HYBRID TESTING OF POWER SYSTEM PROTECTION COMMUNICATION OVER WIRELESS 5G

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USER SPOTLIGHT SERIES 2.0 BY RTDS Technologies

OVERVIEW

- Introduction to VTT
- Motivation
- Introduction to the topic
- Methodology
- Results
- VTT as research partner

VTT – *BEYOND THE OBVIOUS*

VTT is a visionary research, development and innovation partner for companies and the society.

We bring together people, business, science and technology to solve the biggest challenges of our time. This is how we create sustainable growth, jobs and wellbeing and bring exponential hope.

244 M€
turnover and other operating income

2,129
employees

45%
of the net turnover from abroad

32.5%
a doctorate or a licentiate's degree

Established in
1942

Owned by Ministry of Economic Affairs and Employment

VTT RESEARCH ACTIVITIES

5G and beyond in critical communication

Smart Grids

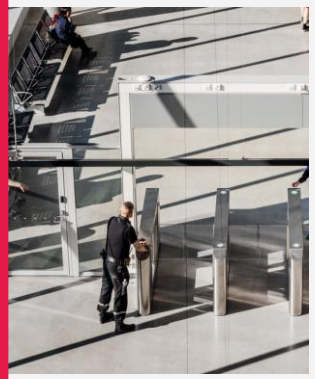
Mobility and Smart City

Control

Smart Grid

Protection

Port Automation



Cybersecurity

Next Generation Mining

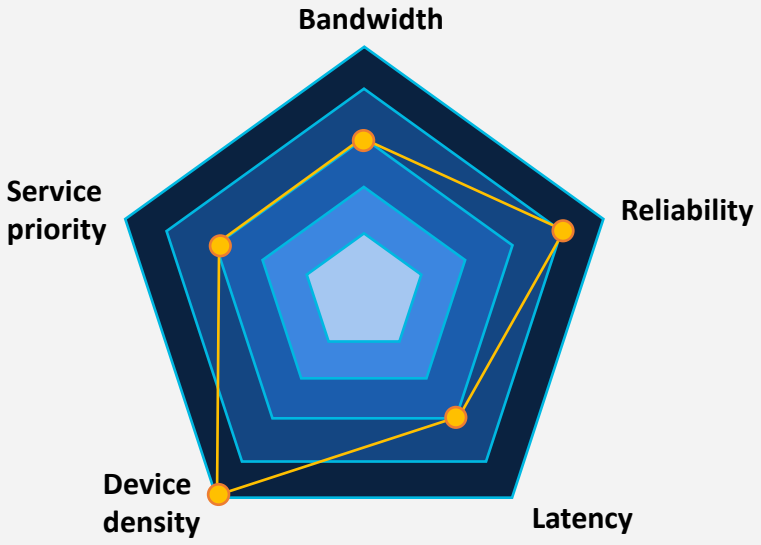
AI applications

WIRELESS COMMUNICATION FOR POWER SYSTEM

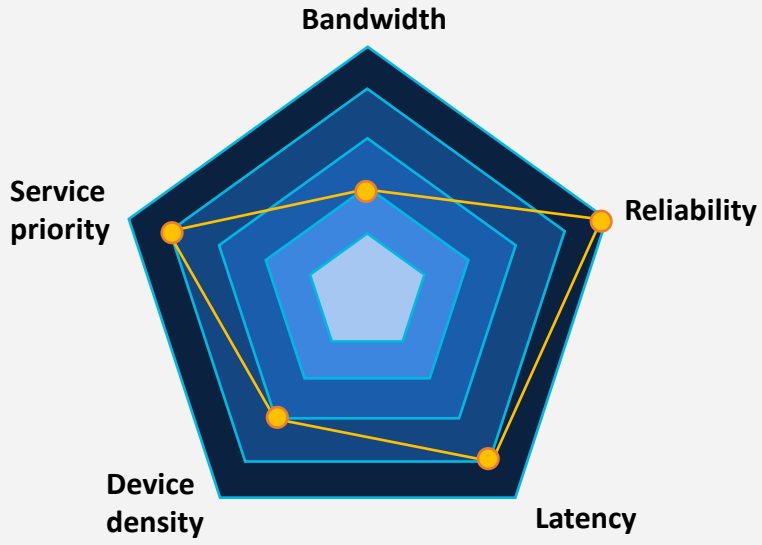
- Enables digitalisation of power system without additional cost of wired installations
  - No underground maintenance
- 2G/3G/4G cellular networks are largely used for remote control and monitoring
- 5G is seen compelling due to the promises for industrial cases
  - eMBB – more capacity
  - mMTC – more communicating devices
  - 5G URLLC – ultra reliable and low-latency communication
  - Network slicing – support for applications with different requirements
  - Edge computing – support for smarter solutions

