

Future Intelligent Transmission Network Substation (FITNESS)

In collaboration with



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Project Progress Report

[External]

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Approval



Name	Position	Date	Signature
C Patterson	Senior Project Engineer	16/08/18	
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Table of Contents

Version History.....	2
Approval.....	2
Glossary of Terms.....	4
1 Executive Summary.....	5
1.1 Project Highlights	5
1.2 Project Risks	6
1.2.1 Technical Risks	6
1.2.2 Project Management Risks	7
2 Project Manager's Report	8
2.1 Project Progress Summary	8
2.2 Project Overview.....	8
2.2.1 Project plan	8
2.2.2 Key project objectives	9
2.3 Project Progress during the Reporting Period	10
2.4 FITNESS IEC 61850 Training Programme.....	12
2.4.1 Lectures with Hands-On Experiments and Live Demonstrations	12
2.4.2 Workshops	13
2.4.3 Special Seminars	13
2.5 Knowledge Sharing and Stakeholder Engagement	14
2.5.1 Knowledge Sharing Events	14
2.5.2 Knowledge Dissemination Events	15
2.6 Outlook to the Next Reporting Period	16
3 Consistency with full submission	17
4 Successful Delivery Reward Criteria (SDRC).....	18
5 Learning Outcomes	19
6 Business Case Update	20
7 Accuracy Assurance Statement.....	21

Glossary of Terms

Abbreviation	Term
HSR	High-Speed Seamless Redundancy
IED	Intelligent Electronic Device
FAT	Factory Acceptance Test
NCIT	Non-Conventional Instrument Transformer
PRP	Parallel Redundancy Protocol
PRR	Portable Relay Room
SAT	Site Acceptance Test
SCS	Substation Control System
SDRC	Successful Delivery Reward Criteria

1 Executive Summary

SP Transmission (SPT), supported by project partners ABB, GE, Synaptec, and the University of Manchester, made a full proposal submission for the project, *Future Intelligent Transmission Network Substation (FITNESS)*, under the Network Innovation Competition (NIC) mechanism in 2015. Ofgem approved the proposal and issued the Project Direction on the 19th of December 2015. The project commenced in June 2016 and is due to conclude in March 2020.

FITNESS brings together two of the largest vendors in the electrical industry to demonstrate the world's first multi-vendor next generation electricity substation using digital technology for full operation; from monitoring to control and protection. The project will also demonstrate the latest in the field of non-conventional instrument transformer (NCIT) technology and research, validating performance against today's Standards; informing, and progressing, the Standards as required, and also future proofing for potential wide-area control.

FITNESS will demonstrate a multi-vendor fully interoperable digital substation solution by deploying standardised and a fully integrated substation protection, monitoring and control system based on the IEC 61850-9-2 Standard in a live substation, that will offer the following benefits:

- **Reduce substation costs** – through reduced cabling and substation footprint
- **Improve system access** – secondary equipment decoupled from primary
- **Improve substation safety** – through reduced 'live' electrical conductors and use of optical sensors
- **Reduce environmental impact** – by reducing overall substation footprint, reduced concrete and copper requirements

1.1 Project Highlights

This is the fourth in the series of annual progress reports for the FITNESS project, covering the project delivery period July 2017 – July 2018, the "reporting period".

The project delivery is in line with the original proposal regarding project programme, resources, budget, risk management, intellectual property rights (IPR) and knowledge sharing. The most significant SDRCs delivered during the reporting period are shown below:

Work Package 2

- **Report on LV secondary systems test results (Nov. 2017).**
- **Report on functionality and interoperability tests (HV tests) (Nov. 2017).**
- **Report on HV test results (Jan. 2018).**

Work Package 3

- **Report on central information infrastructure integration and enhancement (Aug. 2017).**
- **Report on applications exercising data quality (Oct. 2017)**

- Report on flexible phasor-based control platform and interfaces (Mar. 2018)
- Report on EFCC use case and associated substation-to-system interaction (May 2018).

Work Package 5

- Report on on-going training and workshops delivered (reporting period).
- Stakeholder knowledge dissemination events organised (Reporting Period).
- Technical papers and conference participation (Reporting Period).

Achievements

- Selected for a feature article in the upcoming PAC World magazine.
- Awarded the Scottish Green Energy “Sustainable Development Award”.

