Statnett

Statnett project –COSECTIME

Distribution of synchronized time, underline the Green Transition in electrical power production, distribution, and safe operation of the power system.

Short introduction to Statnett and why synchronous -time is important for the system operation
Kjell Petter Myhren, Senior Advisor Statnett R&D

The Statnett COSECTIME Project and use of White Rabbit
Oddleiv Tungland, MsC- engineer, Statnett Project Manager for COSECTIME

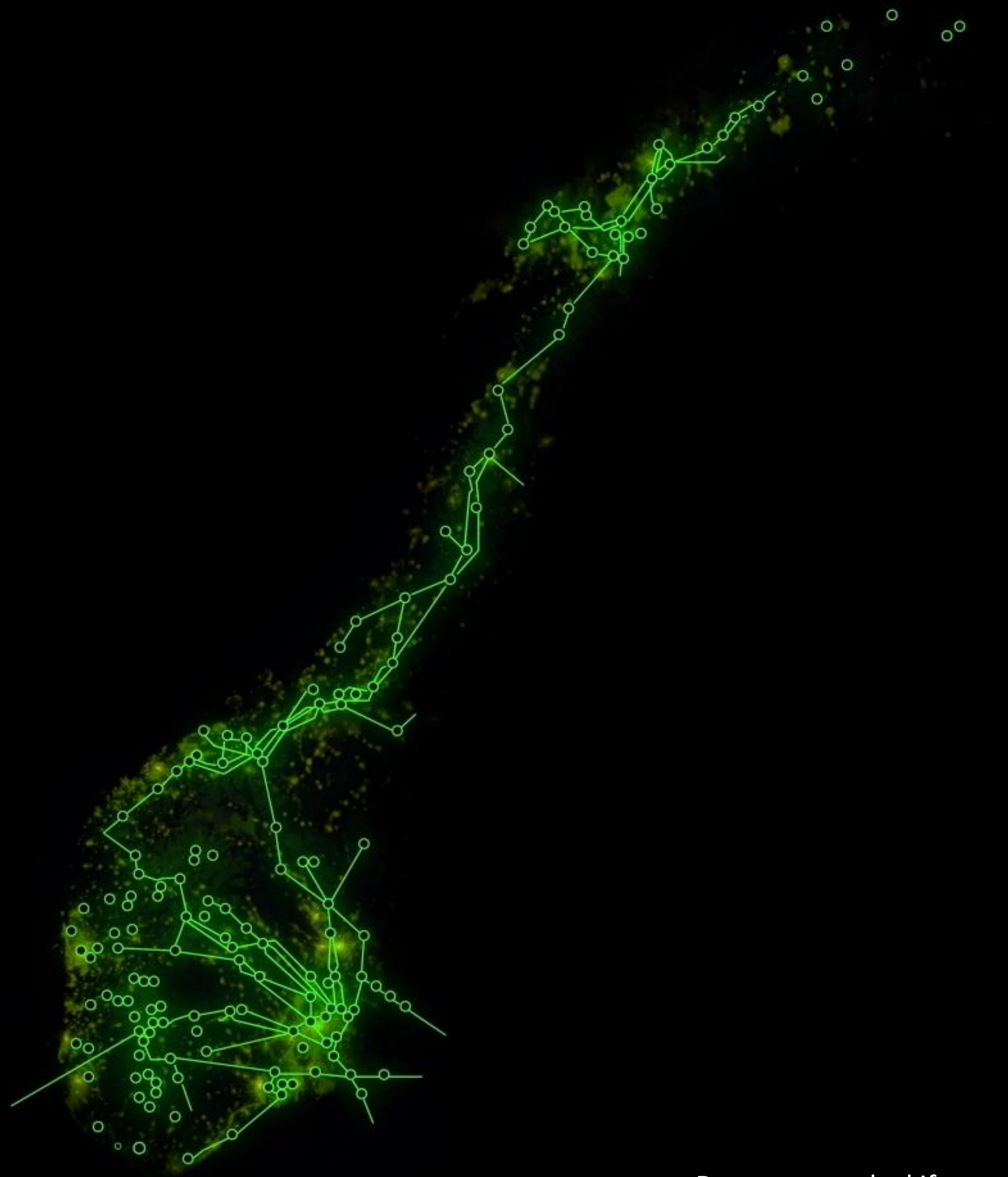
Results, Challenges, and visions for use of White Rabbit
Harald Hauglin, Special Advisor, Justervesenet (Norwegian Metrology Service)

Statnett

The Norwegian Transmission System Operator (TSO)

Statnett SF is owned by the Norwegian State
through the Ministry of Petroleum and Energy (MPE)

- Owns and operates the national high voltage transmission grid in Norway, i.e. the electricity highways.
- The operation of the nordic power grid is a collaboration between Statnett, Svenska kraftnät, Fingrid and Energinet.



The Norwegian power system

146 TWh
Production

134 TWh
Consumption

12.5 TWh
Net exchange

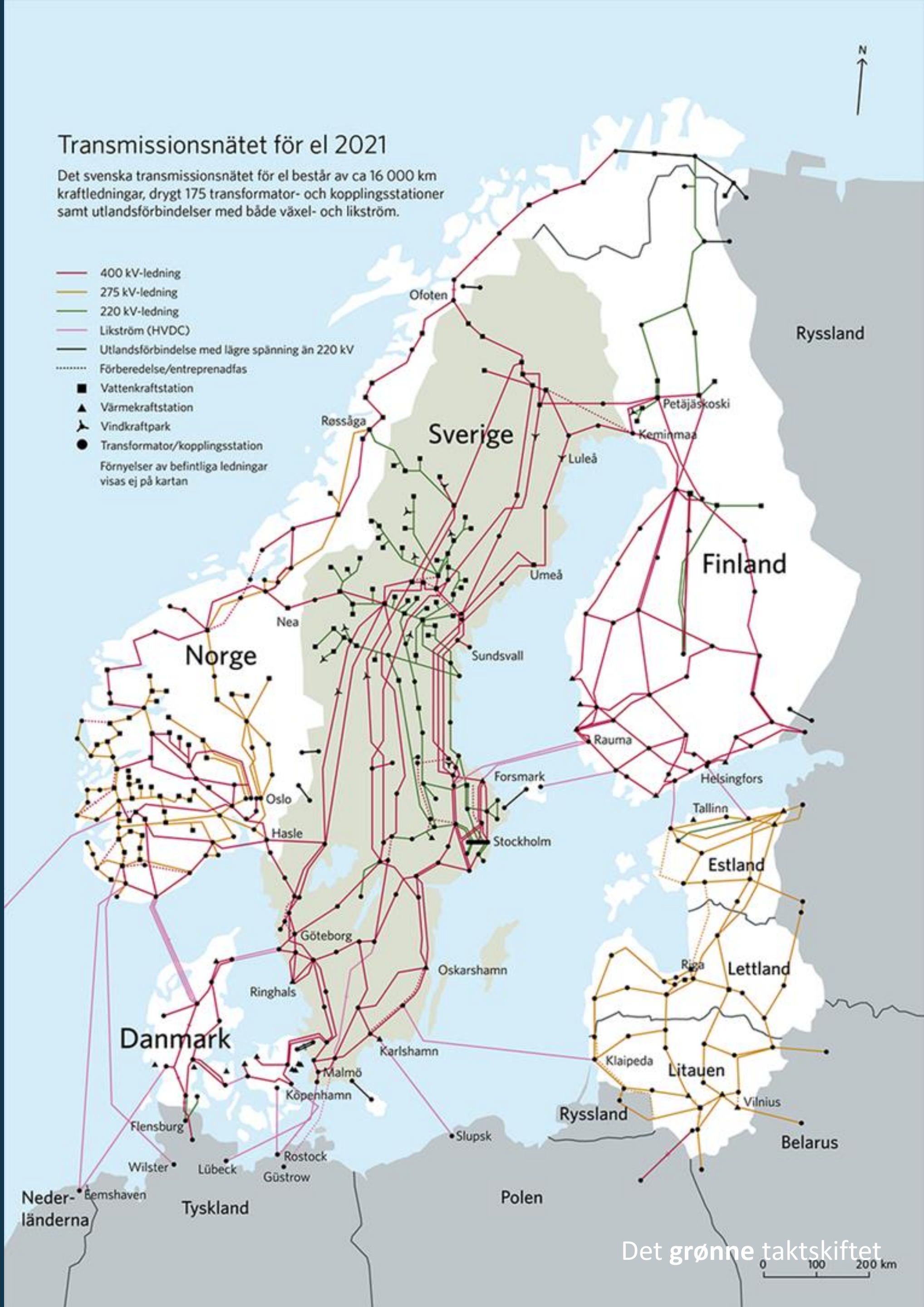
Statnett –
Transmission System Operator (TSO) in Norway

11 500 km high voltage lines

2 550 km subsea and underground cables

190 substations

1 600 employees, 4 office locations (Oslo, Sandnes, Trondheim and Alta)



Det grønne taktskiftet

Statnett

Mix of power production will change from mostly hydro power, to power from sun and wind power plants that are connected to the grid via power electronics, this gives the power grid new characteristic, and the grid needs to be monitored in a new way.

