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_UKPN0020

Project Registration

Project Title

Mobile Asset Assessment Vehicle (MAAV)

Project Reference Number

NIA_UKPN0020

Project Licensee(s)

UK Power Networks

Project Start

July 2016

Project Duration

2 years and 0 months

Nominated Project Contact(s)

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Project Budget

£544,322.00

Summary

The first survey will aim to cover all accessible carriageways in the central London Area. The “centreline distance” of the carriageways is approximately 926km and it is expected that the MAAV will have to drive over 1800km during each assessment. Any object or surface which is energised at more than 1V AC will be recorded and investigated.For each detection the MAAV crew will stop, investigate and collect data on the alarms that were generated. The MAAV software will be updated to display electric field information on the fundamental, second harmonic and third harmonic of the powerline frequency. All data from the investigations will be recorded into a database. A follow-up investigation will be performed at as many identified locations as possible to identify the root cause of the voltage as well as a quantification of the energy losses at each site. The survey will conclude with a report which summarises the findings, data collected and the losses reductions. An analysis of the harmonic information will also be included in the report.The second survey will include the same coverage of the central London area using the MAAV approximately 4 to 6 months following the completion of the first survey. The second survey will identify newly generated contact voltage faults, which will be used to understand the generation rate of these types of faults in the area. The same investigation and reporting process will be followed, except for incorporating any improvements identified from the first survey and report.The data collected will be analysed after each survey to provide a better understanding of the performance, behaviour and health of the central London network. The analysis will include an assessment of the underlying types of faults present, the root causes of the failures and the generation rate of new faults. The impact of proactive elimination of these faults will be assessed at the conclusion of the project along with the energy losses reductions achieved as a part of the programme.

Nominated Contact Email Address(es)

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Problem Being Solved

The UK Power Networks’ electricity distribution network is comprised of more than 89,446 km of underground Low Voltage (LV) cables. These cables form the backbone of the network connecting supply to customers’ properties and street furniture. Faults on LV cables are difficult to detect and locate and are responsible for significant numbers of customer interruptions and customer minutes lost. The fault impedances are generally high allowing the faults to exist for extended periods without operating protective fuses. As the environmental conditions around the faults change the fault impedances also change and some evolve into low impedance faults

with high currents which result in fuse operations. These underground faults are difficult and costly to locate since they are not visible from the surface and often require extended trenching to expose and identify the fault.

These faults also place the public at risk of an electric shock when they come into contact with a surface or object which has become energised by one of these faults. Two examples from January 2016 include a dog which was shocked by a failed LV cable in East Grinstead and a member of the public who was shocked by a council owned lighting column in Portsmouth.

In the UK there is currently no consolidated reporting system for documenting electric shocks to the public and as a result these events are not well understood or documented. In the USA where such systems are in place utilities have documented significant reductions in public shock events. Consolidated Edison in New York has reported an 84% reduction in electric shocks over the first three years of their program.

Method(s)

In 2012 UK Power Networks hired the SVD-2000 to perform a survey of the LV network around the 2012 Olympics venues. Since that time the technology, process and understanding of contact voltage testing have advanced significantly. In July of 2016 the Institute of Electronic and Electrical Engineers (IEEE) published the first peer reviewed standard on the topic. That standard contains a number of newly document processes that were not available at the time of the 2012 survey. The proposed survey will also include measurement and post-detection analysis process that were not available in 2012. For example, during measurements in this survey the harmonic content of the voltage waveform will be collected and analysed. That information provides critical clues about the underlying source of the voltage, thus allowing faults with equal voltages to be addressed based on their risk to the system and public.

The MAAV is a very sensitive mobile electric field detector which will survey the carriageways in search of faults from the LV network. When a fault is detected the technicians will exit the vehicle and use handheld test equipment to pinpoint the location of the fault as well as an acceptable ground reference location for use in the measurement. Fault data, including voltage, harmonic content, location and weather data will be collected. The data will be recorded using a laptop computer in the vehicle and stored in a database for analysis. UK Power Networks will own all data that is collected during this project.

It is assumed that each detection of voltage leakage will represent an LV fault on the network. The MAAV aims to proactively identify and prioritise for repair as many LV faults as possible, thereby allowing an early intervention for a planned replacement of LV fault in an efficient fashion.

