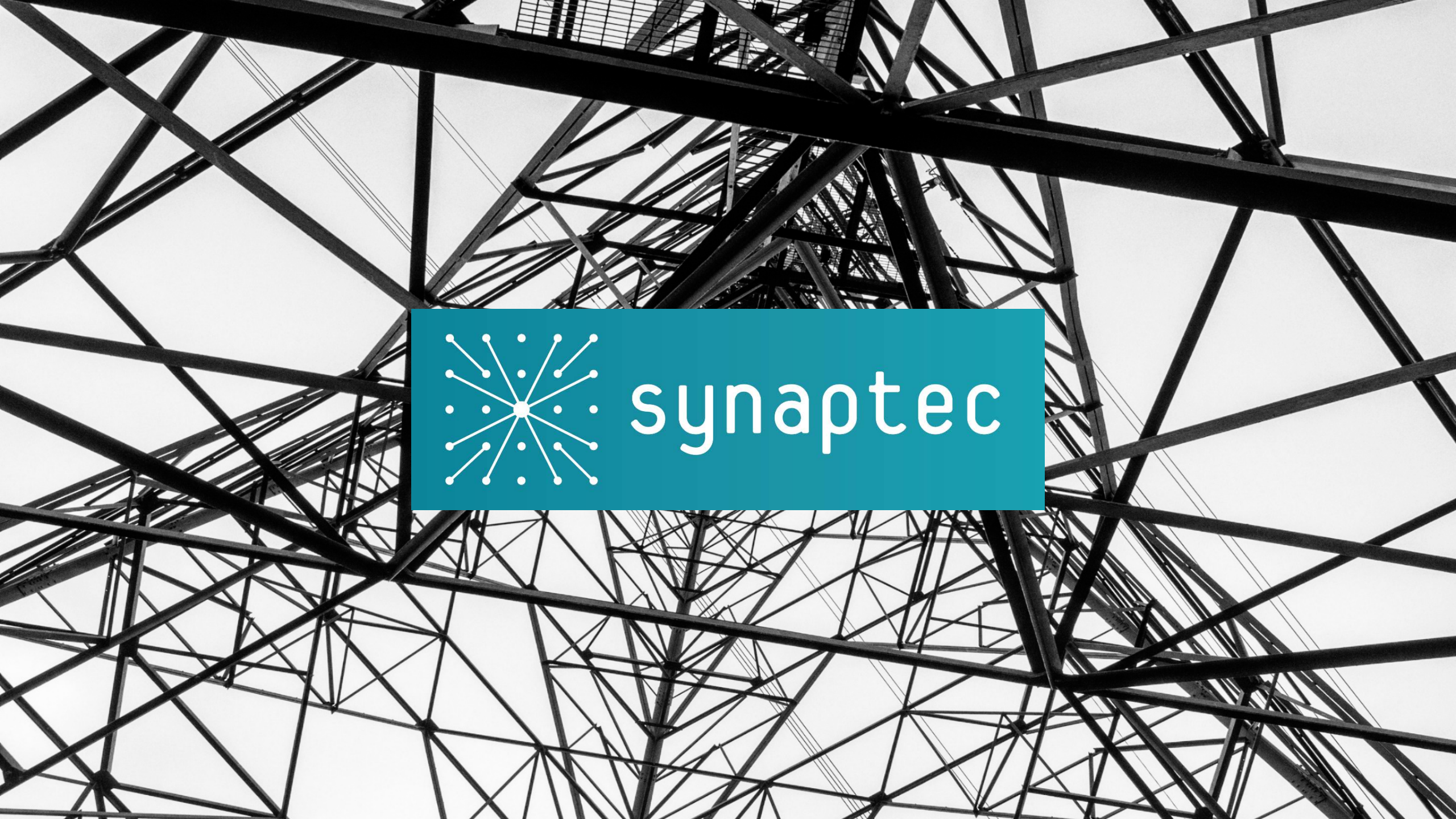
synaptec

Deploying large-scale CPOW monitoring and analysis

Dr Steven Blair

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Synaptec introductions

Dr Steven Blair

Head of Power Systems Technologies

Gordon Lindsey

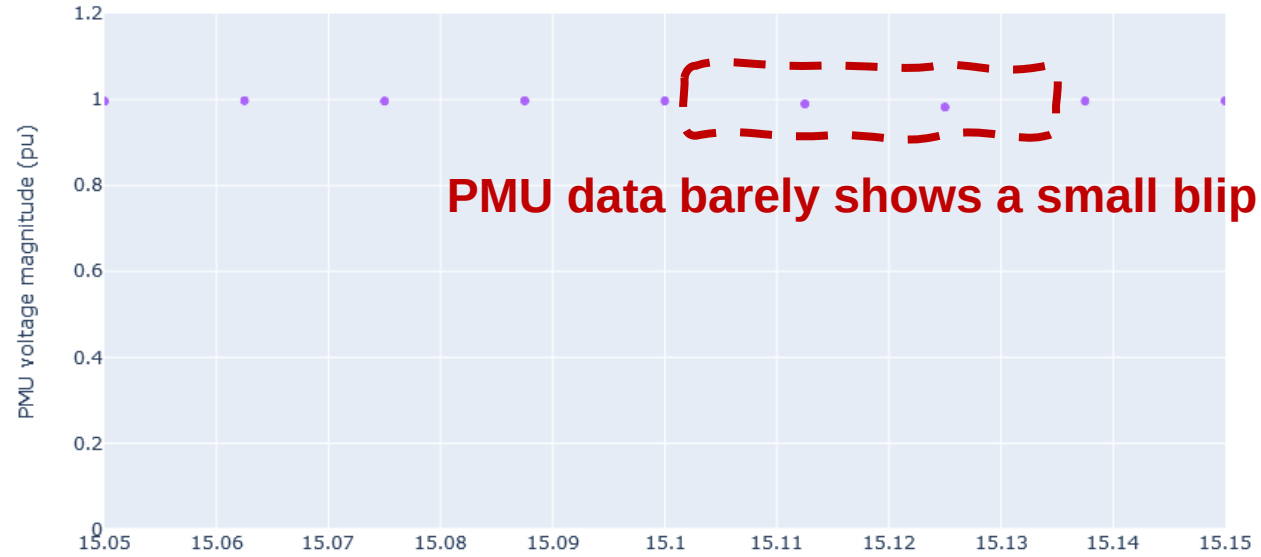
Account Director – Transmission

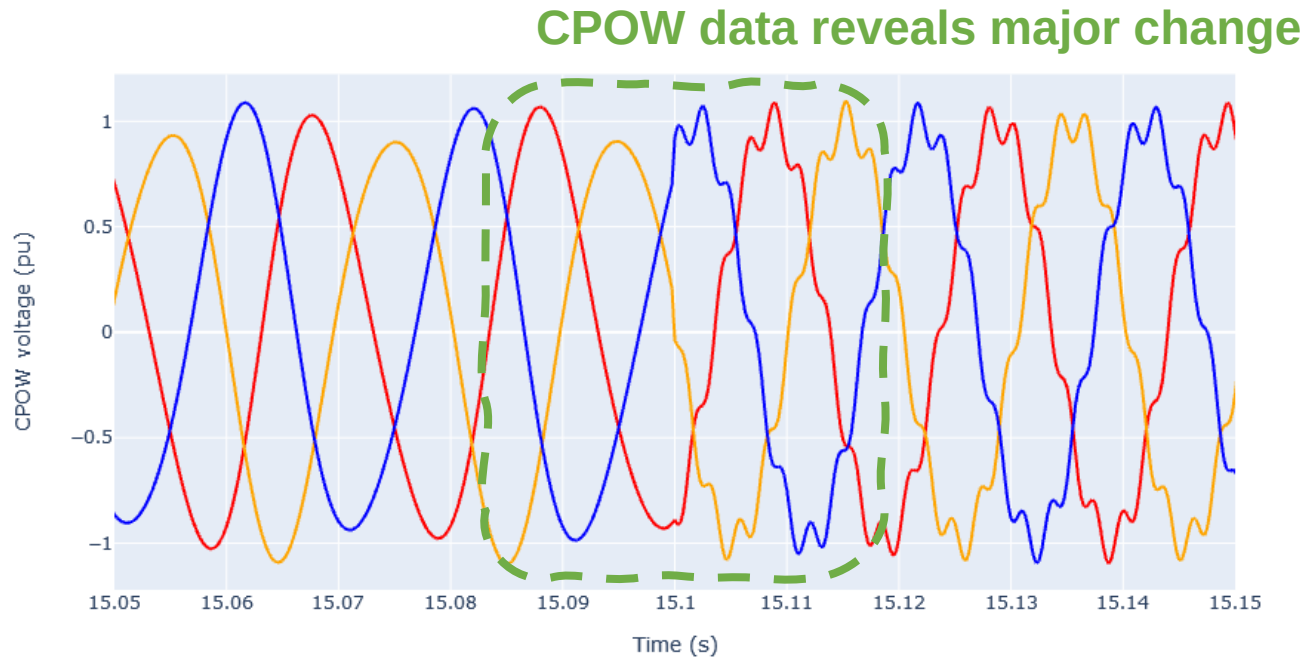
Challenges in grid monitoring

1. Vast quantity of (aging) assets
2. Granularity of monitoring is usually poor
3. Data not time synchronised



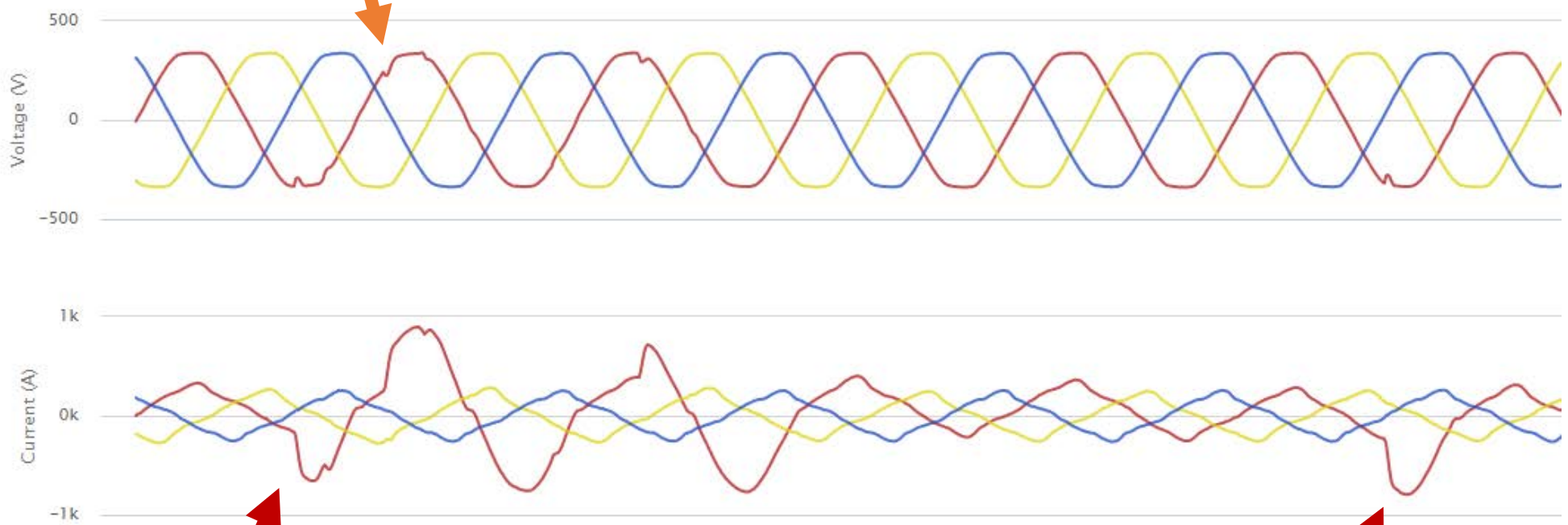
