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

Apr 2022

Project Reference Number

NIA2_NGET0015

Project Registration

Project Title

Fibre Health Monitoring

Project Reference Number

NIA2_NGET0015

Project Licensee(s)

National Grid Electricity Transmission

Project Start

August 2022

Project Duration

1 year and 6 months

Nominated Project Contact(s)

Thomas Charton (Box.NG.ETInnovation@nationalgrid.com)

Project Budget

£712,000.00

Summary

The energy network transition will require more agile, flexible and interconnected networks underpinned by reliable communications networks in particular where services for protection and control are concerned. Operational fibre optic networks are reaching an age where some of the equipment is starting to fail whilst other parts of the network are intact and may be able to provide significant further service life. This project will examine enhanced optical sensing methods to detect and track the ageing process of fibre optic cables and associated fittings with the aim of providing accurate health information and the capability to forecast failures. The research will include new optical sensing methods as well as new algorithms to interpret the data and correlate to other data sources.

Third Party Collaborators

EXFO Europe Limited

ADVA Optical Networking Ltd

Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

Problem Being Solved

Operational telecommunications networks carry critical information which is essential to the secure and efficient operation of electricity transmission networks. Large parts of this Critical National Infrastructure (CNI) have now been in service for over 25 years and failures may become more frequent and more difficult to address. The current monitoring regime provides some information about the current status of the network but offers very limited information on asset health and potential future failures. Unplanned loss of communications requires expensive repairs and electricity network outages and in many cases also leads to constraints and constraint cost to consumers. This project will investigate advanced optical sensing technologies as well as monitoring data analysis tools that aim at accurate fibre health modelling and forecasting. If successful, this will enable asset managers to avoid in service communication

failures, enable forward planning of replacement interventions and extend the average service life.

Method(s)

To address the above problem this project will carry out research into optical sensing technologies that can be deployed at key nodes on the fibre optic network in order to monitor the optical characteristics of the fibre network and derive asset health information. The measured data will be recorded over time and analysed together with other data sources such as environmental data to create an asset health model that allows predictive asset health monitoring and management.

Two slightly different technologies will be evaluated in this project. Both will be installed on the NGET network for several months to monitor fibre optic cables of known asset condition and their suitability, performance, costs and benefits will be compared.

Data Quality Statement (DQS):

- The project will be delivered under the NIA framework in line with OFGEM, ENA and NGET internal policy. Data produced as part of this project will be subject to quality assurance to ensure that the information produced with each deliverable is accurate to the best of our knowledge and sources of information are appropriately documented. All deliverables and project outputs will be stored on our internal Sharepoint platform ensuring access control, backup and version management. Relevant project documentation and reports will also be made available on the ENA Smarter Networks Portal and dissemination material will be shared with the relevant stakeholders.

Measurement Quality Statement (MQS):

- The methodology used in this project will be subject to our supplier's own quality assurance regime which is ISO 9001 certified. Quality assurance processes and the source of data, measurement processes and equipment as well as data processing will be clearly documented and verifiable. The measurements, designs and economic assessments will also be clearly documented in the relevant deliverables and final project report and will be made available for review.

In line with the ENA's ENIP document, the risk rating is scored 5 = low.

TRL Steps = 1 (2 TRL steps)

Cost = 2 (£500k - £1M)

Suppliers = 1 (2 suppliers)

Data Assumption = 1 (defined assumptions and principles)

Scope

The scope of the project covers 2 phases. The first phase consists of research and development activities as well as design and engineering carried out in the suppliers' laboratory. During this phase the sensor and analysis software will be configured and pre-validated as part of laboratory tests. The second phase includes the site installation, data collection, data analysis and performance optimisation.

Phase 1: Development

Both suppliers will set up a laboratory-based test platform and develop the optical sensing solution. Algorithms for data analysis and correlation between optical signals and fibre health will be established. At the end of this phase the optical sensing application including hardware and software will be ready for site installation at one of NGETs substations. The system design and preliminary test results for both solutions will be documented in the phase 1 summary report.

Phase 2: Site testing

The fibre health assessment solutions developed in phase 1 will be installed at one of NGET's substations and will be connected to fibre wrap routes with known asset heath conditions. Monitoring data will be processed by the software and remotely reviewed. Some level of refinement of the test methodology and data analysis algorithms is expected at this stage. The site installation, monitoring and testing process as well as the tuning of the algorithms will be documented in the phase 2 report. The overall conclusions and the learning from the project will be summarised in the final report at the end of the project.

