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 2022

Project Reference Number

NIA2_NGET0009

Project Registration

Project Title

Visual Inspection and Condition Assessment Platform for OHL Steelwork (VICAP)

Project Reference Number

NIA2_NGET0009

Project Licensee(s)

National Grid Electricity Transmission

Project Start

April 2022

Project Duration

1 year and 6 months

Nominated Project Contact(s)

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

Project Budget

£430,000.00

Summary

The innovation project in RIIO-T1: NIA_NGET0215 proved the feasibility of automating Overhead Lines (OHL) Steelwork corrosion assessment using multi-spectral and RGB (Red-Green-Blue) imaging combined with clustering algorithms to grade the extent of corrosion. The feasibility of the method was proven using physical steelwork samples and towers in pre-decided locations such as substations, and test facilities. To move towards an end-to-end solution that is suitable for BAU use, the automation needs to include the capability to classify collected imagery and assign the images to the right section of the tower. This project aims to test the feasibility of and build an end-to-end process for collecting, uploading, and processing visual data for an OHL tower steelwork by combining autonomous drone flights with automated data processing platform.

Nominated Contact Email Address(es)

box.NG.ETInnovation@nationalgrid.com

Problem Being Solved

National Grid Electricity Transmission (NGET) owns 21,900 steel lattice towers in England and Wales. Steelwork condition deteriorates through corrosion, so periodic assessments are made to understand the health of the network. NGET targets the inspection of 3,650 steel lattice towers each year, capturing high definition still colour images of steelwork from a helicopter. These images are then processed manually by a pool of four inspectors and are assigned one of 6 grades in this visual assessment. Whilst the exercise is carried out by a limited number of experienced inspectors, where classifications are marginal, there is a risk of inconsistent subjectivity in addition to substantial time and resource needs. Grade 5 and 6 steelwork also require climbing inspections if assessed incorrectly due to subjectivity in manual analyses.

The innovation project in RIIO-T1: Automated Assessment of Steelwork Condition using Innovative Imaging Techniques (NIA_NGET0215) proved the feasibility of automating this corrosion assessment using multi-spectral as well as RGB (Red-Green-Blue) imaging combined with clustering algorithms to grade the corrosion on steelwork. The feasibility of the method was proven using physical steelwork samples and towers in pre-decided locations such as substations, and test facilities. To have an end-to-end

solution that is suitable for BAU use, the automation needs to include the capability to classify collected imagery and assign the images to the right section of the tower along with its geographic location. Additionally, it needs to be investigated if such end-to-end automation can provide reliable reporting data and recommendations for painting/replacement depending on the assessments carried out. The challenge being addressed in this project is of developing an automated end-to-end pipeline for collecting, uploading, and processing visual data for an OHL steel tower in relation to steelwork corrosion assessment.

Method(s)

Through this project, NGET aim to mesh technologies such as autonomous drone flights, Light Detection and Ranging (LiDAR) and Artificial Intelligence (AI) to create a new automated end-to-end process for condition assessment of steel lattice towers. The end-to-end process will include capturing, processing, and presenting condition information, particularly corrosion of OHL tower steelwork. To achieve this, following technical gaps will be investigated and solved to arrive at an end-to-end process:

1. Collecting 3d lidar and 2d image data in a way that allows the 2d images to be mapped to specific points in the 3d world
2. Fast and automated data collection, without any requirement for beacons / reference markers
3. Aligning 3D and 2D data so regions of interest can be localised in 3D space
4. Managing 2D & 3D data and automating handoff from collection to processing and presentation platforms
5. Development of algorithms to split foreground steelwork from background
6. Development of algorithms to assess corrosion on steel bars using supplied data
7. Displaying results via a web based application

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 Low.

TRL Steps = 1 (2 TRL steps)

Cost = 1 (~ £430k)

Suppliers = 1 (2 suppliers)

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

Scope

Following are the scope elements in this project:

1. Design and Planning: This involves developing the understanding around expected operating conditions for drones, data gathering requirements, operational requirements, selection of towers for reference as well as demonstration flights, etc. Following elements will be covered:

a. Requirements and Use Case Definition

b. Options Selection and Evaluation

c. Reference Towers Selection

d. Design of an Integrated Approach

e. Candidate Algorithm Selection

2. Drone System Development: This involves customising and updating drone, drone platform and Ground Control Station (GCS) to

meet requirements for flight around OHL towers. Following scope elements will be covered:

a. Systems Development

b. Operations Process Development for BVLoS permissions

c. Demonstration Flights

3. Iterative Data Collection: This involves carrying out iterative flights to collect data, feed into the processing platform and optimise the end-to-end process to be developed in the project. At the end of each flight, feedback and lessons will be incorporated into systems, algorithm, and presentation development items (scope items #2, 4 and 5 in this list respectively). Following flights will be carried out:

a. Flight 0

b. Flight 1

c. Flight 2

d. Flight 3

4. Algorithm Refinement and Development: This involves developing algorithms on the data processing and presentation platform. This segment will continue throughout the project, taking feedback from iterative drone flights planned in scope element #3. Following elements will be covered:

a. Localization: Assignment of 3D locations to 2D images captured

b. Segmentation: Separating background from steelwork elements captured in the imagery

c. Corrosion Detection and Evaluation: Quantification of level of corrosion using NGET's grading mechanism