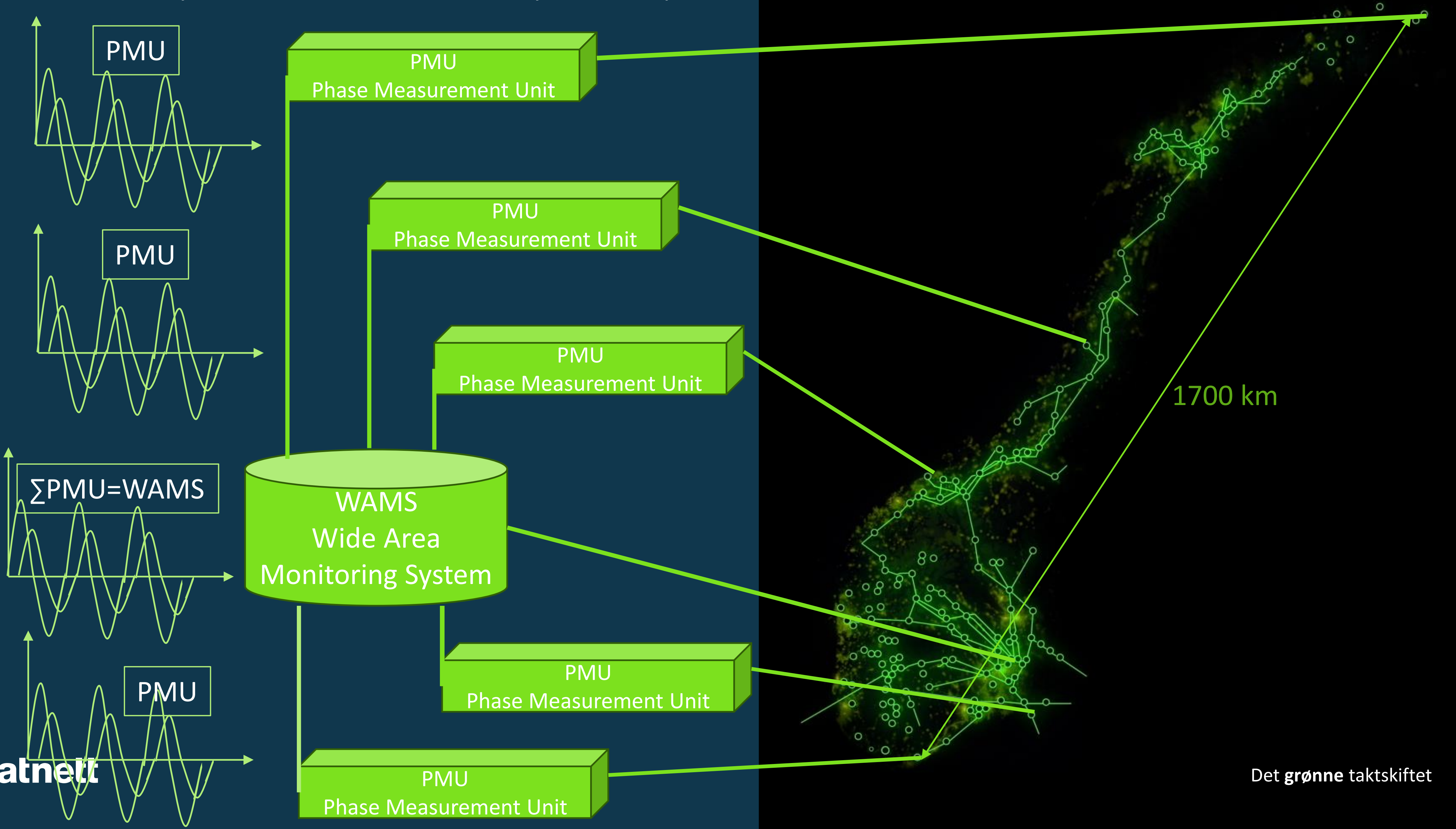
To enable the green transition in a safe way, the power grid needs to be monitored at millisecond level.
The PMU (Phasor Measurement Unit) is a component that can measure conditions in the network at the millisecond level