1.2 Project Risks

There are currently no uncontrolled risks that could impede the achievement of any of the SDRCs outlined in the Project Direction, or which could cause the Project to deviate from the Full Submission. Risks are monitored on a continuous basis with regular review at monthly progress meetings. The key risks are summarised below, with more details in Section 4.

1.2.1 Technical Risks

The previous Project Progress Report highlighted a number of potential design issues as the FITNESS Project Delivery Team moved into the testing phase of works. Some of these issues did arise as expected due to adopting new technology. Fortunately, many of these issues were resolved thanks to the excellent engineering and collaborative approach of the PDT, using the best available tools and robustly testing the FITNESS solution architecture. The technical risks listed below are still relevant or have been newly identified:

- As the FITNESS solution has now been delivered to site, tested and due to be commissioned on July 27 2018 continuous monitoring on site will be required to ensure network and time synchronisation stability. This can be monitored through the SCS system and through use of the tools available in the PRR.
- The high-speed seamless redundancy (HSR) architecture is yet unproven. This will be tested throughout the next reporting period before being deployed on site during the Wishaw – Newarthill 2 works (FITNESS bay 2) in summer 2019.
- The FITNESS solution implements a combination of two different types of network topology (HSR and PRP) for each circuit, both of which are linked to a PRP architecture at station bus level. This introduces several points of potential failure due to the increased reliance on communications.

1.2.2 Project Management Risks

Project Managers at each of the project partners ensure that risks related to project delivery are continuously monitored and managed to ensure the project milestones are not jeopardised. The main project management risks are:

- Possibility of “scope-creep” given inputs from wide audience of stakeholders. With such a ground-breaking project, stakeholder interest is high and task leaders must ensure core deliverables remain the main priority before undertaking additional tasks or deviating from plan.
- Project delivery timescales are a potential risk due to the tight programme to meet site delivery dates. The FITNESS project programme dates agreed between the PDT must be met to ensure adequate time for interoperability and full system tests for bay 2. This also extends to the bay 2 FAT date which must be met while allowing sufficient time to correct any issues and also ensuring the site delivery date is met with time to install, identify and correct any issues and complete the site acceptance tests (SAT).
- Due to SP Energy Networks Safety Rules, the PRR is now officially “under rules” meaning any personnel accessing the PRR must have SP Energy Networks authorisations to enter the live compound.

Further details of Risk Management including Technical Risk and Project Management Risk can be found in Section 4 of this document.

2 Project Manager's Report

This section highlights the projects' key activities, milestones, risks and learning over the reporting period (July 2017 – July 2018).

2.1 Project Progress Summary

Within the reporting period, FITNESS has progressed according to plan. Thorough bench testing off-site took place and ensured a full working system was delivered to site in order to reduce the installation time required and to ensure minimum on-site testing, a key objective of the FITNESS project. The equipment has successfully been delivered to site, installed, tested and is soon to be commissioned. As well as this, all members of the PDT shared the responsibility of ensuring the FITNESS project was presented at several highly reputable industry conference events and participated in working groups with peers from companies from all over the world

During the fourth reporting period of the project, the significant achievements are:

- FITNESS test plans were developed and completed for SCS, network and protection.
- Full detailed design drawings produced and finalised and protection cubicles built to the final design.
- A refined version of the FITNESS architecture was completed. The new architecture includes test equipment mounted in the protection cubicles to allow on-site testing and demonstrations as well as continuous monitoring of the network.
- Protection settings produced and uploaded to each IED.
- Bench testing leading to pre-FAT followed by a FAT.
- Protection cubicles mounted in PRR and all fibre and power supply cables installed.
- All HV equipment for bay 1 delivered to site including: optical current transformers, optical voltage transformers and bay marshalling kiosk.
- Portable relay room and all secondary equipment delivered to and installed on-site including: PRR with protection cubicles mounted inside, remote end (Newarthill) protection cubicle, wall box and telecommunications cubicles.
- FITNESS bay 1 commissioned, tested and proved under load conditions.

2.2 Project Overview

2.2.1 Project plan

Since the beginning of the project in 2016, the primary tasks have been to develop the functional design specification and the detailed system architecture, to determine requirement specifics for

both site planning and procurement activities. With the detailed designs agreed, Suppliers will procure the necessary devices so that offline testing can begin for circuit 2. The high-level project programme is illustrated in Figure 1.

