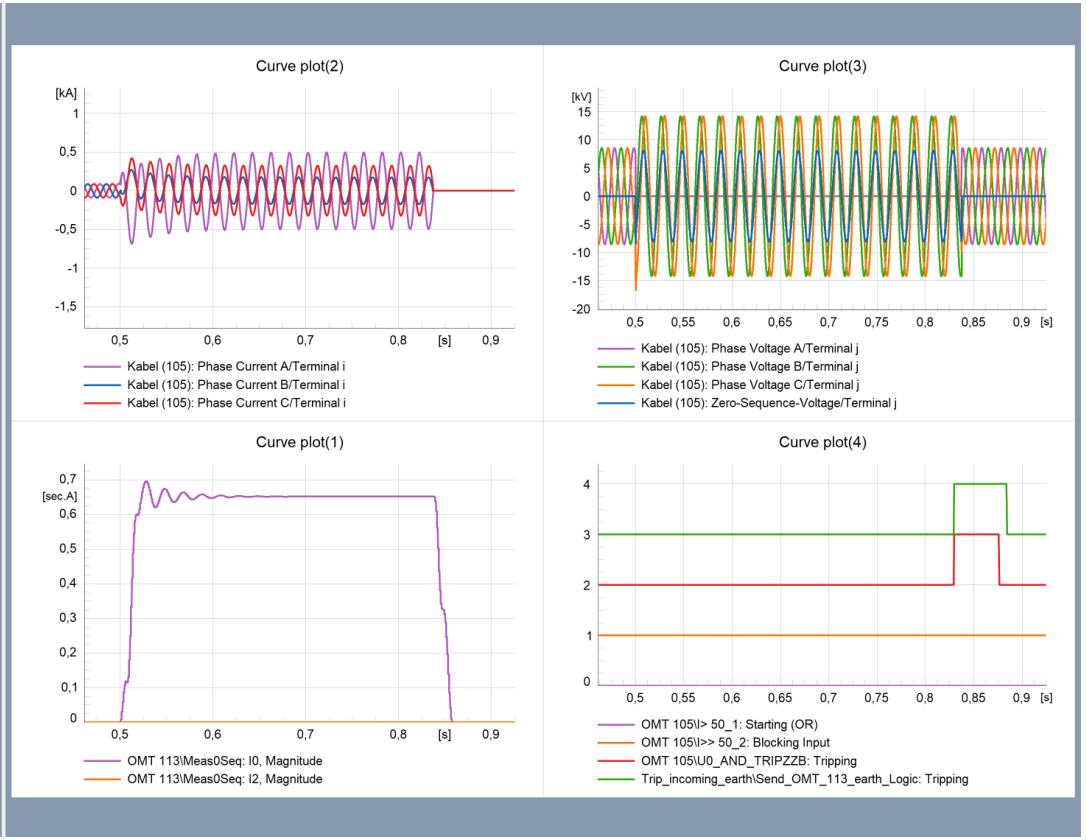
One-phase FAULT using Time-overcurrent plot in PowerFactory



