TSO Grid digitalization, case IoT monitoring at Fingrid

Future Grid Acceleration, March 8^{th}, 2022

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Finnish Power System

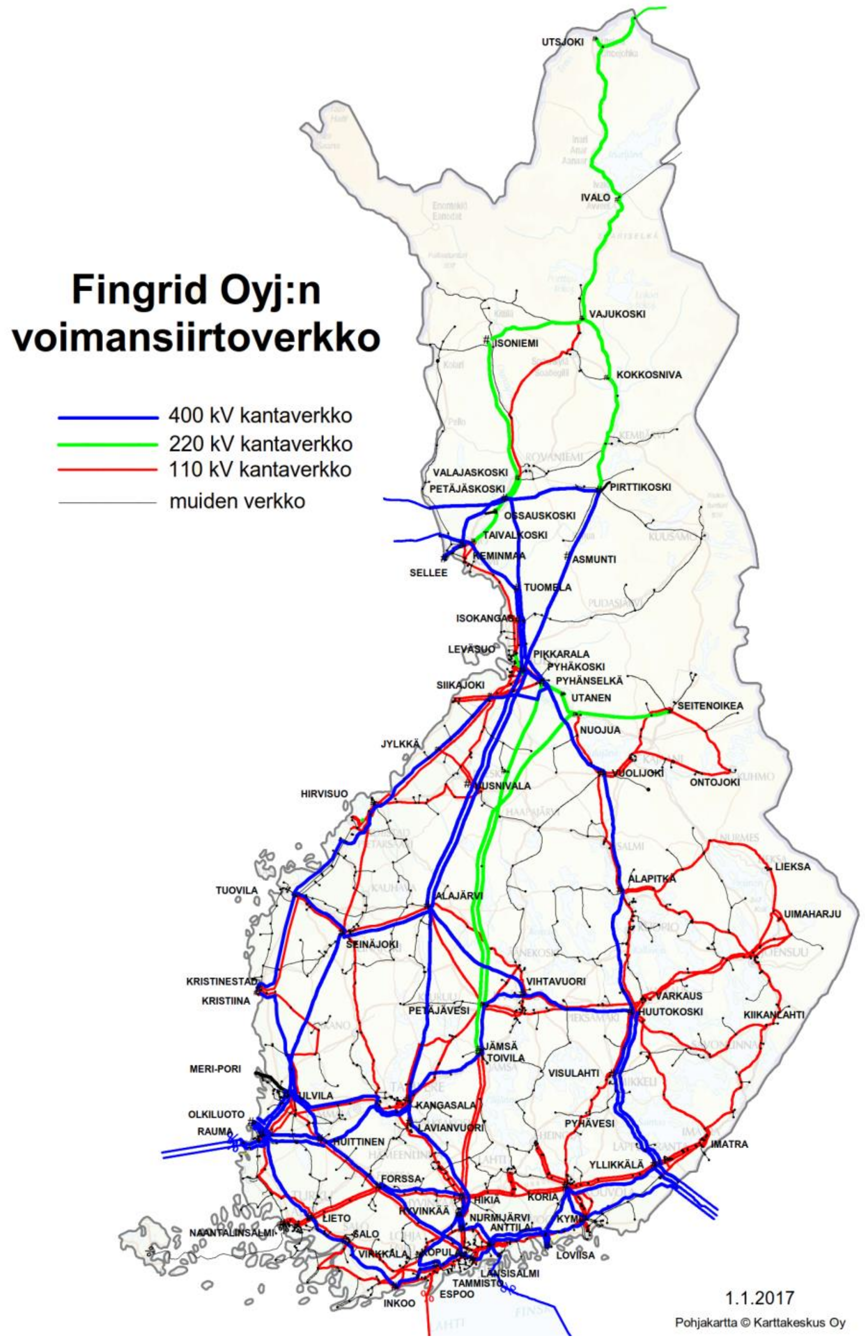
99.99992 %
transmission reliability

System peak load 15 105 MWh/h

14 300 km transmission lines
(400, 220 and 110 kV)
115 substations

1300 circuit breakers
3 600 disconnectors
5 900 instrument transformers

average age of OHL 32 yr
average age of s/s 18 yr



Why IoT ? Back in 2016

Improve real time knowledge of asset condition

Allocate maintenance actions on need basis

- Time based measurements replaced by IoT sensors

Minimize outages of assets condition checks

- New biz models for service contracts

Want to be forerunner in TSO domain

- Change management, internal, external

Constrains: cost effective, affordable, scalable

For power system expertise

Fingrid's journey in IoT monitoring, and continues

2016 – IoT project kick-off
- Concept planning
- Market analysis
- Investigation of condition monitoring systems