5. Presentation: This involves development of the steps required in the end-to-end process for automated OHL steelwork condition assessment including managing data transfer from collection to processing platform, processing steps, and visualisation. Following elements will be covered:

a. Data Ingestion Pipeline

b. Processing Pipeline

c. Presentation Layer

6. Readiness for Deployment at Scale: This involves development and documentation required to transfer deployment-ready project outcomes into BAU. It is anticipated that updated algorithms will be deployment-ready at the end of the project and can be deployed into the existing data processing platform. However, drone and drone control system would be in prototype stage and can be brought to deployment ready stage in 12-24 months. Following elements will be covered:

a. BVLoS Permissions

b. Costed Business Case

c. Implementation Plan

d. Final Reports and Presentation

Objective(s)

This project aims to test the feasibility of and build an end-to-end process for collecting, uploading, and processing visual data for an OHL steel tower to assess the extent of corrosion present on the tower steelwork. The process should be able to:

- Capture high definition images of OHL steelwork through drone flights
- Localise the captured imagery by automatically mapping 2D images to the 3D structure
- Analyse the captured imagery, and assign correct grading based on the corrosion present
- Collate all assessments to generate necessary reporting (as per regulatory requirements) along with recommendations for painting/replacement

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

This project is expected to provide energy networks with an efficient and automated process for condition assessment of corrosion level on OHL tower steelwork which can be adopted by any network licensee operating steel lattice towers. If the method is proven viable and eventually adopted into Business As Usual (BAU), it is expected to reduce the unit cost for condition assessment practice carried out annually, resulting in financial benefits to consumers. It would also result in environmental benefits to consumers from reduction in carbon intensive helicopter surveys. Consumers (and line workers) would benefit from the reduction in reassessments and climbing inspections required to develop concrete inferences from condition data. These benefits will apply to all consumers and are 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).

Success Criteria

The project will be considered successful if the following criteria are achieved:

- Autonomous drone flights can be successfully customised to enable collection of imagery of OHL steel lattice towers
- Captured 2D images can be successfully and accurately mapped to locations in the 3D world
- Algorithms can be developed to automatically assess the localised images and assign grading to reflect the extent of corrosion
- Visualisation and reporting requirements can be fulfilled using the assessment data generated on the processing platform

Project Partners and External Funding

Not applicable as this work will be carried out by NGET.

Potential for New Learning

The study will present to NGET and other GB network licensees an automated end-to-end process for corrosion assessments on OHL steel towers. This project will mesh technologies such as drone flights, Light Detection and Ranging (LiDAR) and AI to create a new automated end-to-end process for condition assessment of steel lattice towers. New learning will stem from use of autonomous drone flights for OHL tower surveys, use of LiDAR and localisation algorithms to map 2D images to locations in 3D world, segmentation algorithms that will separate steelwork from background in images, and AI algorithm development to quantify corrosion in captured imagery. This project will also develop learning on use of an AI platform for automation of condition assessments practices employed for HV assets, data handling from collection to final presentation stages and optimisation of the end-to-end process. If proven successful, the project will also generate understanding on transferring outcomes to BAU through costed business case, implementation plan, systems and process documentation.

Scale of Project

The project is aimed to build an end-to-end process for automation of condition assessment of OHL steel towers. This includes data collection through iterative drone flight surveys to be carried out around select OHL towers on NGET's OHL network. To ensure all learnings and feedback can be incorporated into ongoing development activity, 4 such drone flights have been planned at various points in the project. Remainder of the scope involving data processing, presentation and documentation will be delivered on an AI platform which can be classed as a desktop exercise.

Technology Readiness at Start

TRL6 Large Scale

Technology Readiness at End

TRL8 Active Commissioning

Geographical Area

The project will carry out desktop exercise and drone flight trials in select OHL tower locations within the UK.

Revenue Allowed for the RIIO Settlement

Not Applicable

Indicative Total NIA Project Expenditure

£387,000

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:

The aim of the project is to assess the feasibility of and build an automated end-to-end process for assessing corrosion on OHL tower steelwork, to be used as part of routine condition monitoring activities. This automation step has the potential to be more efficient, have lower subjectivity, reduce the need for reassessments and be more sustainable due to reduction of carbon intensive helicopter survey. Implementing such methods into practice aligns with energy system transition through digitisation and automation, and reduction in carbon footprint of our condition assessment practices.

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

Project business case is built based on volumes and cost details from the current practice in OHL steelwork condition monitoring at NGET.

The baseline method considers the costs related to inspection target of 3650 tower per annum which includes costs for helicopter usage for image capture, drone usage where towers are not accessible by a helicopter, manual assessment of captured imagery by a pool of inspectors and climbing inspections for towers receiving grades 5 and 6 due to worst case of corrosion.