POWER SYSTEM COMMUNICATION REQUIREMENTS

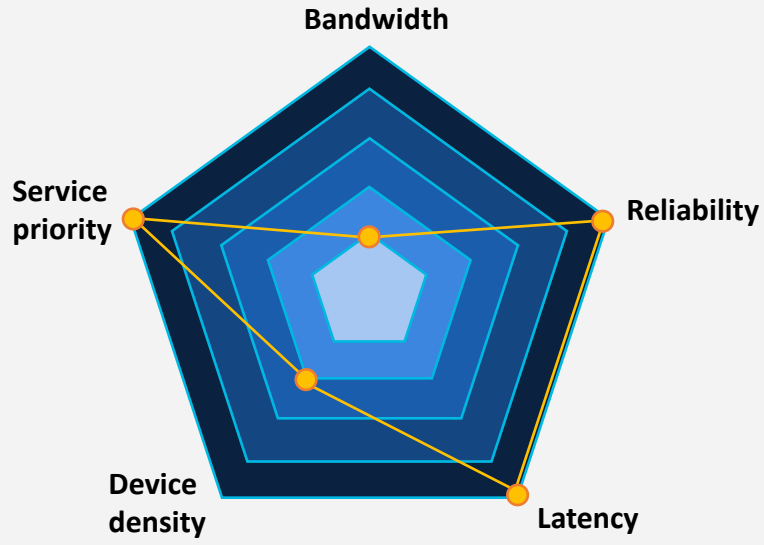
- Power system protection requires highly reliable and low-latency communication
  - Are wireless technologies capable of providing this?



Monitoring



Control



Protection

HYBRID PILOT ENVIRONMENT

- For testing wireless communication in power system protection
- Development and testing of wireless communication technologies on power system protection communication
- Validation and verification of products and services by power system and telecommunication component manufacturers, communication providers and utilities
- Realistic pilot environment for pre-testing before full-scale implementation and roll-out

PRIOR SETUP AND NEEDED UPGRADES

- Upgrades needed
  - Testing of various protection functions
  - Testing of various wireless communication technologies via flexible interconnection between communication networks and power systems
  - Unlimited number of recurring tests
  - Remain as realistic as possible

