Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form. The full completed submission should not exceed 6 pages in total.

Network Licensees must publish the required Project Progress information on the Smarter Networks Portal by 31st July 2014 and each year thereafter. The Network Licensee(s) must publish Project Progress information for each NIA Project that has developed new learning in the preceding relevant year.

NIA Project Annual Progress Report Document

Date of Submission

Jun 2022

Project Reference

NIA_WPD_060

Project Progress

Project Title

Pre-Fix

Project Reference

NIA_WPD_060

Funding Licensee(s)

WPD - Western Power Distribution (South Wales) Plc

Project Start Date

October 2021

Project Duration

1 year and 6 months

Nominated Project Contact(s)

Paul Morris

Scope

This project seeks to overcome the barriers to wide-spread HV pre-fault capability represented by vendor tie in and proprietary software.

This project will utilise HV pre-fault capture capable devices from different manufacturers to demonstrate how they can all contribute into common data platform. This project will also demonstrate how certain existing network devices such as power quality monitors, protection relays and LV monitors might also help contribute to HV pre-fault detection in addition to their basic functions. This project will also show how consistent operational dashboards and reports can be developed from this platform to enable a consistent policy driven approach to be implemented across an organisation. Key activities that will be carried out during the project include:

- Use of trial data from other DNO's to inform platform design and support testing.
- Architecture specification for the common information platform.
- Interoperability specification and setting of pre-fault gathering devices.
- Design of common operational user interfaces.
- Live trial of devices, platform and reports.

Objectives

The objectives of this project are to:

- Develop and validate a process to enable pre-fault capable devices from different manufacturers to contribute information onto the same platform.
- Develop and validate process's to enable pre-fault information to be drawn out of this platform.
- Develop and validate standard reports that enable a consistent and effective pre-fault policy driven decision making to be made in an operational environment.

Success Criteria

- Demonstration of how to gather and then utilise data from existing WPD specification equipment in the pre-fault data chain, devices to include protection relays and power quality monitors.
- Demonstration of how pre-fault information from diverse devices can be gathered into a central location.
- An application guide for how, where and when to deploy different pre-fault equipment.
- A user interface to present pre-fault data in a manner that is useful, consistent and meaningful to operational users.
- A prototype operational protocol for how to leverage technical application into operational outcomes.

Performance Compared to the Original Project Aims, Objectives and Success Criteria

Performance against our project objectives is as follows:

- Develop and validate a process to enable pre-fault capable devices from different manufacturers to contribute information onto the same platform - In Progress
- Contractual conversations have been held with different suppliers for an integration demonstration.
- Develop and validate process's to enable pre-fault information to be drawn out of this platform - In Progress
- A system of prioritisation has been developed with dashboards to communicate this information
- Develop and validate standard reports that enable a consistent and effective pre-fault policy driven decision making to be made in an operational environment - In Progress
-A standardised set of reports have been designed to communicate pre-fault activity on feeders.

Performance against our project success criteria is as follows:

- Demonstration of how to gather and then utilise data from existing WPD specification equipment in the pre-fault data chain, devices to include protection relays and power quality monitors - In Progress
- This will be done by gathering real world trial devices and bench testing of other devices.
- Demonstration of how pre-fault information from diverse devices can be gathered into a central location - In Progress
-This will be met by engaging with different suppliers to verify that suppliers can meet the Pre-Fix compatibility requirements.
- An application guide for how, where and when to deploy different pre-fault equipment - In Progress
- This will use end of project learning to develop guidance on how to apply pre-fix output.
- A user interface to present pre-fault data in a manner that is useful, consistent and meaningful to operational users - In Progress
- We have already designed the user interface and it is now under development.
- A prototype operational protocol for how to leverage technical application into operational outcomes
-This can start once there is a set of operational measurements which the protocols can be based upon.

Required Modifications to the Planned Approach During the Course of the Project

To be able to capture information about pre-fault behaviour in HV networks, we must be able to capture waveform-resolution information about of the current and voltage. At project inception we identified that availability of suitable Current Transformers (CTs) to connect NX44 smart Fault Passage Indicators (FPIs) would be a key influence on project success.

As described in 6.1 we developed evidence regarding the availability of CTs. From the site selection process we have observed that due to legacy specifications where CTs are not present only around 30% of WPD's secondary substations can be retrofitted with FPIs in this
manner. As a result of these lessons, we decided that there was a needed to develop a capability to retrofit NX44 units onto primary circuit breakers and also into substations where there are no spare CT's, but there is an automatic supply restoration system.

We did this by developing two design variations to the standard NX44. The first was a variant intended to be used in primary circuit breakers and the second was aimed at secondary substations that have automatic supply restoration system. In both cases we modified
the input to the NX44 to be able to accept high impedance clip on current sensors. The benefit of these sensors are that they can be clipped around existing CT wiring rather than breaking into existing wiring. This made retrofitting of these units easier because it avoided the need for recommissioning of the circuit.