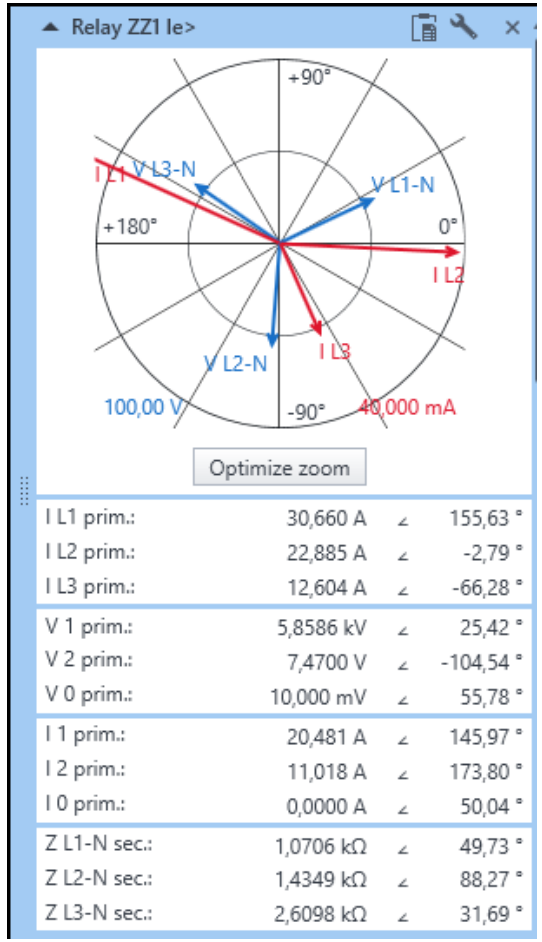


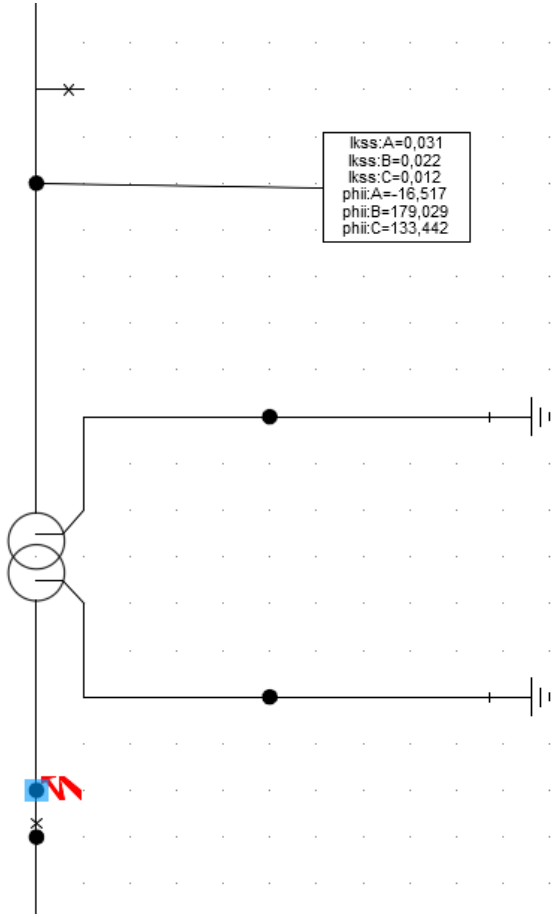
One-phase fault using EMT in PowerFactory





Validation Relay Sim Test and PowerFactory





Both PowerFactory (DIgSILENT) and IEC 61650 system test provide similiar behaviour of the currents and voltages

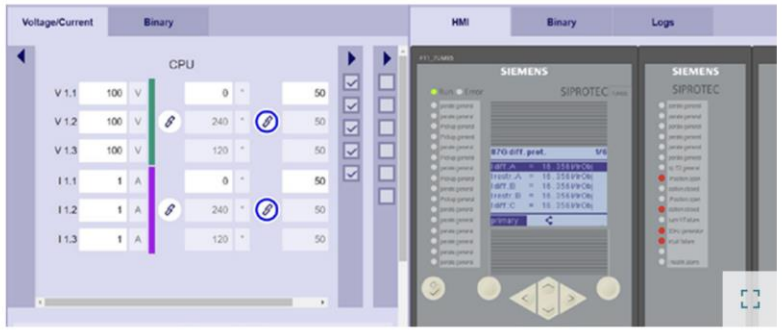
Example: IEC 61850 system test

Digital Twin Siemens and RST

Functions

Testing of the device

- Injection of static currents and voltages
- Simulation of binary inputs and analog units
- Device operation (display, LED, CFC)