Old experimental setup c. 2017

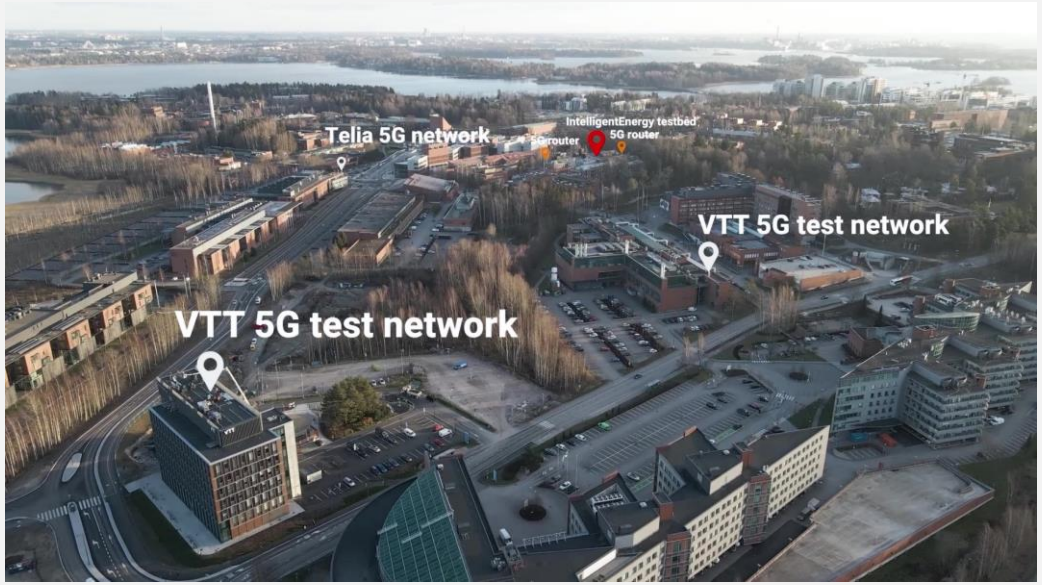
ADVANCEMENTS WITH RTDS

- Controller-Hardware-in-the-loop (CHIL) simulation
- Protection relays and merging units as Devices under Test (DuT)
- Increase in inputs and outputs for both analogue measurements and digital control and status signals
- Capability to test various protection functions
- Realistic power system in simulation
- Automated recurring tests
- Interconnection to 5G test network and commercial wireless networks
- Capability to test telecommunication equipment and operator services

Current experimental CHIL setup

COMMUNICATION TESTBED

- Supported by commercial and test 5G network infrastructures enabling, e.g. large scale trials, pre-commercial deployments, and testing beyond 5G products and services.
- Testing with different types of traffic using real devices, recorded data, traffic generators, and traffic emulation and shaping functions.
- Effects of different technologies, services, configurations, and routing solutions are investigated.

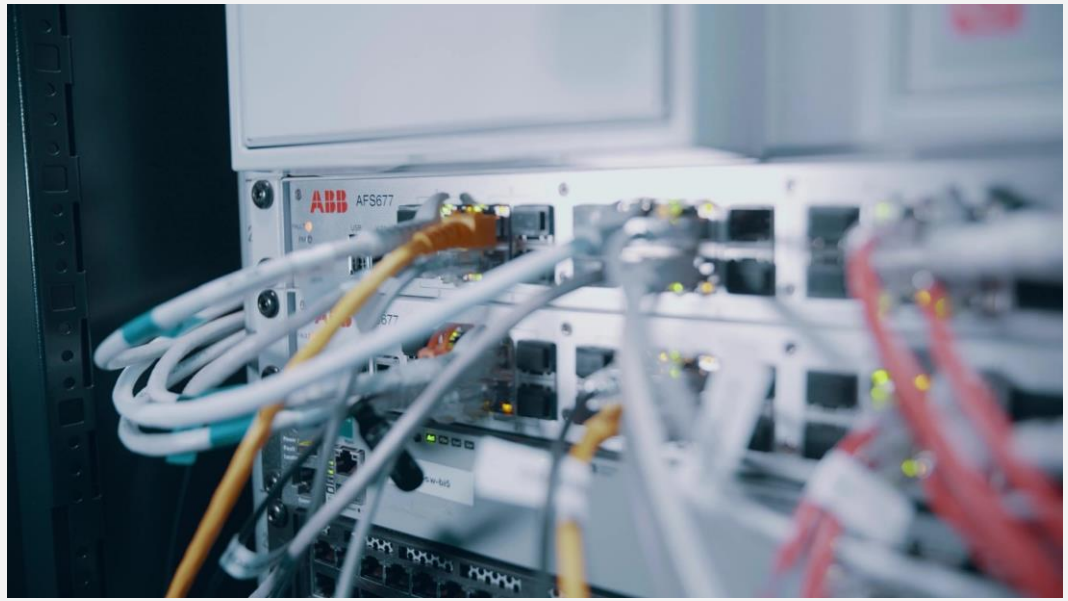


5G networks available in Otaniemi Campus, Espoo, Finland.

