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.

NIA Project Registration and PEA Document

Date of Submission

Jan 2016

Project Reference Number

NIA_NGET0179

Project Registration

Project Title

Travelling Wave Fault Locator Trial

Project Reference Number

NIA_NGET0179

Project Licensee(s)

National Grid Electricity Transmission

Project Start

February 2016

Project Duration

4 years and 3 months

Nominated Project Contact(s)

Aisling Rapier

Project Budget

£250,000.00

Summary

A Travelling Wave Fault Locator (TWFL) is to be installed for protection purposes for Delayed Auto-Reclose (DAR) lockout. This is required on composite circuits, where there is a combination of Over Head Line (OHL) and cable sections, for when a fault occurs in the cable section.Deliverables will include the following:

Stage 1

- Modelling of 2 or 3 different circuits in laboratory conditions to predict performance
- To set up and evaluate field trials on 2 circuits to check sensitivity.
- Installation of TWFLs on 2 circuits (one composite circuit and one cable circuit)
- Implement hybrid circuits in iQ+ on 2 ended circuits.
- Develop firmware and hardware and conduct lab testing.
- Set up live trial

Stage 2

- Evaluate live trials
- Annual project progress reports
- Reviewing data once a day for the first three months, to reviewing data to once a week and then once a month
- Looking at any new results generated
- Dialling into the TWFLs remotely
- Downloading transient waveforms

- Monitoring sensitivity of TWFLs

Stage 3

- Formulating conclusions from data analysis
- Deciding whether a TWFL is suitable for DAR lockout
- Deciding whether a TWFL is suitable for cable fault location
- Deciding whether a TWFL can be used for condition monitoring purposes
- Comparing data analysis with system conditions
- Comparison of data collected and simulation study
- Final project report with recommendations
- Evaluating TWFLs to be left on the circuit or to be decommissioned.
- Decommissioning asset if necessary

Nominated Contact Email Address(es)

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Problem Being Solved

A number of circuits on the GB electricity transmission network are protected with Delayed Auto Reclose (DAR) protection. This acts by opening the circuit breakers at either end of a circuit when a fault is detected and then automatically recloses the circuit breakers after 10 seconds to restore the circuit into use. The circuit will trip again if the fault is permanent, until the fault is investigated and resolved. However, the DAR is very useful for OverHead Line (OHL) circuits, where transient faults (such as those caused by lightning strikes) are the most commonly occurring fault; it eliminates outage time and increases system stability.

The use of DAR on composite circuits, a circuit with both OHL and cable sections has more complex implications. A fault on the cable section of a composite circuit will not be transient. One of the most common causes of fault on cable sections is damage by mechanical excavators, so DAR is not suitable for cable or composite circuits. Reclosing the circuit when there is a permanent fault will result in significantly more damage occurring. Approximately 20% of the circuits on the England & Wales transmission network have cable sections.

Currently for a composite circuit, a Cable Fault Detection (CFD) system is constructed at the Cable Sealing End (CSE) compound. This includes Current Transformers (CTs), fibre -optic communications feeding back to substations at either end of the circuit, and block houses being built containing protection relays and power supplies. This allows the protection system to detect whether a fault is in the cable or OHL. If the fault is within the cable section the DAR will be locked out. However, the CSE compounds are expensive to build, they require maintenance, they increase the visual impact at the ends of cable sections of a circuit and they cannot be built for all cable sections in a circuit. Some composite circuits currently have either no DAR, which means that the circuit will remain out of service until after investigation for all trip conditions. Other composite circuits may have no DAR lockout facility, which means for a cable fault there is significant damage to assets.

This project seeks to prove the accuracy and reliability of an alternative solution, by trialling the use of a Travelling Wave Fault Locator (TWFL) on composite circuits. A TWFL has been used on OHL only circuits in both the USA and Scotland, for fault-finding purposes, and has been proven to be very accurate. However, this would be the first time a TWFL will be installed on a cable circuit and on a composite circuit.

A TWFL eliminates many of the problems associated with a separate CSE compound for DAR lockout purposes. A TWFL can be installed either end of the circuit in the substation. The cost of the equipment is significantly cheaper than building a CSE compound. They will improve the visual impact of the transformation from OHL to cable.

There are three ways in which the successful proof of reliability and accuracy in composite circuits could be beneficial:

1. on existing composite circuits with no DAR or cable only circuits, fault location will be as beneficial as it is for OHL only circuits in reducing the time taken to investigate and remedy a fault. Currently, for cable circuits the method for finding faults involves digging large holes, so the time and civil costs in finding a cable fault would be reduced.
2. for existing composite circuits with DAR, but no DAR lockout capability, in addition to benefit 1, there is also likely to be less

damage and lower repair costs if the fault is in the cable section.
3. for new composite circuits (either completely new circuits or existing OHL circuits that become composite circuits as a result of work done to reduce visual impact), the cost of the additional DAR lockout capability currently achieve with the equipment at the cable sealing ends can be avoided.

