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

Mar 2015

Project Reference Number

NIA_NGET0162

Project Registration

Project Title

Digital Substation – Virtual Site Acceptance Testing & Training

Project Reference Number

NIA_NGET0162

Project Licensee(s)

National Grid Electricity Transmission

Project Start

March 2015

Project Duration

2 years and 9 months

Nominated Project Contact(s)

Iliana Portugues

Project Budget

£405,000.00

Summary

Initial analysis from the NG AS3 project - Working Group 2 (WG2) – "IEC61850/digital substation architecture design and reliability analysis" has demonstrated the feasibility of the concept; the next phase will aim to prove its applicability on the electricity transmission system.

The project aims to develop and demonstrate the first phase of the Digital Substation. The scope of this project can be divided into the following parts.

- Carry out modelling and simulations for any design of substation to create a virtual site substation simulation environment. The VSATT will use RTDS equipment. This will provide the simulation for the primary plant for any operational and fault conditions.

- Implementation of a configurable and extensible AS3 architecture test platform to provide the standardised secondary system interfaces to the primary plant.

- Support and facilitate vendor IED interoperability and performance testing. This study aims to investigate whether solutions from different suppliers will work correctly, safely and reliably when configured to a common specification. It also aims to provide an indication of the viability and implementation costs for future digital substation implementation. This includes the development of specifications for data models, the engineering process, commissioning and testing.

Nominated Contact Email Address(es)

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Problem Being Solved

Protection and control systems are assets which enable remote control and monitoring of the Electricity Transmission Network. Crucially, they protect the public and network during faults by automatically switching faulty parts of the network out. All assets on the transmission network require maintenance and eventually replacement. In order to carry out maintenance of these systems, the electricity network has to undertake outages, which can impact on the rest of the system as it can cause constraints. Planned outages

are managed years in advance to factor in routine maintenance, and can potentially be unplanned to factor in outages required for faults. Due to outage requirements and system access constraints, the current achievable replacement rate for protection and control systems is about 5% per annum. It would therefore take around 20 years to complete a whole cycle of replacements. However, the typical asset life for these systems is 10-15 years, dependant on the system. These life expectancies are due to the fast pace of change in technology, making some of the systems obsolete, creating a lack of availability of technical support.

Driven by these challenges, National Grid has started various initiatives to set up a new Architecture of Substation Secondary Systems (AS3). This project uses the IEC61850 standard for future digital substation implementation, which is low cost and relatively quick to implement (compared to building a new traditional substation). There is a lot of interest in developing this technology to reduce outage requirements for system commissioning and de-commissioning.

The main objective of the AS3 project was to provide a solution to the life cycle issues of substation protection and control assets, particularly the reduction of system access requirements for equipment installation and replacement.

The AS3 project has delivered a review of the substation life cycle issues, a new standard architecture for substation secondary systems and draft specifications for system configuration and Merging Units (MU). AS3 has also completed four piggy-back trials (with ABB, Alstom, NR Electric and Siemens respectively) which have demonstrated and proved the concept and benefits of using IEC61850-9-2 process bus technologies, i.e. reduced site wiring and less Electro Magnetic Compatibility constraints.

Having completed the preliminary work on AS3 (IFI project 'AS3' and NIA_NGET0104 'Proof of concept of IEC 61850 Process Bus technology', the following challenges have been identified:

- Future site trials and equipment acceptance tests for the full deployment of AS3 based digital substations will be very costly and highly risky due to the lack of an established engineering and testing process, high risk of configuration mismatches between devices and un-tested interfaces to existing equipment. All of this makes estimating the required time and effort for a site installation difficult.
- Engineering procedures, including configurations, testing and site commissioning play a vital role in the AS3 architecture. A high level description of these has been provided in the previous project and now these remain to be refined and validated.
- Training is essential to effective implementation of the AS3 architecture on site. This is due to the step change in technology commissioning engineers will be exposed to i.e. the move from hardwired copper connections to Ethernet over fibre.
- The AS3 architecture is also aimed at dealing with equipment obsolescence and improving support arrangements by ensuring that Standard Bay Solutions from different suppliers are built to a common specification and are interoperable and interchangeable. A draft specification has been produced but no interoperability tests have been carried out to date.

Overreliance on GPS as a time source can lead to reduced network security. The AS3 architecture allows sourcing the time reference from the substation network instead of individual GPS receivers. As part of this research the feasibility and benefits of such an arrangement is investigated using the IEEE 1588 precision time protocol..

Method(s)

To address the above challenges the following research and development work is proposed:

At present National Grid does not have an engineering facility or any other means to deploy the AS3 designs and IEC61850 technology to site in an efficient, safe and low cost manner, hence the proposal to develop a Virtual Site Acceptance Testing & Training (VSATT) facility to allow the implementation of substation automation on the network

(Note - A copy of the proposed VSATT architecture and components is attached)

The project is a staged 24 month programme with start in April 2015. will be carried out in the following stages:

Design and build the AS3 infrastructure including modelling of primary plant in the Real Time Digital Simulator (RTDS), fibre network and physical bay arrangement. Apr – Nov 2015

Review and publish Merging Unit and configuration specifications in cooperation with key suppliers Apr – Aug 2015

Develop engineering and configuration tools as well as tools for data flow monitoring and performance analysis May – Nov 2015

Develop and issue interoperability test specifications Aug – Nov 2015

Configure and test supplier equipment in order to validate interoperability, carry out performance analyses and validate the engineering and commissioning process Dec 2015 – Aug 2016

Investigate IEEE1588 time synchronisation with the aim of reducing dependency on vulnerable GPS based solutions Jun 2015 – Sep 2016

Finalise and publish technical specifications enabling interoperability and procedures for testing and commissioning including the lessons learnt from the project Sep – Dec 2016

Adapt the VSATT for utilities and suppliers' staff to carry out virtual AS3 based digital substation implementation and performance analysis for training purposes and also for compliance testing prior to site installation Jan – Feb 2017

Summarise outcomes and deliverables in the final report and arrange a final workshop for stakeholder presentation. Feb – Mar 2017

The project will comprise a number of innovation work streams, including an Architecture configuration tool (software) and IED “plug & play “ functions.