Why do we require continuous point on wave (CPOW)?





Synchronised transient detection and archiving

Synchronous measurements: see time-aligned voltage notching

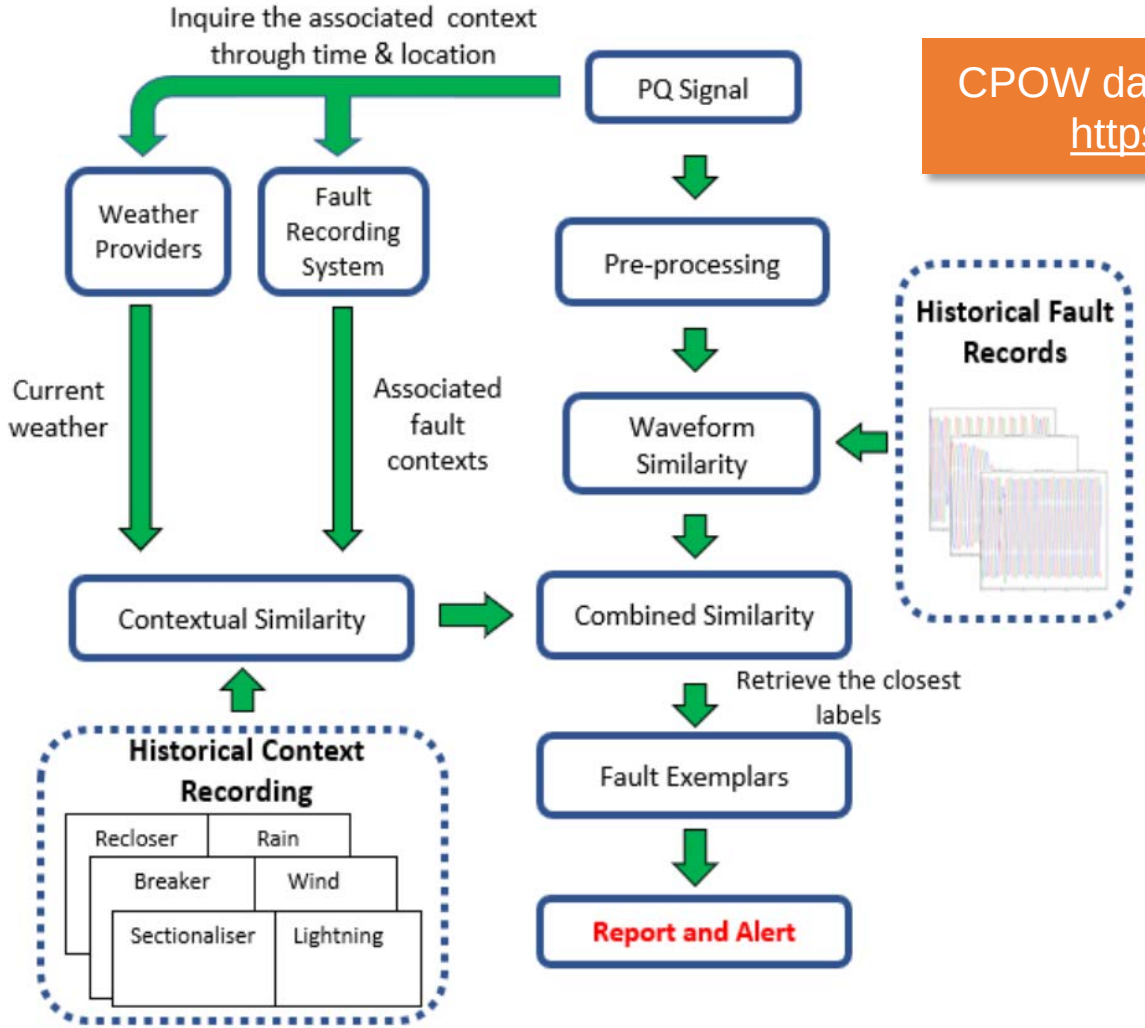


Arcing fault

Re-ignition

Blair, et al, “Automatically Detecting and Correcting Errors in Power Quality Monitoring Data”, 2016: https://doi.org/10.1109/TPWRD.2016.2602306

Automated event classification



CPOW data from DoE/EPRI library: https://pqmon.epri.com/

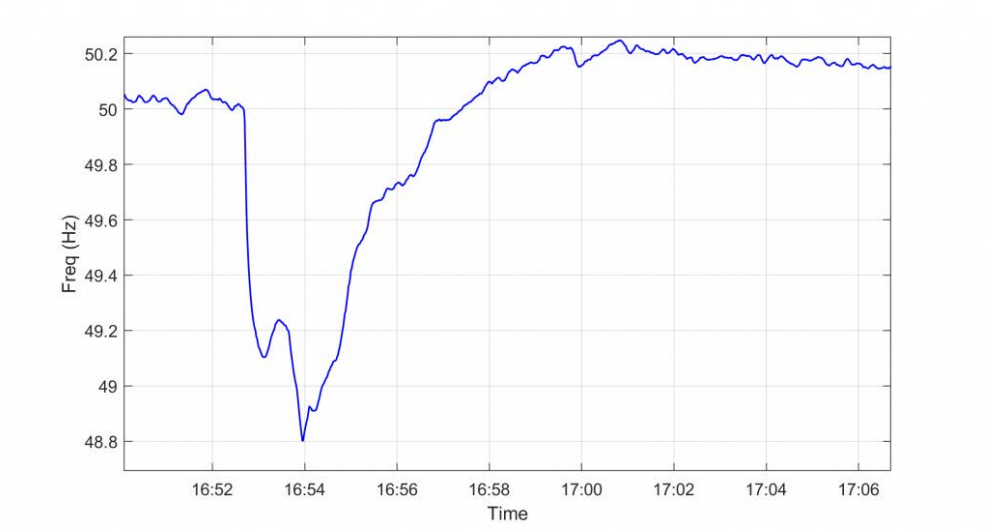
Sampling frequency	Overall accuracy
960 Hz	77.6%
3840 Hz	**94.4%**

