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

Nov 2018

Project Reference Number

NIA_NGTO026

Project Registration

Project Title

Health Monitoring of cables using Acoustic Emission Measurement Techniques

Project Reference Number

NIA_NGTO026

Project Licensee(s)

National Grid Electricity Transmission

Project Start

September 2018

Project Duration

0 years and 4 months

Nominated Project Contact(s)

Jude Robinson

Project Budget

£62,500.00

Summary

National Grid's transmission network consists of many kilometres of cables across Great Britain. The entire network needs to function at a very high level of reliability to ensure an undisrupted electrical supply for consumers. The routine inspection of each individual component to ensure mechanical, structural and electrical performance is an essential, but expensive and time consuming process; especially for cable systems, which are mostly submerged below ground.

Cables and their accessories are subjected to mechanical loading during their time in service. Some failure mechanisms within cable systems are purely mechanical (such as longitudinal splitting of the over-sheath, thermomechanical damage, and mechanical fatigue near cleats) and are often a precursor to electrical failure. Being able to detect the mechanical failures would provide more lead time to manage the assets and take mitigating action.

The aim of this project is to demonstrate the capability of Acoustic Emissions for the monitoring of cables within a laboratory based environment. On completion of the work, the team will be aware of the requirements necessary to scale-up and apply the developed technique.

Nominated Contact Email Address(es)

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Problem Being Solved

National Grid's transmission network consists of many kilometres of cables across Great Britain. The entire network needs to function at a very high level of reliability to ensure an undisrupted electrical supply for consumers. The routine inspection of each individual component to ensure mechanical, structural and electrical performance is an essential, but expensive and time consuming process; especially for cable systems, which are mostly submerged below ground.
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Method(s)

A technology which has shown great potential for the monitoring of structures and components is Acoustic Emission (AE). AE is the radiation of acoustic (elastic) waves in solids, that occurs when a material undergoes irreversible changes in its internal structure, for example because of crack formation or plastic deformation due to ageing, temperature gradients or external mechanical forces. The waves generated by sources of AE can be detected by mounted sensors positioned some distance away and are of practical interest in Structural Health Monitoring (SHM). AE has previously been successfully used in a variety of applications, including metallic and concrete bridge structures, aerospace landing gear components and aerospace fuselage parts with advanced/mixed materials and complex geometries. Trials have demonstrated the capability of the technique to detect corrosion and damage; but this has not been demonstrated on the electrical transmission network and a challenge that has impeded its industrial use is the ability to determine when damage has reached a level where maintenance and/or manual inspection is required.

Utilising existing testing apparatus, we will adopt the following method in this study:

- Develop and carry out a laboratory based demonstration of the proposed AE system capable of detecting the onset of damage for this application at differing locations along a sample of cable. This will allow the signal propagation through a complex structure to be understood and enable identification and specification of damage mechanisms.
- Carry out an accelerated long-term fatigue test on a sample of cable using hydraulic actuators to demonstrate the capability of the technique to identify the onset of damage. Further techniques, such as Digital Image Correlation of Video Strain Gauging will be employed to validate the AE measurements.

The following will be taken into consideration to obtain the best results:

- Identification of optimum positions for location of the AE sensors.
- Monitoring of a live sensor within the laboratory environment to assess background noise.

Scope

The aim is to investigate the possibility of identifying potential failure modes by utilising AE for monitoring cables on the transmission network. This study will adapt existing instrumentation, sensing capabilities and techniques with a view to identifying the required steps needed to develop the technology into a deployable system. The key deliverables of this project are:

- laboratory based demonstration of the proposed AE system capable of detecting the onset of damage for this application at differing locations.
- Complete a long-term fatigue test on a cable sample.
- Specification for autonomous system capable of prognosis, together with the necessary steps to achieve.
- Report of the project's findings, conclusions and scope for further development.