t

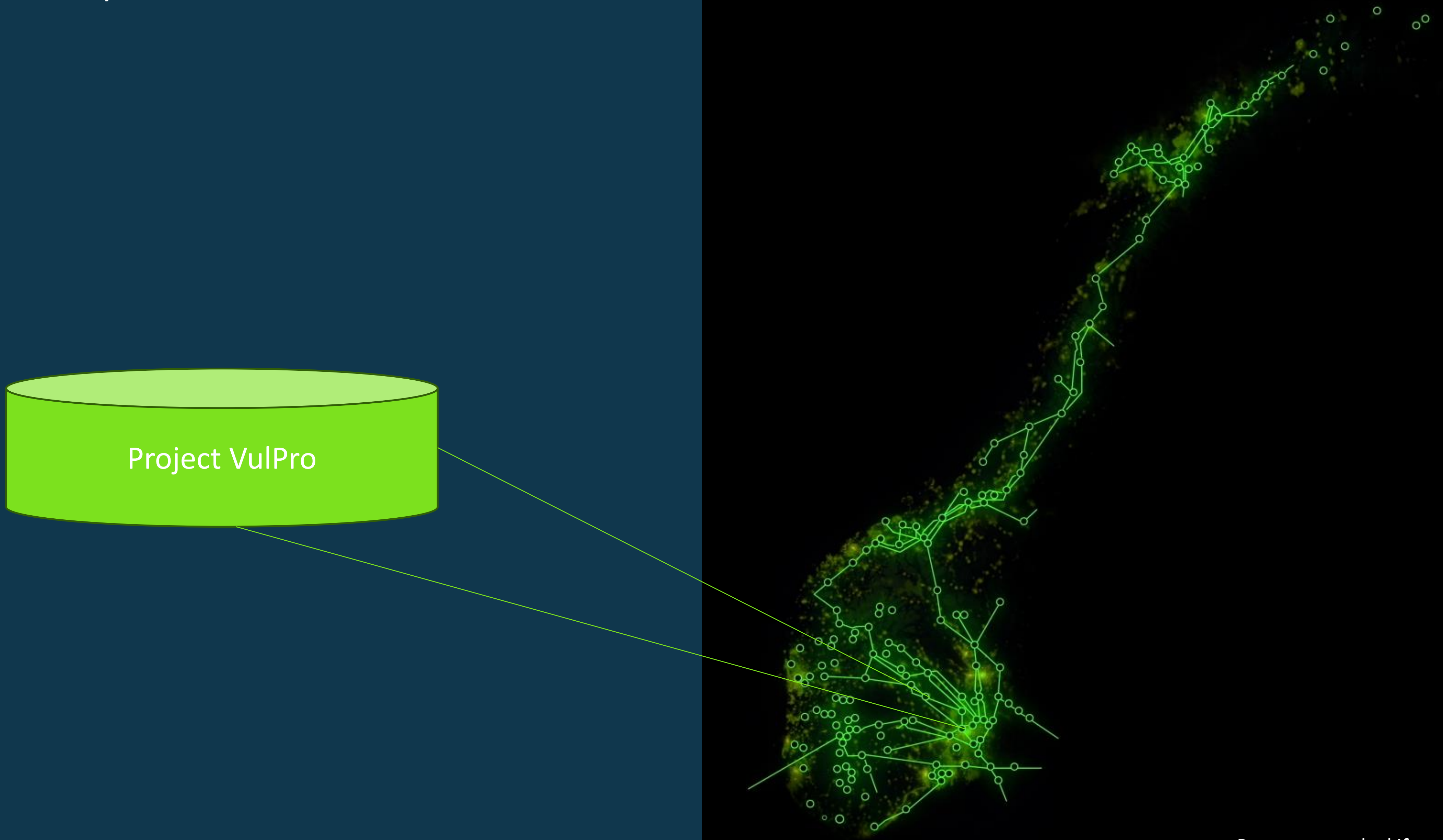
ns | ms | s | min | 15min | time

PMU measurements | Ordinary current and voltage measurements

Coordinated time- synchronization across Norway and Europe

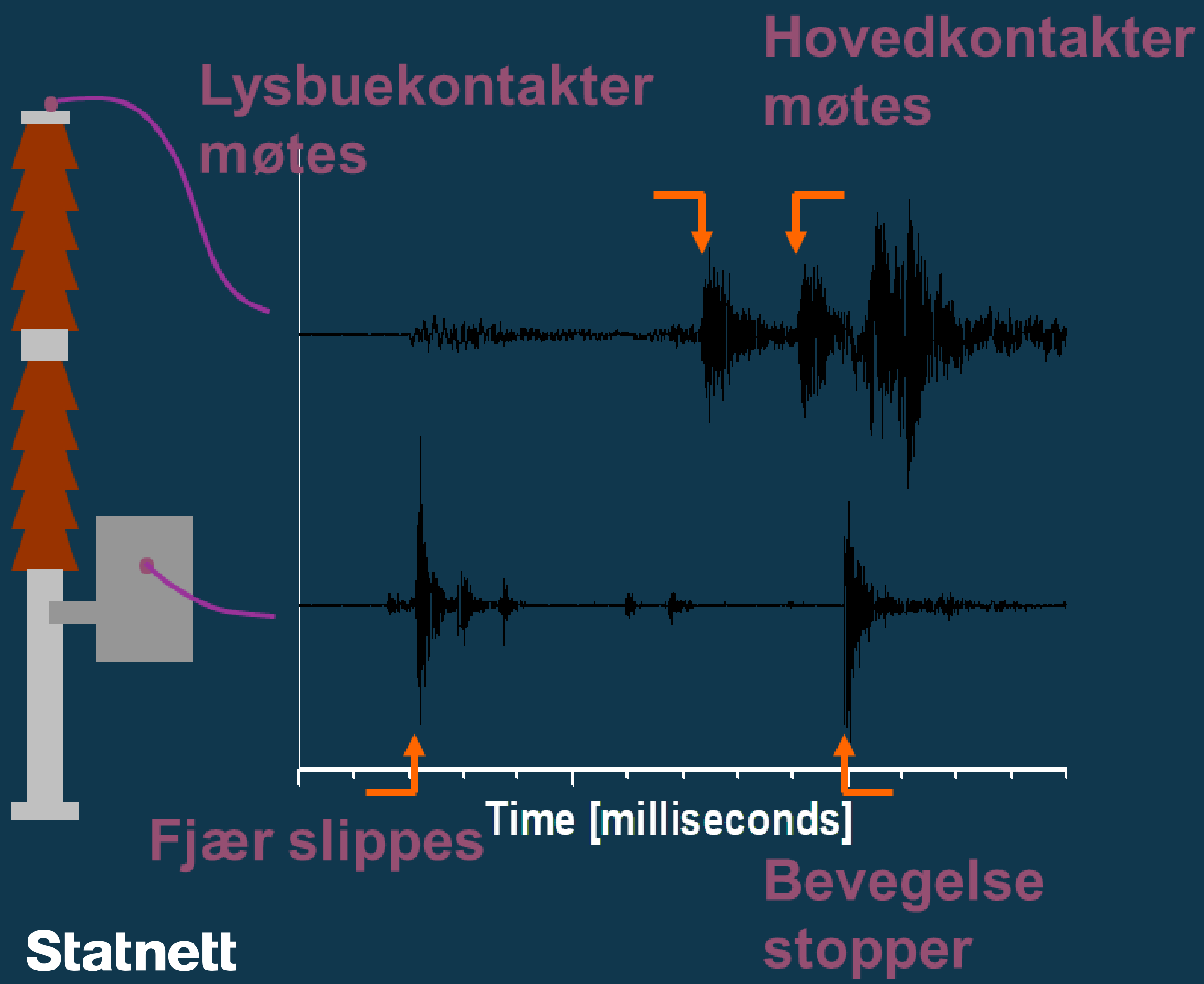


Coordinated time- synchronization between substations



Coordinated time- synchronization inside substations

Condition monitoring of circuit breaker using vibration analysis

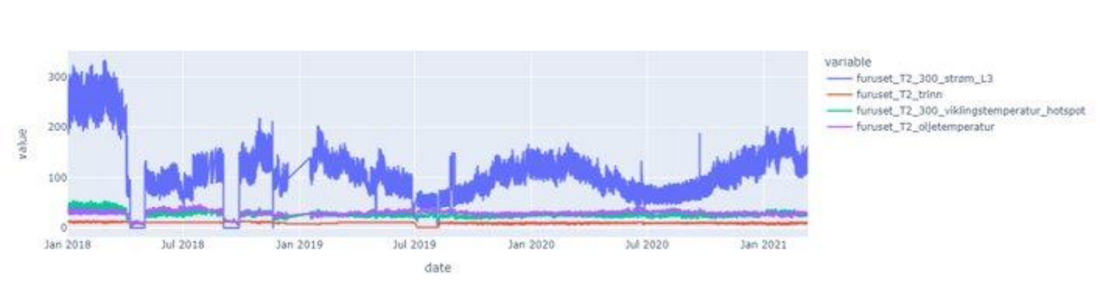


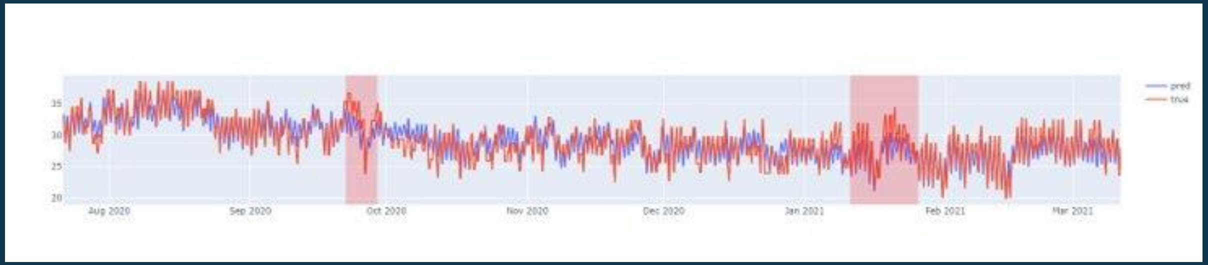
Failure of circuit breaker can have major consequences Failure of the drive mechanism is the most common cause of breakdown Faults in mechanics can be detected early by monitoring the vibration signature when switching in and out Goal Demonstrate the use of vibration monitoring for grid circuit breakers Develop machine learning algorithm to detect anomalies in vibration signals Introduce condition-based maintenance strategy of circuit breaker drive mechanism

HSE Gains-Reduced risk of sudden breakdown, which reduces the risk of: SF6 gas emissions Damage to equipment and personnel of the station Network downtime

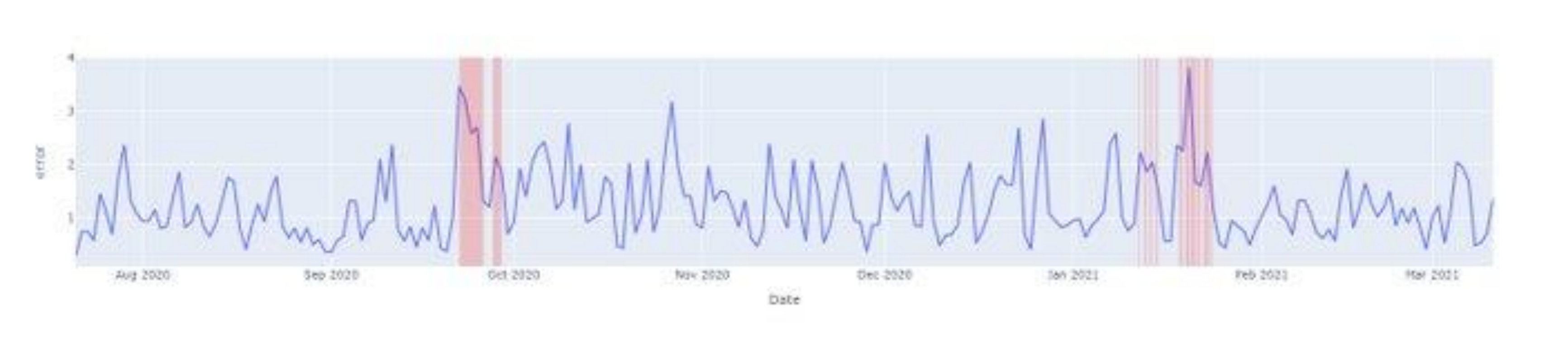
Potential benefits of using extensive hotspot monitoring in power transformers

Investigate how a large number (16) of fiber optic hot-spot paints can be utilized to provide better information on the potential for overheating of the transformer as a function of load



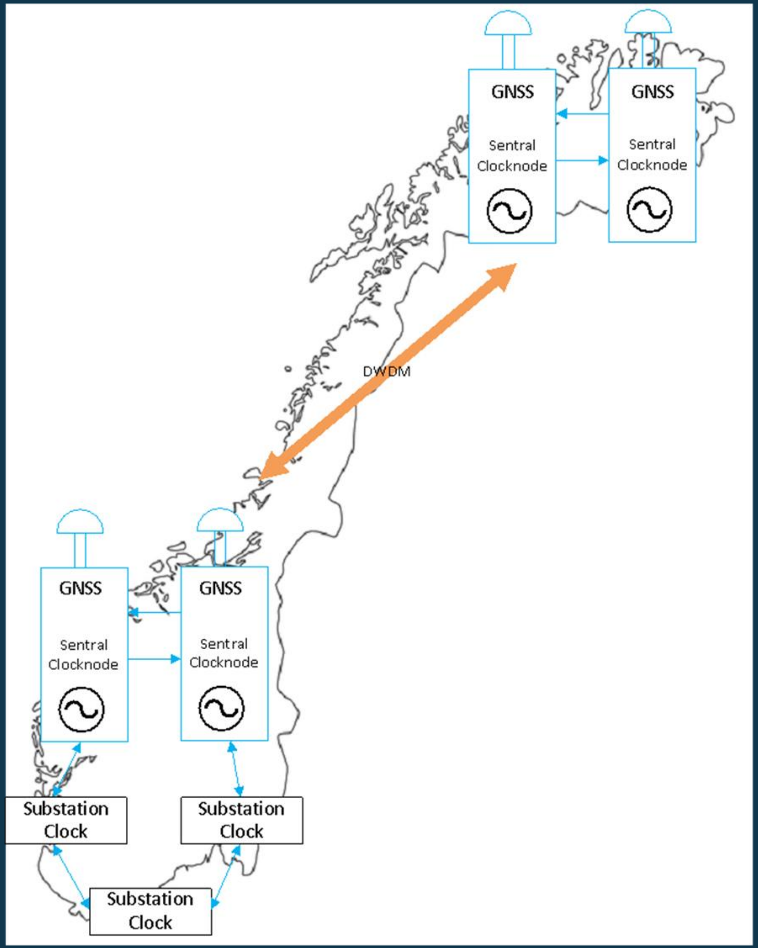


Machine learning for temperature prediction Cooling failure Temperature prediction