KPI METRICS FOR COMMUNICATION

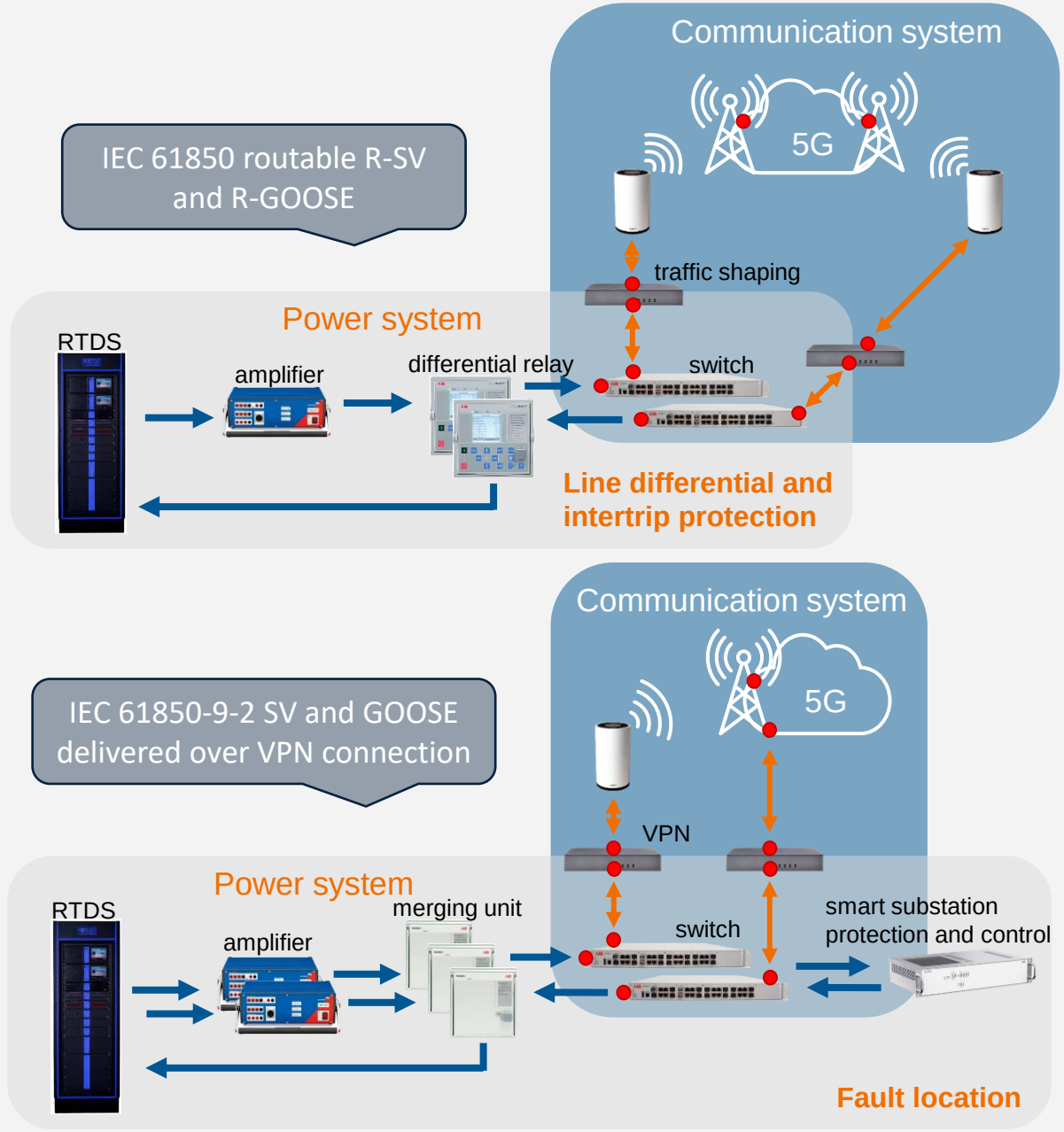
- Fixed and wireless communications, e.g.:
  - Maximum throughput
  - Load
  - Latency and jitter
  - Lost and malformed packets
  - Connection breaks, and downtime
  - Cell id, signal level, and quality