FITNESS Project Programme - Key Milestones	2016			2017				2018				2019				2020
	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
Project Start Up																
System Design																
Offline System Integration & Verification (secondary)																
Offline System Integration & Verification (primary)																
System Site Trials - Circuit 1																
System Site Trials - Circuit 2																
System Site Trials complete																

Figure 1 - High-level project programme

2.2.2 Key project objectives

The project is designed to build the pilot multi-vendor fully-digital transmission substation in the UK. Addressing technological concerns by proving interoperability with legacy equipment and in multi-vendor architectures represents a primary objective of the project however, the 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.

During the project kick-off meeting the following pertinent objectives and questions were raised. Achieving these objectives and answering these key questions will be paramount in the project's ability to successfully transition the FITNESS solution and 61850 principles into the business.

Objectives:

- **Design and Demonstrate:** GB's 1st multi-vendor fully digital substation
- **Educate and Inform:** Raise awareness for IEC 61850 and various applications in future substation design
- **Uncover and Overcome:** Gaps in the standard and resolve issues with interpretation of the standard

Key Questions:

1. Can we rely on multicast Sampled Values (SVs)?
2. How can we provide reliable time synchronisation?
3. Can we rely on simulation tools to robustly prove functionality?
4. How do we manage the evolution of the standard and integrate new IEDs?
5. What is the engineering process? How Will SPT deliver future projects?

2.3 Project Progress during the Reporting Period

The Project Delivery Team (PDT) has successfully undertaken the following activities during the reporting period:

- ✓ The second in a series of FITNESS training events, “Training 1”, was delivered in June 2017 by Opal-RT and FMTP. The five day training course was held in Glasgow and attended by representatives from numerous network operators from across Britain. The training course received excellent feedback from attendees as an introduction, and expanded information on the IEC 61850 standard.
- ✓ A third specialist FITNESS training course, specifically on the Helinks system configuration tool, was planned and organised during the reporting period and was delivered in November 2017. The course was tailored for a small number of experts from SPEN and SSE with the aim of developing their understanding of the Helinks tool.
- ✓ A fourth training event was delivered by a FITNESS project partner, ABB, on their MicroSCADA product. This was training course was delivered to SCADA experts to introduce them to the product and how to configure and operate it on site.
- ✓ The FITNESS LV Test Plan went through significant improvement steps to streamline the testing process and further prove the benefits of a digital substation solution. The Test Plan can now be completed entirely with the use of a PC with the correct tools and produce a test report.
- ✓ Further improvements and reconfiguration of the FITNESS architecture was produced following the findings of bench testing the FITNESS solution.
- ✓ FITNESS FAT for Wishaw – Newarthill 1 (FITNESS Bay 1) successfully completed, demonstrated to, and signed off by SPT.
- ✓ HV FATs successfully signed off for deployment on SPT network for both Bay 1 and Bay 2 NCITs.
- ✓ FITNESS PRR was fitted out with protection cubicles including IEDs, substation control system (SCS) and tested off-site.
- ✓ FITNESS portable relay room was successfully delivered and off loaded in position, at Wishaw 275kV substation.
- ✓ Authored and submitted an abstract paper on the FITNESS bench testing outcomes submitted to several leading industry conferences. Each submission was successful and selected for a full paper submission and presentation to be delivered to leading industry experts at the annual:
 - IEC 61850 Europe, Amsterdam, October 2017.
 - LCNI, Telford, December, 2017.
 - DPSP conference in Belfast, March 2018.
 - Cigre, Paris, August 2018.
 - LCNI, Telford, October 2018.

- ✓ Maintained excellent links with industry reporting findings and playing a key part in various Working Groups such as Cigre, Process Bus Taskforce and Iberdrola's IEC 61850 Working Group.



Figure 2 - FITNESS BMK and PRR at Wishaw 275kV



Figure 3 - FITNESS NCITs on site at Wishaw 275kV substation



Figure 4 – FITNESS Awarded Scottish Green Energy Sustainable Development Award

2.4 FITNESS IEC 61850 Training Programme

The training programme shall cover the differences between conventional hardwire and digital communication technologies, conventional and non-conventional instrument transformers, different design philosophies and device nomenclatures. Understanding the differences between the legacy protection and control principles and IEC 61850 will close the gap and help transition the already experienced engineers to the next generation of substation automation.