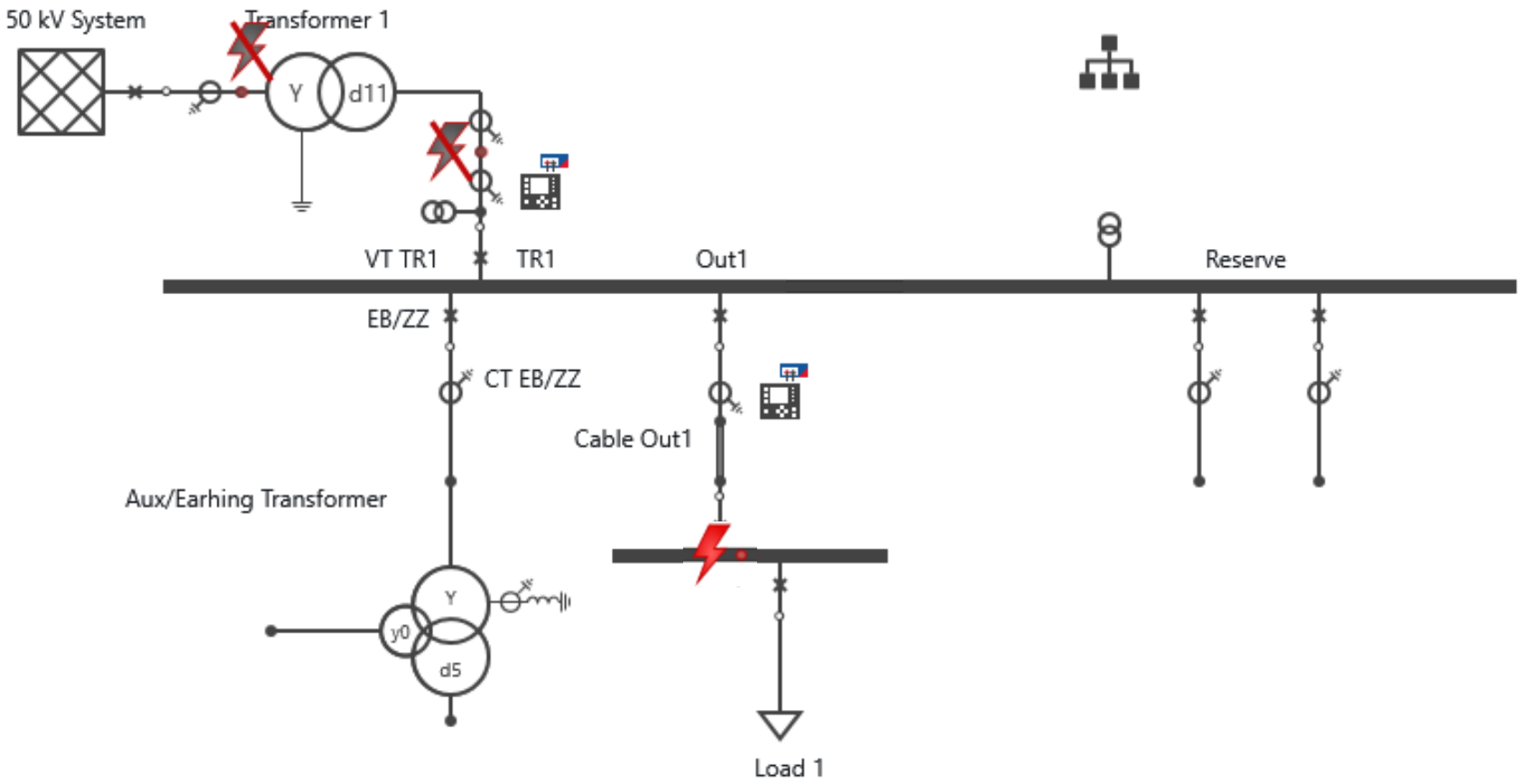


Protection testing

- With static inputs
- With COMTRADE replay