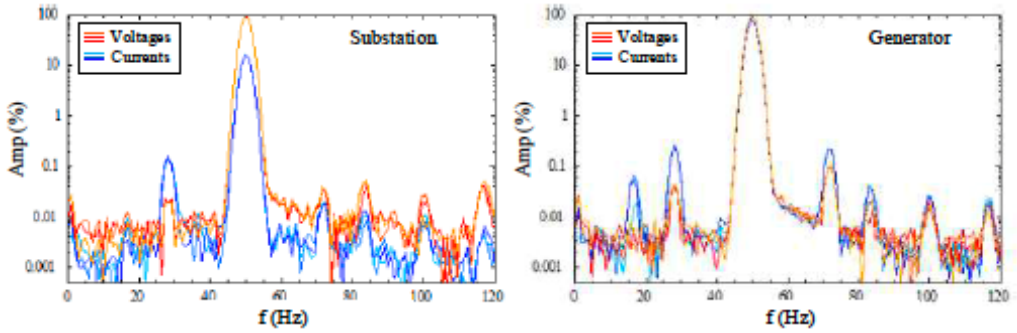
Higher CPOW sampling rate improves classification accuracy

Jiang, et al, "Automated Distribution Network Fault Cause Identification with Advanced Similarity Metrics", 2020: https://doi.org/10.1109/TPWRD.2020.2993144

Oscillation detection and reaction

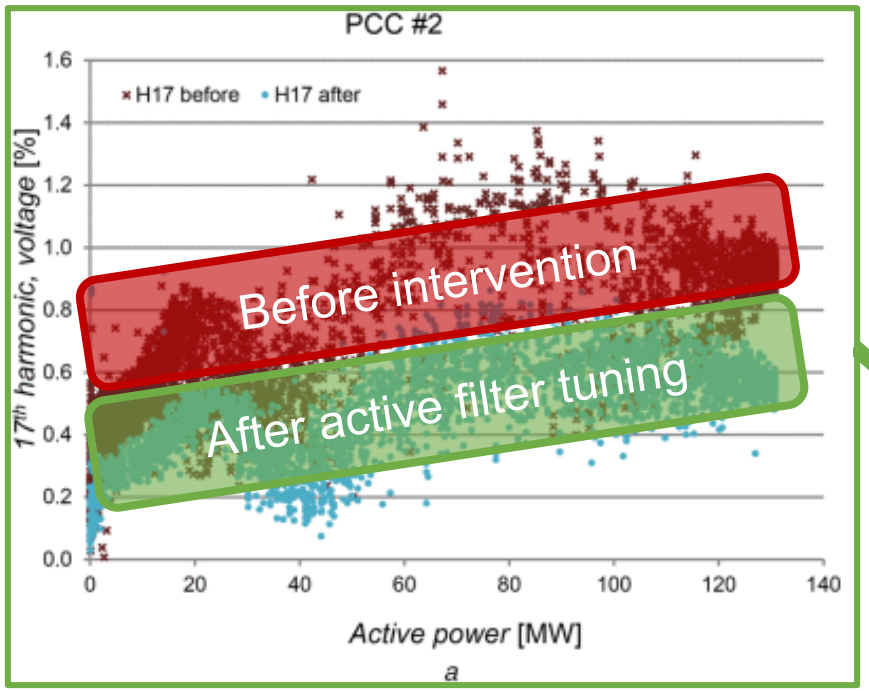
- Sub-Synchronous Oscillation (SSO)
- 9th August 2019 UK partial blackout
  - **10 mins before**: lightly-damped oscillation at 9 Hz – became unstable, tripping Hornsea windfarm (loss of 800 MW)
  - 7.3 Hz oscillation in voltage visible in Scotland ~200 miles away – evidence of power electronic instability
- Workarounds:
  - 0.2 kHz CPOW data in PMU messages
  - FFT at PMU, then append extra data to PMU messages
- **CPOW measurement enables:**
  - Extract any anomalous frequency from the system voltage

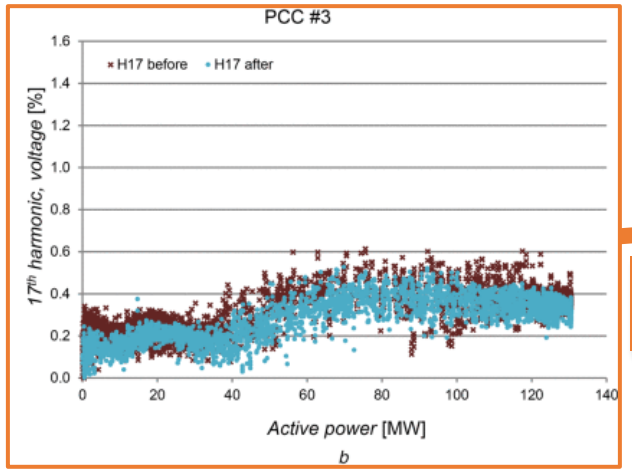




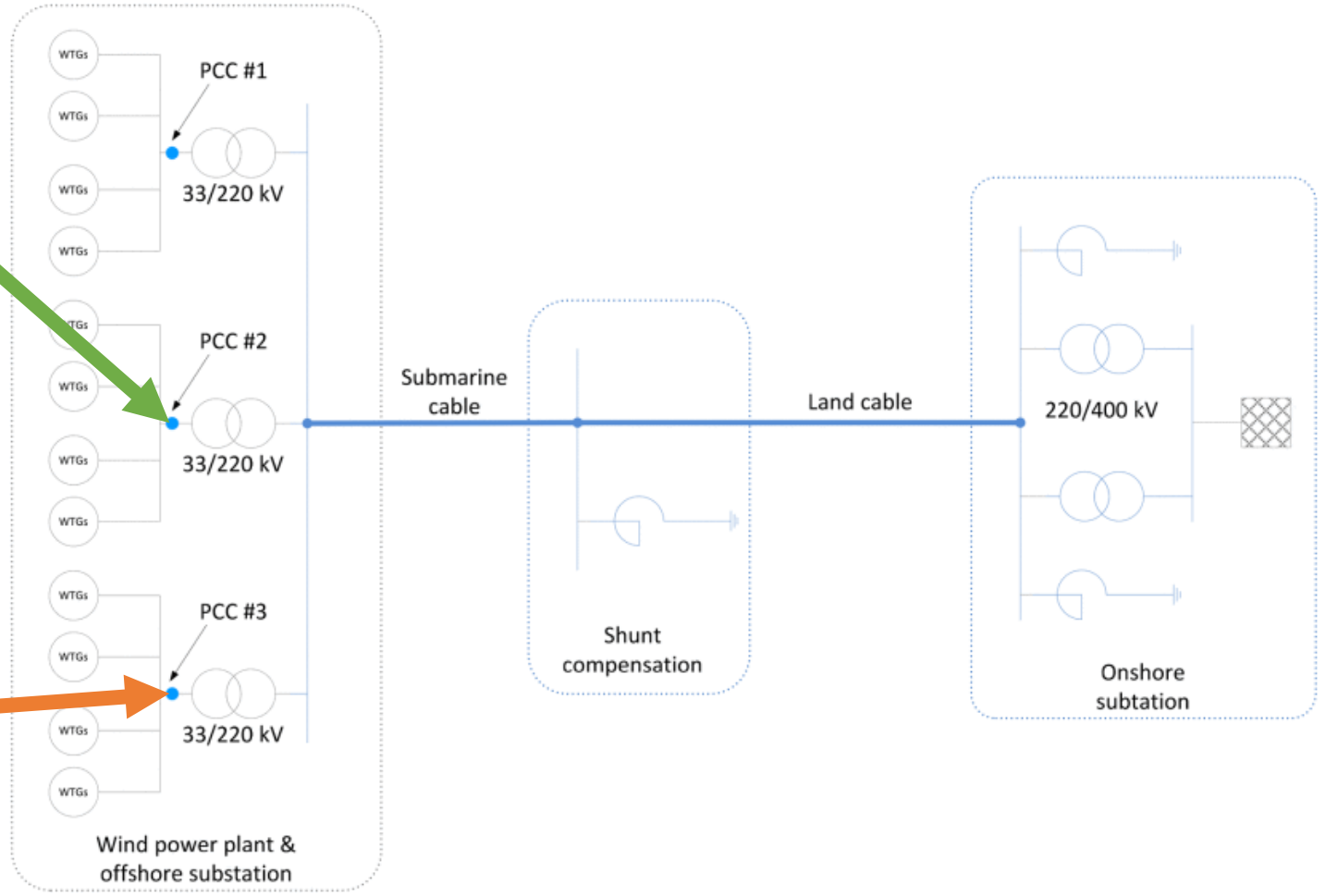
Need CPOW to see all stability threats

Granular PQ monitoring





Issue not visible at other nodes



From: https://doi.org/10.1049/iet-rpg.2016.0111
Photo: https://commons.wikimedia.org/wiki/File:Anholt_September_2014.jpg, CC BY-SA 4.0

