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

Oct 2018

Project Reference Number

NIA_NGTO025

Project Registration

Project Title

Substation Time Synchronisation to Safeguard the Network

Project Reference Number

NIA_NGTO025

Project Licensee(s)

National Grid Electricity Transmission

Project Start

November 2018

Project Duration

1 year and 1 month

Nominated Project Contact(s)

Linwei Chen

Project Budget

£91,110.00

Summary

Substation protection and control systems require each device to be synchronised to UTC (Co-ordinated Universal Time), which is currently achieved using Global Positioning System (GPS). Recent studies on GPS use and dependency have highlighted the vulnerabilities of GPS signals, and a robust solution for time synchronisation based on more diverse sources of time should be developed. This project investigates alternative timing solutions that could deliver independent time references into substations, minimising the risk of a single source failure.

Nominated Contact Email Address(es)

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Problem Being Solved

Time synchronisation is necessary for substation Protection and Control (P&C) devices to correctly measure power system quantities (e.g. voltage, current and frequency) and record substation events in real time. Accurate time stamping is essential for correct protection operation in some instances and system stability assessments. Accurate timing within each P&C device is currently achieved by synchronising the internal clock to a Global Positioning System (GPS) signal. In the past, this has led to substations with individual GPS antennas and receivers installed at each bay. However, recent studies on GPS use and dependency have highlighted several vulnerabilities, such as intermittent signal reception and security issues, e.g. service jamming and spoofing. These issues can lead to time drift between the internal clocks and potentially cause protection mal-operations in the system. To minimise the risk of a single source failure, a resilient timing solution should be developed to provide alternative time sources for substation P&C systems.

Method(s)

To fulfil the resilience requirement, the project investigates alternative timing solutions that could deliver external time references into substations.

One source of time is based on satellite systems, e.g. GPS – a global navigation satellite system that provides geolocation and time information to a GPS receiver anywhere on or near the Earth, where there is an unobstructed line of sight to four or more GPS satellites. It requires the installation of a high-quality GPS receiver and antenna at the substation site. Depending on the receiver type, it could also receive Global Navigation Satellite System (GNSS) time signals from GLONASS, Compass and Galileo constellations.

GPS is the most commonly used GNSS constellation, as GLONASS has until recently not been fully operational and the other GNSS services are under development and have not yet been fully standardised. This study will review the option to include other GNSS constellations as well as GPS, and methods to increase resiliency of the GNSS-based solution. Although GNSS is a widely used source of accurate time, the signals are weak at the Earth's surface and are vulnerable to jamming and spoofing attacks which can result in errors in the received time. For a robust timing system, a second ground-based source of time should be transmitted into substations.

The proposed second source of time is based on optical fibre delivery of the UK time scale UTC using the IEEE 1588 Precision Time Protocol (PTP) v2, which allows high-accuracy time for P&C applications to be disseminated over compatible Ethernet. To implement this technique, a communication link between a remote PTP time server and slave devices at substations is required. The study will investigate the feasibility of using available optical fibre communication networks for time delivery from external IEEE 1588 time servers to substations, e.g. station master clocks. A station master clock is able to internally distribute timing signals via PPS, IRIG-B, SNTP and PTP formats depending on device compatibility.

As well as the two time sources, the project will review the option to install a high-performance clock (as a master clock) at the substation as a holdover solution to loss of GPS signals. Various types of clock will be considered, for example rubidium and caesium atomic clocks. A commercial rubidium standard could provide holdover of ±1 µs to Coordinated Universal Time (UTC) over 1 day, while a caesium clock would potentially achieve better than 10 ns to UTC over 1 day.

Scope

The scope of work is to carry out feasibility studies to assess the viability of adopting the following three options to improve the resilience of delivering time references into substations.

- Enhanced GNSS-based time synchronisation, considering a combined use of GPS, Galileo, GLONASS and Compass Signals to improve resilience against service jamming and spoofing.
- PTPv2 based time transfer over an optical fibre network between independent IEEE 1588 time servers at remote locations and PTP slave devices at substations.
- Installation of holdover clocks (as master clocks) at substations, which can keep time drift within protection requirements in case of GPS signal loss.