Method(s)

A simulation study will be conducted to ensure that a TWFL will still produce accurate results on a composite circuit. This will prove the capability of the TWFL in laboratory conditions. In addition to the laboratory trial, a field trial will be carried out by installing the TWFL on a composite circuit that is prone to faulting as a result of 3rd party excavator strikes. This will provide confidence that a TWFL is still accurate on a composite circuit and on a cable circuit with real-life conditions.

This will demonstrate how a TWFL interacts with the whole system, and whether it could be used for protection purposes. Desk-based work will be conducted to analyse the data that is generated from the TWFLs. This will be used to interpret the sensitivity of the TWFL, the quality of the data received and the accuracy of the equipment.

Scope

A Travelling Wave Fault Locator (TWFL) is to be installed for protection purposes for Delayed Auto-Reclose (DAR) lockout. This is required on composite circuits, where there is a combination of Over Head Line (OHL) and cable sections, for when a fault occurs in the cable section.
Deliverables will include the following:

Stage 1

- Modelling of 2 or 3 different circuits in laboratory conditions to predict performance
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Objective(s)

The objectives of this trial are to

- Reduce the costs associated with faults on a composite or cable only circuits by improving fault location
- Reduce the costs associated with faults on composite circuits with DAR but no DAR lockout capability
- Reduce the costs of protections systems for new composite circuits, or existing OHL only circuits that become composite circuits by introducing cable sections.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

Knowledge gained during this project will allow National Grid to make informed decisions about using Traveling Wave Fault Locators to successfully detect a fault in the appropriate section on a composite circuit; to accurately locate a fault in the cable circuit; and to understand if TWFL will or will not interfere with system stability or other plant functionality.

Specifically we will test Travelling Wave Fault Locator capabilities in the following areas:

- Test for DAR lockout purposes on a composite circuit
- Test as a fault locator on a cable circuit
- Test fitness for purpose when used for condition monitoring purposes
- To gather data of transience occurring on the system

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

This is the first time a TWFL has been used on a composite circuit in the world, further a TWFL has not been used on a cable circuit in the UK, so it is necessary to trial and demonstrate TWFL's accuracy with lower impedance.

The project includes both laboratory testing and trials in a working environment on two circuits. The trial will prove that the equipment can be used as a Cable Fault Detector (CFD) without affecting system stability. As well as the physical site trial, there is also a large amount of resource and time required to analyse the data, which would be desk based.

This is the minimum amount necessary to achieve the objectives of the project.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

Lab work and simulation studies will take place to determine the feasibility of the TWFL operating on a composite circuit. Field trials will be undertaken in the UK, on identified sites on the National Grid Electricity Transmission system. Desk based work will collect and analyse the data remotely.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£208,000

Project Eligibility Assessment Part 1

There are slightly differing requirements for RIIO-1 and RIIO-2 NIA projects. This is noted in each case, with the requirement numbers listed for both where they differ (shown as RIIO-2 / RIIO-1).

Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations (Please complete sections 3.1.1 and 3.1.2 for RIIO-2 projects only)

Please answer **at least one** of the following:

How the Project has the potential to facilitate the energy system transition:

n/a

How the Project has potential to benefit consumer in vulnerable situations:

n/a

Requirement 2 / 2b

Has the potential to deliver net benefits to consumers

Project must have the potential to deliver a Solution that delivers a net benefit to consumers of the Gas Transporter and/or Electricity Transmission or Electricity Distribution licensee, as the context requires. This could include delivering a Solution at a lower cost than the most efficient Method currently in use on the GB Gas Transportation System, the Gas Transporter's and/or Electricity Transmission or Electricity Distribution licensee's network, or wider benefits, such as social or environmental.

Please provide an estimate of the saving if the Problem is solved (RIIO-1 projects only)

The potential financial benefit from proving the suitability of a TWFL is different for each of the three types of benefit anticipated. For each new composite circuit that uses TWFL instead the current infrastructure required in cable sealing end compounds the potential savings are approximately £3m.

Please provide a calculation of the expected benefits the Solution

There are three ways in which the successful trail of a TWFL in composite or cable only circuits could be beneficial. The estimated range of financial benefits for each is described below together with a description of the key elements that influence the associated base costs.