- Timing and synchronisation
  - Clock bias
  - Clock drift
  - Time accuracy

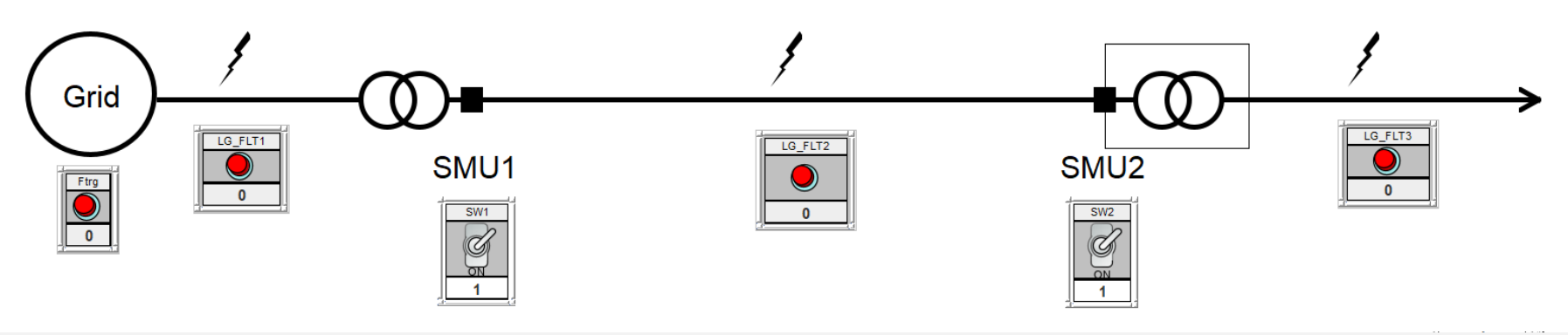


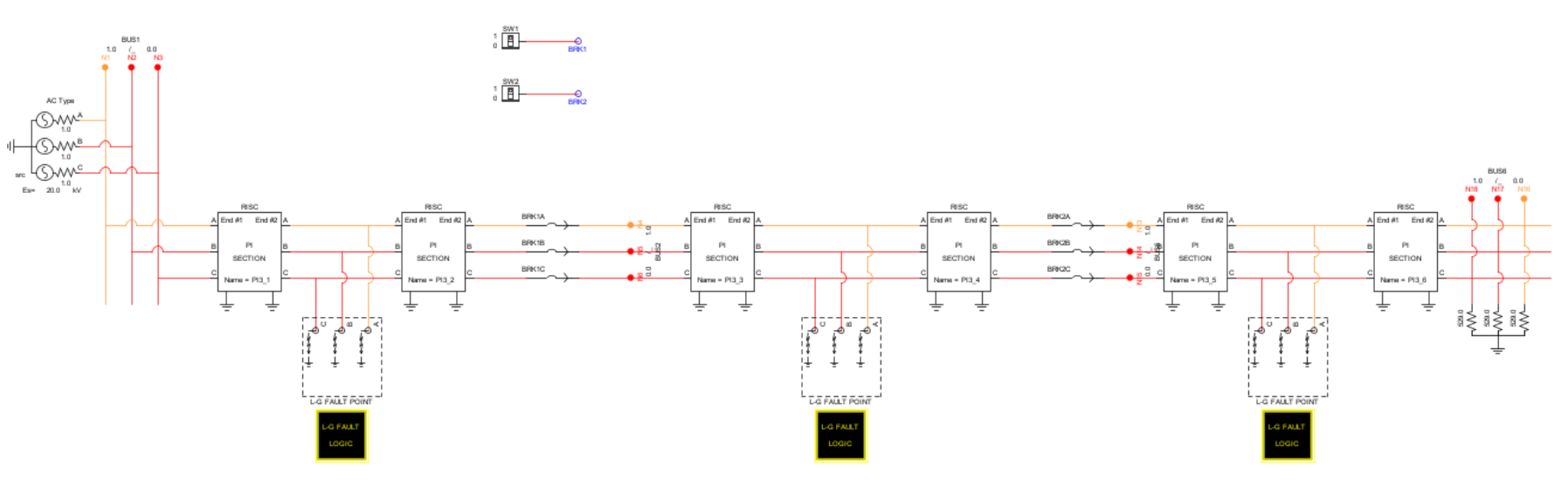
CHIL TESTBED

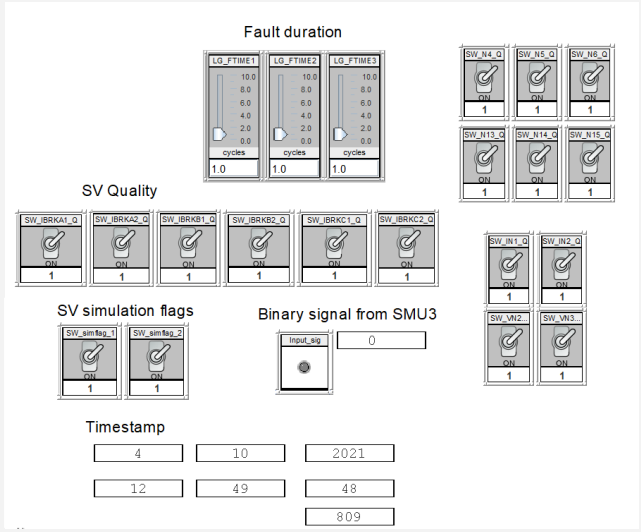
- The measurement testbed integrates communication and power system components.
- The testbed is used for studying the use of 5G for grid protection
  - Line differential protection
  - Intertrip protection
  - Fault location