2017 – Improvements for maintaining process
- New condition monitoring solutions
- Testing of new devices
- Hand-held models

2018 – Innovation competition
- Competitions was published by Spinverse (innovation consulting company)
- Received about 30 applications per monitoring solution
- 7 candidates selected to pitching phase per monitoring solution

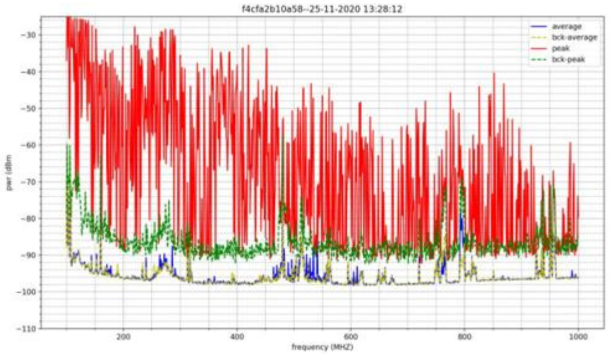
2018-2021 – R&D phase
- Continued to R&D with IonSign and Sulaon
- Sensor development
- Selection of data platform
- Selection of end user tool

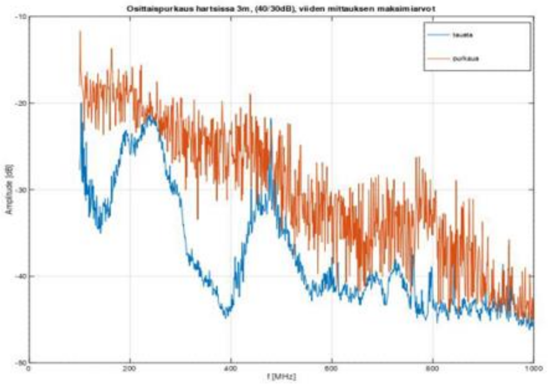
2021 – Concept ready
- Moved to production phase (more installations at substations)
- Model validation
- Data analytics development
- Artificial intelligence solutions

2022 – Switchgear monitoring Roll out
- 20 substations per year
- Ambitious goal towards condition-based maintenance process
- AI model development
- Better visualization of results in UI
- **We know condition of primary assets in real-time**

Model Validation - PoC: case Partial Discharges

- Development stream outputs were tested in simulated environment
  - High voltage laboratory
  - Real phenomena with test object(s)
  - Head to head comparison with different solutions
  - Technically dominant solution (Company) was selected for next phase





IoT R&D phase 2018-2021, three main streams

1. Sensor development

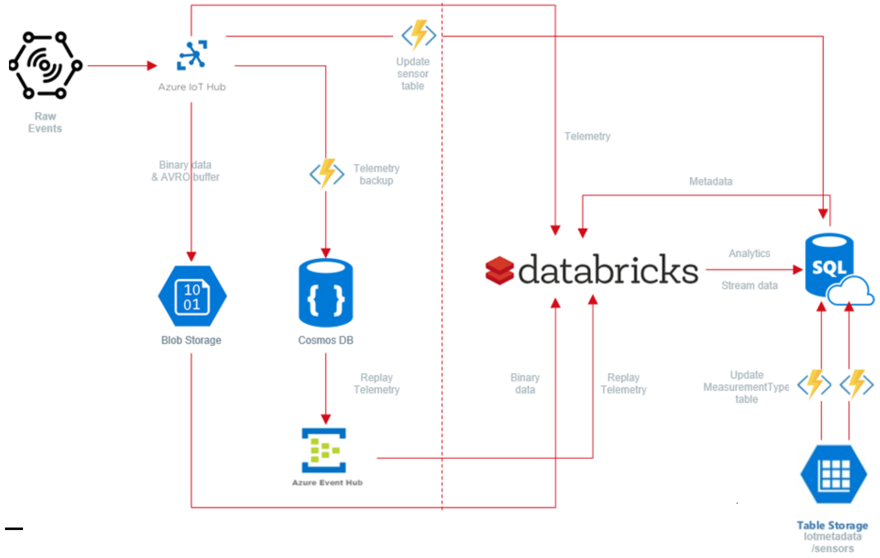
- Reliability centered approach on development, real use cases only
- Innovation challenges 2018-2019 with partner