Scenario 1: No Delayed Auto Reclose (DAR) on existing circuit £240,000 - £19.8m
This event scenario takes into account the costs associated with the resource required to investigate a trip and how long a circuit would be out for that would be avoided, as well as the cost for the TWFL equipment and maintaining it. The savings would be approximately ranging from £240,000 to £19.8m per fault event.

Scenario 2: DAR on existing circuit and no DAR lockout £3.3m-£15.7m
This scenario takes into account the expected cost reduction in a cable fault repair: including time, length of outage, resource, materials, as well as the cost of the TWFL equipment and its maintenance per circuit. The savings would be approximately ranging from £3.3m to £15.7m per fault event.

Scenario 3: Conventional Cable Fault Detector (CFD) compared to TWFL present £2.9m per circuit across the expected 20 year life of the TWFL.
This scenario takes into account the costs associated with the civil infrastructure, materials, supply, communication requirements and maintenance for a CFD in a cable sealing end compound, compared to the materials and maintenance of a TWFL. The savings are approximately £2.9m per circuit across the life of the asset.

Please provide an estimate of how replicable the Method is across GB

Results from this project can be applied to 20% of circuits on National Grid's system. The project is not restricted by voltage so DNOs can benefit from the findings of the trial as well.

Please provide an outline of the costs of rolling out the Method across GB.

Roll out would be phased, with the focus on critical sites with no DAR, or no DAR lockout on first. There are currently 69 composite circuits without any form of cable protection. The circuits would be classed as having high priority depending on whether the cable section goes through urban areas, where it is more likely to be damaged from third parties.

The installation of a TWFL costs in total £30,000. Assuming all above circuits will have TWFLs installed onto them for cable protection then the total cost of the roll-out will be £2.1m.

For future schemes a TWFL will be considered as an alternative option to the conventional use of CTs in a CSE. Although from calculations above a TWFL is significantly cheaper and would be implemented at £30,000 as part of a new circuit.

If this technology is adopted by the Scottish TO's or the DNO's the costs per circuit are anticipated to be similar.

Requirement 3 / 1

Involve Research, Development or Demonstration

A RIIO-1 NIA Project must have the potential to have a Direct Impact on a Network Licensee's network or the operations of the System Operator and involve the Research, Development, or Demonstration of at least one of the following (please tick which applies):

☑ A specific piece of new (i.e. unproven in GB, or where a method has been trialled outside GB the Network Licensee must justify repeating it as part of a project) equipment (including control and communications system software).

☐ A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)

☐ A specific novel operational practice directly related to the operation of the Network Licensees system

☐ A specific novel commercial arrangement

RIIO-2 Projects

☐ A specific piece of new equipment (including monitoring, control and communications systems and software)

☐ A specific piece of new technology (including analysis and modelling systems or software), in relation to which the Method is unproven

☐ A new methodology (including the identification of specific new procedures or techniques used to identify, select, process, and analyse information)

☐ A specific novel arrangement or application of existing gas transportation, electricity transmission or electricity distribution equipment, technology or methodology

☐ A specific novel operational practice directly related to the operation of the GB Gas Transportation System, electricity transmission or electricity distribution

☐ A specific novel commercial arrangement

Specific Requirements 4 / 2a

Please explain how the learning that will be generated could be used by the relevant Network Licensees

This is the first time a TWFL has been trialed on a composite circuit in the world. It will prove whether a TWFL is accurate enough as a fault locator with the change of impedances on a circuit. A TWFL has not been used on a cable circuit in the UK, so it will demonstrate it's accuracy with a lower impedance. This method of using a TWFL as a CFD can be applied to the other GB electricity transmission and distribution systems.

Or, please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the project (RIIO-1 only)

This project fits within the managing assets and efficient build value area of the Electricity Transmission Owner (ETO) Innovation Strategy.

☑ Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees

Is the default IPR position being applied?

☑ Yes

Project Eligibility Assessment Part 2

Not lead to unnecessary duplication

A Project must not lead to unnecessary duplication of any other Project, including but not limited to IFI, LCNF, NIA, NIC or SIF projects already registered, being carried out or completed.

Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

n/a

If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

n/a

Additional Governance And Document Upload

Please identify why the project is innovative and has not been tried before

n/a

Relevant Foreground IPR

n/a

Data Access Details

n/a

Please identify why the Network Licensees will not fund the project as apart of it's business and usual activities

n/a

Please identify why the project can only be undertaken with the support of the NIA, including reference to the specific risks(e.g. commercial, technical, operational or regulatory) associated with the project

n/a

This project has been approved by a senior member of staff

☑ Yes