Objective(s)

The objective of this project is to investigate the capability of two methods of optical sensing technologies together with their associated data processing algorithms in order to assess the effectiveness and performance of each method with regards to asset health monitoring and modelling of optical fibres. The asset health models are aimed at facilitating predictive maintenance and replacement of fibre optic cable by predicting future failures and thus avoiding in service failure of assets. Moving to a predictive asset management regime will also enable the optimisation and extension of the average asset life.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

Financial distributional impact: The project is expected to support energy networks to deliver and manage essential operational telecommunications network equipment more efficiently and at lower cost through predictive asset management. If these savings are achieved, the financial distributional impact of this project aligns with the simplest case discussed in OFGEM's Assessing the impact of economic regulation report. The report confirms that the savings as a percentage of household income are more significant for lower income deciles and therefore the achieved benefits will be particularly valuable to vulnerable consumers. The pricing structure for energy transmission will not be impacted, e.g. benefits delivered as part of this project can be passed on to all consumers including households using a prepayment meter.

Technical and wellbeing impact: The consumer impact of any of the methods or solutions developed in this project is not dependent on any of the following factors:

- Dwelling and location (potentially including tenure)
- Readiness for digital technology
- Personal and social factors (for example, households with disabilities and medical conditions, or which speak English as a foreign language)

Energy technology and usage profiles: The results of this work can be applied regardless of energy technology and will not differentiate between consumer usage profiles.

Success Criteria

The success of this project can be measured based on the extent to which the objectives have been achieved, i.e. the successful development of optical sensing technology enabling the detection of onset of failure modes and forecasting of failures allowing predictive asset management of fibre optic cables, i.e. repair, refurbishment and replacement. To achieve this, the project needs to deliver a successful laboratory-based trial as part of phase 1 and site validation as part of phase 2.

Project Partners and External Funding

Not applicable

Potential for New Learning

This project has the potential to deliver significant new learning in the field of fibre optic monitoring. Currently most monitoring technologies can detect loss and discontinuities but so far, the correlation between various failure modes such as broken fittings or deterioration of materials associated with the fibre optical cable itself and its supporting structures has not been demonstrated. The impact of environmental factors in the ageing process will also be considered and new machine learning algorithms will be developed and trained to provide further insights. Additionally, novel optical sensors will be tested with regards to their capability to provide more detailed information on asset condition and expected life.

The learning will be disseminated through the publication of the final project report and depending on opportunity through publication and presentation of research papers at conferences and through the ENA and CIGRE.

Scale of Project

The scale of the project includes a laboratory-based development and test phase followed by a small-scale site trial at a single NGET substation. The substation tests will allow evaluation and comparison of two different technologies in an operational environment.

Whilst the research and development work as well as the initial validation on samples of optical fibre can be carried out in a lab-based environment the proof of concept on the NGET fibre optic network can be easily facilitated and is an essential part of the validation of the sensing technologies and data processing algorithms.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL6 Large Scale

Geographical Area

The project will be partly laboratory based at the respective suppliers' premises and partly site based. The site demonstration and validation will be carried out at an NGET substation.

Revenue Allowed for the RIIO Settlement

Not Applicable

Indicative Total NIA Project Expenditure

Total NIA expenditure: £640,800

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:

The energy system transition will require a shift to renewable energy resources which in turn are leading to reduced fault levels and inertia as well as a change to the characteristics of fault currents. Protection systems are going to rely on secure communication channels more than ever. Similarly, situational awareness and wide area control schemes as well as enhanced asset management will also drive more reliance on operational telecommunications services which are supported by NGET's fibre optic OPTEL network. It is therefore critical to monitor the health of the fibre optic network, prevent in service failures and enable cost optimised predictive asset management in order to deliver the energy system transition.

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

Not applicable (also see section 2.5)

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)

Not applicable

Please provide a calculation of the expected benefits the Solution

The fibre health monitoring project will deliver benefits to consumers via two value levers. The first lever concerns the avoidance of in-service failures. Based on recent events and asset data from the last 27 years, fibre optic cables tend to fail at a given rate which is likely to increase with age. On average an in-service failure will lead to service depletions and causes constraint costs to consumers as well as repair costs. On average such an event will cost £500k and the probability of such an event occurring will increase with asset age until the asset is replaced and the likelihood of failure is reset.