COSECTIME

Timescale

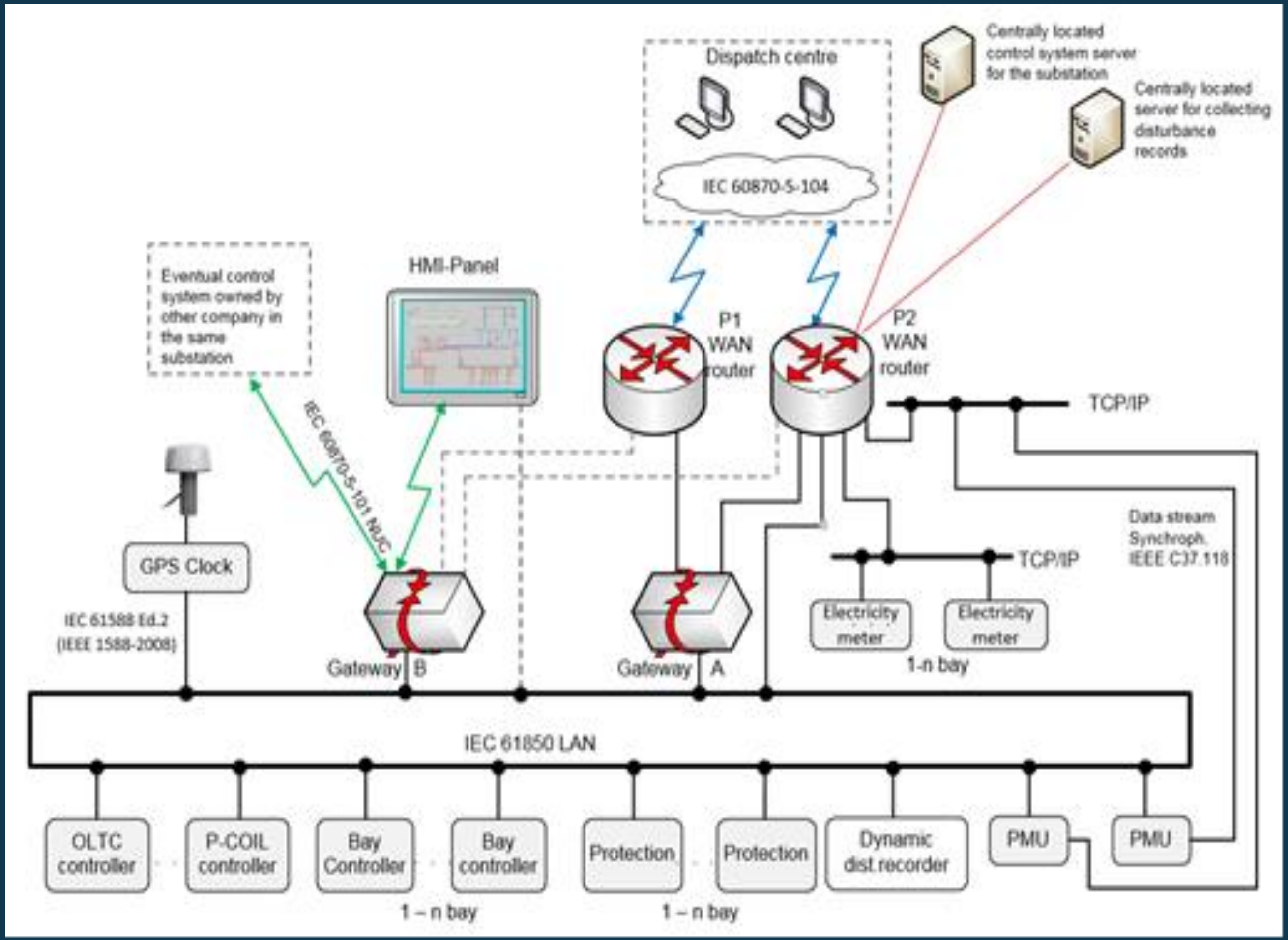


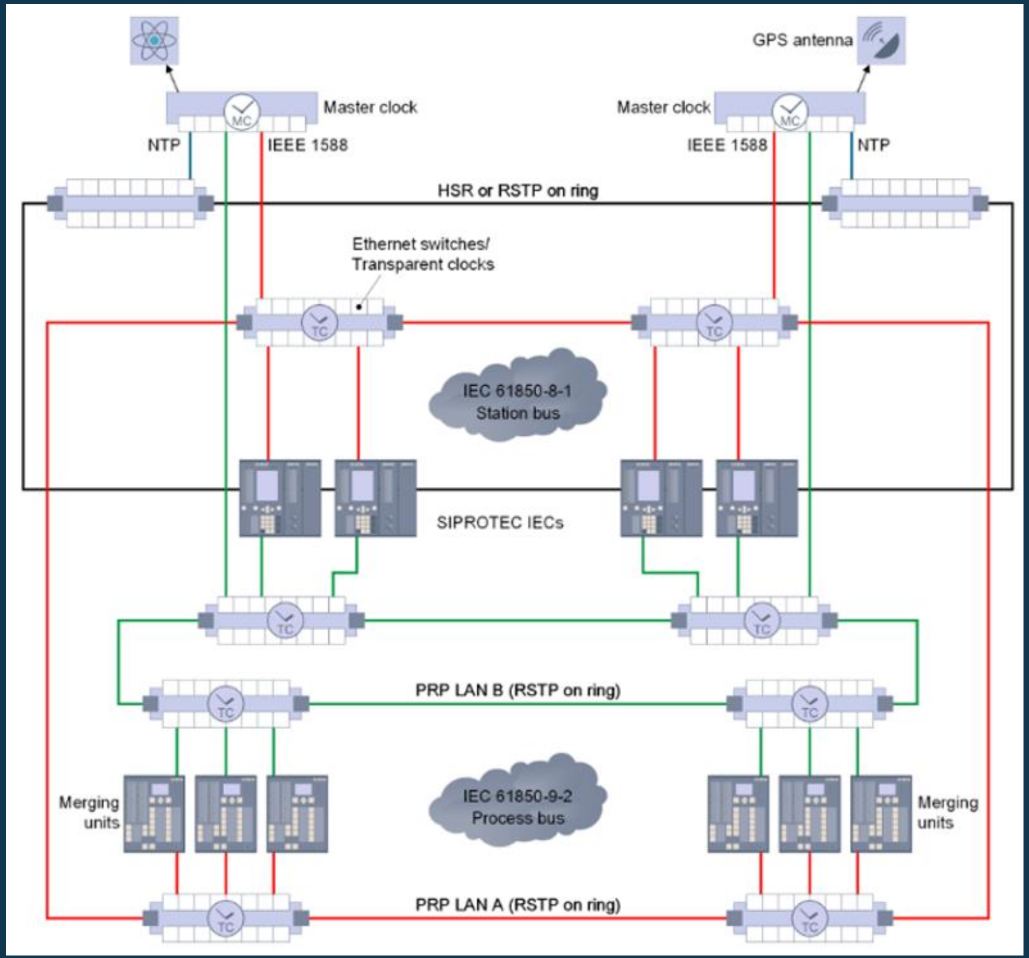
Timetransfer

Digital substation

Digital Pilote Station

Digital Substation





COSECTIME 1

Prestudy

FINGRID · Rte · Statnett · VTT · l'Observatoire de Paris · SYRTE · Justervesenet

COSECTIME 2

Pilot:

Autonomous timescale generation from Statnett cesium clock(s)

Establish high precision timing link to Justervesenet – UTC(JV)

Establish high precision link to Statnett pilot digital substation

Key experiences:

- Clocks will fail
- Networks may be unavailable or unstable

Redundant secure timing sources and timing distribution to digital power protection and control applications *by H. Hauglin et al*
https://e-cigre.org/publication/CSE017-cse-017