Technology scope:

1. **Switchgear monitoring – *Ionsign***
2. **Partial discharge monitoring of current transformers (RFI) – *Sulaon***
3. Control building monitoring – *Haltian*
4. Temperature monitoring on primary paths, sensor – *Haltian*
5. Busbar vibration – *Haltian*
6. Temperature monitoring on primary components, camera
7. SF6 leakage indication system at GIS - *Ionsign*

2. Data-platform

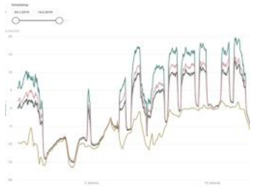
- Messages, data processing, performance indicator calculation
- Cloud platform (Azure-Databricks) ready for specific data channels

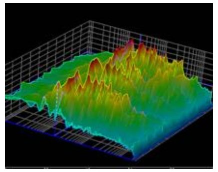


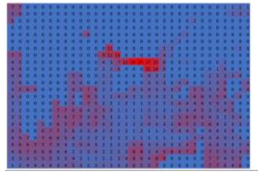
3. IoT UI

- Alarms, results and visualization
- Test run on UI-application ongoing

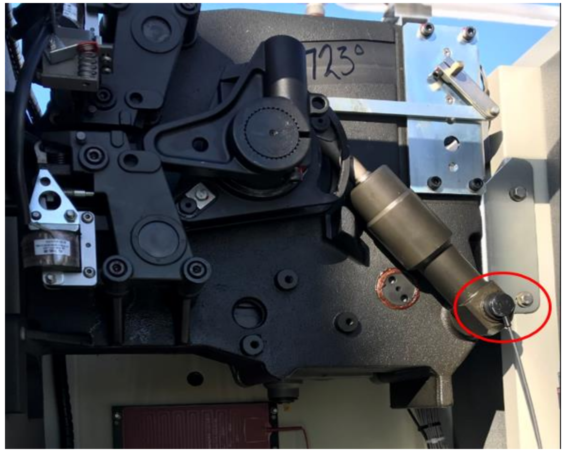
Substation	Asset	Asset Type	TriggerTime (EEST)	Operation	Motor Current Flat Max (A)	Motor Current Flat Mean (A)	Motor Current Flat Min (A)	Motor Current Flat St. Dev..	Motor Current Integral (As)	Motor Current Peak (A)	Operation Duration (s)
KM	AE10Q3	ERO	16.4.2019 15:17:53	Open	1,48	1,31	1,17	0,04	7,77	7,25	5,82
KM	AE10Q1	ERO	16.4.2019 15:05:30	Open	2,05	1,73	1,25	0,13	11,20	6,95	6,42
KM	AE10Q4	ERO	16.4.2019 14:17:13	Open	1,61	1,52	1,31	0,05	9,31	7,58	6,05
KM	AE07Q4	ERO	16.4.2019 14:15:35	Open	1,88	1,76	1,62	0,05	10,19	7,45	5,69
KM	AE08Q2	ERO	16.4.2019 13:36:00	Open	1,56	1,40	1,26	0,05	8,43	8,90	5,86