The survey will generate a list of sites where voltage has been detected and measured. This data will be used along with LV network maps and other operational data to determine which sites are candidates for excavation and repair. The repairs will generate additional data about the underlying fault, the root cause of the failure and the amount of energy lost due to the fault. All of this data will be compiled and analysed as a part of the reporting and analysis phase of the project at the conclusion of each survey.

A second complete survey will be carried out which will provide data critical to the understanding of the failure rate of the system. It will allow for the measurement of new faults that were formed in the time between the two surveys. A business case analysis comparing targeted MAAV driven cable replacement, proactive traditional cable replacement and reactive replacement will be a part of the second report.

The proactive detection and location of faults offers several benefits over the business as usual case. Fault locations identified by the MAAV are generally very accurate determinations of the location of the fault, allowing for efficient excavation and rectification of the underlying problem. Using new measurement methodologies, the data collected during the initial measurement process by the MAAV team provides important details about the nature of the underlying fault. That data, combined with operational and geospatial data, such as network maps, allows for the prioritisation of repairs in a manner that was previously not possible. Using the prioritised listing of faults operational teams will be able to target the response to these weak points in the LV network and make proactive repairs, before they impact customers, in a highly targeted and capital efficient manner. By mending weak spots in the network the risk of cascading failures is minimised. Each energised location also poses a potential risk of electric shock to the public, the proactive identification and elimination of these faults reduces the risk of electric shock to the public.

The MAAV will also be equipped with new analytical tools. Real-time displays of the harmonic content at various frequencies are under development for this survey. That information aims to enhance the sensitivity of the system to arcing LV faults. There is potential that these faults could be better located and characterised by recording and analysing information at the second and third harmonic. Currently utilities in the USA that have implemented similar systems only rely on data at their baseband operating frequency of 60Hz. As well as using baseband 50 Hz sensors; software, sensors and data collection will be implemented at 100Hz and 150Hz during this project to determine if further process refinements are possible.

Scope

The first survey will aim to cover all accessible carriageways in the central London Area. The “centreline distance” of the carriageways is approximately 926km and it is expected that the MAAV will have to drive over 1800km during each assessment. Any object or surface which is energised at more than 1V AC will be recorded and investigated.

For each detection the MAAV crew will stop, investigate and collect data on the alarms that were generated. The MAAV software will be updated to display electric field information on the fundamental, second harmonic and third harmonic of the powerline frequency. All data from the investigations will be recorded into a database. A follow-up investigation will be performed at as many identified locations as possible to identify the root cause of the voltage as well as a quantification of the energy losses at each site. The survey will conclude with a report which summarises the findings, data collected and the losses reductions. An analysis of the harmonic information will also be included in the report.

The second survey will include the same coverage of the central London area using the MAAV approximately 4 to 6 months following the completion of the first survey. The second survey will identify newly generated contact voltage faults, which will be used to understand the generation rate of these types of faults in the area. The same investigation and reporting process will be followed, except for incorporating any improvements identified from the first survey and report.

The data collected will be analysed after each survey to provide a better understanding of the performance, behaviour and health of the central London network. The analysis will include an assessment of the underlying types of faults present, the root causes of the failures and the generation rate of new faults. The impact of proactive elimination of these faults will be assessed at the conclusion of the project along with the energy losses reductions achieved as a part of the programme.

January 2018 update:
The MAAV project requires an extension due to the unexpected findings associated with contact voltage and energy losses including CO2. This will involve work by Princeton University, NJ, USA, to look at the basic fundamental calculations we used to ensure that they were able to be qualified in all respects and also involves comparisons with data on CVL and ConEdison

Objective(s)

The aims of the project are:

- Understand the suitability of MAAV (or similar) for assessing UK urban electricity networks
- Improve the safety and reliability of the LV network
- To understand the frequency at which LV faults manifest themselves as contact voltage faults
- Confirm that a strong correlation exists between contact voltages and LV cable faults
- Collect detailed information about the faults and their electrical properties
- Determine the generation rate of new faults

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

Upon completion of the survey contact voltage fault locations in central London will have been identified, analysed and repaired and the failure rate of the system will be better understood. The primary success of the survey will be the proactive elimination of faults which will enhance public safety and network reliability. Additional value will be created by the analysis of the underlying faults and the quantification of the energy losses. The project will be successful if the following outcomes are achieved:

