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 2019

Project Reference Number

NIA_NGGT0145

Project Registration

Project Title

GRAID ART

Project Reference Number

NIA_NGGT0145

Project Licensee(s)

National Gas Transmission PLC

Project Start

March 2019

Project Duration

2 years and 6 months

Nominated Project Contact(s)

Dave Hardman, Josh Blake

Project Budget

£1,410,447.00

Summary

Carry out a test using the revised Acoustic Resonance Technology (ART) algorithms and electronics to confirm operation on Coal Tar Enamel (CTE) pipework

Assess the feasibility and concept of incorporating Acoustic Resonance Technology onto the GRAID robotic platform

Design and Build the ART sensor package for the GRAID robotic platform.

Test the GRAID robot with ART at the Offline test rig at RAF Spadeadam.

Preceding Projects

NIA_NGGT0102 - Acoustic Resonance Technology (ART)

NGGTGN02 - In Line Robotic Inspection of High Pressure Installations

Third Party Collaborators

DNV

Halfwave AS

Key Engineering Solutions Limited

Pressure Force UK Ltd

Pipeline Integrity Engineers Ltd

Synthotech Limited

Premtech Ltd

Nominated Contact Email Address(es)

Box.GT.Innovation@nationalgrid.com

Problem Being Solved

The Project GRAID (Gas Robotic Agile Inspection Device) NIC successfully designed, built and tested a robotic platform capable of operating within the live gas transmission environments of National Grid's Above Ground Installations (AGIs). The platform completed both Offline and Online testing proving that it could access the unpiggable areas of an AGI and collect reliable data on the wall thicknesses from inside the pipe. The current Non-Destructive Testing (NDT) package uses EMAT (Electromagnetic Acoustic Transducers) to take the data, providing 2 results per scan, each an average wall thickness over the 22mm2 areas. Whilst the NIC was a success as the original aims of the project were met, to leverage as much benefit out of being inside the pipe as possible a different form of NDT is required. The EMAT sensor is slow to collect data as it needs to contact the pipe wall before sending a signal and has a large 22mm2 coverage. Acoustic Resonance Technology (ART) can collect data from an area of 3mm2 which will provide an increase in the overall quality and quantity of the returned data, helping to improve the confidence in the condition model that is generated. It is also expected to decrease the speed of inspection which will help reduce the OPEX cost of running GRAID.

Method(s)

This Study will be split into the following sections:

- Stage 1A – Lab test of the technology. A report will be provided by Halfwave and will be independently verified by PIE to confirm the technology will work on CTE coated pipework.
- Stage 1B – Feasibility and Concept study to understand how ART could be utilised on GRAID.
- Stage 2 – Detailed Design
- Stage 3 – Build
- Stage 4 – Offline testing at Spadeadam test rig
- Stage 5 – Online testing at (proposed at Bacton Terminal) - this stage will be removed

Milestone reports will be provided at the end of each Stage to ensure that deliverables are on track

The following 3rd parties will be a part of this NIA:

1. Halfwave – Leading the NIA to incorporate their ART sensors onto the GRAID platform
2. Synthotech – Technical support to explain how GRAID has been built and to assist in testing
3. DNV-GL – Support for the Offline trials at the Research and Test base in RAF Spadeadam
4. Pressure Force – Cleaning services

Scope

As mentioned above the GRAID NIC project was successfully concluded in November 2018 after meeting all the project milestones. During the project, the limitations were highlighted of the proposed NDT system however at the time ART was an unproven and emerging technology and so EMAT was selected for the GRAID platform. On top of this the robotic platform itself was untested. Now that the platform and ART have both developed further, focus on the NDT can be revisited.

Acoustic Resonance Technology (ART) has been proposed as the NDT of choice for GRAID, however following an In-Line Inspection run using this technology, certain challenges were experienced with the coal tar enamel (CTE) coating on much of the pipework owned by National Grid. Halfwave have since updated the algorithms and electronics in their sensors and state that collecting external wall thickness measurements on CTE is now possible. For this reason, Phase 1A will start with a confirmation test and there will be a stage gate in the project to ensure it is only continued with satisfactory results.

