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 2016

Project Reference Number

NIA_SHET_0020

Project Registration

Project Title

Remote Asset INertial Monitoring & Alerting Network (RAINMAN)

Project Reference Number

NIA_SHET_0020

Project Licensee(s)

Scottish and Southern Electricity Networks Transmission

Project Start

July 2016

Project Duration

3 years and 9 months

Nominated Project Contact(s)

Joe McNeil

Project Budget

£1,087,000.00

Summary

The project will be executed in four phases. Phase 1 is a system design and feasibility study which progresses the maturity of the individual system components towards integration in an initial prototype. During Phase 1 there will be a specification and requirements exercise as well as parallel developments of the sensor, power supply, communications and software elements. A small number of prototype units will be installed at a SHE Transmission test facility for gathering and analysing data from transmission poles. The prototype units will likely use battery power and existing GPRS communications rather than wait for the conclusion of the parallel developments. Phase 1 will take 3 months. Phase 2 will be a small scale technology demonstration of the system. The individual system components from Phase 1 will be integrated and installed at a suitable test facility where a simulated real world deployment will be carried out. Several iterations of testing and refinement are expected using results from the simulated deployment. Phase 2 will take 3 months. Phase 3 will take the technology to TRL8 by building, deploying and testing a large number (i.e. hundreds) of pole mounted devices on a real network. A section of the Skye trident line has been nominated for this exercise due to the age of the wood poles deployed and the challenging environment for both exposure to harsh weather conditions and for wireless communications testing. Ekkosense will provide the low power wide area network infrastructure and the application server needed to support the trial. SHE Transmission will arrange for the installation of the pole mounted devices. Phase 3 is scheduled to last for a full year. Phase 4 moves the proven technology from TRL8 to TRL9, addressing the steps needed to allow adoption as business as usual. Learning from phase 3 will lead to a number of refinements to each of the system components. Additional tasks will include full SCADA connectivity and integration, EMC compliance testing and cost reduction of the sensor for mass production and volume deployment.

Nominated Contact Email Address(es)

transmissioninnovation@sse.com

Problem Being Solved

Power distribution and transmission overhead line conductors are often supported on wood poles. This is especially true in rural areas, such as the Scottish Highlands and Islands, where remote customers are served by very long network segments. In these areas the network is exposed to harsh weather conditions which, over time, can weaken poles and their footings. Despite being robust, the poles, some of which are now over 40 years old, can eventually move, fall or break, which can cause loss of supply to customers. Pole degradation through accelerated ageing can contribute to the risk of failure. Damage to poles can also occur due to impact, e.g. by flying debris during storms or by a vehicle. In some cases, single points of failure can affect significant numbers of customers. This is true in locations such as the Isle of Skye where wooden trident poles support about 70km of 132kV transmission line. This section is part of a radial circuit which extends from the mainland across Skye to deliver power via subsea cables to serve the Western Isles. A single wood pole failure here could affect the supply of more than 10,000 customers. The time taken to restore supply can range from a few hours to several days, depending on how quickly the defective pole can be located and replaced. Although regular scheduled inspections and proactive maintenance and refurbishment activities are carried out, in the event of a fault, the DNO/TO response will usually be reactive after the fault has occurred. SHE Transmission is seeking ways to trigger a proactive response through early warning alerts about pole movements in addition to faster and more precise fault alarm systems which will contribute to improved supply restoration time if a pole does fail.

Method(s)

The Remote Asset INertial Monitoring & Alerting Network (RAINMAN) is a new technology being developed to detect events which have caused wood poles to tilt, deform, spring, twist, degrade or fail due to impact. Ekkosense, the developer, has unique sensing hardware and analytics software which can differentiate between normal weather-induced pole movements and sudden damaging impacts. The technology can also measure small incremental changes over time which could suggest that a pole is gradually leaning. A small, low-cost device is attached to each wooden pole by a simple fixing. The device contains the movement sensors, an autonomous power source and low power wireless communications. The device will collect data and communicate with an application server as required. The application server will perform analytics and raise alarms graded by priority, superimposed on a map display to indicate precise location. There will be three main alarm events. The first is a for a sudden high magnitude 'g' event indicating a pole-strike or line-strike, requiring immediate investigation. The second is for a high magnitude movement or change in inclination, indicating that a pole has fallen over and requiring immediate attention. The third is for a low magnitude event of either 'g' (e.g. vibration) or inclination (e.g. tilt) indicating a change to a pole over time. This would trigger DNO/TNO proactivity on pole maintenance for avoiding a possible outage. Within this project the RAINMAN system will be refined, developed and ruggedised for field trials. SHE Transmission will identify high risk network segments which are supported by wood poles and will facilitate field trials over a winter season to assess the performance of the system.