- With state sequencers

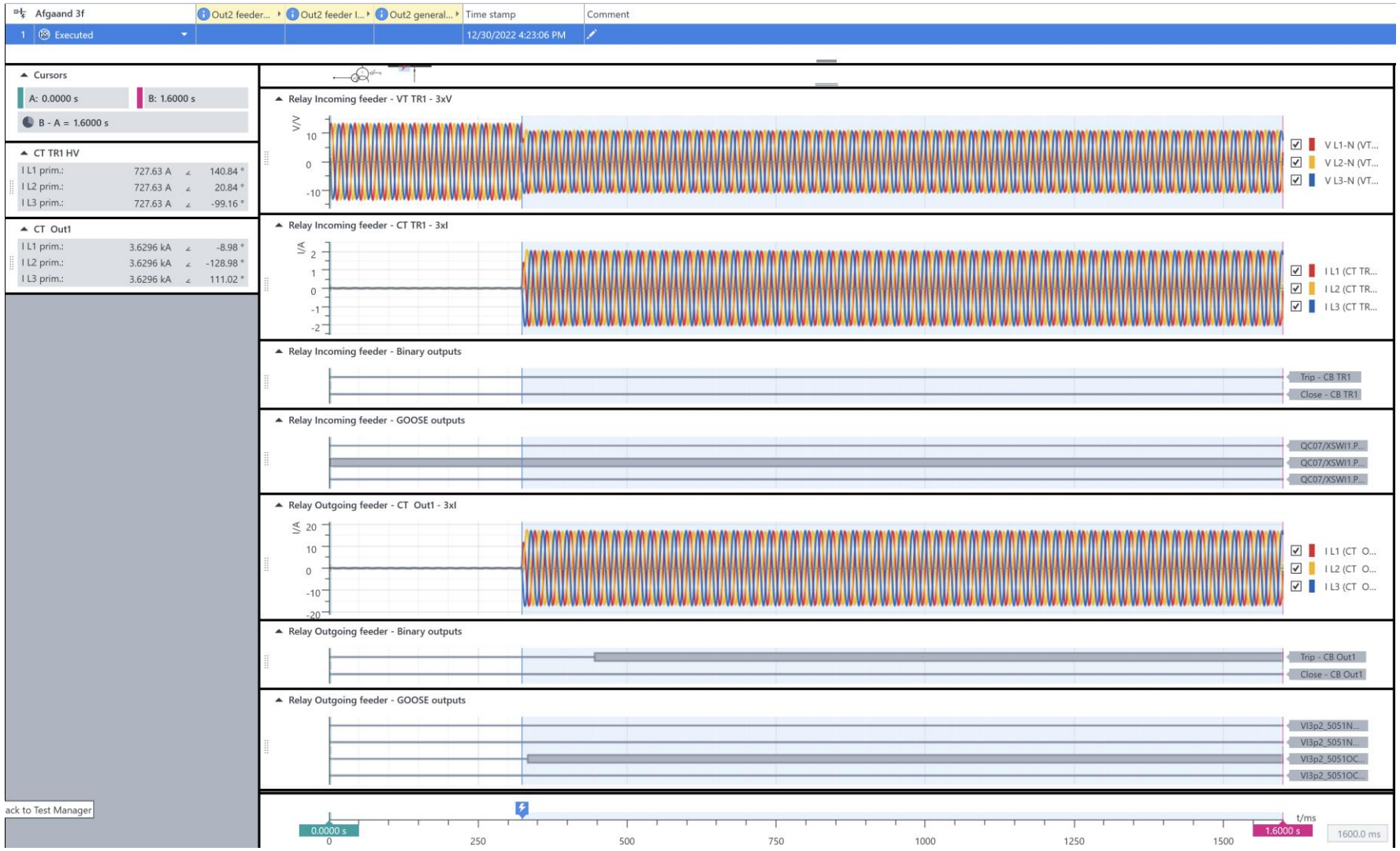
Relay Sim Test,

Digital Twin



