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Future Intelligent Transmission Network Substation (FITNESS)

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Topics covered

- Overview project FITNESS
- Business benefits and drivers
- Optimising architecture design for long term
- Overcoming the technical challenges when implementing the process bus:
  - Reliability
  - Time synchronisation between devices
  - Cyber-security
  - Measurement accuracy
  - Confidence in the solution
FITNESS Overview

Future Intelligent Transmission Network Substation (FITNESS) is a flagship innovation collaboration project awarded by the UK regulator, Ofgem, to accelerate the progression to 61850-based transmission network substations, and:

- Reduce environmental impact of substations
- Enhance substation safety
- Enable increased flexibility and greater controllability in substations

Major benefits are expected to include:
- A reduction in substation costs,
- improved system access,
- reduced network constraints.

Predicted benefits to GB customers by 2050:
- Faster deployment and improving network availability: £260m-£592m savings in constraint payments
- Reduced cabling and substation footprint: £572m-£858m savings in substation costs
FITNESS Overview

Jan 2016 – March 2020 to:

• design and demonstrate full IEC 61850 operation and interoperation
• educate and inform the industry (including internal) of the technology
• uncover and overcome issues with the interpretation of the standard
• work with IEC Working Group to develop standard as necessary

<table>
<thead>
<tr>
<th>Date</th>
<th>WP1 Substation Design Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep-16</td>
<td></td>
</tr>
<tr>
<td>Sep-17</td>
<td>WP2 Off-line trials complete</td>
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<tr>
<td>Nov-18</td>
<td>WP5 Digital Substation training complete for install</td>
</tr>
<tr>
<td>Aug-18</td>
<td>WP2 Substation Bay#1 – live operation starts</td>
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<tr>
<td>Sep-18</td>
<td>WP3 Information exchange &amp; application demo</td>
</tr>
<tr>
<td>Sep-18</td>
<td>WP3 Flexible control infrastructure demonstration</td>
</tr>
<tr>
<td>Aug-19</td>
<td>WP2 Substation Bay#2 – live operation starts</td>
</tr>
<tr>
<td>Mar-20</td>
<td>Close down</td>
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Benefits and business drivers

- SPEN innovation strategy
- Short-term and long-term gains:
  - Reduced substation costs & reduced network constraints
  - Improved system access

Targeted areas of improvement and optimisation in conventional design
Multi-Vendor Interoperability

Multi-vendor interoperability:
✓ Between ABB IEDs and GE merging units;
✓ Between GE IEDs and ABB merging units;
✓ Between ABB/GE merging units and SYNAPTEC Interrogator;
✓ Between ABB IEDs and GE Substation Automation System;
✓ Between ABB IEDs and GE SCUs (for protection trips);
✓ Between GE IEDs and ABB SCUs (for protection trips).

End to end integration of substation and central system applications, to increase visibility and situational awareness.

Bus architecture for measured sampled values (SV) published to all secondary devices

- Distributed optical sensing
- Non-conventional voltage transformers (NCVTs)

First demonstration of NCITs as single unified data source to replace separate transformers for protection, measurement and power quality (PQ);
Greatly improved access to information sources without CT/VT connections;
## Proof of interoperability

<table>
<thead>
<tr>
<th>Location</th>
<th>Equipment</th>
<th>GE P546 (21P/21N/87L)</th>
<th>ABB RED670 (21P/21N/87L)</th>
<th>Synaptec Distributed Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wishaw</td>
<td>ABB MU (CT &amp; VT)</td>
<td>Circuit 1</td>
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<tr>
<td></td>
<td>GE NCIT-CT/VT</td>
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<td>GE MU (CT &amp; VT)</td>
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<tr>
<td></td>
<td>ABB NCIT-CT &amp; CVT</td>
<td>Circuit 2</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Synaptec NCIT Distributed Sensor</td>
<td></td>
<td></td>
<td>Circuit 1 &amp; Circuit 2</td>
</tr>
<tr>
<td>Newarthill</td>
<td>Conventional CT &amp; CVT</td>
<td>Circuit 1</td>
<td>Circuit 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conventional CT (no CVT available)</td>
<td>Circuit 2, 87L only</td>
<td>Circuit 2, 87L only</td>
<td></td>
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</table>
Process Bus Architecture

• Piloting new technologies affecting key aspect of network operation - Protection and Control

• Purpose to determine optimum architecture
  • Performance, Redundancy / reliability, maintenance, and, scalability

• IEC61850 standard does not specify what kind of redundancy is required

• ABB and GE have different preferred PB architectures:
  • Parallel Redundancy Protocol (PRP)
  • High-availability Seamless Redundancy (HSR)

• Technical assessment and Life-Cycle Analysis to determine chosen architecture

• Most significant challenge is to instil sufficient confidence across the business that benefits are both attainable and sustainable and can be achieved without degrading system reliability and security.
Process Bus: ABB and GE Preferred Architectures

HSR
- Dual-ring
- Not segregated from SB

PRP
- Dual LANs
- Segregated from SB

Future Intelligent Transmission Network Substation (FITNESS)
Primary objective is to overcome technical challenges and bring technology and practices to BaU.

A **technological leap** from Single Function IEDs to Integrated C&P:

1. **Reliability**
   - Examine and validate performance, Operational / maintenance
2. **Time synchronisation between devices**
   - Highly dependant on GPS systems, state of existing comms infrastructure
3. **Cyber-security**
   - Masses of digital data, integration with existing IT systems
4. **Measurement accuracy**
   - Non-conventional instrument Transformers deployed, time synch errors
Technical Challenges

Time Synchronisation is vital to ensure the substation devices properly synchronise events and data acquisition

• The method of time synchronisation can be either direct (GPS, 1PPS, IRIG-B) or synchronisation over LAN (distributed time synchronisation).

• LAN synchronisation can be applied on the existing Ethernet network to distribute synchronisation information without the need for a dedicated cabling infrastructure (more cost effective)

• FITNESS:
  • uses IEEE 1588 Precision Time Protocol (PTP) - power profile, and dual Grand Master Clock with “Best Master Clock”
  • switches (at both SB and PB) and IEDs must be able to act as Transparent Clocks (TC) and as Boundary Clock (BC) respectively
Technical Challenges

Previous 61850 demonstration trialled in 2015/16

- Experienced difficulties of implementing IEC 61850 with added complexity of using propriety configuration tool

However, business remains committed to explore the benefits of employing 61850

Internal stakeholder engagement to identify specific concerns:

- Key questions from Protection Engineer Manager:
  - Can we rely on multicast SVs?
  - How can we provide reliable time synchronisation?
  - Can we rely on simulation tools to robustly prove functionality?
  - How do we manage the evolution of the standard and integrate new IEDs?
  - What is the engineering process? How will SPT deliver future projects?
Technical Challenges

How we are addressing the technical challenges?

• Assessment of both HSR and PRP architectures with support from independent parties - Christoph Brunner (IT4Power) & Haiyu Li (University of Manchester).

• Full solution complement testing and training at HV testing facility prior to deployment

• Establish and educate engineers on testing procedures to support process bus implementation
Thank you

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