Synaptec: light-speed power network insights

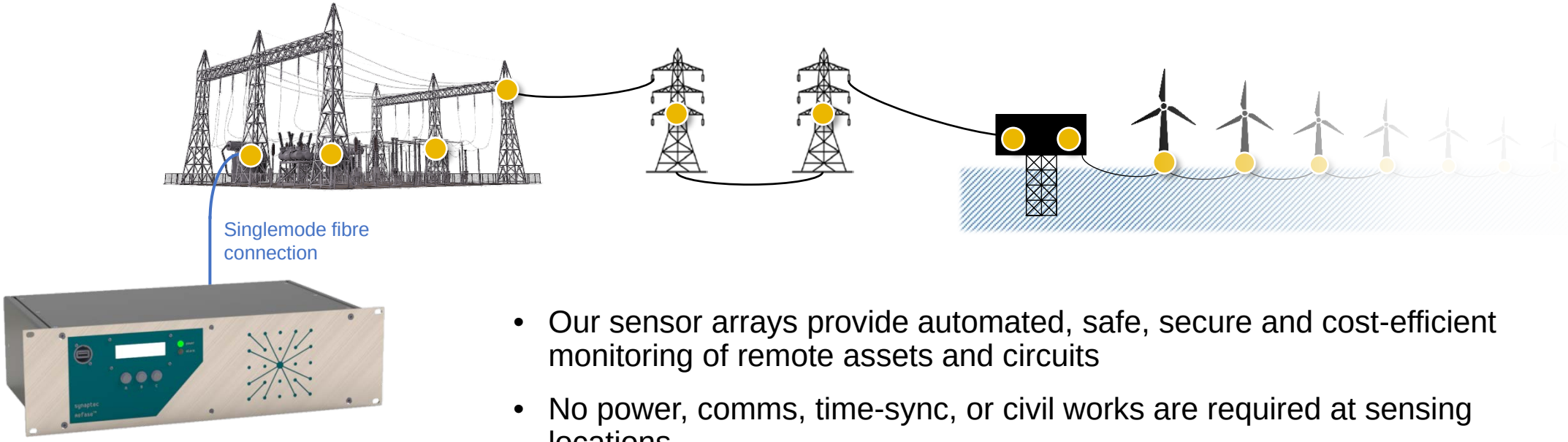
- Synaptec developed the first **completely passive** solution for distributed electrical and mechanical sensing
- Unified electrical and mechanical visibility and control of power systems at **unprecedented speed, range, and price**
- Proven in mission-critical transmission applications, it is uniquely able to perform protection and **automated condition monitoring** of remote MV and HV assets

SP ENERGY NETWORKS · Statnett · WILLIAMS ADVANCED ENGINEERING · CATAPULT Offshore Renewable Energy · SSE · VATTENFALL

Founded in 2015 — 2020

- UK's first digital substation
- Centralised busbar protection
- Proof of concept for offshore wind
- "No-build" grid connections
- First scale offshore deployment

How our sensor arrays are deployed



- Our sensor arrays provide automated, safe, secure and cost-efficient monitoring of remote assets and circuits
- No power, comms, time-sync, or civil works are required at sensing locations

- Our sensors measure **voltage**, **current**, **strain**, **vibration**, **temperature**
  - Electrical sensors are primary or secondary-connected and IEC compliant (**0.2** metering, **5P** protection)
  - Installed new or retrofitted safely and quickly using **existing installation techniques**

- Leverages standard telecoms fiber available (e.g. in OPGW and cables)
  - **50 sensors** per **100 km** of fiber
  - Measurements are **immune to EMI** and **inherently secure**

Holistic automation and insights

Timescale

Days, months and years

Minutes

Milliseconds to seconds

Asset management

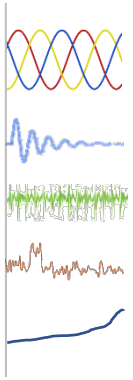
Identify changes and outliers over time to predictively maintain, avoid failure, and extend asset lifetime

Real-time monitoring

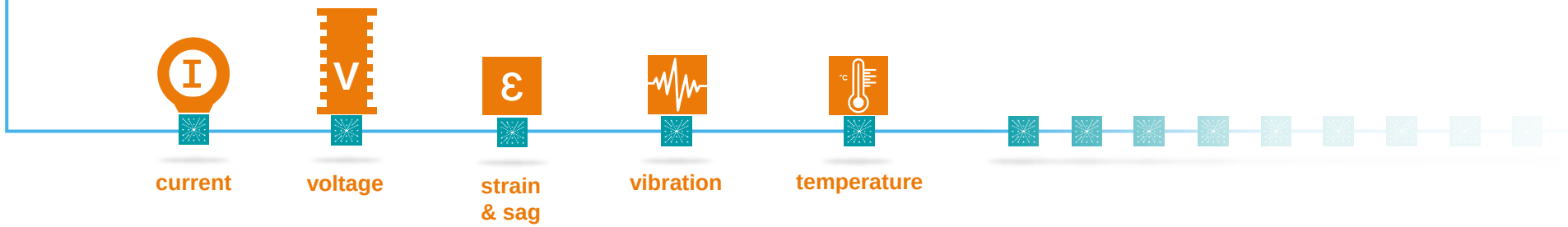
Real-time thermal rating, sag monitoring, oscillation detection, overheating alarms

Time-critical control and protection

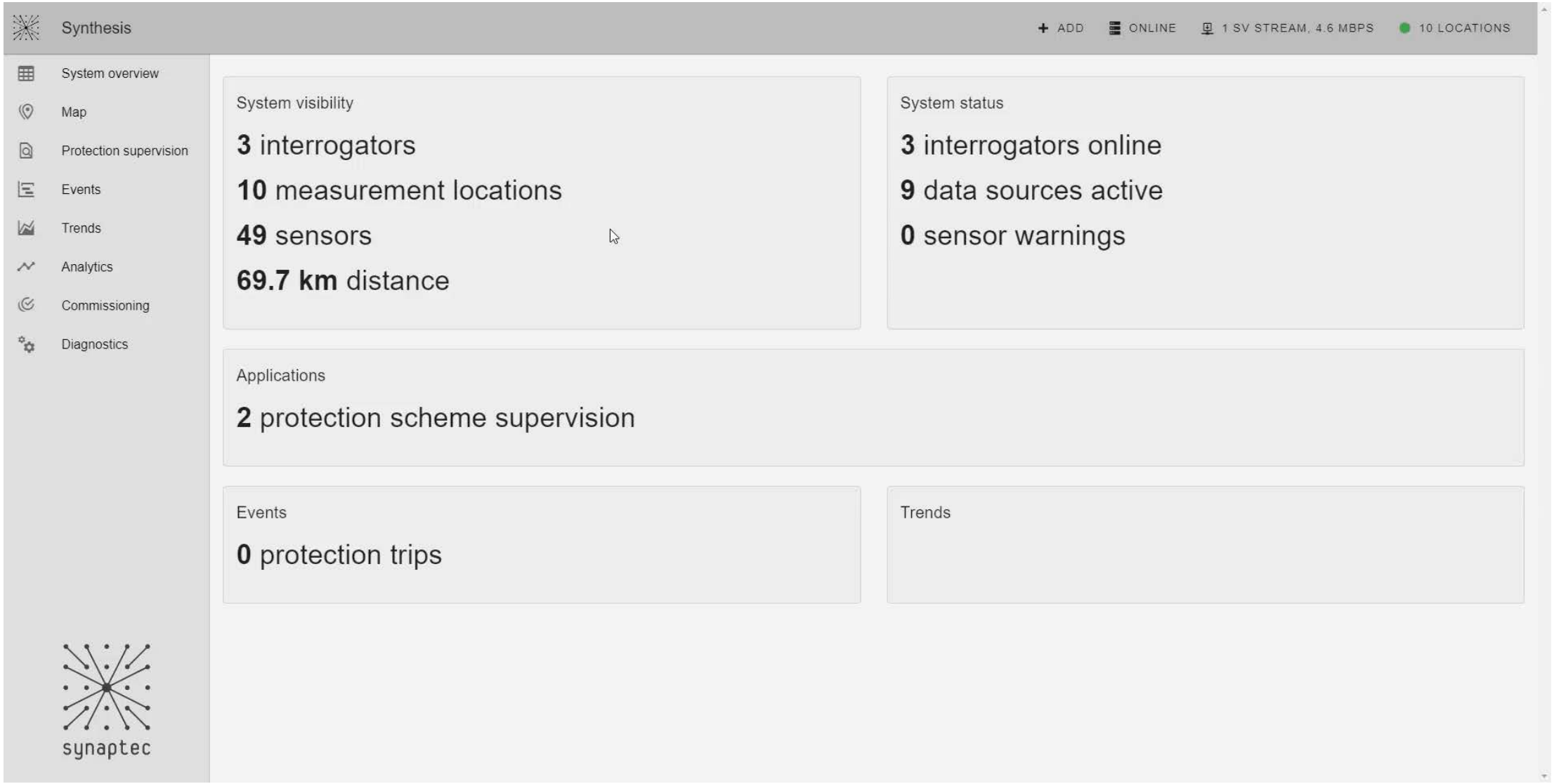
Centralised protection, wide-area protection, synchrophasor-based control