RTDS CONFIGURATION





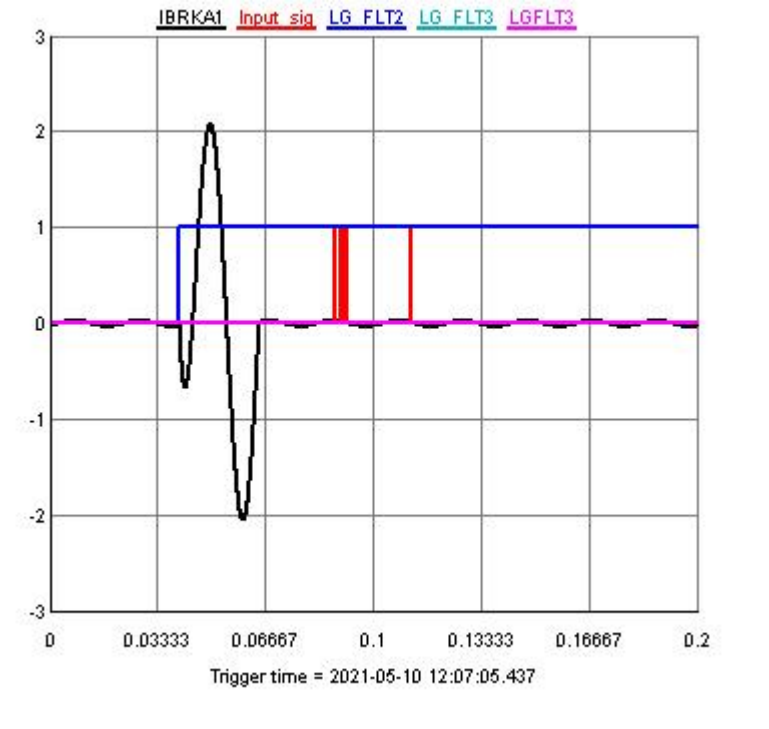


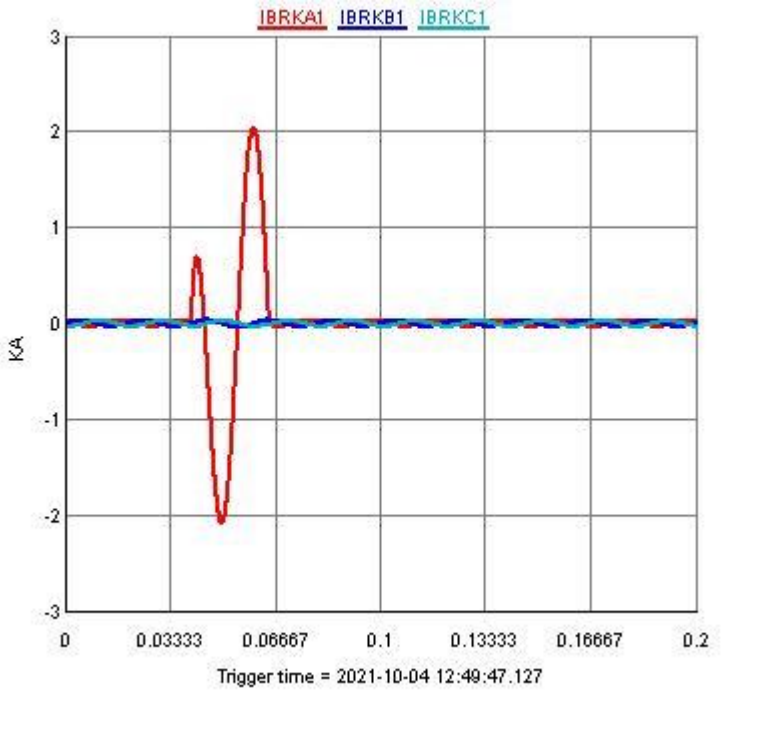
RESULTS

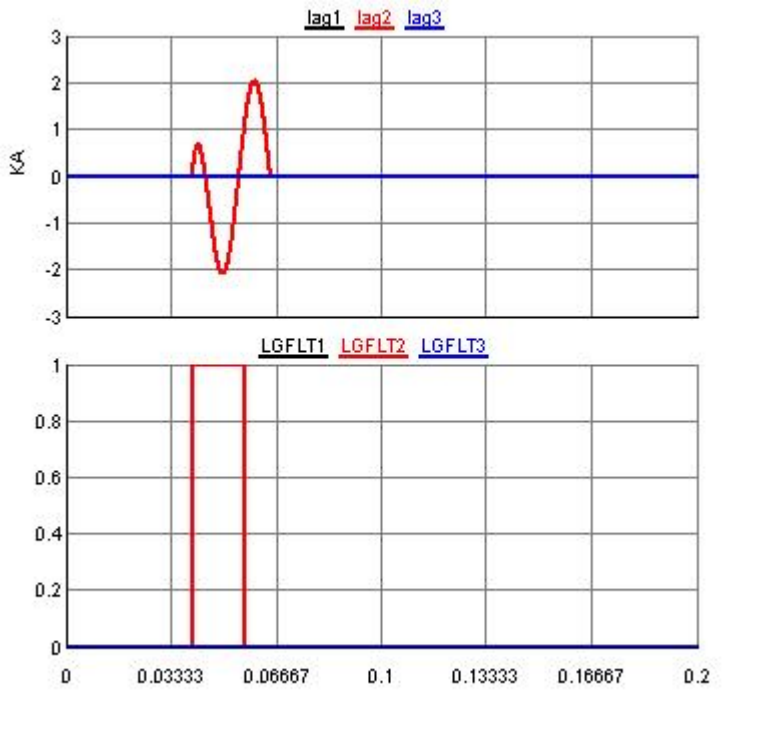
SSC600 > Programmable LEDs

Programmable LEDs

Description	Value
DPHHPDOC[1]_OPERATE	
DPHLPDOC[2]_OPERATE	
PHIPTOC[1]_OPERATE	
DPHHPDOC[2]_OPERATE	
DPHLPDOC[1]_OPERATE	
PHIPTOC[2]_OPERATE	
Q01 GOOSE ALARM	
Q01 PROCESS BUS ALARM	
Q02 GOOSE ALARM	
Q02 PROCESS BUS ALARM	