COSECTIME 3

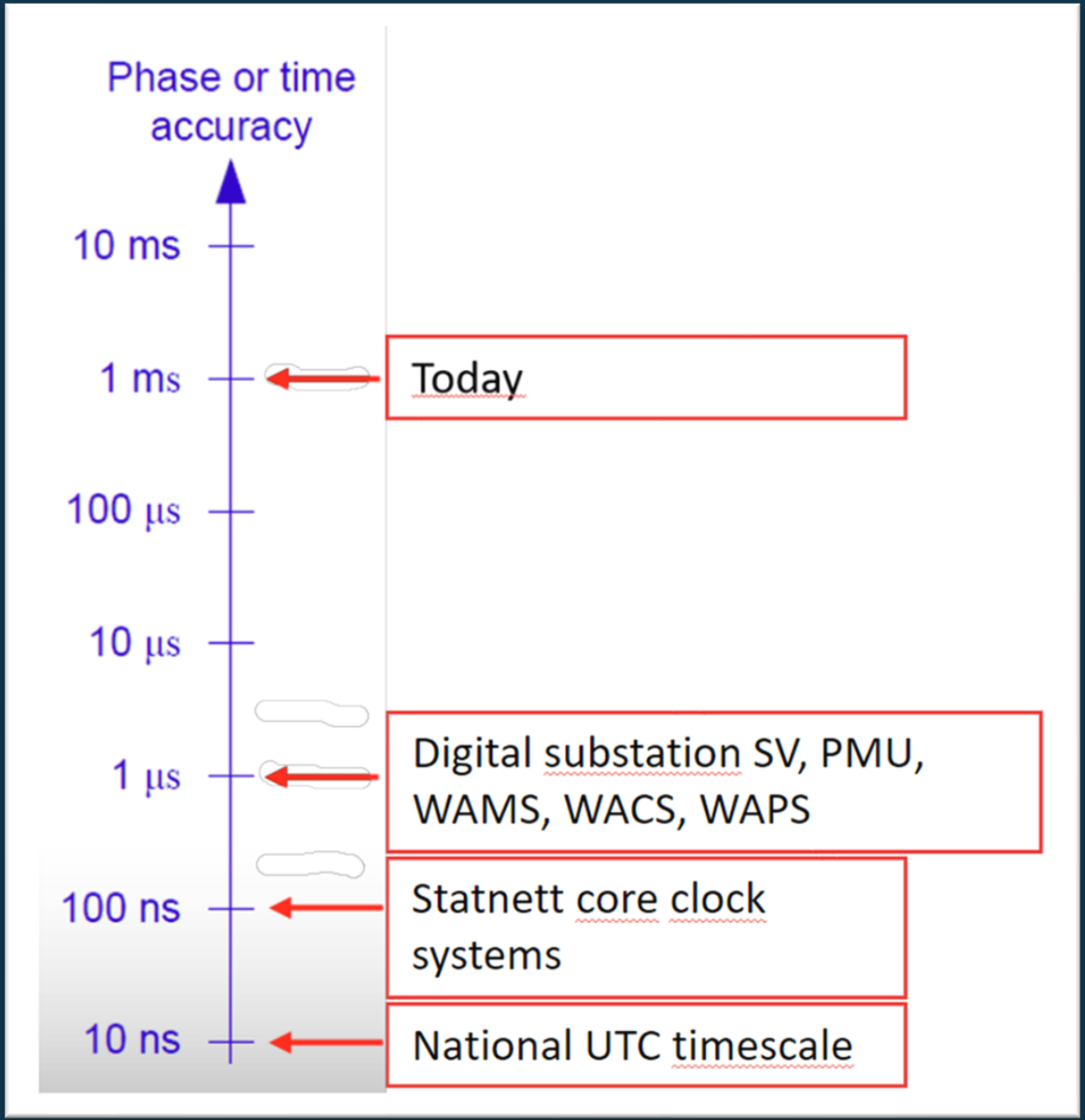
Technology qualification:

Geographically distributed core atomic clock systems

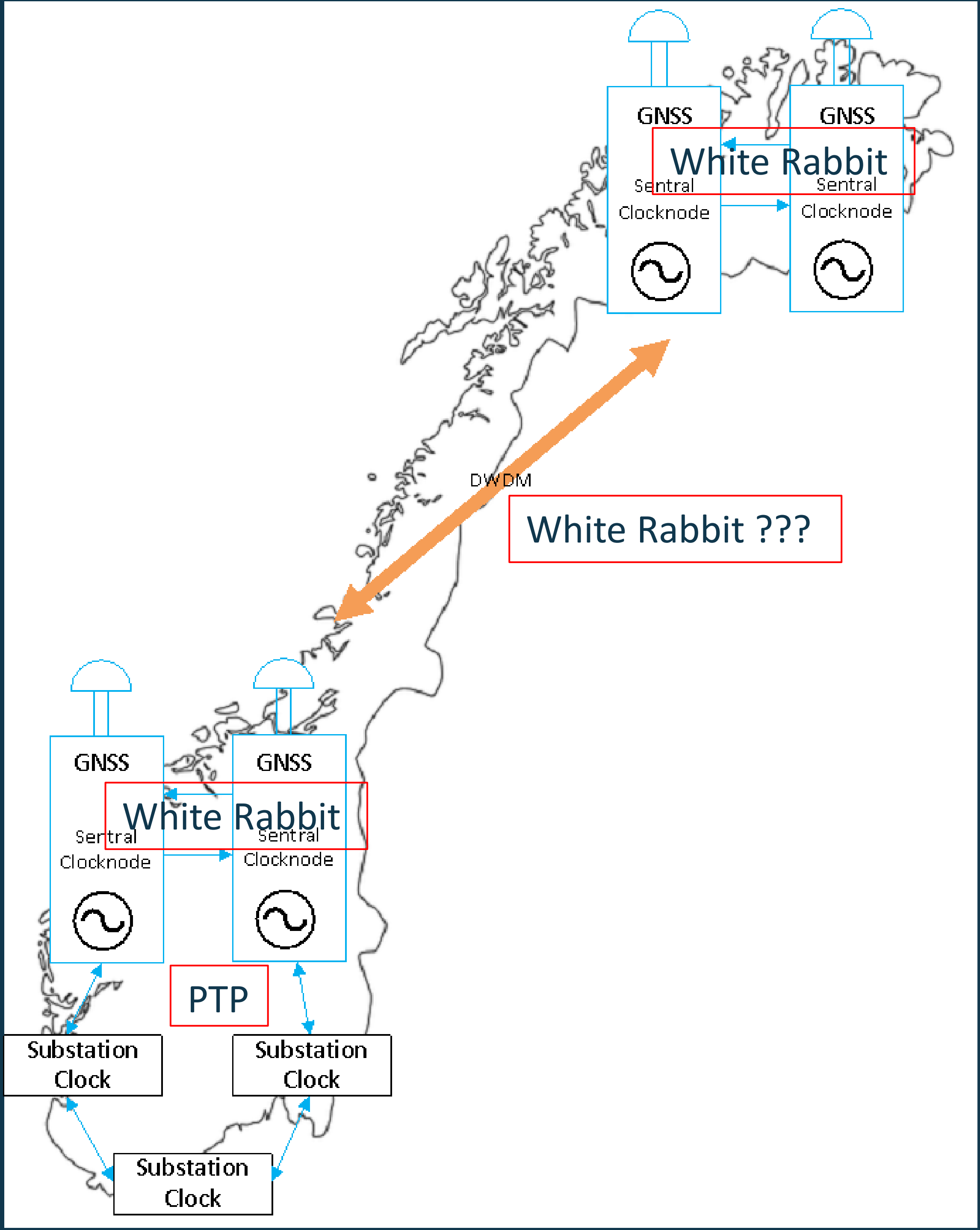
Clock systems connected by dedicated high accuracy links