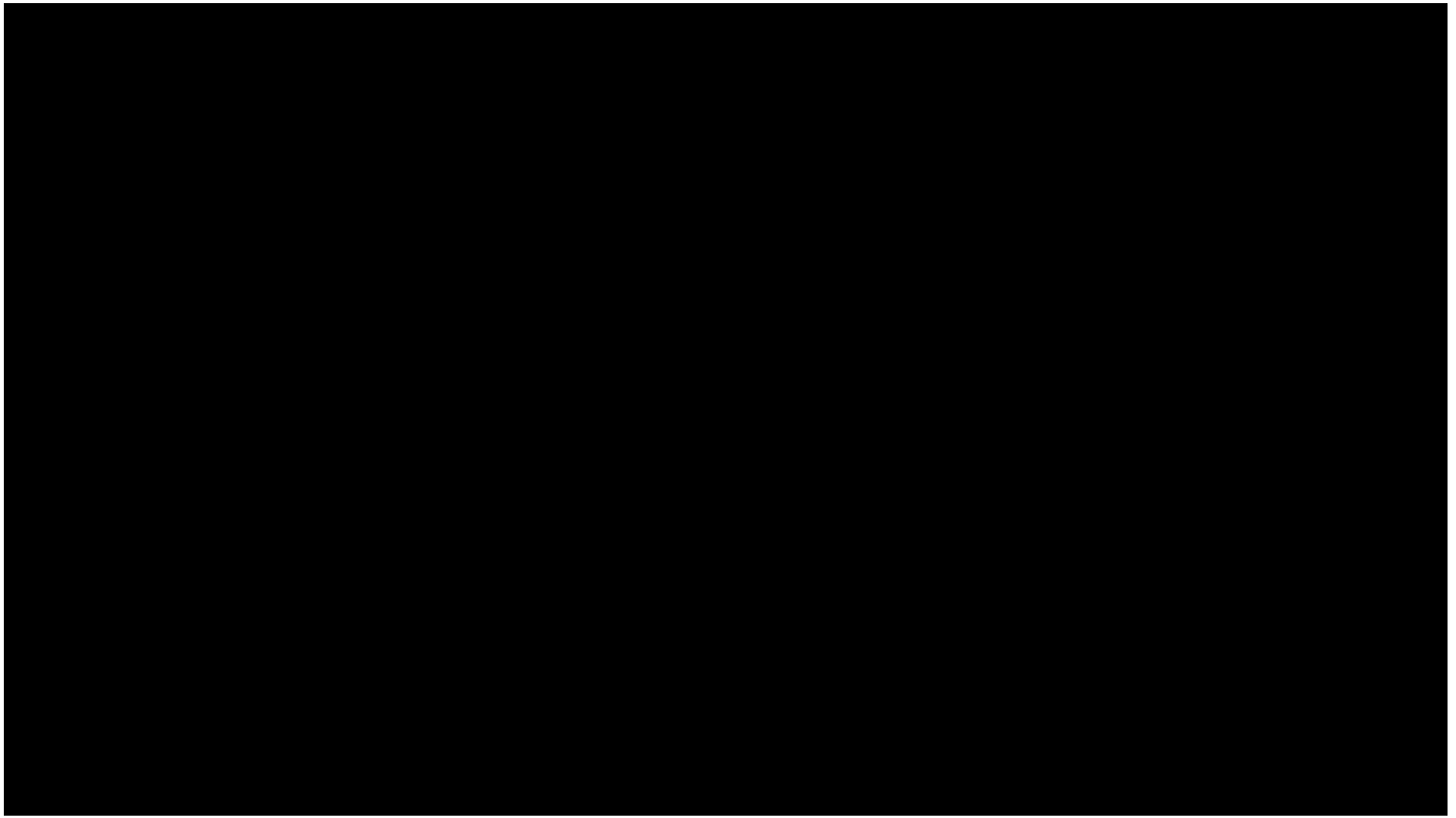
Relay Sim Test, three phase fault outgoing feeder