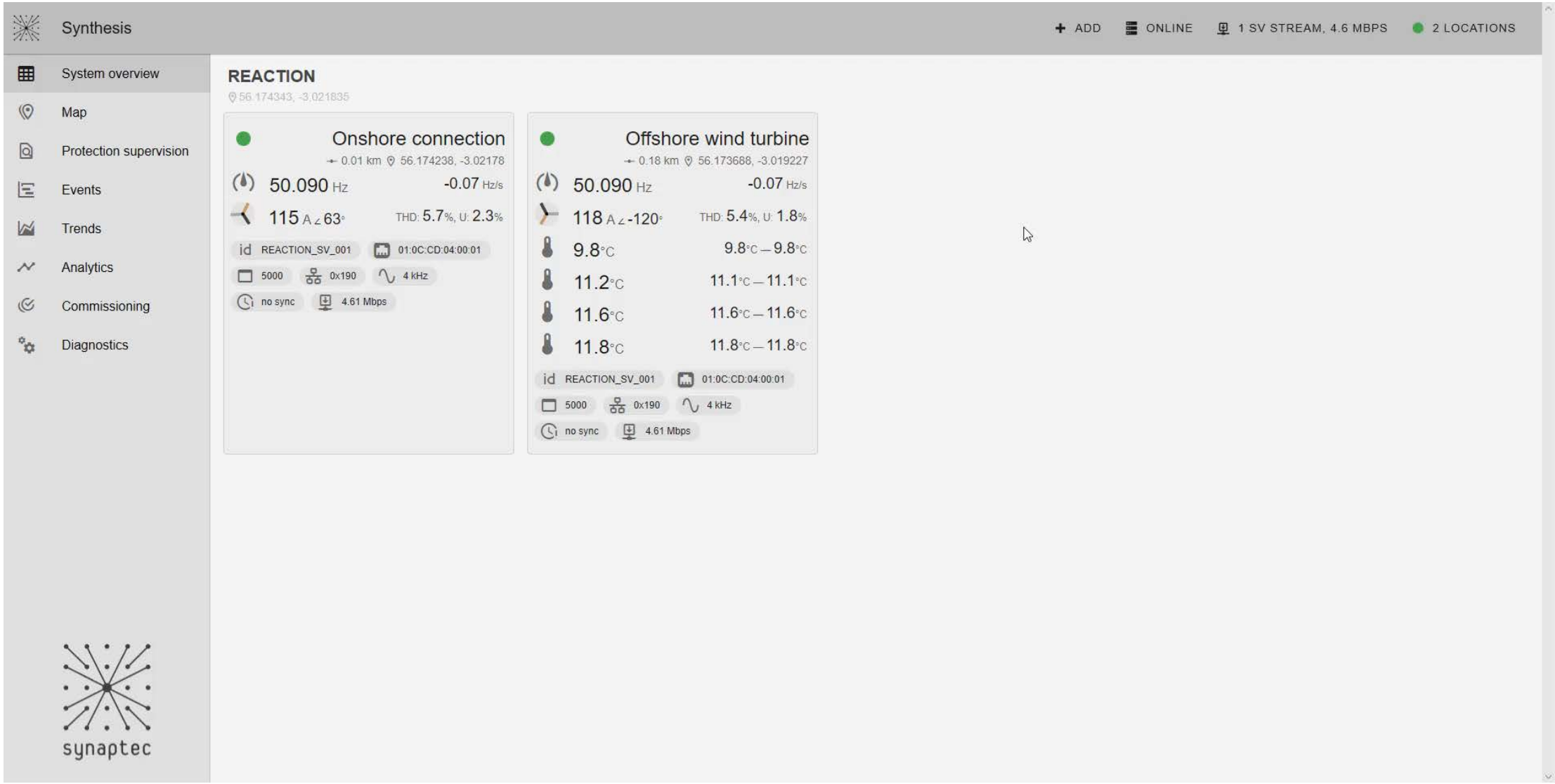
- Synchronous, continuous, measurements at **35 kHz**
- Correlated and published in one data stream
- Unified data historian and analytics platform
- Using industry standard data formats



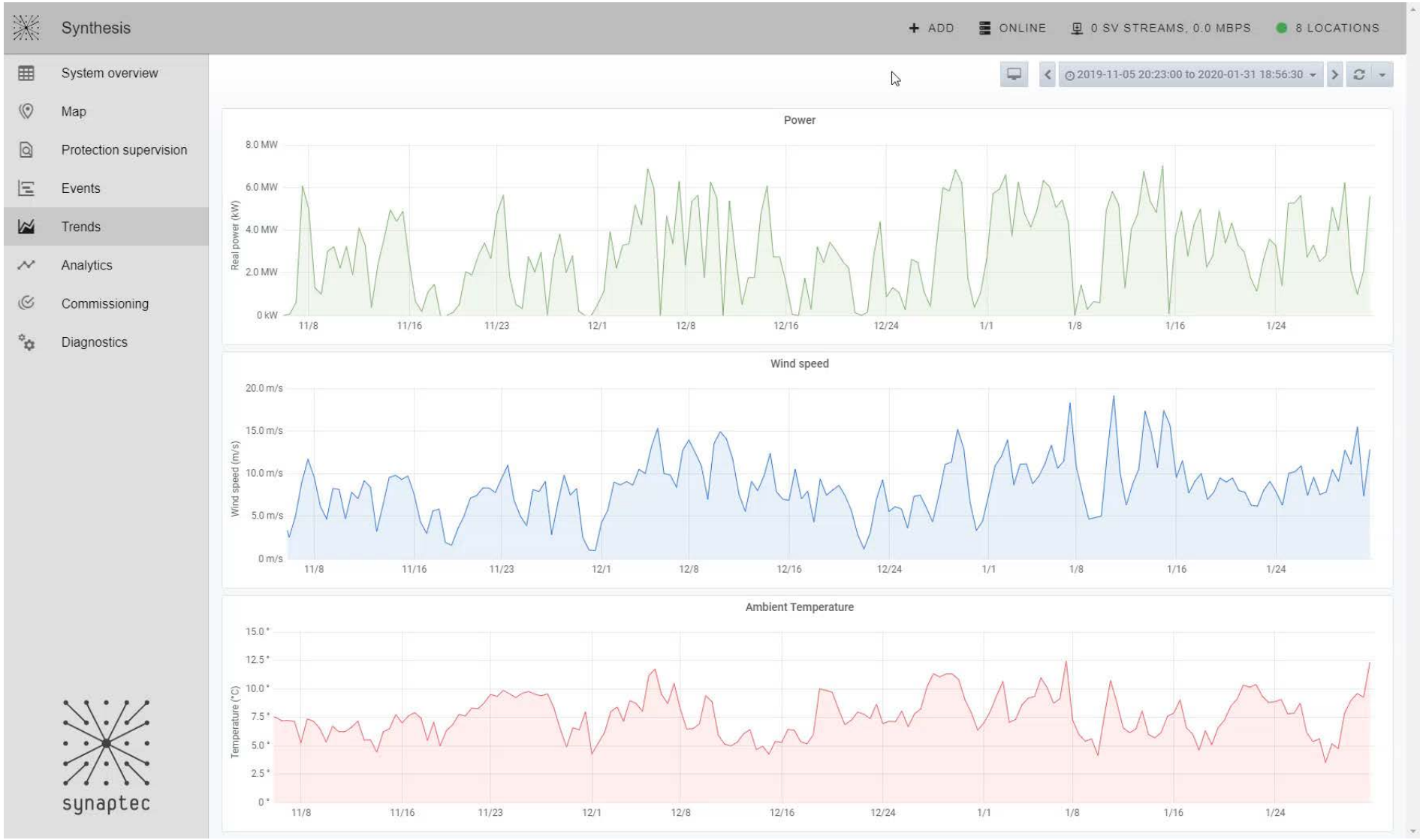
Geographic overview of sensor infrastructure