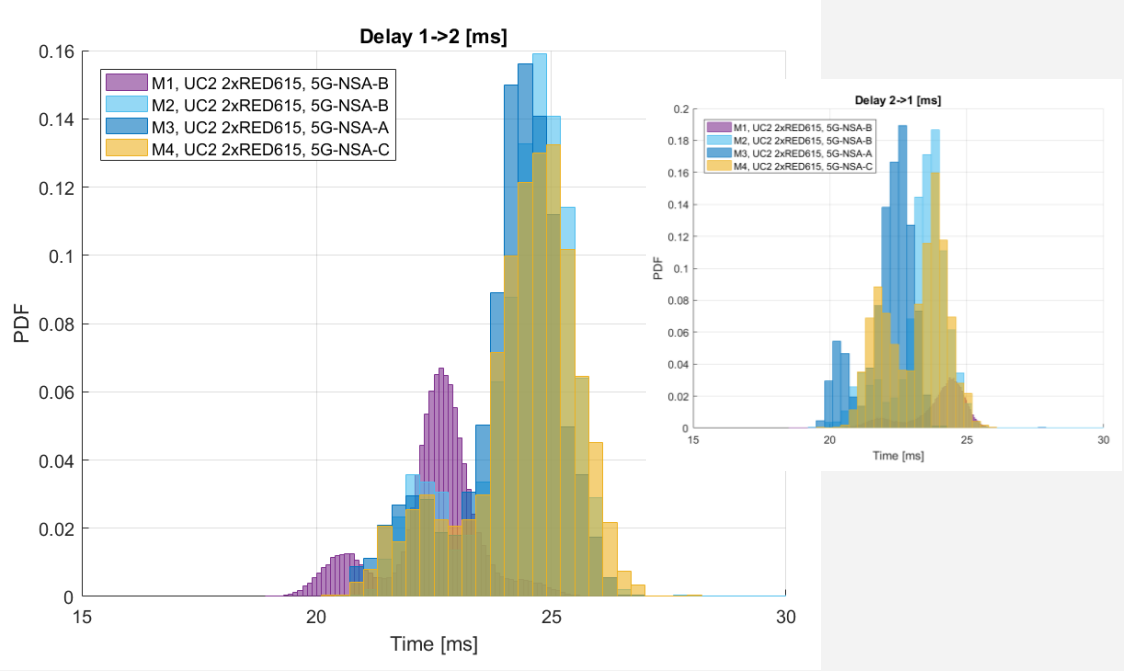


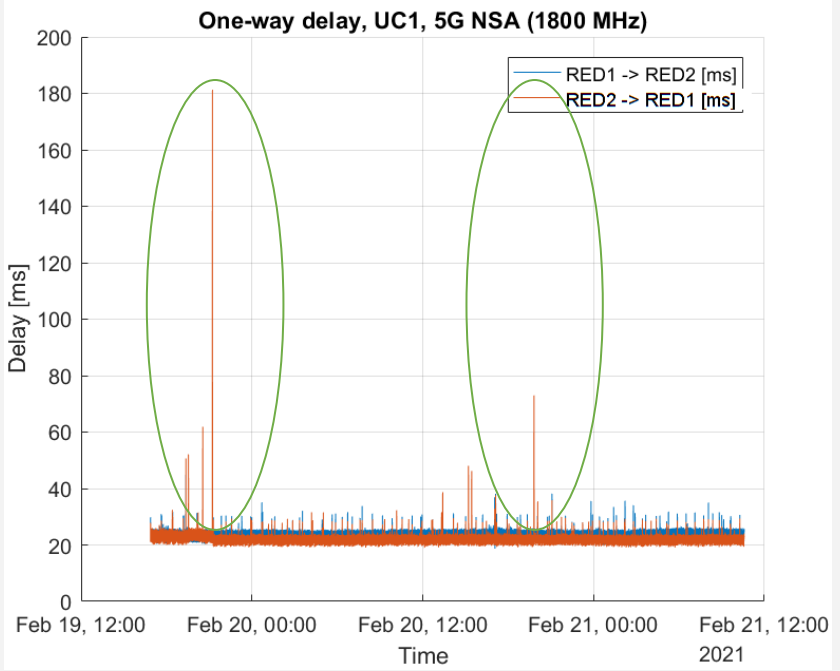




EXAMPLE RESULTS

- Average latency for intertip and line differential protection ≈ 22-24 ms (incl. two wireless links)
- Out of 16 000 faults, 99.88 % were protected



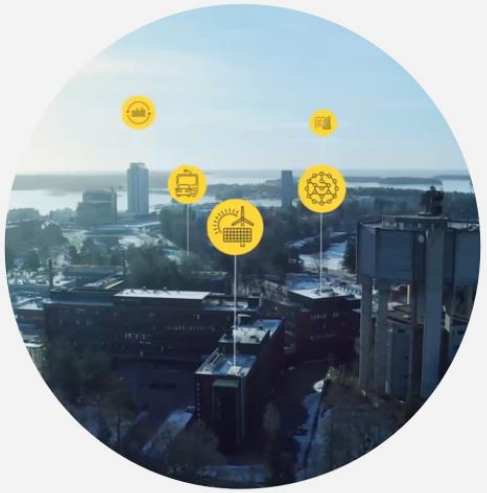


Averaging period: 1 s

VTT AS A RESEARCH PARTNER

- Testing and validation in commercial and test networks
  - Test network open for partners
- Testing and validation of time-critical applications
  - mMTC, eMBB, and URLLC
- Hardware-in-the-loop simulations
  - RTDS simulator for power system simulations
  - Wide selection of ABB relays, grid emulator and controllable loads
- Available free of charge via H2020 ERIGrid 2.0 lab access; 4th call is open: https://erigrid2.eu/vtt/
- Contact: petra.raussi@vtt.fi, +358 40 168 7303

THANK YOU!



Smart Otaniemi innovation ecosystem:
https://smartotaniemi.fi/

Reference to the full video partially shown in this presentation:
https://youtu.be/VX_tfka4iuM

5G Test Network Finland ecosystem:
https://5gtnf.fi/