- A determination of the generation rate of contact voltages per mile of survey which can be used to better understand the cost and benefits on a larger scale deployment (from completion of the first survey and assessments)
- Documentation of the nature and behaviour of the faults that have generated contact voltage hazards
- A greater understanding of the electrical properties of the contact voltage faults
- An estimation of the generation rate of new fault, which in turn can be used to optimise future survey frequency (from completion of the second survey and assessments)

Project Partners and External Funding

Power Survey Company – no external funding

Potential for New Learning

Whilst contact voltage surveys have been conducted in some cities in the USA they have only once been trialled in the UK with a previous generation of the technology. The impact that system design differences may have on the efficacy of the testing using current technology in the UK is unknown. As an example many US cities use unshielded LV cables which are installed in underground ducts, while the vast majority of LV cable in the UK is shielded and directly buried. It is also possible that the electric fields associated with increased operating voltage (230 volts in the UK vs. 120 volts in the USA) will create interference which will desensitise the detector. The electrical signatures present at 100Hz and 150Hz are presently unknown and may provide for additional proactive detection capabilities in the future. Finally, an understanding of the instantiation rate of new cable faults and the underlying root causes of these faults will provide new information which will aid and improve the management of LV networks in the UK.

Scale of Project

This project will trial MAAV in central London area that contains over 2,000km of LV underground cables along with joints. The MAAV will assess all accessible road surfaces in the survey for the presence of contact voltage faults from buried cables and accessories.

Technology Readiness at Start

TRL6 Large Scale

Technology Readiness at End

TRL8 Active Commissioning

Geographical Area

Central London

Revenue Allowed for the RIIO Settlement

There is no allowance in the RIIO-ED1 settlement for detection of contact voltage on LV network or for improving Quality of Service.

Indicative Total NIA Project Expenditure

£ 544,322

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 solution will improve cost efficiency by pinpointing cables which have faulted and provide for increased system reliability by proactively identifying and removing faulted LV cables. Additionally, the project will reduce the probability of an electric shock to the public by proactively mitigating energised structures from the public landscape. The NPV analysis performed showed that the expected savings over the ED1 period are expected to be over £4.14m with the assumption of saving approximately 1,000 LV faults per annum and reducing the number of fatal, reportable and animal injuries per annum over ED1 period after the implementation of MAAV.

Please provide a calculation of the expected benefits the Solution

Base Cost: £0

Currently there is no cost allocated for the survey of contact voltage or to determine if there is a correlation between contact voltage and LV faults. This does not include the excavation/repair cost as the proactive replacement would cost a similar amount.

Method Cost: £208,500

Cost of deploying the solution but not the development of technology at project scale. This includes the cost of surveying approximately 926km for contact voltage and data analysis.

Benefits: £470, 403

It is assumed at least 1000 LV faults per year can be avoided by identifying contact voltage that can potentially lead towards an LV fault for a planned intervention. Also includes health and safety benefits avoiding injuries related to contact voltage.

Financial Benefits: £ 261,903

Financial benefits deriving from the formula provided in the CBA document.
Base Cost – (Method Cost – Benefits)

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

Within GB DNOs there are approximately 320,000km of LV underground cables where MAAV can potentially be used to detect voltage leakage and identify potential faults for early intervention. As there are similar construction standards within all GB DNOs, once the technology of MAAV is developed and demonstrated the method applied can be replicated into other DNOs LV underground network.

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

A complete coverage national roll-out would cost over £32m based on several assumptions. It is unlikely that this would provide benefits so it is expected that any roll-out would only cover dense urban or high profile areas (10% coverage) costing approx. £3m.

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 characteristics of the faults in the area where the testing will be performed are expected to be similar to the faults generated by other licensees because of the similar construction standards used by all in the UK. Media reports of contact voltage related injuries to the public suggest that these types of faults are present in other licenses networks. Hence, if successfully demonstrated the product MAAV and the methodology used can be applied to other network licenses as well.

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.

This assessment technology does not overlap with any other assessment technologies that UK Power Networks is using or evaluating or (to the knowledge of the authors) have been used by any other DNOs.

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