The second value lever concerns extended lifetime of fibre optic assets. By monitoring asset health the average useful lifetime of fibre optic cables can be raised from 40 years to 45 years. Delaying replacements and only replacing the assets that have got a high likelihood of failure will provide significant savings.

If successful, it is assumed that the new sensing technology could be available on the market within the next 2 to 3 years. The cost of a rollout on the NGET network is estimated at £2.4M.

Based on the modelling of likelihood of failure and extended asset life whilst considering the project cost and rollout cost the Net Present Value (NPV) of this project, shows a benefit of £2.9M. The benefits will reach consumers in terms of reduced constraint costs and reduced funding requirements for the ongoing provision of a secure and reliable operational telecommunications network.

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

The aim of the project is to develop the required enhanced optical sensing technology and machine learning tools with a view of future market availability to all GB networks. This technology can be applied by all licensees which use a fibre optic operational telecommunications network.

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

Once fully developed, it is expected that each device can monitor multiple fibres at each substation with a range of 50-100km. In order to get full network coverage, it is estimated that NGET may need around 60 new monitoring devices at a unit cost of £40k each, hence £2.4M estimated rollout cost.

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 from this project, as documented in the project deliverables, will benefit all network licensees. The results of the research will be documented in the project deliverables and the learning will be made available to all network licensees. Based on the outcomes, other networks can implement these technologies and integrate them into their own fibre optic network management solutions.

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

Not applicable

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.

A review of ongoing and previous projects has not shown any duplication with regards to this work. Fibre optic sensors have been studied for temperature sensing (UKPN IFI and others) as well as noise and vibration sensing (NIA_NGET0034) however no

application to fibre optic health assessment or application of coherent OTDR has been reported to date.

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

Not applicable

Additional Governance And Document Upload

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

Recent developments in optical sensing technology have led to new opportunities for analysis of optical signals in fibre optic telecommunications networks. Such devices are not currently commercially available and have not been evaluated with regards to their capability to deliver enhanced insights into asset health. The project will also apply new Machine Learning (ML) algorithms to the sensor data and correlate with other data sources such as environmental and operational data.

Relevant Foreground IPR

The foreground IPR created in this project will be embedded in the project deliverables, i.e. the reports, design documentation, requirements specifications, test results, software and demonstrator configuration. The suppliers will bring their own background IPR to the project with regards to optical sensing, Machine Learning and data processing. The learning from this project can be used by other licensees without access to the background IPR.

Data Access Details

Data for this project and all other projects funded under the Network Innovation Allowance (NIA), Network Innovation Competition (NIC) or the new Strategic Innovation Fund (SIF) can be found or requested in a number of ways:

- A request for information via the Smarter Networks Portal at https://smarter.energynetworks.org, to contact select a project and click ‘Contact Lead Network’. National Grid already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.
- Via our Innovation website at https://www.nationalgrid.com/uk/electricity-transmission/innovation
- Via our managed mailbox box.NG.ETInnovation@nationalgrid.com

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

There is currently significant uncertainty regarding the feasibility, and accuracy of the proposed method. The new sensing technology has not been applied in any commercial products and has not been tested yet. It is likely that it will be capable to detect signs of ageing but the method is yet unproven and the accuracy of asset health modelling remains to be validated. The commercial and technical risks are described in more detail below.

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

Technical risks:

The new optical sensing technology is in the early stages of research and its capability to provide insights regarding asset health for fibre optic cables is yet unproven. There is also no in service experience of this technology on fibre optic networks validating the results. Similarly, the ability to apply Machine Learning tools to the data and model asset life accurately remains to be proven. Whilst there is a good chance that the project will deliver the expected benefits, there are also some technical risks making NIA funding necessary.

Commercial risks:

The above technical risks contribute to significant uncertainty regarding the effort required to develop a product ready for market rollout. This risk is holding back the development and investment. By proving the key use cases for this technology, further development will be possible, and a market-ready product can be developed for the benefit of licensees and consumers.

This project has been approved by a senior member of staff

☑ Yes