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

May 2017

Project Reference Number

NIA_NGGT0110

Project Registration

Project Title

Advanced Manufacturing (3D Printing) of NTS ready components

Project Reference Number

NIA_NGGT0110

Project Licensee(s)

National Gas Transmission PLC

Project Start

May 2017

Project Duration

1 year and 8 months

Nominated Project Contact(s)

Alan Horsburgh; box.gt.innovation@nationalgrid.com

Project Budget

£260,970.00

Summary

The diversity of advanced manufacturing techniques such as 3D printing allows almost any shape to be produced without any product specific tooling being required, significantly lowering the manufacturing overhead on low volume parts. National Grid Gas operates a highly meshed network with a vast array of complex equipment. Much of this equipment requires specialist maintenance and a wide ranging parts inventory. To improve maintenance and part longevity, there is a need to examine alternative manufacturing techniques that will allow the company to specify improved components with the attendant, efficiency, maintenance and environmental savings.

The two most likely techniques for advanced manufacture are direct metal laser sintering (DMSL) and electron beam melting (EBM) that both produce metallic components by locally welding or sintering layers of metallic powder together using a high temperature laser or beam. These techniques produce high density parts suitable for stress critical applications. There is a unique advantage of these techniques that has yet to be fully exploited. As the part is created layer by layer it is possible to control the microstructure of each layer during deposition. There is also the opportunity to incorporate sensors directly into the material, potentially providing the self-monitoring component which will start to drive a more realistic ‘Condition Based Maintenance (CBM)’ regime. This has the potential be a very powerful capability for future asset maintenance activities.

Third Party Collaborators

Premtech Ltd

Nominated Contact Email Address(es)

Box.GT.Innovation@nationalgrid.com

Problem Being Solved

National Grid has a wide range of operational equipment and assets where spares may not be readily available due to obsolescence or where there are opportunities to improve capability of replacement parts. To realise these opportunities and optimise the health of National Grid's asset base, there is a need to explore the latest techniques and technology around 3D printing of components. These techniques are improving rapidly in terms of material and component complexity but there is a need to establish the working envelope of 3D manufactured components to enable National Grid to fully utilise the benefits such techniques afford.

Method(s)

A detailed feasibility study will be conducted to ascertain the suitability of advanced manufacturing techniques to produce spare/obsolete parts. The study will compare different advanced manufacturing techniques based on three dimensional material deposition to determine the best available technology when considering compliance with technical specifications, mechanical and service properties, impact to safety, security and the environment. The programme (Phase 1) will deliver a component capatibility and cost benefit matrix (3CBM) to facilitate the assessment of the technology for deployment within the business inclusive of the necessary legal and Intellecutal Property (IP) considerations.

This programme will be conducted in three stage gated phases to ensure appropriate progress is being achieved.

Phase 1. Feasibility and Component Identification.

Identification of Parts – 'Current Inventory'.

Provide a component cost benefit matrix (3CBM) for component selection.

Undertake a Intellectual Property (IP) review of the 3CBM to ascertain the IP implications and develop a framework for assessing any component that may be added to the 3CBM.

Phase 2. Manufacture and Evaluation of 3D Printed Components

Establish Best Available Technology (BAT) and engage key Supply Chain and Other Operators.

Evaluate 3D scanning techniques as a means of providing efficient and accurate data for 3D Manufacturing processes.

Demonstrate 3D Manufacturing capability as a proof of concept for a single component.Use 3D printing techniques to produce four components identified in Phase 1.

Evaluate mechanical properties of components.

Develop Technique for Defining Tolerances.

Evaluate Environmental and Safety Impact.

Establish Technique for Part and Material Identification.

Phase 3. Defining and Developing Business Capability (inclusive of Standard) to ensure 3D techniques can be employed in the business

Definition of Workflows for component manufacture in line with the 3CBM.

Defined Quality Assurance (QA) metrics.

Develop Protocols and NG Technical Standard to ensure technique can be implemented within the business.

Scope

The diversity of advanced manufacturing techniques such as 3D printing allows almost any shape to be produced without any product specific tooling being required, significantly lowering the manufacturing overhead on low volume parts. National Grid Gas operates a highly meshed network with a vast array of complex equipment. Much of this equipment requires specialist maintenance and a wide ranging parts inventory. To improve maintenance and part longevity, there is a need to examine alternative manufacturing techniques that will allow the company to specify improved components with the attendant, efficiency, maintenance and environmental savings.

