Date of Submission

May 2021

Network Innovation Allowance Closedown Report

Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form.

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.

Project Progress

Project Title

Overhead Line Vibration Monitoring System

Project Reference

NIA_SSEPD_0020

Funding Licensee(s)

Scottish Hydro Electric Power Distribution, Southern Electric Power Distribution

Project Start Date

November 2015

Project Duration

4 years and 0 months

Nominated Project Contact(s)

SSEN Future Networks Team

Scope

Under IFI project 2014_08 Monitoring of Conductors and Poles, a prototype sensor system, comprising of line mounted sensors, and a communications system was developed to operate on overhead lines up to 11kV. This project will take that work further to produce a production ready system. The newly developed sensors will be encased within environmental protective cases, and are powered by solar panel, which trickle charges a backup battery within the case. They will then be installed on overhead lines in several areas of the distribution network and left for an extended period of time to determine the suitability for use. In terms of effect on the installed infrastructure, ability to withstand weather events, and ability to maintain power on during the winter months will also be assessed.
Connections to the SCADA system will be made and tested.

Objectives(s)

The project will:

1) Prove whether the production prototypes will survive winter months when mounted on live overhead lines;

2) Determine whether there is any sign of degradation to the wires where the sensors are mounted;

3) Will indicate whether there is any sign of vegetation encroachment onto the overhead line network;

4) Prove whether, or not, the sensors can communicate quickly and effectively with the SCADA system;

5) Provide an indication that non-vegetation objects have collided with an overhead line or pole. Examples would be poles moving due to soft ground and line collisions by raised farm trailers or forestry vehicles;

6) Determine the viability of deploying the sensor system as an alternative to replacing sections of overhead line with underground cabling.

Success Criteria

The project will be a success if:
1) It can be confirmed whether or not the system is able to detect the collision between the overhead wires and trees, branches and/or farm, forestry, or construction vehicles, on live lines.
2) Confirm whether or not the sensors and communication system can withstand the effects of the weather on the system.
3) Confirmed whether or not the mounting of the sensors will have a deleterious effect on the overhead lines.
4) Determine if and when the sensor system is a viable alternative to replacing an overhead line with underground cabling.

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

This project trialled a micro-circuit mounted 11kV line collision and pole movement sensor system which used licence free radio frequency to communicate over a short range to a communication collection gateway situated in a substation. The substation gateway was connected into the Substation Control and Data Acquisition (SCADA) system. During the field trial it was possible to receive real-time email notification when the movement alarm was triggered.

Below is a summary of the project's success against the original aims.

1) Prove whether the production proto-type produced will survive winter months when mounted on live overhead lines;

During the winter of 2017/18, the overhead line sensors where mounted on a de-energised section of line, close to Aberdeen. This proved the ability of the overhead line sensors to cope with the extremes of Scottish weather.

At the beginning of December 2018, the overhead line and pole mounted monitoring system was installed at the Perth Training School. The section of circuit chosen was energised to simulate the live system conductions. Over the seven-month period the overhead line sensors regularly alarmed and positively identified movement. The small solar panels adequately charged the internal battery, which positively proved the overhead line sensors design and operational ability. The pole mounted movement sensors however did not survive longer than two months, on inspection both showed signs of water ingress. The pole mounted sensor enclosure requires a redesign and different ways of keeping moisture off the circuit boards need to be investigated.

2) Determine whether there is any sign of degradation to the wires where the sensors are mounted;

The overline conductor was visually examined after the removal of the overhead line sensors and no signs of degradation or damage were observed. It should be noted this is not conclusive evidence as the OHL mounted device was attached for a short duration of time and in-depth lab testing of the OHL at a material level was not conducted.

3) Indicate whether there is any sign of vegetation encroachment onto the overhead line network;

The overhead collision and pole mounted sensors individually had the ability to monitor and send a notification upon one of 5 events;

- a change in angle, slope, lean or inclination;
- a displacement event where the location of the equipment physically changes;
- a sudden acceleration event;
- a dip in battery voltage, a warning that the device may not communicate; and
- a communication failure during the comms health check or 'heart beat' sequence.

