

17th December 2018

Project GRAID

COMPLETION OF STAGE 5

SUCCESSFUL DELIVERY REWARD CRITERIA 9.8

Project Background

1. National Grid Gas Transmission (NGGT) and its partner organisations are engaged in an exciting project that is addressing the issue of how to inspect complex, below-ground pipework found at High Pressure Installations. The project is developing ground-breaking technology to provide the world's first robotic platform that will be able to provide real-time data on the condition of high pressure underground assets.

2. National Grid is collaborating with three British Small Medium Enterprises (SMEs) to develop ways to accurately assess the condition of its pipework assets that cannot currently be inspected via conventional Pipeline Inspection Gauges (PIGs). The complexity of pipework at High Pressure Installations (up to 94 bar(g)) presents a significant challenge for any robotic solution.

3. The solution being developed will enable NGGT to look inside their High-Pressure Installations for the first time since their installation, in some cases going back nearly 50 years. The current asset management strategy for this pipework relies on above ground survey techniques, and is based on good design and construction practices having been applied to these assets. If corrosion is suspected the only way to confirm this presently is through excavation, which is both financially expensive and environmentally adverse. This project will enable a proactive, risk based approach to the management, maintenance and replacement of these ageing assets.

SDRCs

4. Project GRAID SDRC 9.8 is as follows:

<p>(9.8) Implement into Business As Usual completed by 26th November 2018:</p> <ul style="list-style-type: none">- Design and manufacture and deliver a pre-commercialised in line inspection platform.- Specifications 100% complete check and approved for the platform that are acceptable by National Grid as specifications suitable for company use.- Deliver an agreed mobilisation strategy to NGGT including training package for all future operators.	<p>A report will be submitted by 19th December 2018 demonstrating that the measurable for SDRC 9.8 have been achieved.</p> <p>Publish evidence of internal senior sign-off confirming successful completion of SDRC 9.8 no later than 19th December 2018.</p>
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- Operating procedures (including health and safety) written and published on project website and recorded in project file. The robotic platform to be included as standard operating practice within NGGT asset management policy.	
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5. This report includes the evidence for SDRC 9.8 – Implement into Business As Usual, along with the end of Stage 5 details. As this is the last stage gate there has been no change to the agreed deliverables from the original Project Direction.

Completion Evidence

6. The project will be judged for the purposes of the NIC Successful Delivery Reward against the Successful Delivery Reward Criteria. The table below lists the activities that have taken place to meet SDRC 9.8 along with the documentation that evidences their completion. The documentation is held on the project's SharePoint site and can be made available for the Ofgem Project Officer as per request.

SDRC 9.8

Ser (a)	Activity (b)	Outputs (c)	Evidence (d)
a	Design and manufacture and deliver a pre-commercialised in line inspection platform.	GRAID robotic platform and all the required equipment handed over to National Grid following the successful hand over pressure test.	GRAID Synthotech G01-NGGT-R-0012 Rev 1.1.pdf
b	Specifications 100% complete check and approved for the platform that are acceptable by National Grid as specifications suitable for company use.	Specification documents have been completed for the robotic platform and Launch Vessel and handed over National Grid	GRAID Synthotech G01-SPC-010v2.0 - General Specification.pdf GRAID G01-SPC-010v2.0 - General Specification Confirmation.pdf
c	Deliver an agreed mobilisation strategy to NGGT including training package for all future operators.	Mobilisation strategy agreed between the existing project partners including a maintenance and training plan for Project GRAID.	GRAID Synthotech G01-NGGT-R-0012 Rev 1.1.pdf GRAID Synthotech Training Plan v1.0.xlsx GRAID Premtech PREM128-REP-0000-0502 Rev 02.pdf
d	Operating procedures (including health and safety) written and published on project website and recorded in project file. The robotic platform to be	Operating procedures for the GRAID robotic platform compiled by Synthotech and converted to National Grid templates to be presented on the project website. Incorporation into NGGT asset management policy has	Sections 7 to 12 below

	included as standard operating practice within NGGT asset management policy.	commenced with highlighted changes passed to the relevant authors for existing and new documents.	
Ser (a)	Activity (b)	Outputs (c)	Evidence (d)
a	Evidence of Senior sign off	Senior sign off	Project GRAID_SDRG_9.8_Report-End_of_Stage5 Senior Signoff.pdf

SDRC 9.8 Evidence

7. Technical specifications have been supplied for the robot, control centre, postman's trolley, driver cabinet, transportation trolley and the launch vessel. These documents define the technical aspects of the individual items and cover such topics as safe use, transportation and operation. The specification was written to comply with National Grid Policy for this type of document allowing innovative thinking to occur by not prescribing in detail the aspects of the current GRAID platform. In several conversations with the National Grid Policy team these specifications have been 100% checked and approved for use internally.

8. A mobilisation strategy has been defined and agreed with all the project partners with a copy included in the Synthotech Stage 5 report (**GRAID Synthotech G01-NGGT-R-0012 Rev 1.1.pdf**) with details about what the next GRAID connections would be like in the Premtech report (**GRAID Premtech PREM128-REP-0000-0502 Rev 02.pdf**). The site cost calculator (example in the Synthotech report, Table 2) includes an allocation for preparing the GRAID robot and site ahead of the inspection, an inspection window which can be increased or decreased depending on the available time and demobilisation. In this way, a plan can be put in place as soon as a connection opportunity is available. Within the cost calculator is included an allocation for maintenance, notably at the start, following a pressure test, any changes or replacements can be made before the 'live' trial starts. During demobilisation, the team would also be required to carry out any maintenance such as replacing any damaged tracks and re-rubberising them. If more significant maintenance is required, then parts may need to be returned to the workshop at Synthotech for this to be completed.