Management of the time reference system

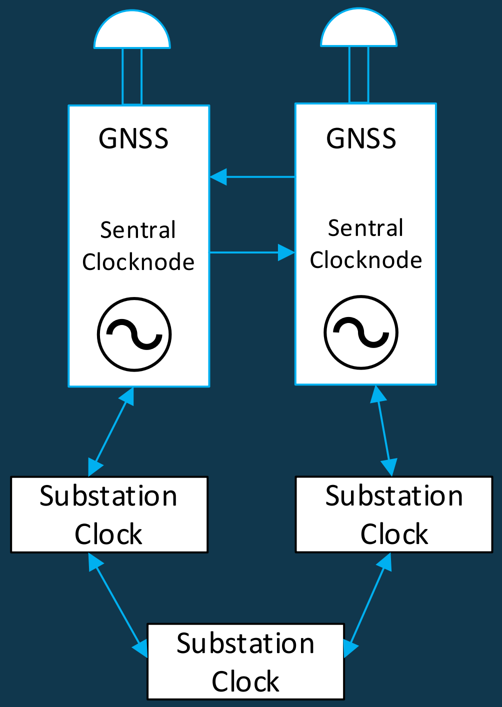
High level of resilience

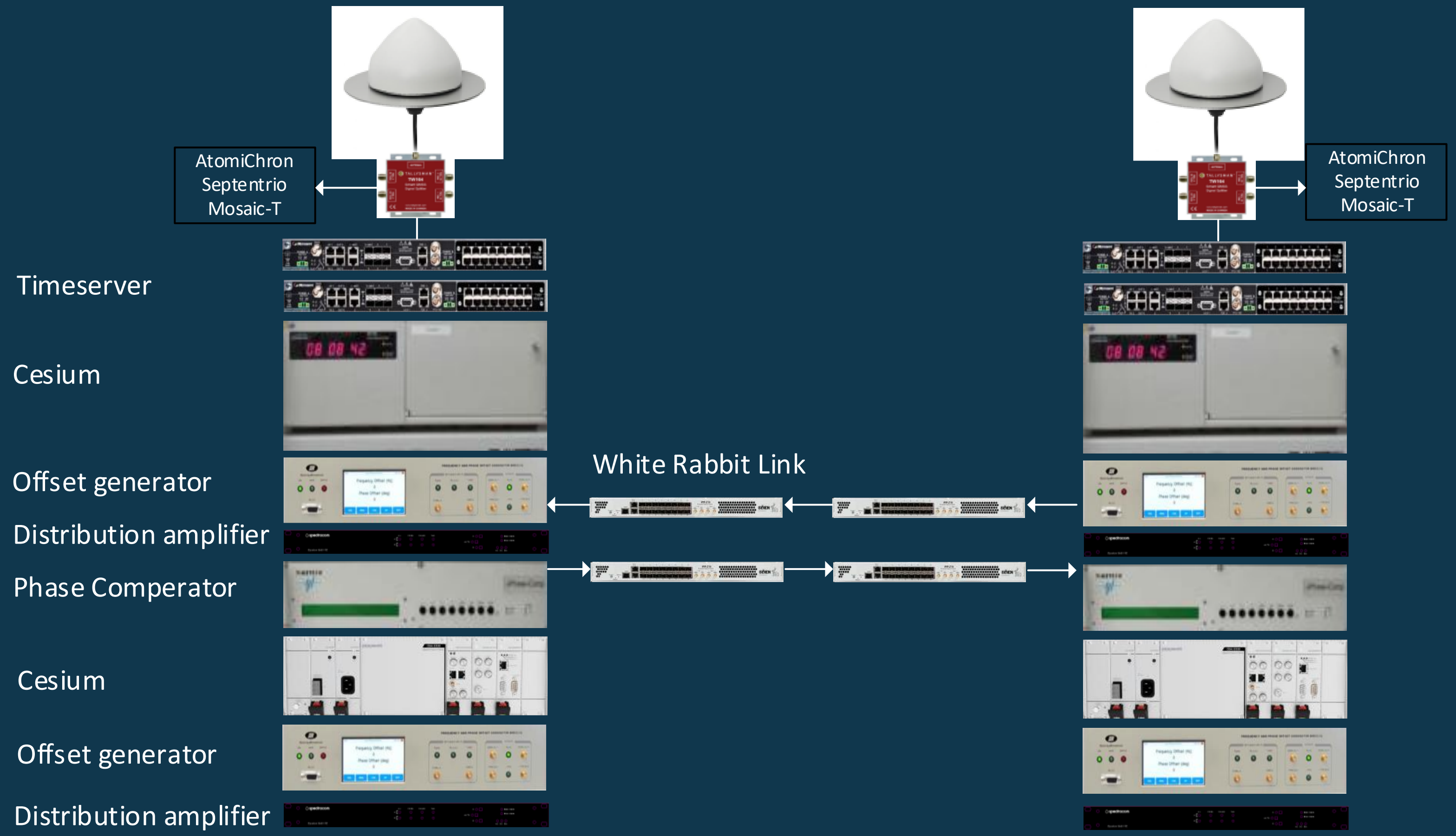

Phase or time accuracy
10 ms
1 ms
100 μs
10 μs
1 μs
100 ns
10 ns
Today
Digital substation SV, PMU, WAMS, WACS, WAPS
Statnett core clock systems
National UTC timescale

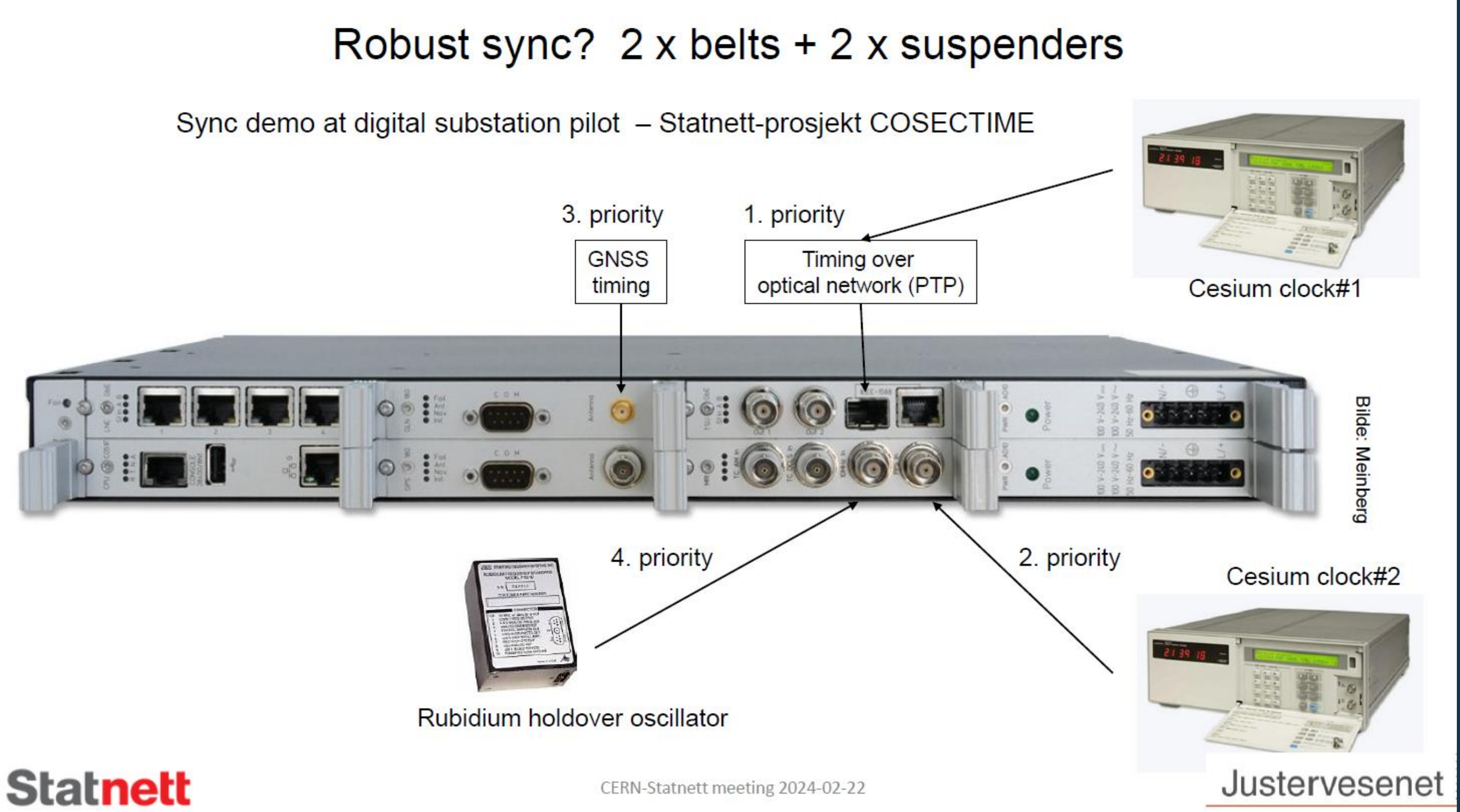
- Ring topology over upgraded DWDM network
- All equipment ready for high accuracy sync
  - Precision Timing Protocol (PTP) aware routers
  - DWDM with support for bi-directional PTP
- Deployment in regional test ring
- Deployment and tests in DWDM lab environment