Digital Twin



Relay Sim Test, short circuit outgoing feeder

Digital Twin



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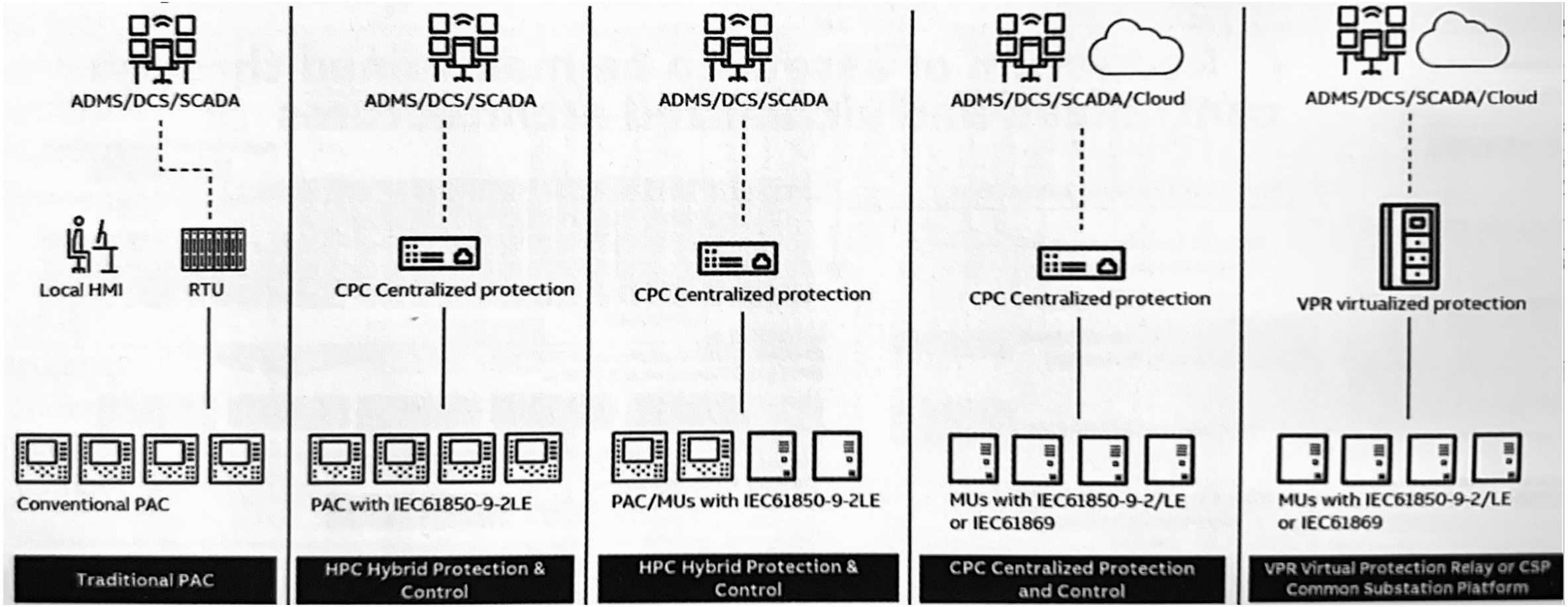
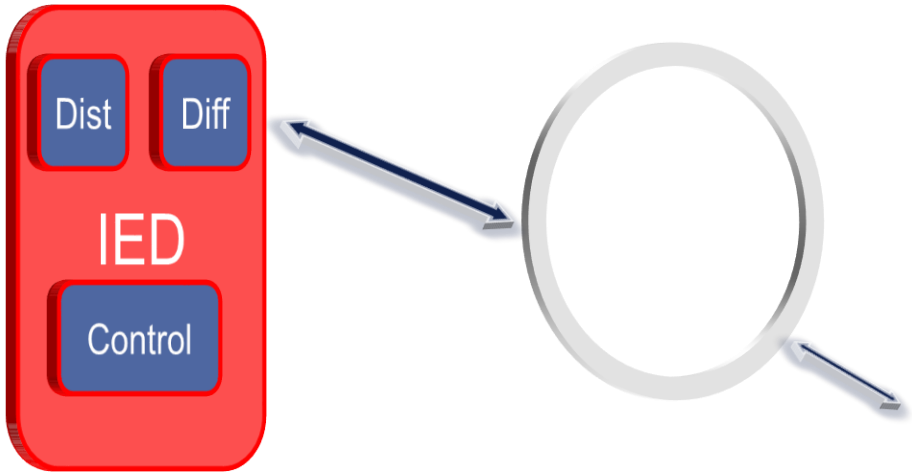
STEPWISE APPROACH IN CENTRALIZED & VIRTUALIZED ARCHITECTURES



