Scottish & Southern Electricity Networks

Date of Submission

July 2017

Network Innovation Allowance Progress 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	Project Reference
Thermal imaging Observation techniques for Underground CAble Networks (TOUCAN)	NIA_SSEPD_0021

Project Licensee(s)	Project Start Date	Project Duration
Scottish Hydro Electric Power Distribution, Southern Electric Power Distribution	Jan 2016	20 Months

Nominated Project Contact(s)

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Scope

Thermal imaging equipment has traditionally been specialised and very expensive but thermal sensing technology has advanced to the point where it is relatively inexpensive to manufacture and is more readily available. This has resulted in a number of comparatively inexpensive devices becoming available on the open market, including some very low cost devices which attach to a smart phone or tablet. Within the context of rapid location of underground cable faults trials and investigations with a range of imaging devices and solutions will be carried out and, if successful, recommendations made for equipping repair operatives and depot staff. A training programme for safe and efficient use of the equipment will be designed and delivered.

Objective(s)

- Produce a literature review of available products
- Select and acquire product examples for testing based on cost and performance criteria
- Establish common equipment testing and results recording methods
- Evaluate equipment performance in simulated fault scenarios
- Issue equipment to field operatives for evaluation in real fault scenarios
- Acquire data and develop tools for performing a detailed cost benefits analysis
- Document all results, conclusions and recommendations
- Evaluate project outcomes for possible adoption by BAU

Success Criteria

The project will be successful upon the achievement of the following results and conclusions after assessing devices as complementary tools:

1) A range of thermal imaging devices are successfully evaluated as to their ability to locate or assist in locating underground cable faults and in which conditions;
2) Practical comparisons are made between the performance of low cost devices with that of higher specification equipment;
3) Substantiated recommendations are made on whether or not there are benefits in equipping field operatives with thermal imaging cameras, and low cost devices in particular.

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

• Produce a literature review of available products
Over a 6 week period from the beginning of January 2016 a desktop State-of-the-Art study was conducted into thermal imaging techniques, equipment and methodologies. We sourced advice from experts in the field to complement our own knowledge and learning. This study phase produced knowledge and learning which would be needed during later project phases. A literature study report has captured our methodology. This objective has been fully met.

• Select and acquire product examples for testing based on cost and performance criteria
A number of devices were to be tested and compared in the field for performance and suitability for use in the application. The objective of this phase was to establish which devices were available on the market to purchase and then to compare them against a list of requirements, eventually selecting the best candidates from a shortlist. From this phase 20 different thermal cameras were purchased and issued for assessment in the field trials. This objective has been fully met.

• Establish common equipment testing and results recording methods
Thermal imaging cameras require a level of user education in order to achieve desired results. Cameras need to be set up correctly. Users need to understand how to use the cameras in different scenarios and how to interpret the image data. Work during this phase of the project included determining the best way to train the camera users, developing the training methodology and delivering it to the operatives involved in the field trials. Data collection and analysis are the cornerstone of the project. The correct data has to be collected from the field trials in order to assess the true benefits of using the devices alongside conventional methods. Further work in this phase of the project is to define the correct use model for the field operatives, to define which data would have to be collected and recorded during the field trials, the best way to record and communicate this data to the analytical team and to define the data analytics methodology. The objective is to be able to prove or disprove that the use of thermal imaging cameras has benefits to the business and its customers. This objective has been fully met.

• Evaluate equipment performance in simulated fault scenarios
One of the major tasks was to carry out fault simulation work with Kelvatek. This will complement results from field trials with increased fault volumes and data granularity. Three containers were built and installed in a controlled environment at Kelvatek's test site in Lisburn, Northern Ireland. Each container was loaded with different examples of typical backfill material and had different surface types. Faulty cables were buried in the containers and energised on a test network. We were able to measure detected heat signature readings, varying the camera model, the cable type, the fault type and environmental conditions. Direct performance comparisons between camera models on the same type of fault and under the same conditions were made. Data was used to enhance learning for field operatives. This objective has been fully met.