2.4.1 Lectures with Hands-On Experiments and Live Demonstrations

The skilled instructors will share their personal experience and enrich their lectures with real world examples. From basic theory to high level principles, the training sessions will each address their specific topics and orient the trainees.

Live practical demonstrations with hands-on experiments will be run by the instructors and explained step-by-step. The live demonstrations will be given in the most interactive manner possible so that attendees can, at any time, interrupt, comment and ask questions. Past training sessions have shown this is the most efficient way to provide training on the use of a complex setup. Success is achieved only if enough time is allowed for interactions, but at the same time, a successful live demonstration calls for active participation of the trainees. When possible, demo license software should be made available for every 1 to 2 trainees to use in certain guided experiments.

2.4.2 Workshops

It is recommended to hold workshops approximately 6 months after a training session so that trainees can address specific issues they encountered or share their field experience with others. The workshops shall have duration of 2 days to allow for exchange between experts and trainees from different fields. The purpose of the workshops is to:

- Practice on examples with software and hardware;
- Allow attendees to give feedback from the field and have their questions answered by the experts and the rest of the group;
- Offer a review of the last training session, along with some tailored training, with speakers and instructors selected based on trainee feedback or requests.

2.4.3 Special Seminars

Seminars are being considered as an additional type of knowledge dissemination medium. The goal would be to invite subject matter experts in areas that are directly in line with or complementary to the IEC 61850 scope of the FITNESS project. This could be:

- Experts from third-party Vendors,
- Engineers who have field experience with implementation, testing or design of IEC 61850 solutions,
- Experts in complementary topic, selected based on trainee requests.

2.5 Knowledge Sharing and Stakeholder Engagement

The 61850 Standard have been in development for over a decade and the benefits of this technology are numerous and well established, however the industry has yet to widely deploy. The shift to digital technology represents a step change; replacing longstanding and reliable technology and practices with a completely new suite of technologies and practices of which the industry has very little experience that have been largely limited to off-line trials.

Bringing large-scale innovations such as FITNESS from demonstration to business-as-usual is a challenging feat and, although we have received support from the necessary business areas, the progression into day-to-day operations will require comprehensive internal stakeholder engagement and through open debates with external parties to ensure all concerns and challenges are addressed.

The fundamental objective of this project is to accelerate the adoption of this technology, which is based on achieving the following two equally important conditions:

1. Technology readiness: achieved by demonstrating the technical operation including multi-vendor interoperability.
2. Cultural readiness: achieved by instilling sufficient confidence and experience in 61850 implementation.

Knowledge dissemination will be fundamental to this project satisfying these conditions; stakeholder events and technical workshops ensure we collect and distribute experience and learning amongst all stakeholders.

During the reporting period, the following knowledge activities have been undertaken to establish a suitable framework to support Project FITNESS to achieve its goals:

- FITNESS IEC 61850 Training 1 held in Glasgow, June 2017. The training course was hosted by SPEN and delivered by Opal-RT, FMTP and Helinks.
- FITNESS Helinks system configuration tool training delivered by Helinks in Glasgow, November 2017.
- FITNESS Steering Board meeting attended by key internal and external stakeholders.
- Wider stakeholder engagement activities undertaken, including paper submissions and presentations at prestigious conferences around the world.
- FITNESS project selected to feature in the upcoming PAC World magazine.

2.5.1 Knowledge Sharing Events

The second in a series of FITNESS IEC 61850 training course was held in Glasgow in June 2017 hosted by SPEN and delivered by Opal-RT, FMTP and Helinks. The course was attended by Network Operators and Vendors from across Great Britain. The course was a great success and received excellent feedback from attendees.

The training course covered a number of topics and in great detail over the course of three days and catered to personnel from various backgrounds from automation to protection systems. Presentation topics included, among others, the following:

- Smart Grid and IEC 61850;
- Substation Automation Protection and Control;
- Time Synchronisation Protocols;
- IEC 61850 Commissioning and Maintenance.



