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

Sep 2022

Project Reference Number

NIA2_NGET0010

Project Registration

Project Title

Non-intrusive Tower Foundation Inspections using UGW (NITFI)

Project Reference Number

NIA2_NGET0010

Project Licensee(s)

National Grid Electricity Transmission

Project Start

October 2022

Project Duration

1 year and 0 months

Nominated Project Contact(s)

Anusha Arva (Box.NG.ETInnovation@nationalgrid.com)

Project Budget

£257,000.00

Summary

Overhead line (OHL) towers have foundations for each tower leg that are typically 4m deep and are a mixture of pad and chimney, and piled designs. To avoid the failure of OHL tower foundations, periodic and accurate inspection of these buried assets is essential. Currently, there is a significant reliance on intrusive methods of inspection involving digging up of the foundations to collect samples which is a carbon and time intensive process. Although several non-intrusive methods exist, getting precise and reliable results with a single measurement is a challenge. This project aims to adapt Ultrasound Guided Wave (UGW) testing to function as a portal inspection kit for condition assessment of overhead line tower foundations.

Third Party Collaborators

The Welding Institute

Nominated Contact Email Address(es)

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Problem Being Solved

National Grid Electricity Transmission (NGET) operate around 22,000 overhead line (OHL) towers on their network. This population of towers have foundations that are a mixture of piled and a pad & chimney design and are typically around 4m deep. The failure of a foundation is a tower life limiting fault, and so must be remedied immediately if a fault occurs. In order to ascertain if a tower foundation is still intact and of sound structure, NGET conduct surveys of tower foundations.

As part of current NGET maintenance practices, tower foundations are inspected using intrusive methods which are costly and time consuming. Non-intrusive alternatives are also available and have been used to survey assets by NGET as well as other utilities.

However, they do not currently provide the consistent, precise insight that NGET require to accurately assess the condition of the underground assets. Existing non-intrusive methods have required taking measurements at the same OHL foundation site in multiple weather/soil conditions in a year, and then combining these to form an overall assessment. This has resulted in increased inspection costs and turnaround times for assessments. A non-intrusive method of OHL foundation inspection that can provide precise, consistent, and reliable assessment of the foundation condition is yet to be established/developed.

Method(s)

This project aims to adapt the Ultrasonic Guided Wave (UGW) Testing technology to monitor concrete OHL tower foundations. It is a non-intrusive monitoring technique that uses a portable probe, pulser-receiver, and customised software. The probe is mounted on the foundation-steel interface of the OHL tower, and an ultrasonic pulse is sent through it. Reflection of the pulse wave is received by the receiver and analysed by the custom software to detect presence of cracks, changes in thickness caused by corrosion.

Given the fact that a number of non-intrusive methods currently exist but do not provide satisfactory assessments on OHL foundation condition, this project aims to explore an alternate method. UGW testing has been chosen in particular as it is portable, and the concept has been successfully proven for the case of corrosion assessment in mains steel gas pipeline. The method was found to have easy to handle hardware, covering larger inspection area and providing instant data relating to condition of the asset with good confidence level. This project aims to adapt the UGW method to apply to OHL tower foundations with modifications such as change in cross section of the probe and associated measurement kit along with lab trials and field trials conducted at locations with different soil conditions to validate the method.

Data Quality Statement (DQS):

The project will be delivered under the NIA framework in line with OFGEM, ENA and NGGT / 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. 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 6 (low)

TRL Steps = 2 (3 TRL steps)

Cost = 1 (£257k)

Suppliers = 1 (1 suppliers)

Data Assumption = 2 (Assumptions known but will be defined within project)

Scope

The scope for this project is broken down as follows:

Task 0 – Array Acceptance Criteria

a. Knowledge sharing on OHL tower foundations and current practices

b. Review of NGET’s requirements specific to foundation inspection

c. Development of acceptance criteria to assess the performance of a prototype array during the course of the project

Task 1 – System Specification and Requirements

a. Review of wave propagation properties and existing standards to aid the design specification of the prototype probe array

b. Design of prototype linear probe array in order to implement an ultrasonic guided wave (UGW) inspection of the condition/structural integrity of the tower foundation encased steel work (interface between tower leg and stub). This scope of work will require the design and development of the prototype probe array to ensure back-cancellation of the signal, beam focus and suitable excitation frequency to achieve penetration depth.