Objective(s)

The goal of this project is to demonstrate the capability of AE for the monitoring of cables within a laboratory based environment. On completion of the work, the team will be aware of the requirements necessary to scale-up and apply the developed technique.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The project will be successful if the findings clearly identify whether AE technology is able to:

1. Clearly detect damage and give an indicator of the health of a cable. Traditional non-destructive testing techniques and laboratory based tests will serve as a benchmark for comparing the AE indicator to and evaluating its performance.
2. Deliver assessment criteria which will provide accurate information in comparison with more established and recognised techniques.

Project Partners and External Funding

No additional partners.

Potential for New Learning

This project has significant potential for new learning of the use of AE for monitoring power transmission cable systems. The technology and techniques to be developed will be useful to all network licensees for monitoring and assessing the health of their assets.

Scale of Project

The project is a three month study designed to assess the capability of AE technology for the structural health monitoring of cables. The work will be mainly laboratory based to determine the effectiveness of the technique and to enable the development of necessary

algorithms and data extraction methods to give the desired output.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

All the work will be carried out in laboratories and facilities within the School of Engineering at a research institute.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£62,500

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)

AE is an existing technology, proven in other applications, with the potential to provide information to asset managers which could extend asset life and defer investment. This tool also has the potential to minimise unexpected failures and help optimise asset replacement planning.

Please provide a calculation of the expected benefits the Solution

Research project

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

At this stage, it is difficult to assess how many sites would require the installation of such a system and how much this would cost. It may be that the cable transmission network only requires monitoring at remote sites or at areas prone to extreme weather (e.g. long period of ice or high winds) to be monitored requiring protection for the sensors, or that it may be more useful in monitoring substation components where less protection is required. If successful, results of this project will in some part dictate the future application direction.

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

As an estimate, a typical AE sensor ranges from £50 to £500 but there are cheaper alternatives, whereas commercial AE systems can cost in the region of £12,000 but are designed to be multi-functional; a system specifically designed for this application could be as low as £50 to £100 per self-contained unit. There would be additional costs for training and the development of the knowledge to translate the data into information. At this early stage, it is estimated that rolling out this technology across GB would cost around £5 million.

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

The learning generated will provide an opportunity for network licensees to monitor, assess and evaluate the mechanical condition of their assets, leading to improved asset management. This technique, if proven, could be used by any network licensee. Each licensee could adopt the use of AE detection technology as part of their condition monitoring process.

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' value area of the Electricity 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.

The application of AE research to cable systems has not been done before. A search on the Smart Networks portal identifies two vaguely similar projects:

www.smarternetworks.org/project/prj_689 : The investigation of acoustic emissions from overhead line conductors. In this case, the term 'acoustic emissions' refers to audible noise production and is distinctly different to the 'acoustic emission' measurement technique described here.

www.smarternetworks.org/project/nia_nggt0045 : The development of acoustic emission measurement technique for valve leak detection. In this case, the technology is the same but it was developed for the very different application of detecting valve leaks and not for the transmission network.

We have concluded that there is no duplication of this work.

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

This project seeks to exploit technology that exists, to monitor acoustic emissions by applying it to the electricity transmission system; specifically cables, to identify potential failure modes in the system. This project will build on knowledge of AE and undertake research into how the unique environment presented by cables impact on the AE. Analysis of the information gathered will develop an understanding of the signal patterns generated by the cable. This has not been done before. The research is low TRL as it is a study to understand whether it is possible to develop a tool which can be used to improve knowledge of the health of the cable asset.

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

There is an opportunity for this research to be used to provide value to consumers, by reducing replacement works and deferring investment. There is a risk that identification of useful signal patterns to align with potential cable failure modes may not be possible. Without the NIA funding this research would not be performed, and the business would be justified in not exploring this opportunity.

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

The project can only be funded through the NIA as there are significant risks which warrant further investigation and development of this research area, prior to its use within the business. The main risk is: It is not certain that this method will prove feasible – While a value case has been defined for this project, it is contingent on obtaining an as yet unknown level of technical knowledge. No matter what the outcomes of this project are, these will be valuable to utilities managing their assets. However, these benefits are not sufficient for the business to justify the project's budget. Without the NIA funding this risks would never be mitigated, and the business would not research this area; resulting in the potential benefits never being obtained or investigated.

This project has been approved by a senior member of staff

☑ Yes