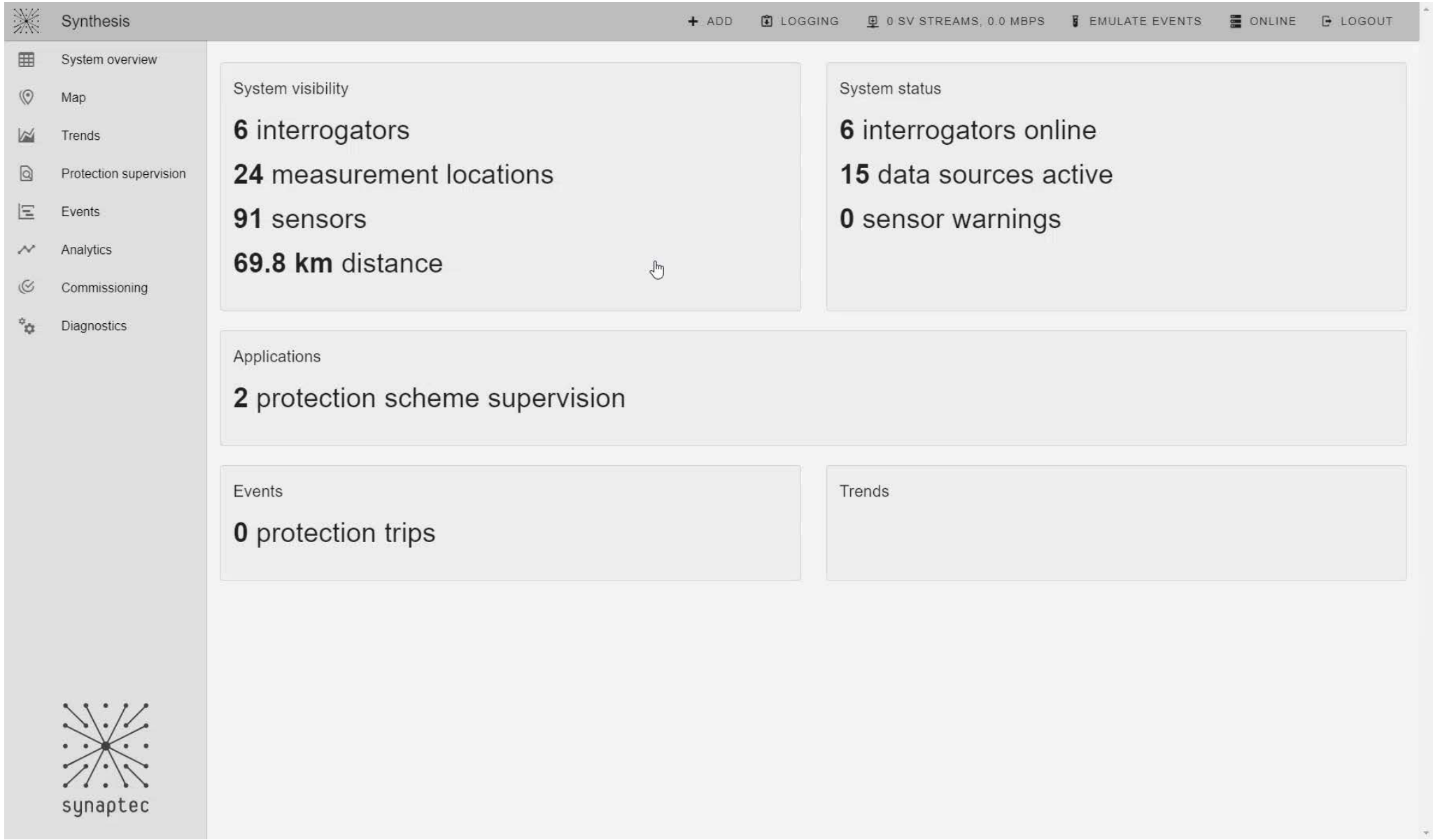
Real-time, continuous, high-resolution data