The main objectives of this early test is to demonstrate sufficient tail signal (resonance energy) performing the measurements on the object with external coating, and to document that wall-thickness values can be obtained using existing algorithms. This work will be independently checked by PIE.

As part of the RIIO-T2 submission, GRAID is proposed to be used on up to 20 sites during the price control period, to gain as much benefit out of these inspection windows, the most suitable NDT should be deployed on GRAID. ART can increase the speed of inspection whilst returning a higher quality and quantity of data than the current EMAT solution. This in turn can reduce the on-site costs for an inspection and help to increase the confidence in the condition model which will eventually assist the Asset health team in making decisions about the future of the AGI assets.

Change Control – Feb 2020
Following the successful completion of Stage 1A and 1B - Feasibility Report the preferred option for integrating ART onto the GRAID chassis was decided. A total of 6 designs were considered in the report and each were summarized on their merits and challenges.

Ultimately the key driving factor for the designs was the fact that the ART sensors need to be positioned in the centre of the pipeline to provide accurate data.

Whilst GRAID is very agile to move around the complex pipework it would not be able to provide these minor adjustments to get the sensors central. For this reason, a series of motors has been incorporated into the design to allow the operator to amend the position slightly to find the optimum position, this has led to an increase in the design time and material costs.

The 6 concepts were compared and concept 6 was chosen as having the greatest flexibility to provide these 3 minor adjustments.

The project completion date has been extended to March 2021 to account for the increased complexity of the design and build and due to contract negotiations at the beginning of the project.

In response to the increased cost and time of the project it was decided that the data modelling aspect of the project would be removed although data from the live trial would still be collected and stored by National Grid for later analysis and processing. Halfwave will submit a Fitness for Service report to culminate
the Online trial as agreed at the beginning of the project.

Change Control – March 2021
The project end date will be extended to August 2021 to provide time to carry out the offline trial of the platform at DNV's Spadeadam research and test facility. The remaining project milestones will be as follows:

Phase 3 – March 2021
• Halfwave – Complete FAT in Bergen, Norway
• Synthotech – Engineering Support, Harrogate, UK
• DNV GL – Complete rig modifications, RAF Spadeadam, UK

Phase 4 – August 2021
• Halfwave – Transport equipment to UK and support offline trials
• Synthotech – Robot modifications / preparation and support offline trials
• DNV GL – Facilitate offline trials at RAF Spadeadam

Phase 5 – During the course of the GRAID ART NIA project it was always considered that the final stage relating to an 'online' trial of the platform at Bacton Terminal could only go ahead if the time permitted and was not considered a success-criteria for the project. This contract variation is therefore needed as the Bacton Terminal online trial of GRAID will not go ahead as planned, instead greater focus will be put on the offline testing of GRAID at RAF Spadeadam.

Objective(s)

- Stage Gate 1 – April 2019;

Carry out a test using the revised ART algorithms and electronics to confirm operation on CTE pipework and provide a completion report to be independently appraised by PIE.

- Stage Gate 2 – July 2019;

Assess the feasibility and concept of incorporating Acoustic Resonance Technology onto the GRAID robotic platform.

- Stage Gate 3 – Feb 2020;

Design and Build the ART sensor package for the GRAID robotic platform.

- Stage Gate 4 – May 2020;

Test the GRAID robot with ART at the Offline test rig at RAF Spadeadam (DNV-GL)

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

- A lab test procedure and report produced by Halfwave
- An independent review of the lab test results by Pipeline Integrity Engineers
- A completed Feasibility and Concept report
- Completed Detailed Design report
- Manufacture and Assembly completion report
- Successful Offline Testing

Project Partners and External Funding

External Funding – Nil.

Potential for New Learning

The potential for learning from this project will be whether the Acoustic Resonance Technology can be incorporated onto the GRAID robotic platform and how this could be achieved. If completed successfully, both the quality and quantity of results will be improved for use in the condition model.