• Issue equipment to field operatives for evaluation in real fault scenarios
Teams of operators would be required for conducting the field trials. Teams are to consist of personnel already engaged in front line response at the early stages of LV faults and LV fault location requests. The task during this phase of the project was to build 4 such teams for delivering good project results. During the course of the project there will be 12 months of field trials in order to capture results over full seasonal variations. Mid-term results from the field trials were coupled with results from the Kelvatek simulation exercise in order to produce a short list of three thermal cameras. After consulting with users at a quarterly project review meeting one camera was selected from this list as the preferred model for business as usual recommendation. Selection criteria included cost, practicality, robustness and performance. In order to extend the trialling of these devices a second procurement stage issued cameras to an extended team coupled with transfer of learning for upskilling. This objective has been fully met.

• Acquire data and develop tools for performing a detailed cost benefits analysis
The type of data to be collected by the field trial teams has been established and analysis methods formalised. The methodologies are implemented. A running cost benefit analysis has been carried out as soon as field trial results became available with monthly updates reported. It became apparent after only the first three months of field trials that positive results were emerging. Operatives were locating faults with thermal cameras in certain conditions. Data collected was translated into financial benefit based on CI/CML savings through faster supply restoration and through excavation savings thanks to more precision on location. Initially it was thought that the financial case would not be fully understood until one month after the completion of the twelve month field trials. However, after nine months of data collection and analysis there were enough positive indicators to justify early preparation of a formal business case. This objective has been fully met.

• Document all results, conclusions and recommendations
Documentation from the literature reviews, training programme, procurement exercise and simulation work have been complemented by reports from field trials and results analyses. Many of these results contributed to knowledge sharing material which was exhibited at the LCNI conference in October 2016, together with a demonstration of some of the thermal cameras under test. A booklet of this material was circulated to other DNOs. Supported by concrete evidence from field trial and simulation results, the project has concluded that some thermal imaging cameras can be successfully used to locate underground cable faults on LV networks. The

project recommends the FLIR E5 camera as the best compromise (from devices available today) for use in the application. This objective has been fully met.

• Evaluate project outcomes for possible adoption by BAU
Evaluation and assessment of the results from field trials and simulation work followed by conclusions and recommendations emerging from the project have resulted in a paper being produced and submitted to the DNO's business lead. The paper shows the financial benefit realisable at scale from the issue of thermal cameras to all LV restoration teams based on actual results from the contained trials. A business case supporting a recommendation to implement thermal imaging for underground cable fault location in business as usual practice has been approved and the process of BaU implementation has started. This objective has been fully met.

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

• Data acquisition – Originally data from field trials was to be collected by email or on paper forms. This was changed to using interactive forms given the availability of the Grid IView app to field staff. Grid IView is a mobile app which displays network maps on mobile devices and can capture and update field reports in real time. The cost of the development of the interactive forms for Grid IView has been minimal and can be met within the original project budget with minor adjustments to the project plan. It was thought that the use of interactive forms would facilitate more efficient and accurate data acquisition as well as making direct digital importation into analytical software tools possible. However, it was determined that the Grid IView application was not yet mature enough to support this application and implementation would have delayed the project. Data acquisition continued using paper and e-mail systems in order to keep the project schedule on track, but the Grid IView implementation will be completed at a later date outside of this project's scope.

Lessons Learnt for Future Projects

• Camera Procurement – During the procurement exercise it was discovered that the range of thermal imaging products has expanded over recent times, with significant improvements in price/performance ratio. We have already learned that it is not necessary to purchase expensive high-end cameras for this application, the extra features of these devices typically does not improve heat signature detection capability. With the help of our supply partner market research was revisited before further device procurement was executed in order to ensure that any potential benefits from any new or improved products are not lost. No new products have emerged during the project's schedule.

• Camera design preferences – From an early stage in field trials it emerged that cameras which can be operated single-handedly are much preferred by operators (i.e. pistol grip type design). Some cameras exhibited poor battery life and needed recharging too often. Two cameras exhibited reliability problems. An integrated 'hot spot' indication feature is liked, as is the image merge capability of cameras with both visible light and infra-red spectrum capability. A camera which works 'out of the box' is much favoured. This learning was included in device selection criteria.

• Learning benefits beyond the project scope – By virtue of the TOUCAN project field operatives engaged in trials have thermal cameras also available for use when they are engaged in other network maintenance activities. Encouragement is given to use these devices in activities beyond the project's scope in case other benefits can be discovered. Examples of these applications have been in locating phase imbalance in overhead lines, insulator breakdown and hot spots in substation equipment indicating potential early failure.