Figure 5 - FITNESS IEC 61850 Training 1

2.5.2 Knowledge Dissemination Events

The FITNESS PDT has shared the responsibility for presenting FITNESS at knowledge dissemination events. As a result of this shared goal, FITNESS has been presented at several prestigious conferences across the world along with paper submissions of the findings and results. Papers and presentations have been delivered at the following events during the reporting period:

- IEC 61850 Europe, Amsterdam, October 2017.
- LCNI, Telford, December, 2017.
- DPSP conference in Belfast, March 2018.
- SP Transmission Staff Conference Poster Session in Glasgow, June 2018.
- Cigre, Paris, August 2018.

2.6 Outlook to the Next Reporting Period

The next reporting period will include the learnings and outcomes from the site installation and commissioning of the FITNESS project for Bay 1. This will also include monitoring the performance and stability of the FITNESS solution for the duration of one year.

The bay 2 architecture will also be thoroughly tested off-site, followed by FAT and delivered to site next year for installation and commissioning including the primary (NCITs) and secondary (protection) equipment.

Over the coming period, FITNESS will undertake the following activities, including commencing offline testing from which the learning generated will be effectively disseminated across SPEN to enhance understanding and improve overall readiness for live deployment:

- Bay 2 protection and network off-site testing followed by FAT.
- Delivery and site installation of bay 2 NCITs.
- Further FITNESS IEC 61850 training events.
- Learning outcomes from FITNESS presented at conferences.
- Frequent monitoring and testing of the FITNESS solution on site with performance comparisons against the conventional substation.

3 Consistency with full submission

At this stage of the project delivery, FITNESS remains consistent with the original Full Project Submission with regards to project schedule, budget, resource allocation and programme.

4 Successful Delivery Reward Criteria (SDRC)

The Successful Delivery Reward Criteria set out in the Project Direction links with the Project Milestones and the identified targets directly. This SDRC can be used to check the progress of the project delivery and position the progress against the original proposal. Table 1 lists all the required evidences in line with project direction for reporting period.

Table 1 - SDRC in reporting period

SDRC (Evidence)	Planned Date	Completion Date
Report on LV secondary systems test results	November 2017	November 2017
Report on functionality and interoperability tests (HV tests)	November 2017	November 2017
Report on HV test results	January 2017	March 2018
Report on central information infrastructure integration and enhancement	August 2017	August 2017
Report on applications exercising data quality	October 2017	October 2017
Report on flexible phasor-based control platform and interfaces	March 2018	March 2018
Report on EFCC use case and associated substation-to-system interaction	May 2018	May 2018
Report on on-going training and workshops delivered	Annually	Annually
Stakeholder knowledge dissemination events organised	Annually	Annually
Technical papers and conference participation	Annually	Annually

5 Learning Outcomes

During the reporting period there have been few learning outcomes to date however as the detailed design phase draws to a close and testing begins, we anticipate key learning related to interoperability and architecture testing during the forthcoming period.

Table 2 – Learning outcomes

Lessons Learnt (+/-)	Lesson Learnt	Recommended Action
Positive	By procuring the best available testing tools, the testing process was made much easier. This is crucial to ensuring the network is stable and the protection schemes operate as expected.	Ensure the required testing equipment is available throughout testing.
Positive	Delivering training to professionals who are likely to be working with this technology allowed SPEN to engage with and learn from Other's experiences and concerns from various roles and experience levels from across the industry. Valuable feedback received informed future training courses.	Future training courses will allow further discussion as well as more hands on and technical experience for Users who will be working with the technology. This is invaluable in encouraging the adoption of the IEC 61850 standard. Surveys will be taken after each training course and the feedback taken into consideration.
Positive	Importance of internal and external Stakeholder engagement. The stakeholder events enable the project team to engage with external experts and bring them together with key internal to the ultimately benefit all.	FITNESS will continue to focus on stakeholder engagement as the project progresses and ensure key stakeholders needs are understood and addressed.

6 Business Case Update

No developments have taken place since the issue of the Project Direction that affect the business case for the Project.

7 Accuracy Assurance Statement

I therefore confirm that processes in place and steps taken to prepare the PPR are sufficiently robust and that the information provided is accurate and complete.

Signature:

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Date: 16/08/18

Signature:

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Date: 16/08/18