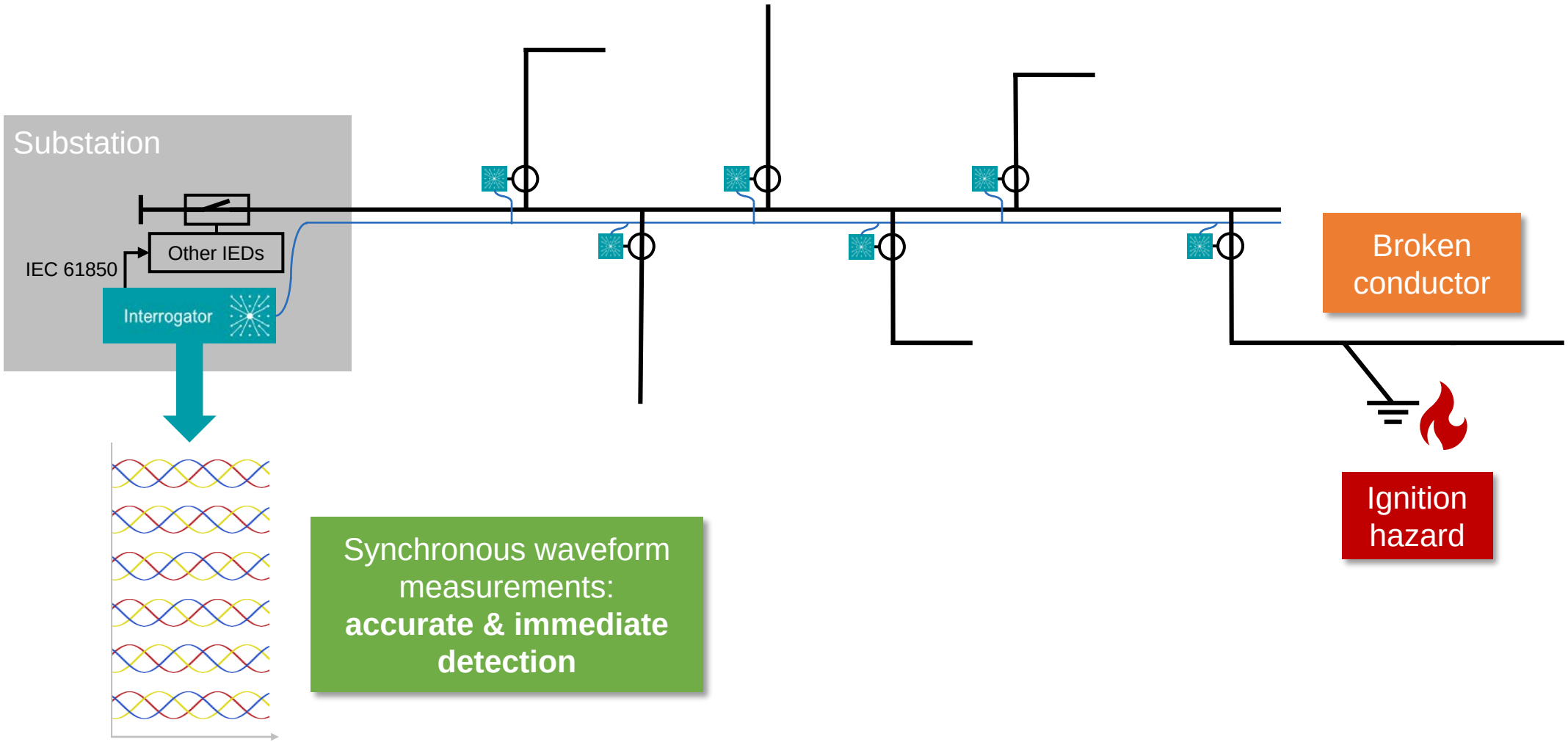
Detailed long-term trends



Scalable and flexible deployment

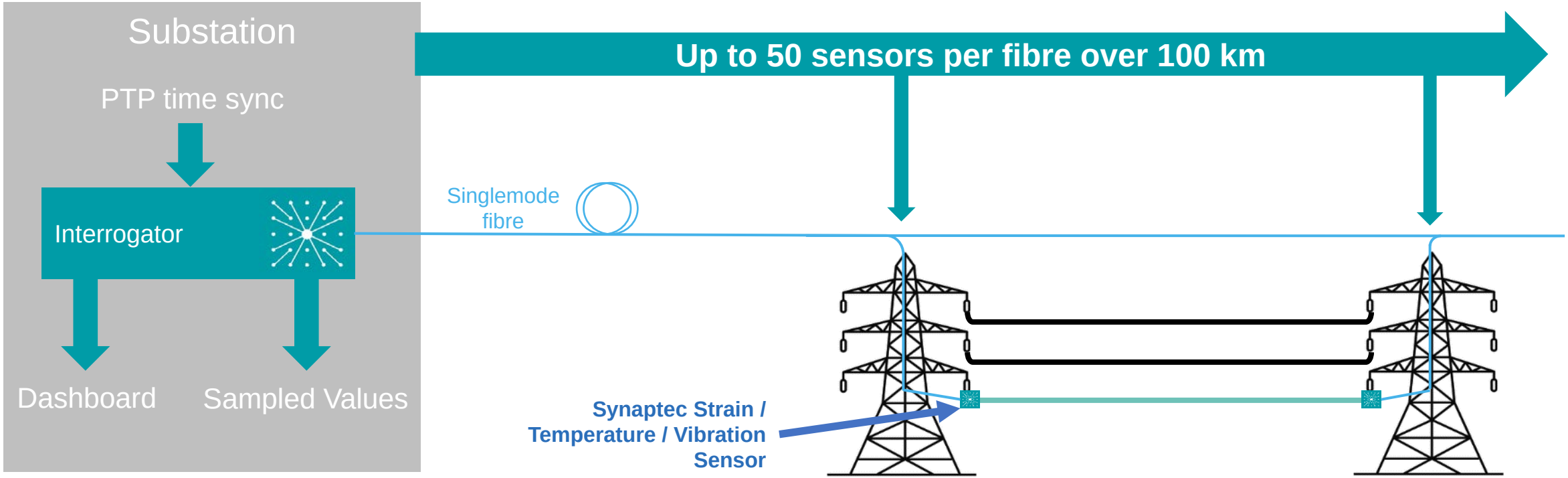


Application: long-range fallen line response



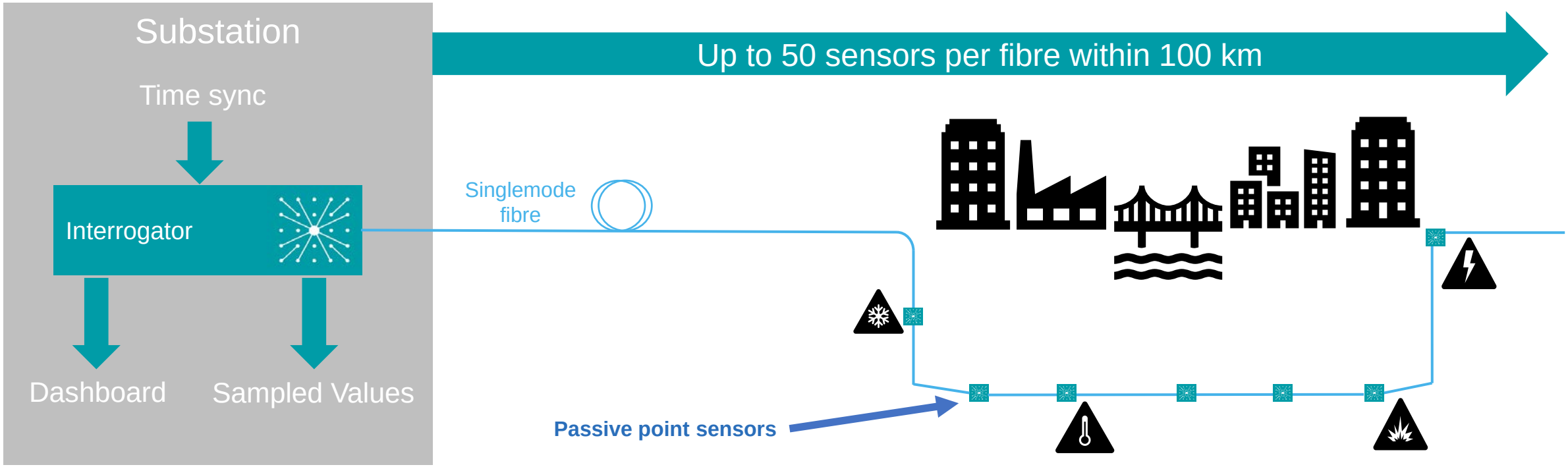
Application: OHL RTTR and sag monitoring

- Complete real-time thermal rating (RTTR) solution
- Detect remote ice loading on a cable or overhead line
- Provides time-synchronised **Current**, **Temperature**, **Vibration**, and **Strain** measurements
- Works where there is no access or power (remote, extreme cold, or deserts)
- Live dashboard - early warning of ice build-up and sag (detect ice loading)



Application: underground cable health

- Real-time temperature monitoring at hundreds of discrete points
- Simple attachment of passive sensors easily connected without need for power or battery requirements
- Ideal for cross bundled and inaccessible joints underground
- Live dashboarding of cable temperatures and thermal changes
- Enables real-time control by dynamic rating of UG assets by monitoring thermal bottlenecks in real-time