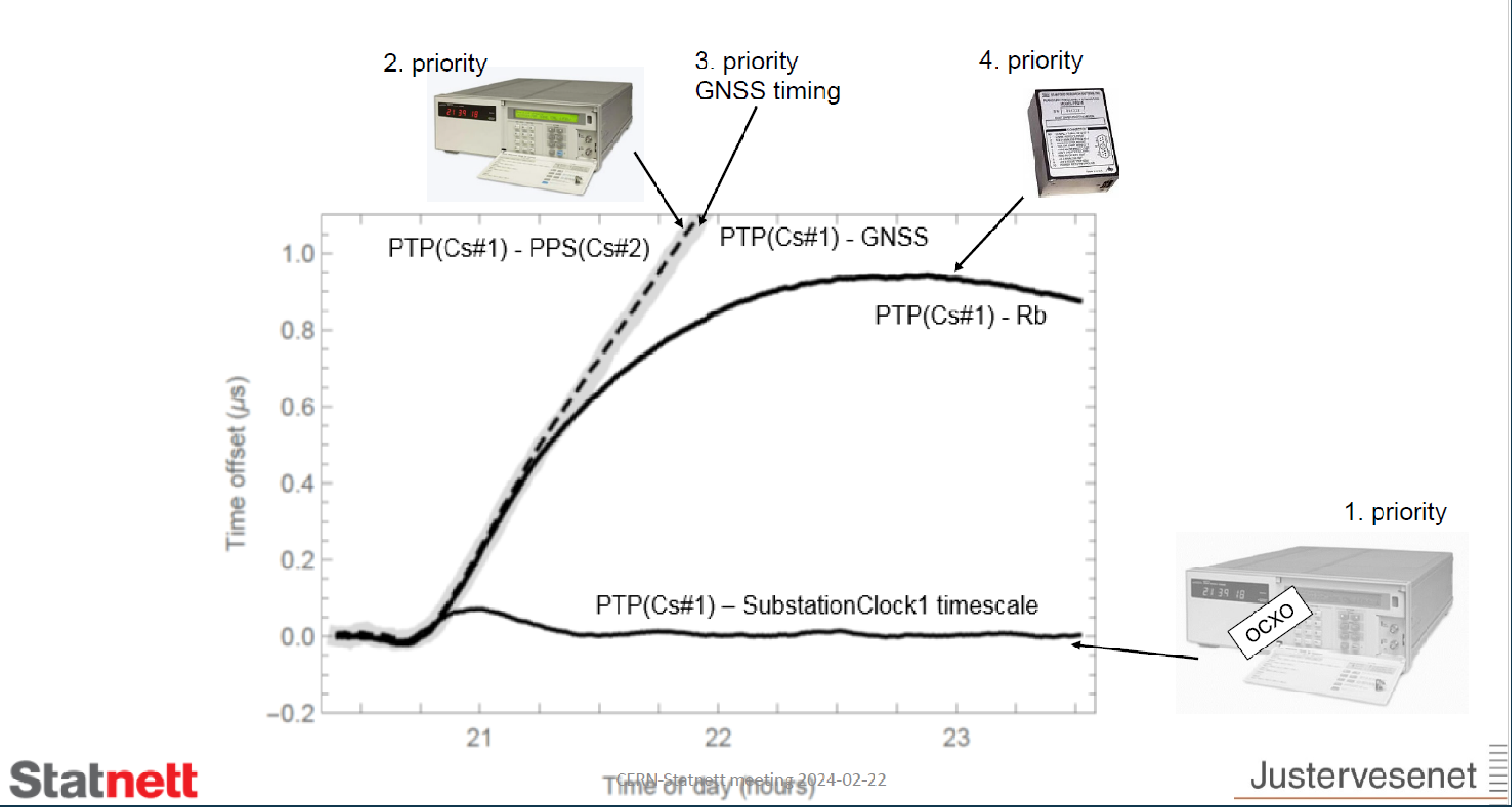


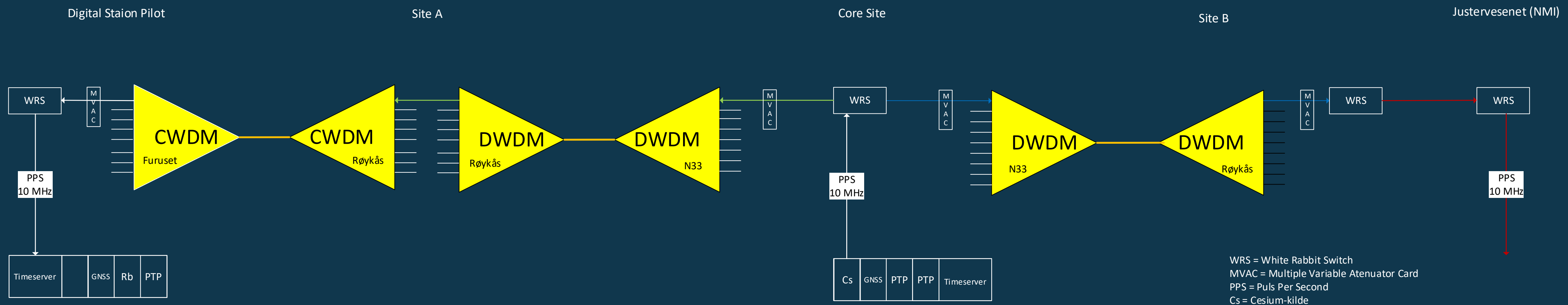
Statnett


GNSS
Sentral Clocknode
GNSS
Sentral Clocknode
Substation Clock
Substation Clock
Substation Clock


AtomiChron Septentrio Mosaic-T
AtomiChron Septentrio Mosaic-T
Timeserver
Cesium
Offset generator
Distribution amplifier
Phase Comperator
Cesium
Offset generator
Distribution amplifier
White Rabbit Link

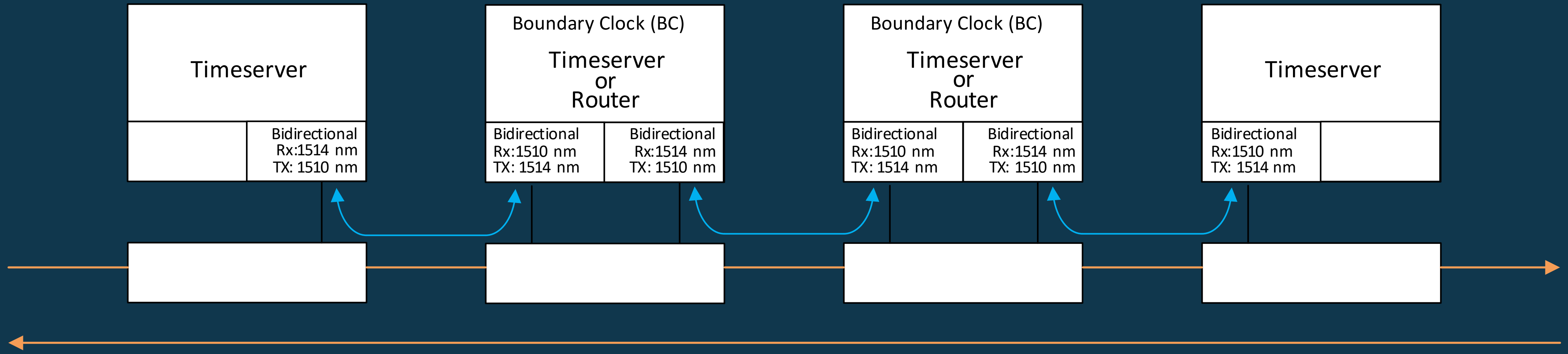

Robust sync? 2 x belts + 2 x suspenders
Sync demo at digital substation pilot – Statnett-prosjekt COSECTIME
3. priority
GNSS timing
1. priority
Timing over optical network (PTP)
Cesium clock#1
Bilde: Meinberg
4. priority
2. priority
Cesium clock#2
Rubidium holdover oscillator
Statnett
CERN-Statnett meeting 2024-02-22
Justervesenet

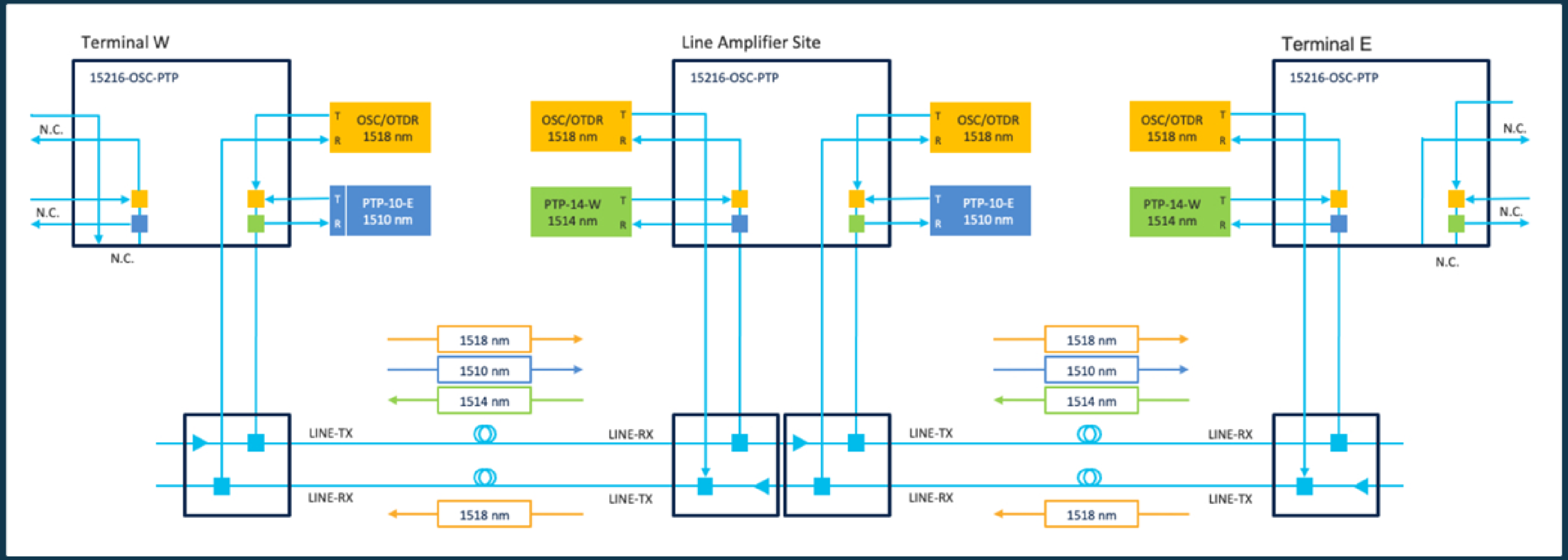

2. priority
3. priority
GNSS timing
4. priority
1. priority
OCXO
PTP(Cs#1) - PPS(Cs#2)
PTP(Cs#1) - GNSS
PTP(Cs#1) - Rb
PTP(Cs#1) – SubstationClock1 timescale
Time offset (μs)
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
21
22
23
Time of day (hours)
Statnett
Justervesenet

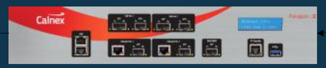


WRS = White Rabbit Switch
MVAC = Multiple Variable Atenuator Card
PPS = Puls Per Second
Cs = Cesium-kilde
Rb=Rubidium
GNSS = Global Navigation Satellite Systems
PTP = Precision Time Protocol