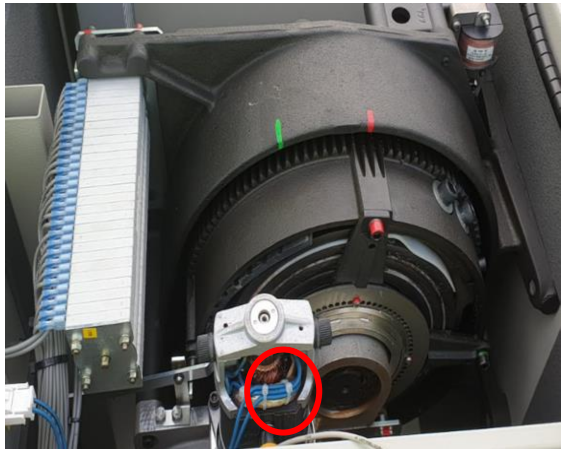


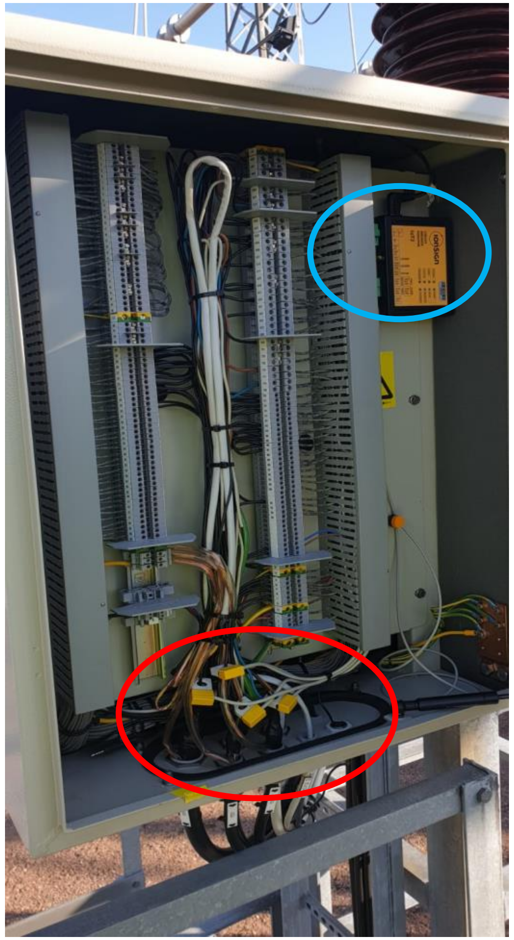


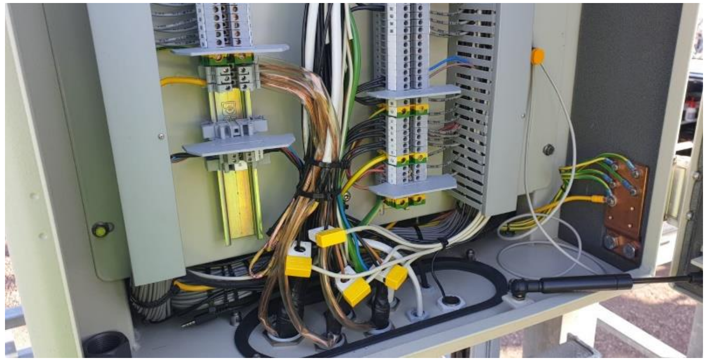


Example of Switchgear monitoring - IoT for circuit breakers





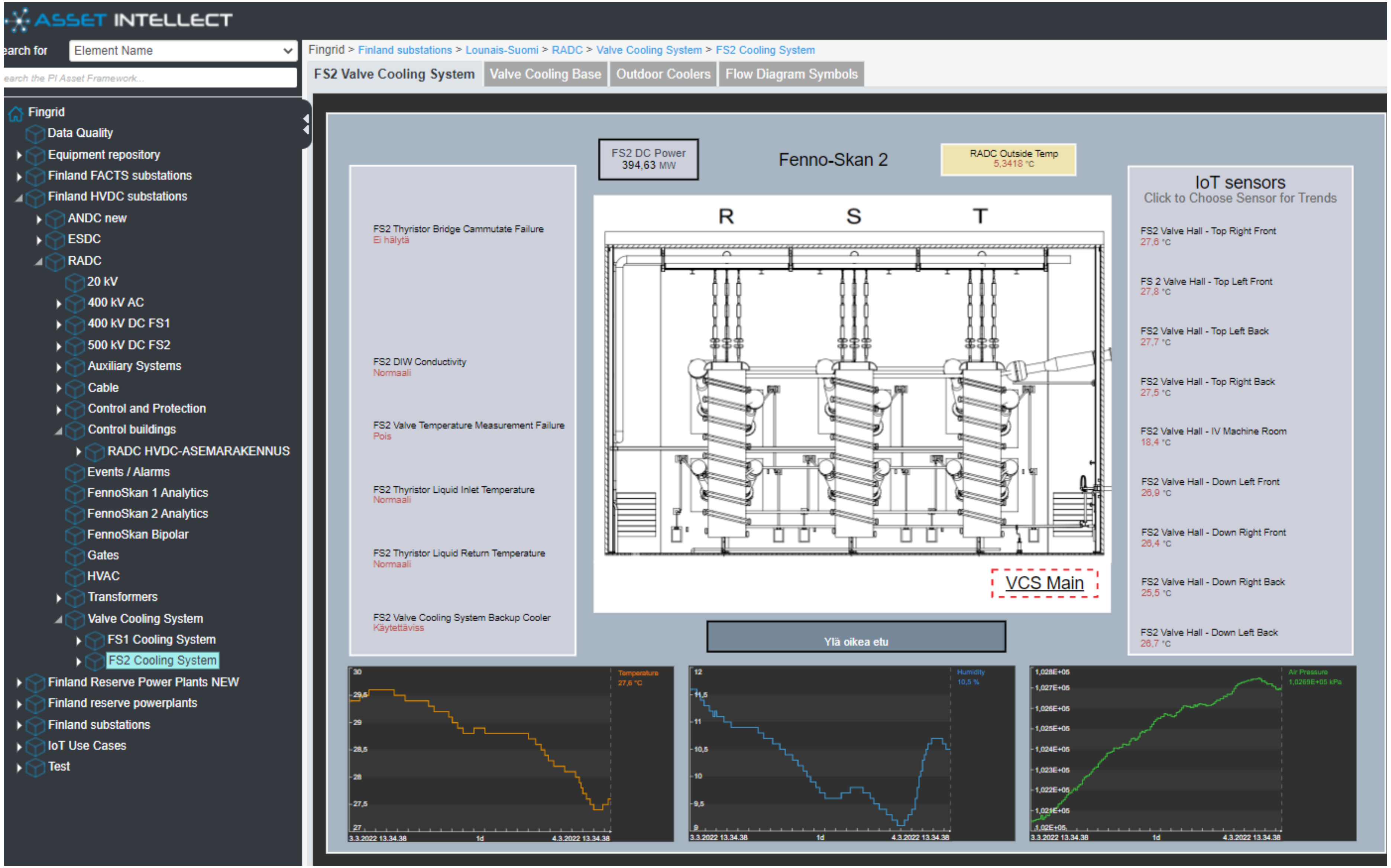




IoT consists of:

- 1 piezo sensor-AE (motor)
- 4 Hall-sensors (trip, close coils, motor)
- 1 air-electret microphone (internal)
- 1 MEMS sensor (damper)
- 2 binary inputs (NO, NC)
- temp/humidity sensor.

User Interface – 800 MW HVDC Fenno-Skan 2 valve cooling



Vision in year 2025

The busiest day at Fingrid's substation

- Improve real time knowledge of asset condition
  Allocate maintenance actions on need basis
- Minimize outages of assets condition checks
- Want to be forerunner in TSO domain

Lessons learned – so far

- Visible top management support is vital
- Common vision and engagement
- Perseverance and continuous learning process
- It's far from technology project but change management – human inertia
- From technology viewpoint IT and OT are converging – may cause collisions
- Prioritization of potential use cases. Cost benefit - Biz impact approach
- Low – cost sensors vs. high quality measurements – challenge
- Fail fast – short development sprints
- Results will be cached out – if not tomorrow but in coming years

Thank You!

Q&A

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