The two most likely techniques for advanced manufacture are direct metal laser sintering (DMSL) and electron beam melting (EBM) that both produce metallic components by locally welding or sintering layers of metallic powder together using a high temperature laser or beam. These techniques produce high density parts suitable for stress critical applications. There is a unique advantage of these

techniques that has yet to be fully exploited. As the part is created layer by layer it is possible to control the microstructure of each layer during deposition. There is also the opportunity to incorporate sensors directly into the material, potentially providing the self-monitoring component which will start to drive a more realistic 'Condition Based Maintenance (CBM)' regime. This has the potential be a very powerful capability for future asset maintenance activities.

Objective(s)

This programme will explore different advanced manufacturing techniques and define an on-going strategy for National Grid in respect to future component manufacture capabilities and component cost benefit. The three phase programme will define all the key aspects of technique, product capability (mechanical/material), quality assurance and integration within the appropriate standards to enable rapid deployment within the business.

The examination of these new manufacturing techniques will place National Grid Gas in a strong and highly informed position to define suitable on-going component capability to suppliers.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The benefits of using advanced manufacturing (3D printing) techniques include, but are not limited to:

Operational assets that might be rendered obsolete due to unavailable (obsolete) parts can have their asset life extended, delaying replacement expenditure.

The costs of storing spare parts can be reduced as fewer parts are needed to be stored when low lead (delivery) time parts can be sourced.

he shorter delivery time reduces downtime and increases the availability of equipment and plant.

The potential to improve the design of a replacement part without incurring the cost of new tooling.

The potential to take advantage of the improved components and explore the potential of 'intelligent' parts with inbuilt sensor capability.

Project Partners and External Funding

Project Partners – **Premtech and The Institute for Innovation & Sustainable Energy (IISE – Derby)**

External Funding – **(nil)**

Potential for New Learning

The programme will offer a clear insight into the latest 3D manufacturing capability for the manufacture of components related to all aspects of the gas Transmission network. It will provide a comprehensive baseline in terms of mechanical, corrosion and manufacturing tolerance properties of these techniques.

Scale of Project

The programme will involve both desktop design studies and physical manufacturing of candidate components that will be then be mechanically tested to asses performance. Corrosion and other Quality Assurance assessments will also be undertaken. It is proposed that suitable components will be evaluated under off-line simulated in-service testing conditions.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL6 Large Scale

Geographical Area

All work will be conducted in the UK and involve Gas Transmission assets.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£260,970

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 programme is broken down into three phases. Phase 1 will be exploring the range of candidate components that would economically manufactured by 3D printing techniques. This Phase 1 will incorporate the development of a cost benefit matrix to determine effective component selection.

An initial Carbon Benefit assessment has been undertaken which shows the potential savings in terms of material wastage, transport, maintenance and replacement of 420kgCO2e/kg of component manufactured. Further refinements and data capture will take place throughout the programme in line with the 3CBM.

The initial cost savings for obsolete or ad-hoc component manufacture for the limited set of gearbox, valve, actuator and covers has been determined as:

> Component failure which cannot be replaced due to obsolence requiring new item (gear gox, actuator, valve) replacement – 85% saving due to refurbishment of component.
>
> Ad-hoc component manufacture – 50% saving on lead times and improvements due to expedient return to service.

Based on mix of replacement type (1 or 2) the projected potential savings by employing 3D manufacturing techniques is £210,00/annum.

Other benefits due to potential to re-engineer components and alter materials of manufacture are not included in the above analysis but are thought to have considerable benefits. These possibilities will be considered during the programme and the results of this analysis presented in the final findings of the project.

Please provide a calculation of the expected benefits the Solution

A component cost benefit matrix (3CBM) is being developed in Phase 1 of the programme which will inform the suitability of the technique for wide spread adoption in the business.

The cost savings analysis presented above highlights the potential savings that are potentially realised based on the limited subset of components considered. It is considered that 3D Manufacturing has a wide applicability within Gas Transmission and this programme will help to inform the debate but enable future exploitation of this technique.

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

It is envisaged that 3D manufacturing will have specific applicability to take advantage of the unique properties such a technique affords. However it is expected that 3D manufactured components will be employed holistically across the gas network.

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

Establishing fully developed deployment costs will be part of the programme (Phase 1). The current development of 3D manufacturing equipment and the range of components that such equipment will manufacture form the basis of the detail component cost benefit matrix (3CBM) analysis in Phase 1.

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

This programme aims to establish the potential of 3D manufacturing techniques for gas industry components. The results of this work will have considerable synergy with other gas and electricity 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)

The project is aligned to our reliability theme- there is considerable pressure on National Grid Gas to deliver a robust and effective asset health programme. Improved 3D component manufacturing techniques could offer a range of solutions which improve asset performance enhancing maintenance and operational efficiencies.

☑ 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.

The current NIA portfolio of other distribution networks does not indicate similar type of programme. All networks will be fully informed of the progress of the current initiative.

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