DEVELOPMENT SUPPLIERS: VIRTUAL system

Standard IED



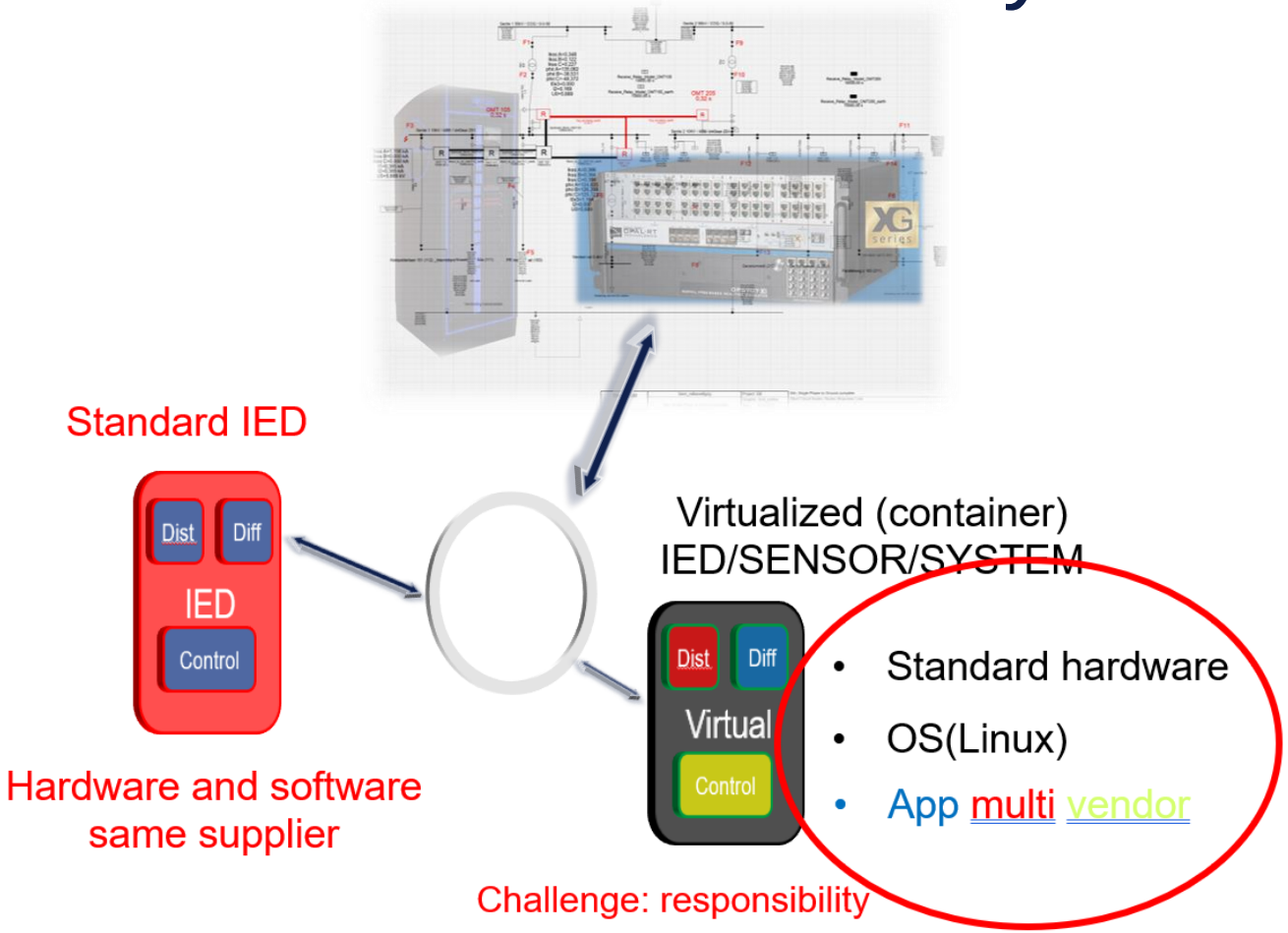
Hardware and software same supplier

Virtualized (container) IED/SENSOR/SYSTEM

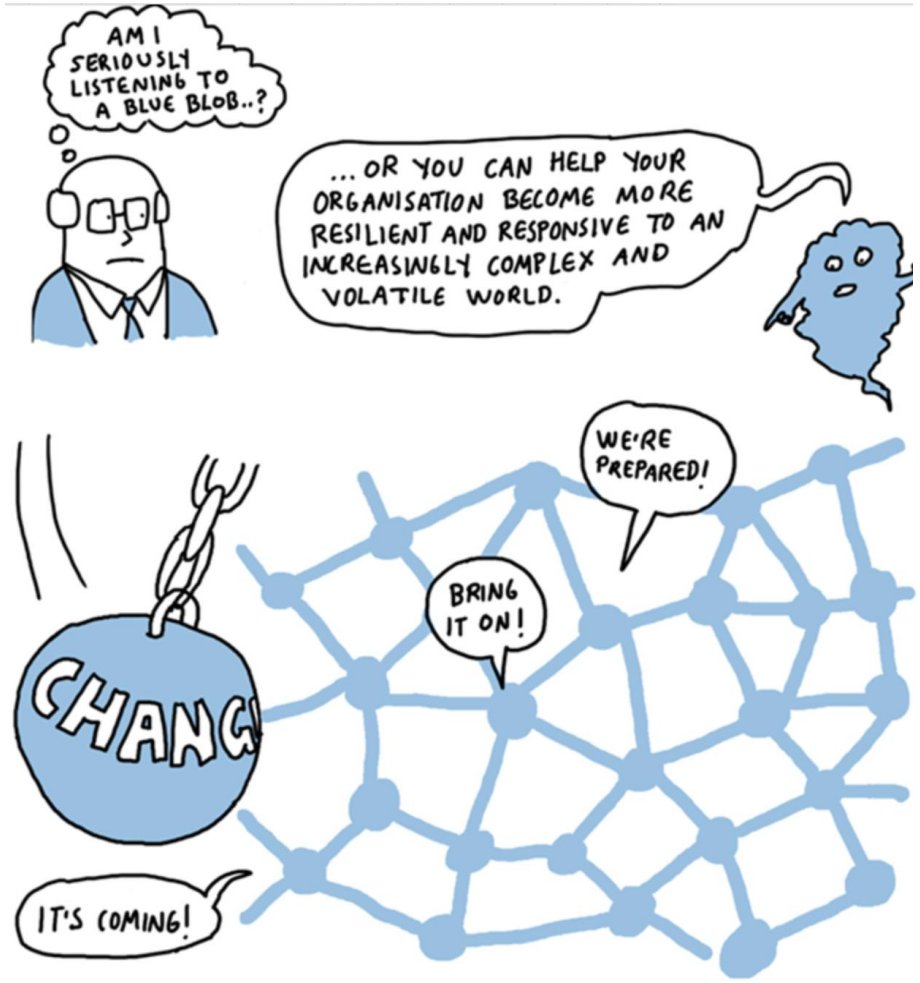
- Standard hardware
- OS(Linux)
- App multi vendor

