## B5 - Protection & Automation
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The rise of the Digital Twin applications
from a single protection device to full digital substations

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Motivation

- Higher flexibility in existing power grids require adaptions of protection systems.

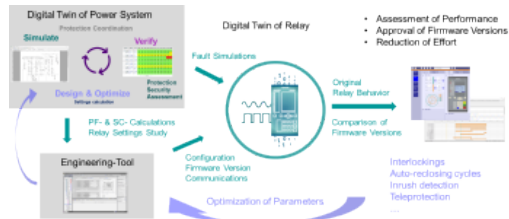- New methods for agile testing and approvals are even more needed.
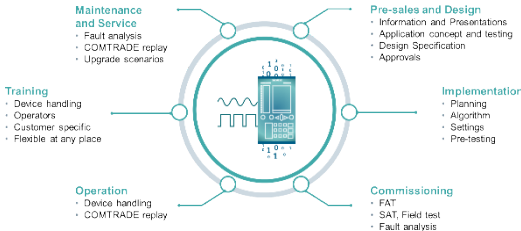
"Digital Twins of devices give protection engineers the ability to configure all relevant parameters, communication protocols, and to test different aspects like communication mapping and reactions of protection devices before they are mounted in the field."

Use Cases in Protection & Automation

1. Configuration and Parameter Testing.

2. Selectivity and Performance Testing.

   a. Protection of three terminal lines with distance protection and tele-protection scheme: POTT, PUTT, weak infeed, etc.
      => analysis of different timings

   b. Testing of adaptive schemes: adaptive auto-reclose with recovery voltage detection
      => analysis of complex functionalities

   c. Testing of additional functions: e.g. inrush detection
      => analysis of blockings and specific functionalities

3. Training of staff

Benefits and limitations of Digital Twin in case of protection system analysis

"The Digital Twin comes with extremely high model accuracy, because the original, vendor-specific firmware and protection algorithms are implemented in it."

Tension triangle to compare different methods

SIL = Software in the Loop
HIL = Hardware in the Loop

- Selectivity
- Configuration and Parameters
- Pick-up and Tripping Behavior
- Performance
- Communication

Accuracy Level

- Physical Phenomena
- System Approval
- Dedicated Function

Effort

- Simulation
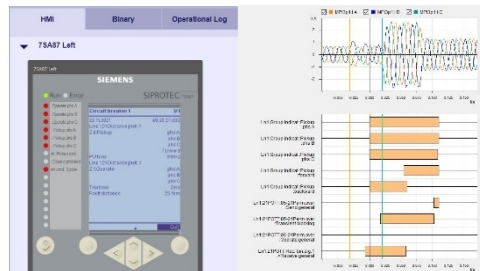- Hardware Laboratory
- Experts + Equipment

Proposed Workflow for Protection System Analysis and Approval

- Combination of simulation software with Digital Twin devices reduces effort in testing equipment

- Communication protocols are utilized in Digital Twin environment

- Fault cases will be simulated in software and tested within Digital Twin environment

Use Case – Software Open Loop Test with Digital Twin

- Analysis of a 380 kV double circuit line with tele-protection POTT via protection interface
  => testing of transient blocking during current reversal

- Parameterized transient blocking is verified in Digital Twin analysis by utilizing COMTRADE export of simulation software

- Protection experts can use fault records and trip logs for detailed root cause analysis and optimization
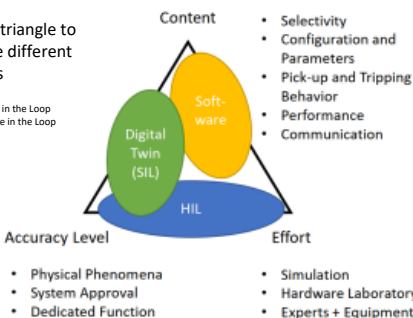

Conclusion

- Digital Twins of protection and automation devices fill the upcoming gap of testing facilities for digital substations.

- The virtualization of devices will play a significant role in the future, projects can save costs, speed-up, and uncertainties can be reduced before starting commissioning in the field.