Scope

The project will be executed in four phases. Phase 1 is a system design and feasibility study which progresses the maturity of the individual system components towards integration in an initial prototype. During Phase 1 there will be a specification and requirements exercise as well as parallel developments of the sensor, power supply, communications and software elements. A small number of prototype units will be installed at a SHE Transmission test facility for gathering and analysing data from transmission poles. The prototype units will likely use battery power and existing GPRS communications rather than wait for the conclusion of the parallel developments. Phase 1 will take 3 months. Phase 2 will be a small scale technology demonstration of the system. The individual system components from Phase 1 will be integrated and installed at a suitable test facility where a simulated real world deployment will be carried out. Several iterations of testing and refinement are expected using results from the simulated deployment. Phase 2 will take 3 months. Phase 3 will take the technology to TRL8 by building, deploying and testing a large number (i.e. hundreds) of pole mounted devices on a real network. A section of the Skye trident line has been nominated for this exercise due to the age of the wood poles deployed and the challenging environment for both exposure to harsh weather conditions and for wireless communications testing. Ekkosense will provide the low power wide area network infrastructure and the application server needed to support the trial. SHE Transmission will arrange for the installation of the pole mounted devices. Phase 3 is scheduled to last for a full year. Phase 4 moves the proven technology from TRL8 to TRL9, addressing the steps needed to allow adoption as business as usual. Learning from phase 3 will lead to a number of refinements to each of the system components. Additional tasks will include full SCADA connectivity and integration, EMC compliance testing and cost reduction of the sensor for mass production and volume deployment.

Objective(s)

• Define system requirements
• Conduct a feasibility study to prove that the concept is sound
• Develop pole movement sensors and demonstrate functionality
• Develop an autonomous power supply for pole mounted sensors and demonstrate functionality
• Apply a low power wide area wireless communication system to sensors and demonstrate functionality
• Develop software based analytics and an application server and demonstrate functionality
• Devise and demonstrate a safe and cost effective method for installing sensors on wood poles
• Advance system performance following business requirements criteria in simulated scenarios
• Evaluate system performance against business requirements criteria in a real world installation
• Document all results, conclusions and recommendations
• Provide a documented conclusion from a proven cost benefits analysis
• Evaluate project outcomes for possible adoption by BAU

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The project success criteria:

1) Whether or not the Ekkosense sensors and the associated software analytics can provide timely, reliable and accurate warnings of wood pole movements or failure
2) Whether or not a reliable, resilient autonomous power supply can be developed for low power pole mounted devices
3) Whether or not a low power wide area wireless communications network can be made to function reliably for telemetry in a hostile, rural environment

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

Phases 1 and 2 of the project will be carried out at small scale in order to develop the system components and test the feasibility of the concepts before committing to field trials. The field trials in Phase 3 of the project will need to be extensive in order to acquire enough learning to fully assess the sensors, power supplies and wireless communications for BAU rollout potential. The 132kV wood pole trident line from Broadford to Ardmore across Skye covers about 70km and has more than 800 poles. A long section of this line would be a good choice due to its exposure to harsh weather, the age of its poles and the mix of landscape topology. Some trials may also be needed in an urban scheme to collect complementary wireless communications performance data for built-up areas. Phase 4 of the project refines the technology, develops the SCADA interfaces and prepares the system for potential adoption into business as usual. The scale of this project is deemed commensurate with the scope of work expected in this project.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL9 Operations

Geographical Area

Development work will be carried out at Ekkosense's Nottingham premises. Field trials will be carried out in SHE Transmission's license area.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

Total NIA expenditure = £675,000 of which 90% (£607,500) is allowable NIA Expenditure.

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)

If the problem is solved excessive pole movement will be identified prior to a potential failure and the financial benefit is expected to be £290,765 on the proposed circuit.

Please provide a calculation of the expected benefits the Solution

The expected financial benefits of this demonstration project are calculated from reduced outages to customers and have been valued based upon the penalty (CI/CML) consequences of a specific outage incident and the prevention of a recurrence. In January 2015 the Broadford to Ardmore (Isle of Skye) Trident transmission line was out of commission for 2 days due to wood pole failure during storms. The method, if installed, could have reduced the costs of the failure by alerting the DNO to poles which have been overstressed or damaged during or immediately prior to the storm and by providing precise location data to linesmen for speeding up repair time.

Base cost (Cost of Trident line outage) = £695,500
Method cost (AIIM installed on the Trident line poles) = £404,735

Over RIIO-T1 the financial benefit is £290,765

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

The method could easily be replicated on any pole supported transmission or distribution line across GB, providing additional savings potential. There could be variations in wireless communications and fixing methods, but the sensor unit and application software will be universally deployable.

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

The method could be installed on any wooden or composite pole which supports any transmission or distribution network section, but the cost of monitoring a particular section of network will be specific to that instance. A guide on which to base approximate costs is provided here.

1) The sensor unit cost within the project is £250. This could reduce by 10% or more once the manufacturing process has been refined and goes to volume.
2) The sensor installation cost is estimated to be around £40 - £50 per pole in volume, depending upon accessibility and applicable procedures.

3) The cost of connectivity depends on the method employed. This project will use LPWAN technology but other solutions (such as GPRS) could be used. Using LoRaWAN in a rural location, for example, where one base station might be sufficient to serve 10km of line (or about 125 poles), the installation costs for wireless coverage should be less than £100 per km (operating costs excluded).
4) There will be an annual service cost for the application server, data processing software and hook-up to ENMAC. This is expected to be about £24,000 per year per server.

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 project will deliver shareable learning in the areas of pole movement sensing, pole damage sensing, pole location data capture, the efficiency of low power wide area wireless communications and the efficiency of photo-voltaic battery charging power sources in harsh environments.

If a DNO or TO can receive timely, reliable and accurate alert information about exceptional events affecting wooden poles and act upon it accordingly this will result in a reduction in the number of supply interruptions to customers and/or reduce the time to power restoration. The shareable learning from this project will contribute to the design of early warning systems in this context.

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

n/a

☑ 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.

n/a

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