The field devices remained silent when normal conditions were experienced.

During the overhead collision and pole mounted sensor installation at Perth Training School, a 90% accuracy rate was recorded on the overhead line collision sensor, with known forced movement of the overhead conductor. This was considered satisfactory performance with regards to the overhead line mounted sensor detecting forms of movement.

As a weather station had been installed it was possible to look for a correlation between high continuous winds events and gusty days. Over the 7-month period no notifications were received from the overhead line collision sensor during periods of extreme winds. This confirmed that the internal calculations and notification settings within the overhead line mounted sensor accommodated naturally occurring environmentally induced overhead line movement.

The rigorous testing of the overhead collision sensor positively proved that unnatural conductor movement could be identified. However, additional development of the overhead line collision sensor is required to help identify the likely causes of movement that triggered a notification.

Enhancement of the system is required to positively determine signs of vegetation encroachment on the overhead line network. The system would benefit from gathering several notification levels for each movement type and/or wider use of data analytics to combine weather and fault information, as well as a movement notification.

4) Prove whether, or not, the sensors can communicate quickly and effectively with the SCADA System;

With the install of the overhead collision and pole mounted sensors at Perth Training School, the necessary communication collection gateway was installed at a substation, which provided the required access to the SSEN SCADA system. Once the communication pathway was commissioned, it was possible to receive real-time notifications via email when the overhead line sensors where triggered. This positively proves the ability of the trialled technology in quickly and effectively communicating with the SCADA system.

5) Provide an indication that non-vegetation objects have collided with an overhead line or pole, examples would be pole moving due to soft ground, line collisions by raised farm trailers or forestry vehicles;

During the trial of the overhead line monitoring system at the Perth Training School, it was possible to simulate poles falling and overhead conductors sagging excessively, for instance, to view positive event notification. But as the notification does not contain any information it's not possible to tell the difference between these types of event.

Again enhancement of the system is required to positively determine signs of vegetation encroachment on the overhead line network. The system would benefit from gathering several notification levels for each movement type and/or wider use of data analytics to combine weather and fault information, as well as a movement notification.

6) Determine the viability of deploying the sensor system as an alternative to replacing sections of overhead line with underground cabling;

Across SSEN's network there are remote agricultural tracks under the overhead line network therefore there is a risk that a farmer may strike a wooden pole or hit an overhead line with a vehicle. To reduce the risk to the farmer or land owner, in certain locations the overhead line is replaced with an underground cable instead. At the outset of this project it was foreseen that the overhead collision and pole mounted sensors could be used as a more cost efficient and less disruptive solution than undergrounding cables.

The trial showed positively that the overhead line units detected un-natural line movement, but it has been deemed that overall, the present overhead collision and pole mounted sensor system is not a suitable alternative to replacing sections of overhead line with underground cables.

The challenges that require addressing are:

- Pole movement sensor units should be redesigned and the circuitry waterproofed;
- Communication medium should be replaced with a low power wide area option which uses a collection gateway, as an alternative to the radio free license frequency that was trialled, which only travels 80 meters and therefore requires a pole mounted comms relay on every pole (like a daisy chain) which pushes up sensor infrastructure costs; and
- Enhanced data analytics functionality and fault information linking movement notification to a field event.

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

An extension was required to the project timescale as challenges had been encountered in sourcing an appropriate location for the trial. Perth Training School was identified as the best location, as the overhead line upon which the collision sensor was attached could have been energised. The location was also suitable to simulate events such as a conductor drop, poles being climbed, pole mounted fuses being changed and objects hitting the overhead line conductor.

Lessons Learnt for Future Projects

The key learning points are summarised below;

· The Scottish weather means that water ingress in field units is highly likely, regardless of the IP rating. Any glanding of the units needs to be underneath and sealed well to limit water ingress. The electronic elements within the units need to be waterproofed and if possible, the units also need to be 'potted' to limit the available air space. Limiting the air space reduces the temperature differentials, thus preventing the pulling in of moisture from outside.