Task 2 – Manufacture of Prototype Array

a. Completion of detailed drawings of the prototype probe array in order to aid manufacture

b. Assembly of component parts of the prototype probe array in a laboratory and preliminary tests

Task 3 – Laboratory Testing

a. Integration of the prototype probe array with data acquisition hardware in order to collect data

b. Development of signal processing algorithms/control scripts to analyse the collected data

c. Testing the prototype in laboratory conditions and resulting refinement to the probe

Task 4 – Field Testing

a. Development of Risk assessment and method statement (RAMS) for field trials at trial locations identified by NGET

b. Field trials conducted at predefined OHL tower locations covering different soil conditions along with resulting refinements to the probe

Task 5 – Demonstration

a. Field demonstration of the refined prototype to demonstrate the capability to detect defects such as cracking and thickness loss due to corrosion

Objective(s)

The objective of this project is to adapt UGW testing for OHL tower foundation inspection and validate the same through lab and field trials. The following elements will need to be achieved to satisfy the overall objective:

- To define inspection system requirements, particularly for required minimum defect sizes
- To develop a prototype (guided wave) probe array for the inspection of tower foundation legs
- To conduct laboratory verification trials of the developed UGW array
- To trial the method on in-service tower foundations under different soil conditions
- To undertake refinements to the prototype as necessary including analysis of which environmental factors affect the measurement and report
- To conduct demonstration of the prototype at one location after refinements from prior trials.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

An assessment of distributional impacts (technical, financial and wellbeing related) for this project has been carried out using a bespoke assessment tool, which assesses the project as having a positive, negative, or neutral effect on consumers in vulnerable situations. To help inform the assessment, this tool considers the categories of consumers identified in the Priority Services Register.

This project has been assessed as having an overall positive impact on consumers in vulnerable situations. The assessment has identified that this project will look to reduce the costs for households while reducing the amount of disruptions to them in the home. Other considerations including the project's impact on supply, disruption on public/private roads have been made in carrying out this assessment.

The project does not have a negative impact on consumers in vulnerable situations and hence no mitigation measures have been recommended in the tool.

Success Criteria

This project will be considered successful if:

- UGW testing system is successfully adapted to be used on OHL tower foundations
- UGW probe design, build and measurement kit modifications are successful
- The adapted UGW testing kit passes the lab tests, field trials and demonstration successfully

Project Partners and External Funding

Not applicable

Potential for New Learning

This project will generate learnings on whether UGW testing method can be successfully adapted to work on OHL tower foundations through the design, manufacture, lab and field trials of a probe prototype. Field trials under different soil conditions will generate learning on the reliability and accuracy of measurement through this method. Learnings will be generated on the efficiency of the method to function as a portable, non-intrusive method of condition assessment of OHL tower foundations.

Scale of Project

Getting accurate and reliable readings with a single measurement in existing non-intrusive methods of OHL foundation inspection has proven to be a challenge. This requires a new method to be adapted end-to-end for application on OHL foundations which includes adapting the hardware, software, along with all works required for validating the method. Hence, this project considers the build of a prototype of the probe from scratch, modifications to other hardware, adapting existing software for post processing of measured data. This prototype system will be tested in laboratory and field trials ranging across different soil conditions to develop confidence on reliability and accuracy of the method. This is the minimum scale of works, and therefore investment, required to develop UGW testing method to function as a non-intrusive method of OHL foundation inspection.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

The development and manufacture of the prototype probe will be done at Cambridge. Assembly of the prototype and laboratory testing will be carried out in the supplier's premises in Cambridge. Field trials will be conducted at five different locations across NGET's network. Data analysis and reporting will be desk-based.

Revenue Allowed for the RIIO Settlement

Not Applicable

Indicative Total NIA Project Expenditure

£231,300

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:

This project supports energy system transition to a net zero network by reducing the need for carbon intensive intrusive inspection of OHL tower foundations, increasing the ease of collection of condition data for OHL foundations across the network and enabling NGET (and potentially other licensees owning OHLs) to take more informed intervention decisions based on the condition of the OHL foundations.