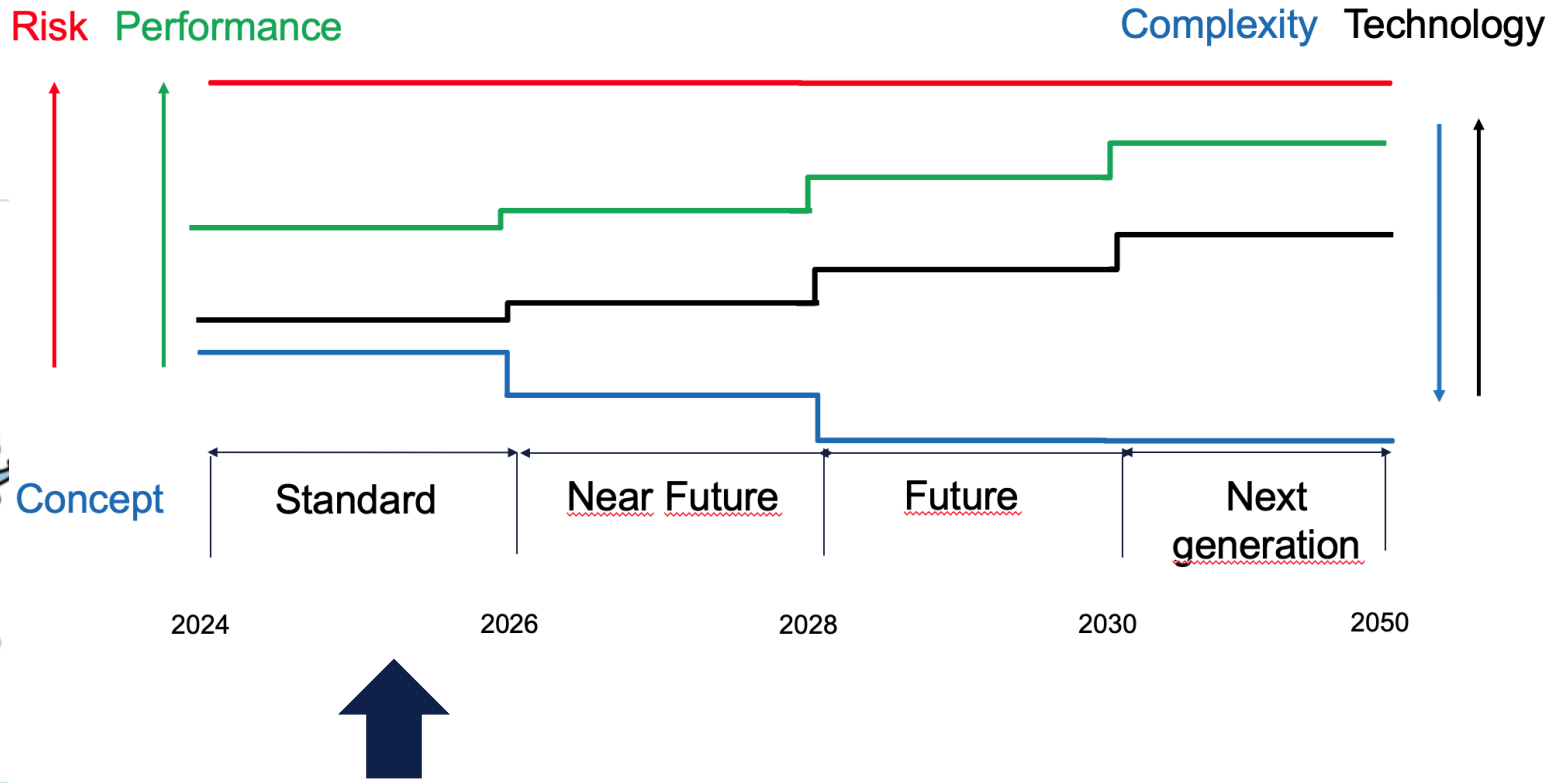
Challenge: responsibility

DEVELOPMENT DNV:
RT Test lab VIRTUAL/DIGITAL system



Wrap up





Centralized protection:

When/Where will this be implemented?

Thank you!

More information:
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