The implementation challenges, security issues, timescales and full costings for each of the above options will be analysed throughout the study. The requirements and implementation of automatic switchover among the three options will also be studied.

Objective(s)

The project aims to investigate the benefits, costs and challenges of using alternative technologies (i.e. multi-GNSS, IEEE 1588 based time dissemination over optical fibre, and holdover clocks) to reduce security risks and enhance resilience of the existing GPS-based solution for substation time synchronisation.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

If successful, the research undertaken in this project will inform National Grid on the following points:

1. The performance and security risks of using enhanced GNSS-based time synchronisation with a multi-GNSS disciplined oscillator.
2. The feasibility and requirement of using IEEE 1588 based time delivery to transmit timing references across National Grid substations.
3. A review of different types of holdover clock available in the market and ways to integrate these into the time delivery for improved resilience.
4. An automatic switchover method with detailed hardware and software requirements.
5. Full costings for each of the above options and timescales for implementation.

Project Partners and External Funding

N/A

Potential for New Learning

The work will provide the basis for understanding the feasibility, costs and timescales to implement alternative solutions (i.e. multi-GNSS, IEEE 1588 based time distribution over fibre, and holdover clocks) for substation time synchronisation. The learning from this project will benefit all network licensees

Scale of Project

The project will collaborate with a third party to carry out feasibility studies to assess the viability of using alternative substation timing solutions.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL3 Proof of Concept

Geographical Area

The study will be predominantly desktop based.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

The total NIA project expenditure is £91,110.

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 work aims to investigate the viability of using alternative time synchronisation solutions to reduce the reliability issues and security risks of existing GPS technologies. Financial benefits would be primarily derived from the reduction of loss of supply costs associated with protection mal-operations due to unreliability of GPS timers.

Please provide a calculation of the expected benefits the Solution

The project will analyse the full costs and timescales to implement the proposed options for external time delivery into substations. Comparisons will be performed to identify the optimal substation timing solution, and the financial benefits will be assessed through the project.

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

The lessons learnt from this project will provide Network Licensees across GB with a more informed understanding of time delivery to substations using multi-GNSS, time dissemination over fibre, and holdover clocks. The knowledge gained will support key strategic and investment decisions in respect to mitigating or resolving GPS vulnerabilities.

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

The costs to roll out the proposed options will be estimated through the project.

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):

- [x] 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

☐ 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 outcomes from the project will be available to the general public via the ENA portal.

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

This project fits within the Managing Assets value area of the Electricity Innovation Strategy.
☑ 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 known projects being undertaken for this scope of work. The review has included the ENA smart portal and supply base. Previous projects (e.g. Digital Substation – Virtual Site Acceptance Testing & Training) have focused on how to distribute timing signals within substations, while this project aims to investigate different solutions of transmitting external time references into substations.

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

With growing requirements for substation resilience and increasing availability of new technologies, the project will investigate the benefits, costs and challenges of using alternative methods (i.e. multi-GNSS, IEEE 1588 based time distribution over fibre and holdover clocks) to reduce security risks and enhance resilience of the existing GPS-based solution to substation time synchronisation. The work will provide the basis for understanding the feasibility of implementing alternative solutions to mitigate or address reliability and security issues associated with GPS.

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

The nature of a research programme means it inherently carries a risk that the research may be unsuccessful or identify unforeseen costs/barriers to implementation. The NIA funding offers the most appropriate route for the National Grid Electricity Transmission (NGET) to assess the viability of using alternative technologies for substation time synchronisation and identify an optimal solution that can be applied to all Network Licensees.

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

The inherent risk of the project is detailed above and the learning from the project will be directly relevant to all Network Licensees. For this reason, NGET believes this project is appropriately funded through NIA, and material from the project will be available to the general public via the ENA portal.

This project has been approved by a senior member of staff

☑ Yes