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

Not applicable

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

Since this is an improvement in an operational practice, the benefits are calculated until the end of RIIO-3, that is, 2030/31. The baseline method considers existing volume and budget (capitalizable per RIIO-2 governance) for tower foundation inspections approved for RIIO-2. It is assumed that inspection volume and therefore the budget will increase by 50% in RIIO-3 due to increase in aging towers and other operational improvements in inspections during RIIO-2. The baseline is compared against the UGW testing method which is the innovation option. If the development of this portable inspection system is successful, it is anticipated to reduce the need for intrusive inspections of OHL tower foundations on 40% of the annual inspection volume in RIIO-2 and 90% in RIIO-3 volume. This will result in a benefit of approximately £800k over the CBA evaluation period. Further, reduction in intrusive inspections is also anticipated to result in benefits such as avoided use of concrete and diesel involved in intrusive methods, amounting to a saving of £6,188.

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

Given the portable nature of the system being developed in this project, it can be replicated and used on routine foundation inspections across NGET's network.

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

The outline costs for rolling out this method depends on the unit cost established for the measurement system which can only be determined once the kit modifications are determined within this project. At this stage, it can be estimated that cost of one unit of the kit along with the cost per inspection is a fraction of that of an intrusive inspection.

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 learnings generated in this project are relevant to all licensees that own OHL assets. If this project is successful, this method can be implemented by other network licensees who own steel lattice towers without special requirements apart from purchase of the measurement system.

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.

Given that non-intrusive inspection of buried assets is a problem common to many of the network licensees, a few projects have been initiated around this subject. For example, NIA_SPT_1607 explored use of 2 other non-intrusive inspection methods (ground penetrating radar and vibration response). IFI 0620 explored a number of such methods namely Transient Dynamic Response, Linear Polarisation, Ground Penetrating Radar, Ultrasound and Ultrasonic testing. However, NGET believe that there is still a need to develop a more reliable method for use on OHL foundations.

The project closest to this one is NIA_NGN_078 which proved the concept of UGW testing for detection of corrosion on gas mains steel pipeline. The method was found to be easy due to portability of the system and was successful in detecting corrosion in circular buried assets while covering larger inspection areas. The project under consideration builds on and adapts the system in NIA_NGN_078 to work for OHL foundation inspections which is effectively using the method on a different use case. Hence, this project is not causing unnecessary duplication of work already carried out in this area.

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

Although a number of non-intrusive methods of inspection of assets exist in the industry, getting accurate and reliable results with a single measurement per site has been a challenge for OHL foundations. The concept of UGW testing method has been tested successfully for detecting corrosion on gas pipelines through an NIA project in RIIO-T1. However, its adaptability and development for application to OHL tower foundations has not been explored in GB to the best of the knowledge of those involved.

Relevant Foreground IPR

The foreground IPR will be the learnings generated on adapting UGW testing method to OHL foundation inspections. The learnings will be captured in the form of drawings & one unit of the prototype probe array, reports on requirement analysis & acceptance criteria, outcomes of lab testing, field testing and demonstration.

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

This project looks to adapt and develop a kit to inspect OHL foundations non-intrusively. This involves a range of activities such as design, development and manufacture of a prototype probe array, modifications to existing software for post processing of data, lab trials and field trials. Throughout this range of activities, there are uncertainties could render the method infeasible for the use case. It is also unknown at this stage whether the method will be robust across different soil conditions or foundation types. Given these uncertainties/risks and the range of activities to be undertaken, the project cannot be funded through business as usual funds. Further, carrying out this project within the tight timelines and delivery plans of business as usual activities is challenging and puts value to consumers at risk.

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

There are technical risks involved in adapting the UGW testing method to work on OHL tower foundations such as development of an appropriate probe array, performance in different soil conditions, reliability, and accuracy of results etc. Using an untested method such as UGW testing on business as usual schemes can introduce risks on delivery and quality of outcomes. Hence, to de-risk the technology for the use case of OHL tower foundation inspections, NIA funding would be appropriate as well as crucial.

This project has been approved by a senior member of staff

☑ Yes