If the innovation option is proven successful by year 2022/23, it is anticipated that helicopter usage for image capture will reduce by 10% in 2023/24 and further 5% per annum until end of RIIO-3, with similar increase in drone usage. A one off-cost of £150k will be incurred in 2025/26 to replace the existing drone fleet and enhance the fleet size to accommodate more drone usage. Manual analysis of captured imagery will also reduce to 50% in 2023/24 whilst adoption to BAU takes place and will be limited to quality assurance on 10% of assessed towers per annum from there on.

Considering the above, the innovation method has a benefit of approx. £1,284,000 for UK consumers. This number also includes benefits from avoided use of helicopter fuel due to reduction in helicopter usage for image capture. This can be implemented by other network licensees who own steel lattice towers, with modifications to grading framework implemented in the automation software.

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

It is estimated that if the innovation project is successful, the new condition assessment process could be employed on 75-80% of the NGET network of around 22,000 towers. The findings have the potential to benefit all GB network licensees (at both Transmission and Distribution level) that own and operate steel lattice towers.

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

Costs of rolling out this method will be evaluated as part of the techno-economic assessment to be undertaken in this project. At the onset, we anticipate these to be initial training costs, and one-off cost to replace and expand our existing drone fleet in 2025/26.

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

All network licensees that maintain steel lattice structures face similar challenges around efficient and reliable visual inspection of HV assets. Learnings generated in this project regarding visual data capture, data handling, and post processing of captured imagery will help utilities gain insights that can augment or improve their condition assessment practices.

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.

There have been few projects (completed: NIA_SPEN_0063 and NIA_WWU_037) in the UK that explore the use of drone flights for visual inspection of electricity assets. They, however, have focussed on detection of common defects in OHL assets such as broken/contaminated/flashed insulator, cracked pole, conductor damage, missing danger plates etc.

The scope element of trialling BVLOS flights for visual inspection is relevant to the one in NIA_WWU_045. The difference between the

two is that NIA_WWU_045 involves a more extensive work to enable BVLOS operations in the UK while it is an optional element within the proposed project. In case CAA approval for BVLOS cannot be secured within the project timescales, iterative demo flights will be carried out remotely with the safety pilot present.

The precursor to this project: NIA_NGET0215, provided the feasibility outcome for automating the corrosion grading of OHL tower steelwork based on physical samples and trials at pre-decided tower locations. On the contrary, the proposed project aims to focus on automating the end-to-end process of detecting, quantifying and reporting on the corrosion element of OHL tower steelwork condition.

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

Visual inspection of OHL towers have been done using helicopter surveys, foot patrols and climbing inspections. Where these methods are not feasible, drones flying within visual line of sight are being employed. Processing of captured imagery still requires human intervention as automatically segregating steelwork from background is not reliable with simple solutions like pixel clustering. To overcome known issues and to optimise the process, innovation is required for efficient capture of data during visual inspections and advanced AI algorithms that can automatically assess the condition of the asset from the imagery. This project aims to test the limits of technologies such as autonomous drone flights, LiDAR and AI data processing platform, and mesh them together innovatively to create an end-to-end automated corrosion assessment process for OHL towers.

Relevant Foreground IPR

The foreground IPR will be relating to the end-to-end process for collecting, uploading, processing and presenting corrosion assessment data for OHL steel lattice towers. Suppliers will contribute background IP in the form of autonomous drone flight technology and AI platform for data processing which will remain their property. NGET will contribute background IP in the form of expertise in OHL condition monitoring, and corrosion assessment methodology.

Foreground IPR developed in this project will include reports detailing requirements, use cases, detailed steps involved in the automated condition assessment process, business case, implementation plan, and process documentation. Imagery collected during drone flights, processed images, and corrosion map created after data processing, will also form the foreground IPR of this project.

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

Since this project involves meshing a few different technologies together to automate an entire process, there is an underlying risk associated with several points in the project where the method could fail. Example of such points in the project are if the iterative flight trials fail to capture data fit for purpose, algorithm development for localisation and segmentation fail due to accuracy or repeatability issues, etc. It is important to note that the scope element designed to assess readiness for deployment may also reveal some unforeseen barriers to implementing this method into BAU. Due to all these underlying risks, the project cannot be carried out as part of business as usual activities.

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

Automating the step of assigning corrosion grading to OHL steelwork in the condition assessment process was explored in

NIA_NGET0215 using physical steelwork samples and drone trials in known locations. This project revealed two major technical risks in automating the process:

a. Inaccurate identification of the collected imagery if the correct section and geographical location of the tower are not assigned to the images (localisation issue)

b. Incorrect assessment of corrosion levels if the steelwork merged with the background in the collected imagery, a problem more severe in fall and winter due to the presence of brown hues in the background (segmentation issue)

These risks warrant a dedicated research and development activity aimed at developing innovative solutions that can be de-risked prior to use in BAU practice, making NIA the more appropriate funding mechanism for this project.

This project has been approved by a senior member of staff

☑ Yes