The results of the lab test on coal tar enamel coated pipe will also confirm if ART has been advanced sufficiently to be used on the Pipeline Inspection Gauges (PIGs) as challenges had been raised following the previous ART trial (NIA_NGGT0102).

Scale of Project

Both desk based and trial in a working environment.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

- Initial test – Bergen, Norway
- Feasibility – Norway and PMC Depot Ambergate, UK
- Design / Build – Bergen, Norway and potentially Harrogate, UK
- Offline Test – RAF Spadeadam, UK

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£1,410,447.00

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)

Providing the technology works then using ART on GRAID will have significant effects on the quality and quantity of data collected alongside a substantial reduction in the length of time an inspection will take on site. For example, the current resolution of the EMAT sensors is 22mm2 and to collect a 100% coverage of 1 metre of pipe would take 49 working hours. A comparison of this with ART would be a resolution of down to 3mm2, a 100% coverage of 1 metre of pipe would take less than 1 hour. The implication of this for labour, equipment and site setup costs would be sizable especially with a planned strategy of 20 sites over the RIIO T2 period.

Additionally, this increase in quality and quantity of data will have a significant impact on the confidence of the condition model that was developed by PIE. Based on statement of supports it is thought that with ART data the model could be used to extrapolate across to sites which have not been inspected, further increasing the coverage that the GRAID robot can have.

The ART sensors are also being developed to look at crack detection as well and so this could be an additional use for the GRAID robot in the future.

Please provide a calculation of the expected benefits the Solution

Expected financial benefits:
Using the 22mm2 resolution EMAT sensors it would take approximately 49 hours to 100% scan a 1metre section of pipe. As a conservative assumption, 10, 1metre sections of pipe would be of enough interest to require a detailed inspection per route (field joints / wind water lines / welds). This would take 11 weeks on site to complete and using the costs proposed for operating GRAID would come to £372k per site.

Using the 3mm2 resolution ART sensors the same inspections would take 3 days on site to complete and using the costs proposed for operating GRAID would come to £60k per site.

There is also deemed to be a financial saving in the reduced amount of time welfare and support units such as generators are needed, based on previous work it can be assumed that a day cost for this is in the region of £3000. For 11 weeks of EMAT this would cost £165k and for 1 week of ART this would cost £15k.

Taking these amounts across the 20 sites proposed for GRAID in T2 this would be:

EMAT – 372x20 + 165x20 = £10.7m
ART – 60x20 + 15x20 = £1.5m

Total saving = £9.2m

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

Once incorporated onto the platform, the GRAID robot could be used on any NGGT site with an applicable connection point. It could also be used on any Distribution network or global transmission network which also had the relevant pipe sizes and a connection point.

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

No additional cost on top of existing solution.

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 use of ART within the UK gas transmission and distribution markets is unproven. If the challenges experienced from the first use of ART on In-Line inspection can be proven to be addressed, then this technology can be used more frequently across all network licensees.

Incorporation of ART onto the GRAID platform will be used by National Grid specifically to enhance the output of the platform. If completed successfully this tool can be offered to the wider gas industry both in the UK and abroad to inspect their unpiggable pipework.

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

Reliability and Maintenance
☑ 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 is the only project worldwide progressing high pressure robotics with Acoustic Resonance Technology.

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

Previously ART was trialed for pigging but the incorporation of the Acoustic Resonance Technology onto the GRAID platform has not been completed before. Now that the GRAID platform has been extensively tested both Offline and Online and has proven to operate in the ‘live’ gas transmission conditions, this work is needed to integrate the two technologies.

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 ability to use GRAID as BAU is unproven. This development will further improve the viability, however there are a number of technology and integration risks that business would not be able to fund as BAU.

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 major risks for this project relate to the ability of ART to operate effectively with coal tar enamel coated pipe which is common across the National Transmission System and then to integrate the technology with the robotic platform. The benefits of GRAID will be delivered in future price controls and will be applicable to other network licensees, therefore the NIA is ideally suited for this project.

This project has been approved by a senior member of staff

☑ Yes