Scope

Initial analysis from the NG AS3 project - Working Group 2 (WG2) – “IEC61850/digital substation architecture design and reliability analysis” has demonstrated the feasibility of the concept; the next phase will aim to prove its applicability on the electricity transmission system.

The project aims to develop and demonstrate the first phase of the Digital Substation. The scope of this project can be divided into the following parts.

- Carry out modelling and simulations for any design of substation to create a virtual site substation simulation environment. The VSATT will use RTDS equipment. This will provide the simulation for the primary plant for any operational and fault conditions.
- Implementation of a configurable and extensible AS3 architecture test platform to provide the standardised secondary system interfaces to the primary plant.
- Support and facilitate vendor IED interoperability and performance testing. This study aims to investigate whether solutions from different suppliers will work correctly, safely and reliably when configured to a common specification. It also aims to provide an indication of the viability and implementation costs for future digital substation implementation. This includes the development of specifications for data models, the engineering process, commissioning and testing.

Objective(s)

The project aims to address the lifecycle issue described above by enabling the application of AS3 based designs on the transmission network. The main enabling factor is to develop a Virtual Site Acceptance Testing & Training (VSATT) facility to achieve the following:

- Test and demonstrate interoperability between suppliers’ Standard Bay Solutions.
- Finalise and validate technical specifications, processes and procedures that are vital to achieve interoperability and enable site roll out.
- Reduce the overall technical and commercial risks associated with secondary systems and drive customer value as a result of:
    - improved supplier choice resulting from interoperable equipment
    - lower installation cost as a result of reduced site wiring requirements and plug and play replacement.
    - Lower engineering cost as a result of automating key parts of the engineering and configuration process.
    - Reduced system access requirements.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

A successful demonstration of this project will provide the following key deliverables:

- To assemble an engineering facility (VSATT) for partner vendors to carry out virtual site acceptance tests on an AS3 based digital substation design.
- To assess feasibility of vendor interoperability on a station bus using IEC61850-8-1 and MMS control data exchange between bays supplied by different suppliers and between bays and master unit.
- To demonstrate IEC61850 technologies and the benefits of AS3 based digital substation implementations and performance to stakeholders.
- To determine the feasibility of IEEE1588 time synchronisation for key substation functions.

- To produce a suite of technical specifications and documented processes enabling safe site installation of interoperable AS3 based solutions.

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

The project will develop a test environment which will be housed in an existing protection test facility. This will enable the project team to demonstrate proof of concept. It is this scale because the feasibility to assess one bay has been completed and in order to consider different types of substation and demonstrate interoperability, a larger test facility is necessary. The VSATT is designed to allow configuring at least 4 Bay Solutions. The project cannot reduce the scale and still provide the benefits to consumers that are necessary.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL3 Proof of Concept

Geographical Area

The project is applicable to all substations across GB. This will provide a tool that is transferable to other applicable parts of the transmission system.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

NGET NIA project expenditure is £405,000

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)

This research is mainly driven by the lifecycle issue, i.e. the lack of a solution enabling secondary system replacement within the constraints of available outage time. The use of AS3 is expected to also deliver savings. Factors that are expected to contribute to savings are:

- Signals transmitted over Process Bus instead of hard wiring,
- Installation and commissioning will be much safer and quicker than traditional approaches. "Plug and play" will be possible for the installation and replacement due to use of IEC61850 based fibre optical bus and standardised interfaces. Therefore the required outages of primary system will be significantly reduced ensuring availability is maintained. Installation costs are also reduced by reducing the need for cross-site secondary circuit cabling.
- Improved asset management and replacement options. As a result of the ease of asset replacement and reduced outage requirements the asset replacement strategy could allow assets to remain in service for longer. It would even be possible to automatically configure a spare bay to replace a faulty one.
- Increased completion for bay replacements due to interoperability and interchangeability of equipment. This is expected to lead to improved choice and reduced lead times for projects and as a result drive overall cost down.
- A higher degree of automation can be achieved in the engineering process. This should drive the project delivery time scales risks and cost down.

Exact figures are difficult to estimate in the absence of a tender event but a conservative estimate would be a saving of approximately £50K (5%) per substation with AS3 implemented. With an expected roll out rate of approximately 50% of substations refurbished or newly built to have AS3 each year this would deliver a total saving of approximately £500K per year.

Please provide a calculation of the expected benefits the Solution

Research.

Continuing to use non IEC 61850 based solutions does not address the lifecycle issues outlined at the beginning of this document. Test in situ on a live substation requires a long series of outages on multiple bays and would introduce the risk of an unplanned trip. Opportunities for offline "piggy-back" trials have already been exhausted which is why the laboratory based facility seems to be the only viable option to carry out this research.

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

The method can be applied to all substation configurations in GB. However, the principle is only valid for substations where IEC 61850 will be considered.

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

Roll out only with new projects – no retrofit envisaged at this stage.

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).
- [x] A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)
- [x] 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

Although there has been work carried out on the IEC 61850 substation communication protocol, there is no facility to test the interoperability of different vendor solutions without putting the actual substation at risk.

The project will enhance the understanding of the technical and practical viability of this method and identify potential value and opportunities, barriers and areas for further research. Therefore, the findings could benefit other transmission and distribution network operators.

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

- [x] Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees

Is the default IPR position being applied?

- [x] 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