· A binary notification, which was simply a '1', was received when a movement event triggered a notification. Therefore, you need to know what the trigger point is; a lean of 10 degrees, a displacement of 2.5 meters or an acceleration of 0.7m/s. The limited information within a notification makes it very difficult to distinguish between movement events, for example a bird sitting on the line and flying off notifies in the same way as the reclose of a pole mounted fuse. If the overhead line collision device is to be used to identify types of likely events, then the device needs additional levels of notification to identify the severity of movement.

· The licence free radio frequency chosen for the communication medium has low auxiliary power requirements which means the units are very small in size, but the low energy signal can only travel between 80-100 meters. This means a signal relay box or unit must be mounted on every pole, which is costly in both materials and install resource. Licence free radio frequency communication options are more suitable for monitoring within a substation. Low power wide area communication options are more suitable for monitoring overhead line infrastructure in remote locations.

· When developing a code to transfer field information from remote monitoring equipment into a central collection point, simple sequential numbering allows the decoding element to occur after the information is placed in the storage area. There is greater access to decoding resource and options associated with displaying the information once the original data is in the storage area. In the case of the overhead line collision and pole movement system information, coding was complex as it included a position and an alarm. It was necessary to place the decoding logic just after the collection gateway and before the information was placed into the storage area. Due to the location of the decoding logic any changes required access to the substation, which reduces the number of people able to carry out works and it extends the associated time.

· It is possible to generate an email notification both to SSEN and to the external equipment manufacturer to notify of a movement event, through the present SCADA system. Being able to set this up has saved time checking weekly to find out which, if any, units have sent notifications. On receiving an email notification, it was then possible to investigate the activities that had been carried out at the training centre.

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

There are positive concepts associated with the overhead line monitoring system, such as;

- the movement analytics is undertaken in the field;

- the devices are silent until a parameter is broken in the field;

- there is a regular connectivity check undertaken to ensure all the elements are well and able to report;

- trials proved that the overhead collision sensor did not report naturally occurring environmentally induced movement; and

- field monitoring systems can be configured to report directly into the SCADA system, from which real-time email notifications, both internally and externally, can be achieved.

Trialling the system has proven that non-natural overhead line movement can be detected with a suitable level of reliability.

It has also been shown that the present overhead line monitoring system requires;

- development of a more suitable communication system that reduces the volume of infrastructure required;

- options investigated on how to improve the type of movement event, to help provide more detail. This could be as simple as data analytics reviewing the movement data and suggesting a likely cause, providing 2 or 3 levels of notification per unit to identify the strength of movement; and

- development is required for the pole mounted sensors to ensure they are waterproof, reliable and meet their life expectancy.

The overhead line collision device shows promise in detecting overhead line conductor sag, this would warrant further investigation aimed at addressing;

- the heat caused by summer time warm weather conditions which can increase the overhead line conductor sag;

- the winter time heavy ice loading events where ice forms on the overhead line conductor can cause the line to sag, due to the additional weight of the ice.

Data Access

No network or consumption data has been gathered during the project.

The data collected has been a time-stamped positive trigger notification.

Data sharing requests can be made in accordance with SSEN NIC and NIA Data Sharing Procedure; https://www.ssen.co.uk/InnovationLibrary/Distribution/

Foreground IPR

No foreground IPR has been created during this project.

Planned Implementation

There are no plans presently to progress the overhead line monitoring system into business as usual, as significant changes to the design, sensor reporting and communication infrastructure are required.
Knowledge gained will be shared and disseminated to ensure other projects benefit from the learning.

Other Comments

There is a huge amount of valuable learning to be gained from installing overhead line equipment in a training school location, where it is subjected to the elements and a higher than normal volume of manual handling. Also access to the installed equipment is much easier, therefore adjustments, equipment replacement and software upgrades are possible without the requirement of seeking a network outage.

Standards Documents

The learning from this project has no implication on standards.