The primary circuit breaker variant was also modified to be able to accept a 110V DC input rather than its standard DC or AC input voltage.

As a result of these changes we were able to increase the scope of where Pre-Fix data could be gathered from. This approach has also increased the ease of retrofit with an ability for one-team place 2-3 NX44 units onto the system in a working day.

To date there have been no major changes to the project delivery plan. There have had to be some changes to the installation plans for overhead line mounted units. These changes stemmed from the availability of suitable authorised live-line staff in the wake Storm Eunice. Our response to this was to replace some of the planned live installations with planned shutdowns. To date all changes have been contained with our internal change control process.

Lessons Learnt for Future Projects

6.1. Availability of Instrument Transformers

The majority of WPD's substations have a Voltage Transformer (VT) that can provide three phase output. However, in older substations VTs with a two phase output can be found. This has implications on how voltage transients can be captured for use within the
impedance to fault module. We have discovered that some devices, such as the PQube, can provide three phase transient output when connected to a two phase VT, but not when there is only a single phase output. The learning here is that to roll out a pre-fault capability
to all HV networks any VT's with single phase or two phase output will need to be improved to become three phase.
We have always been aware that in underground cable networks, to be able to fit intelligent FPIs into secondary substations, there will be a requirement to have access to CTs that monitor the downstream feeder. From the site selection process we have observed that due to legacy specifications where CTs are not present only around 30% of WPD's secondary substations can be retrofitted with FPIs in this manner. This proportion is expected to increase over time as the present procurement specifications already expect that there will
be adequate CTs installed as standard. To overcome this limitation for the Pre-Fix trial we reviewed a number of options. These 6.1. Availability of Instrument Transformers
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progressed due to the smaller hazards associated with installation.
As a result of the works to develop installation protocols onto RMUs and primary circuit breakers, we have established a capability to install two to three smart FPIs per day and can assure at least one location will become available per HV feeder.

6.2. Pre-Fault behaviour in HV cable networks

As a result of the FPI devices that have been installed to date, we have able to begin observing what anomalies occur in HV underground networks. We are still developing a robust opinion as to what a normal vs abnormal rate of peck is within a cable network. Taking one feeder as a case study, we have observed the behaviour of an anomaly upon it since the beginning of March. This feeder used to be rated at 6.6 kV feeder but has been uprated to run at 11 kV. The feeder has a total length of 3 kM, serves ten secondary

substations and has two breach joints which are considered to be a good risk indicator.
Since the start of March, we have observed an average peck rate of two pecks per day, but these pecks do tend to cluster into busy days leaving quiet days. A large proportion of the pecks that have been captured have a distinctive pattern as depicted in Figure 2. The size of
the pecks across these observations has consistently been around a 200-250% spike in amplitude, returning to the baseline current. To date, the majority of the observations have not lasted longer than one cycle before extinguishing. We have observed that the phase which experiences the largest peck is not always consistent, but the point on wave at which the peak-peck initiates (relative to a common frame of reference) appears to be consistent within the observation period.
We also observe that this pecking event is still has a large margin before reaching the overcurrent protection settings upon, indicating that the magnitude of peck will need to grow considerably before causing a power cut.

There has not yet been any form of fault clearance on this circuit hence we have no external verification of which asset is responsible for projecting this anomaly, nor its precise location. Consideration has been made as to whether it could be a downstream fault occurring on the LV network. We have also compared these waveforms against the signatures that are discussed within the IEEE PESTR731 . As part of this exercise, we have noticed that there is a similarity to the signature associated with a cable joint with excessive
moisture that is discussed within this document. We therefore retain the hypothesis that the anomaly in Figure 2 could be due to a potential joint defect, but this view still retains significant uncertainty.

Note: The following sections are only required for those projects which have been completed since 1st April 2013, or since the previous Project Progress information was reported.

The Outcomes of the Project

Project Pre-Fix is not yet at the stage of finalising outcomes, but the following outputs have already been delivered

- · WPD system requirements document
- C-DIP spec
- Capture device spec
- Algorithm requirements spec
- User Interface Wireframes
- Data dictionary
- Device settings
- Installation protocols

In later stages of the project, the following outputs will be delivered

- Updated algorithms
- Platform development and testing
- User documentation for platform
- End of trial System and devices report
- End of trial observations report
- Pre-fault policy documentation
- Close down report

Data Access

As per the PEA, to further Pre-fault research by other DNO's, Pre-fault evolution data and waveforms will be made available on request once available. This data will be made available in a suitable format e.g. COMTRADE files.

Foreground IPR

Project Pre-Fix will generate the following relevant foreground IPR:

- Specifications for device compatibility with the Pre-Fault platform
- Device setting and configurations for contribution onto the Pre-Fault platform
- Functional specifications for the Pre-Fault platform and underlying modules

- Pre-fault platform implementation
- Data and learning reports
- Data visualisation and dashboards support Pre-Fault network policies

The Common Disturbance Information Platform software developed in this project will be made available to other GB DNOs without an additional licence fee.