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

Jul 2018

Project Reference Number

NIA_NGTO013

Project Registration

Project Title

Predicting Vibration Fatigue for Overhead Line Conductor Systems

Project Reference Number

NIA_NGTO013

Project Licensee(s)

National Grid Electricity Transmission

Project Start

July 2018

Project Duration

1 year and 1 month

Nominated Project Contact(s)

Ben Muncey

Project Budget

£89,000.00

Summary

Conductor vibrations are one of the most common reasons for conductor fatigue and failures. CIGRE has highlighted that for ACSR (Aluminum Conductor Steel Reinforced) there is uncertainty in relation to self-damping since it depends on the tension shared between aluminum strands and the core at different temperatures. This uncertainty is even more prominent with High Temperature Low Sag (HTLS) conductors. Furthermore, the current methods for quantifying vibration fatigue are based on beam theory (which is valid only for homogeneous conductors) which ignores the properties of the interlayers (e.g., trapezoidal vs. round strands). Past work indicated that the natural frequency under the assumption of the conductor with isotropic properties (i.e. solid homogeneous beam) results in more than 40% error on vibration effects when compared to the composite (sandwich beams) conductor assumption.

Currently, there is no existing method to calculate the fatigue of composite (bimetallic, bi-material) conductors and there is also a lack of metrics (apart bending stress) that can be associated with the effect of vibrations on conductor and conductor bundles condition (life expectancy and fatigue).

As a result, there are high levels of uncertainty in the expected life of these assets. Better understanding vibration fatigue will allow for more accurate assessment of life expectancy.

Nominated Contact Email Address(es)

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Problem Being Solved

Conductor vibrations are one of the most common reasons for conductor fatigue and failures. CIGRE has highlighted that for ACSR (Aluminum Conductor Steel Reinforced) there is uncertainty in relation to self-damping since it depends on the tension shared between aluminum strands and the core at different temperatures. This uncertainty is even more prominent with High Temperature Low Sag (HTLS) conductors. Furthermore, the current methods for quantifying vibration fatigue are based on beam theory (which is valid only for homogeneous conductors) which ignores the properties of the interlayers (e.g., trapezoidal vs. round strands). Past work indicated that the natural frequency under the assumption of the conductor with isotropic properties (i.e. solid homogeneous beam) results in more than 40% error on vibration effects when compared to the composite (sandwich beams) conductor assumption.

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of metrics (apart bending stress) that can be associated with the effect of vibrations on conductor and conductor bundles condition (life expectancy and fatigue).

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Method(s)

Finite Element Analyses of vibrations on complex structures will be used to quantify the vibration amplitudes against existing simple experimental measurements available for common conductors, as well as GAP and ACCC HTLS conductors (from data already available) and other available data from NG.

This initial approach aims to verify that a tool to quantify the fatigue of complex conductor structures (and differentiate among the different conductors) based on the vibrations is possible. This preliminary/feasibility study could, later on, be combined with experimental measurements in a small test-bed to capture the effect of different operating temperatures and tensions to validate and finalise a more advanced tool that can be used to predict conductor (single and bundles) life expectancy due to vibration fatigue.

Scope

1. Review the current modeling practices and identify the cases for which existing (CIGRE) calculations are not adequate (have a significant error) and thus not appropriate to be implemented on all conductor types.
2. Develop a preliminary tool that can capture the structural effect of conductors and allow the effect of structural differences to be quantified. Quantify also the error (in relation/comparison to the current practice) and its significance.
3. Perform Finite Element Analyses using COMSOL on a single conductor and a twin bundle to identify the complexity, computer resources, and time required for modelling conductor vibrations and compare Finite Element Analysis (FEA results with current CIGRE standard calculations (used currently by the industry).

Objective(s)

To demonstrate that conductor structure and stranding geometry affect vibration fatigue (for conductors and bundles) and develop a preliminary computational tool to quantify it.
To identify the properties that make some conductors more immune to vibrations and correlate these with any benefits on increasing overhead line systems' power flows.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The development of a tool that can quantify the vibration effect of single conductors with and without dampers and be capable of differentiating the response of various conductor types (with same overall diameter and strength).

The identification of some properties that make conductors more "immune" to vibration and vibration fatigue.

Development of initial FEA models that indicate that conductor bundle vibration (and fatigue) modelling could be performed within a reasonable time and computer resources.

Project Partners and External Funding

n/a

Potential for New Learning

This feasibility study will assess/identify conductor design characteristics that could reduce vibration fatigue on single conductors and bundle systems. Furthermore, it will assess if these design characteristics (that affect conductor response) could be used to assess the life/fatigue of the conductor systems.

If the study shows that design aspects affect the vibration response considerably, then conductors that perform better can be identified. Furthermore, a simple tool to capture conductor fatigue based on conductor properties could be realized. These would be applicable in all OHL systems across the GB network at all voltage levels helping to increase design, maintenance, and replacement efficiency.

Scale of Project

This short feasibility study was chosen to be this scale to ensure that benefits can be obtained, before a larger project is commissioned. The potential impact of this type of research is very large, but there are risks in adopting a large project at this early stage. This project will answer keys questions and inform the development of this technology further.

Technology Readiness at Start

Technology Readiness at End

TRL2 Invention and Research

TRL4 Bench Scale Research

Geographical Area

Desk-based with simulations

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

89,000

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 ability to identify the conductor characteristics that affect the vibration and implement them in a tool that differentiates conductor performance will help to quantify the life expectancy of the different conductor types and bundles and thus help to quantify the risk to fail. Therefore, conductor systems that are more resilient to extreme winds can be identified.

Please provide a calculation of the expected benefits the Solution

Research project therefore a cost benefit analysis is not required.

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

This is applicable to any overhead line in across the UK.

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

The understanding could be applied across the whole of the GB electricity transmission network, this would involve updating the methods upon which condition fatigue is calculated. This would likely require further work, plus some additional implementation costs for adopting this new methodology if successful. At this very preliminary stage the total estimated cost associated with the improved life estimation of the assets is circa £5m.

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 operate overhead lines with rules of conductor tensions to minimize vibration effects as well as with additional hardware to mitigate the vibrations that are independent of conductor technology and materials. The results of this project will provide new understandings to help them identify conductor technologies that perform better on vibrations but also review their technical practices on the appropriateness of the same approaches on common and HTLS conductor technologies. The findings of the project will be relevant across GB. The project results would guide us and other Network Licensees in the UK on how current practices can be further optimised and provide them insights into the life-expectancy (due to vibration fatigue) of the conductors.

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

Managing Assets - Managing Assets through their lifecycle
Corporate Responsibility - Doing the right thing (safety)
☑ 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.

There are no existing projects that aim to quantify the effects of conductors and bundles vibrations on its life expectancy.

The proposed project aims at providing metrics/methodology to quantify the vibration fatigue considering the complex geometry of the conductor (i.e., core and outer alulminium force distribution) and help to understand the reasons that diferences in vibration response between similar size conductors but of different technology exist.

There are two ENA projects that are investigating vibrations on distribution overhead lines at low voltage (33 kV and 11 kV), which are focused on developing a system which can monitor vibrations on OHLs in service.

http://www.smarternetworks.org/project/nia_ssepd_0017
http://www.smarternetworks.org/project/2014_01

33kV and 11kV assets consists of substantially different types of conductor, tower and fitting arrangements. In addition, the above projects do not investigate the underlying physical phenomenon of the conductors in the detail that this project does.

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