Application: centralised digital substations

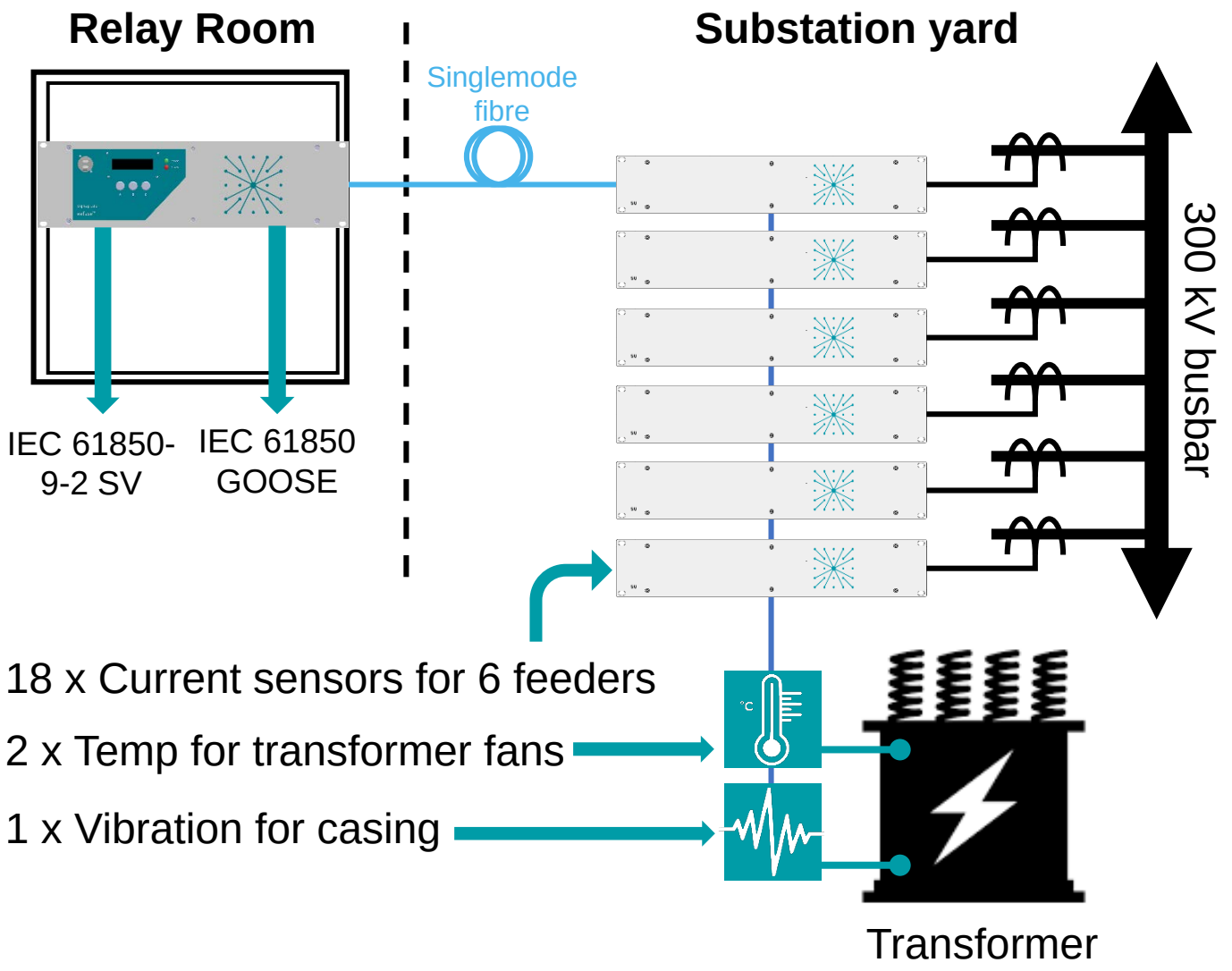
Statnett

Protection and control system

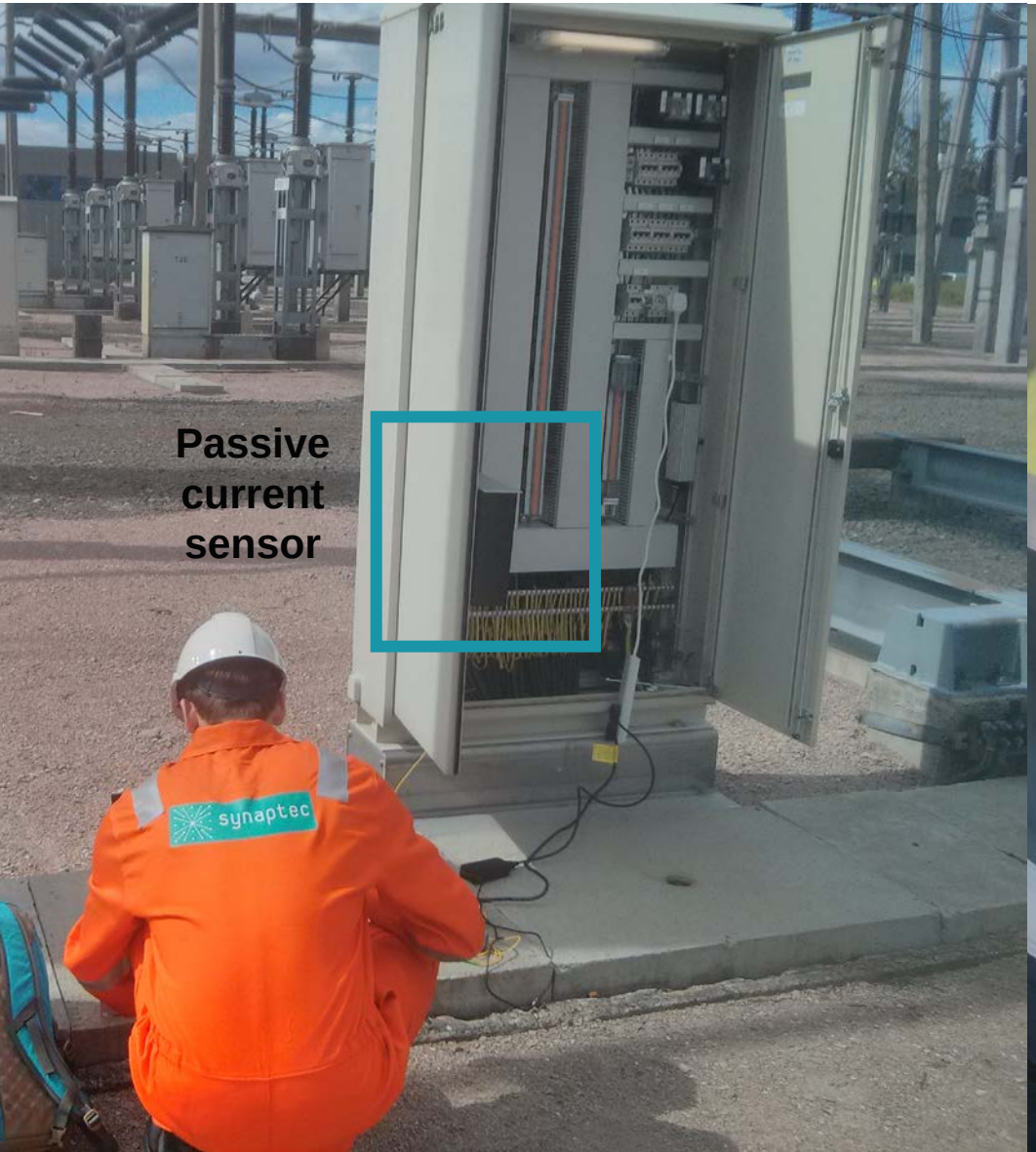
- Six-feeder busbar protection scheme, retrofitted to existing CTs in each bay
- Integrated protection algorithm
- Continuous Point on Wave (CPOW) via 4 kHz IEC 61850 Sampled Values
- Trip signals using IEC 61850 GOOSE
- Synchrophasor and Power Quality outputs

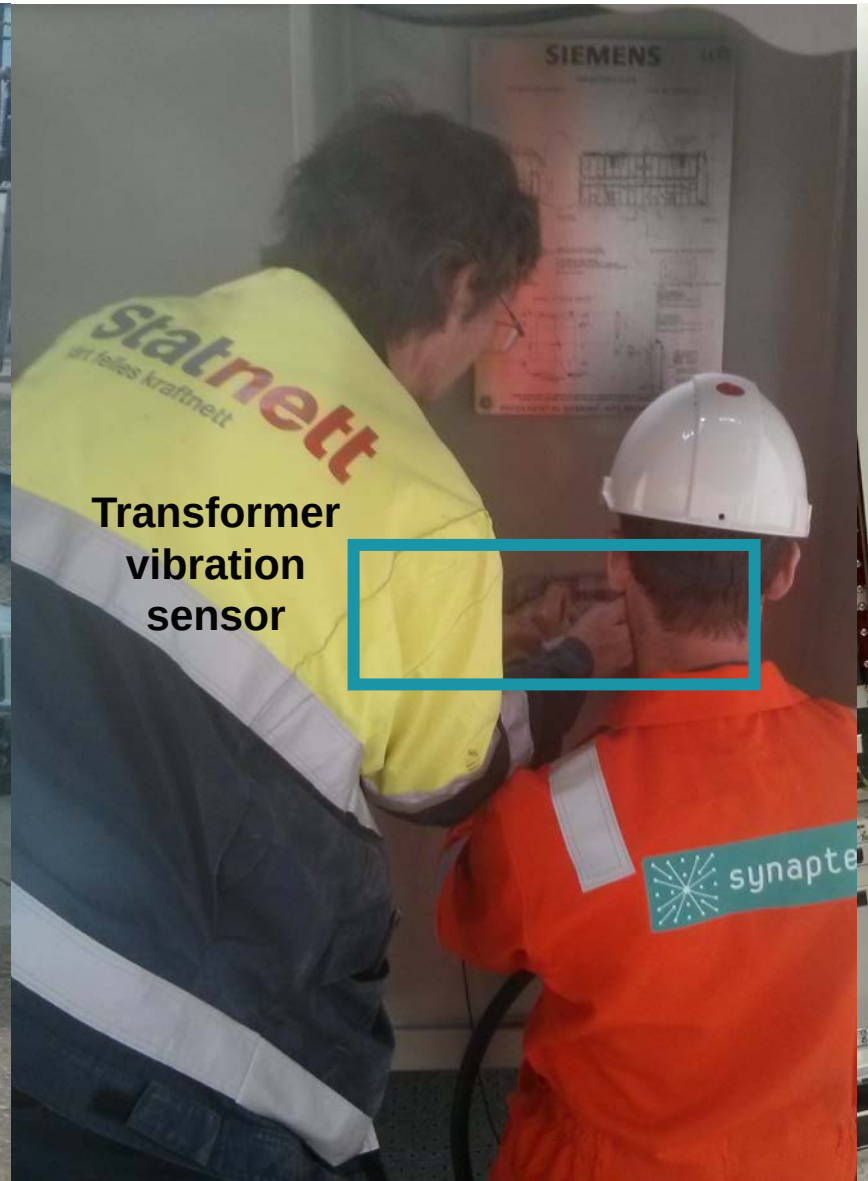
Condition monitoring

- Mechanical monitoring of HV transformer for temperature and vibration for **digital twin** model



Standard installation and commissioning





Solutions for grid monitoring

1. Vast quantity of (aging) assets
   Passive, wide-area sensing
2. Granularity of monitoring is usually poor
   High sampling rate for every sensor, delivered immediately
3. Data not time synchronised
   Inherent time-synchronisation of every measurement



Summary

- Secure
- Maintenance-free
- Live, real-time data
- New, integrated data sources
- Low carbon footprint

Contact

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