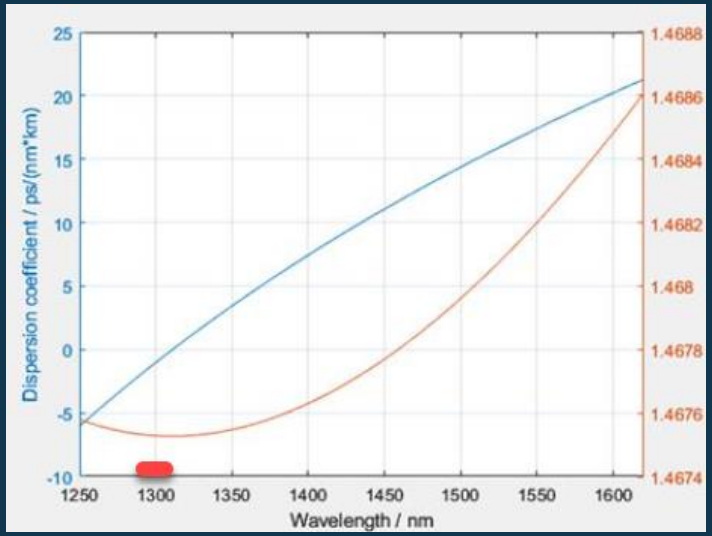
PTP over DWDM

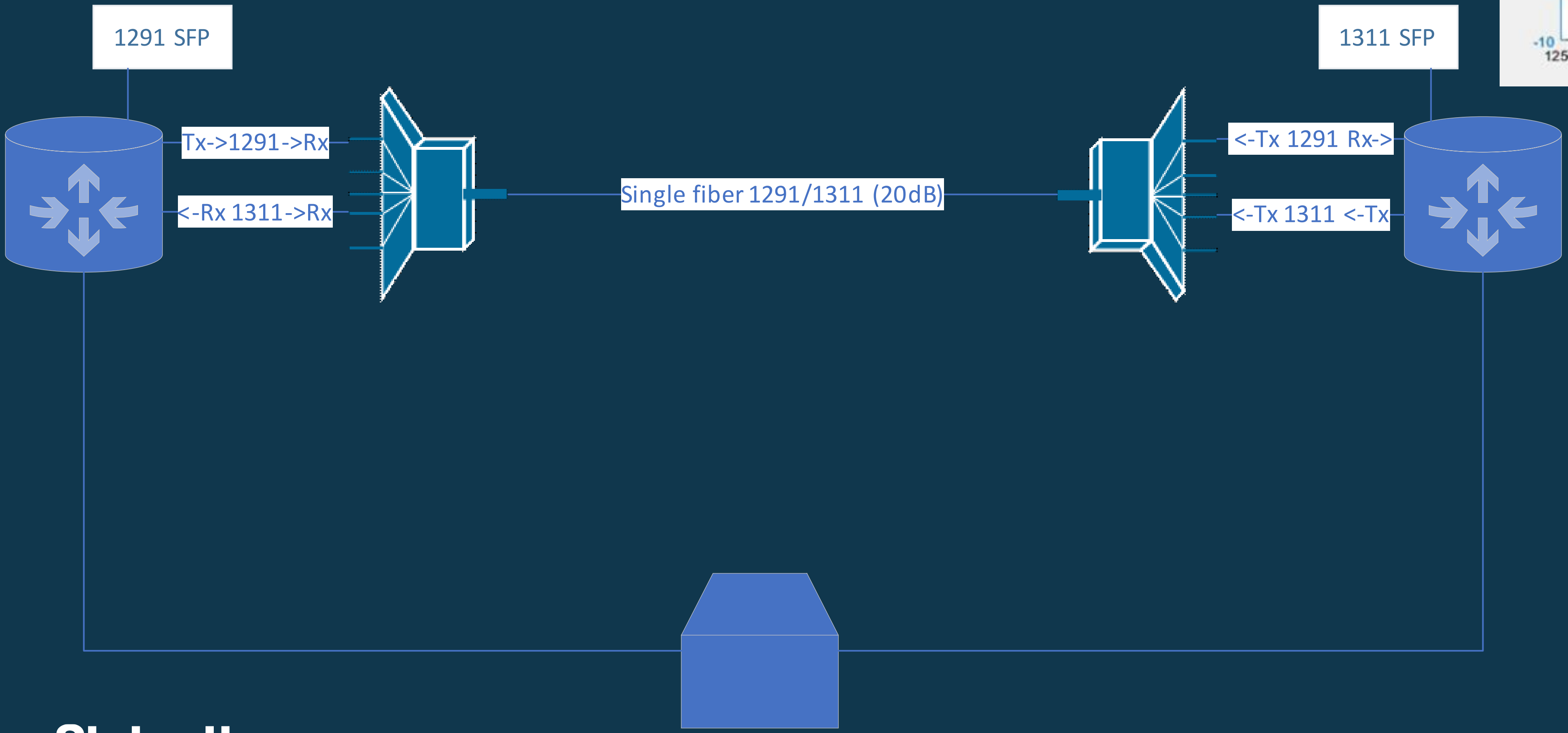






Prinsippskisse for overføring
PTP over ulike bølgelengder
via CWDM





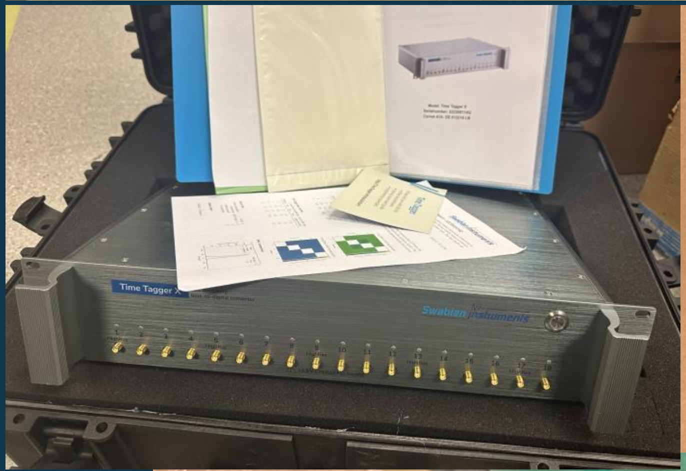
Gunnar Bjørndal Riis
Kjell Olav Nestegard
20/12-22


XHE
DIV
Hylle
Hylle


Calnex
Paragon-X


TIC-01
14 43 28
Statnett SNCs23
14 43 28


Licensed under CERN OHL v.1.2
WRS-3/18
18 Port White Rabbit Switch


Time Tagger X
Swabian Instruments

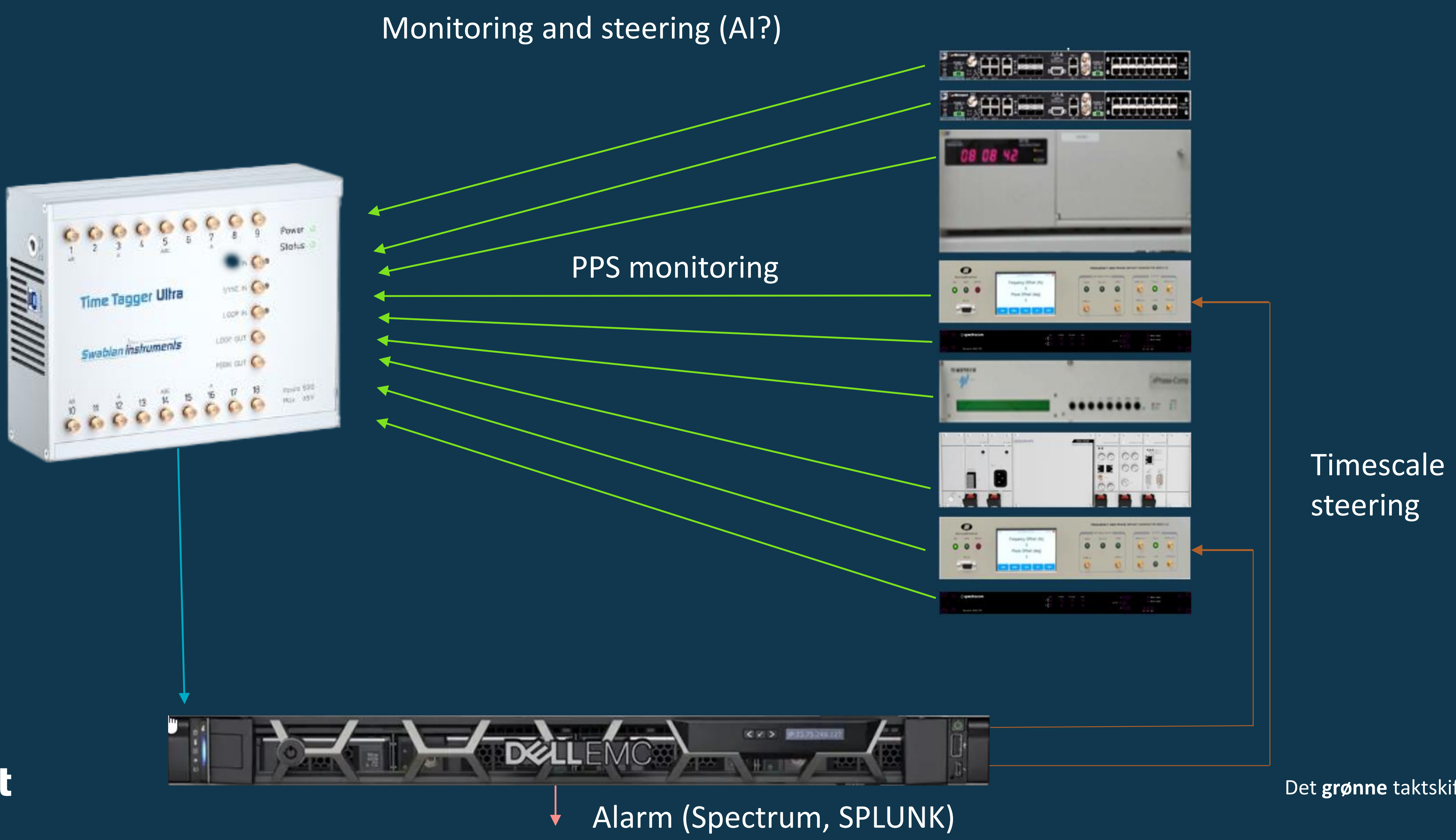

SPECTRADYNAMICS
FREQUENCY AND PHASE OFFSET GENERATOR HROG-10


Microsemi
1G/10G Module
10G PORTS

Challenges

- Will WR work through DWDM with transponders? (optic – electric – optic)

Challenges


Monitoring and steering (AI?)
PPS monitoring
Timescale steering
Alarm (Spectrum, SPLUNK)
Time Tagger Ultra
Swabian Instruments
DELL EMC

Statnett

The Green Pulse