In previous reporting, it was stated that the team at PMC would take an active role in the mobilisation strategy of GRAID following the end of the NIC. This is still the plan for National Grid, however the skill set required for high-pressure robotic operation is new to National Grid. As more inspections are planned, technicians from NGGT Operations can be trained in the various aspects of maintenance and operation. In the meantime, PMC will be storing the robotic platform and associated equipment and will play an active role in constructing new connection points, site management under CDM Regulations and pressure testing as required.

Regarding training, a plan has been developed by Synthotech (**GRAID Synthotech Training Plan v1.0.xlsx**) which details the amount of time and the objectives to complete. At the end of this plan, Synthotech will deem the technicians as capable to operate GRAID, leaving National Grid to deem them competent to use GRAID on a 'live' site. A method of recording the accomplishments has also been developed which is similar to a driving test.

Locations for the training will vary between the test site owned Synthotech, the Offline test rig at DNV-GL Spadeadam and an actual site on the NTS.

9. A large quantity of documentation has been produced by the Project GRAID team throughout the project, this includes operating procedures for using the robotic platform. These documents were drafted during the Offline trials and were periodically checked, used on site, updated and re-published. Prior to the Online trials starting a Safety Critical Task Analysis (SCTA) was created which covered all the tasks in the operating procedures but specifically highlighted those which have a critical safety aspect. Measures were then put in place to ensure that competent staff carried out the role and that all prior steps were complete. Hand overs between different teams and personnel were also highlighted in the document to ensure this was carried out correctly and there was a clear ownership of tasks within the team. As a result of this, when the Online trials began the SCTA could be used and updated if required so that following closure of the project the document had been through several iterations and is suitable for use on site. During mobilisation, before the GRAID robot is used again the SCTA will be reviewed and checked, making any amendments before it is followed on site. A copy of this document (in draft form as final versions will be confirmed during mobilisation) is supplied within the appendix here, has been uploaded to the project website (<http://projectgraid.com/documents/project-graid-operating-procedures>) and is stored on the internal project file as per the SDRC requirements.

10. For a complex task, such as providing a GRAID robotic inspection on site the team developed a process flow diagram that aims to define the high-level steps that need to be followed. This process starts with the inception of an idea for a GRAID connection and end with the close out documentation and demobilisation from site. National Grid has documented many of its processes in the form of a flow diagram and so copying this format will help to incorporate GRAID into the wider systems in place at National Grid. A copy of the combined high level processes can be found in the appendix; however, a broad overview can be seen below:

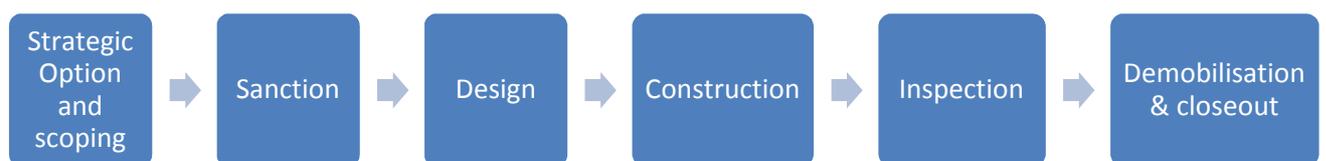


Figure 1 - Simplified GRAID Process flow.

11. To ensure all the project documentation such as the operating procedures, technical specifications, safety critical task analysis and process flows is shared internally, a project file will be created within a shared folder structure. This will enable anyone within the wider National Grid Gas Transmission (NGGT) team to access the files and understand how GRAID could be used on the National Transmission System.

12. Alongside all the new documents being created as part of Project GRAID there have been several existing documents highlighted that could be amended to include the use of the robotic platform. In collaboration with the internal Policy team and following several discussions the following list was compiled:

Policy Ref	Document Name	Comments
T/PM/PS/3	Management Procedure for Ensuring Compliance with the Pressure Systems Safety Regulations 2000	Include the GRAID Launch Vessel and closure mechanism
T/SP/E/56	Specifications for Ancillary Pipeline Equipment	Include the GRAID robotic platform
T/PM/NDT/1	Management Procedure for Carrying Out Non-Destructive Testing	Incorporate inspections via the GRAID robot
T/PM/MAINT/5	Management Procedure for Maintenance Activities of Pipeline Equipment Operating Over 7 Bar(g)	Incorporate inspections via the GRAID robot
T/PM/IGEM/TD/1	The Application of IGEM/TD/1 (Steel Pipelines and the Associated Installations for High Pressure Gas Transmission) By National Grid Gas	Include robotic inspection capability when building a new site
T/PM/IGEM/TD/13	The Application of IGEM/TD/13 Edition 2 (Pressure Regulating Installations for Transmission and Distribution Systems for Natural Gas) By National Grid	

Table 1 - Existing documents which could be amended to include reference to the GRAID robotic platform.

It was deemed that the On-Line Inspection or 'OLI' suite of Management Procedures would be the ideal place to store the GRAID procedure documents and as such a new document has been written to feed into this suite. For all the other amendments listed in Table 1 the relevant authors have been identified and notification has been given that a change is required. As per the process for National Grid Policy changes these amendments are logged against each document and when it is updated all the changes will be made. This work will continue following the end of the NIC project and towards the next RIIO price control period, it will also be a part of much wider discussions around the policy of In-line Inspection within the business.

End of Stage 5

13. Stage 5 is the final stage gate in the Project GRAID programme of works, with an official end date for the NIC of the 26th November 2018. Following this date the End of Project Closure Report will be produced, peer reviewed and provided to Ofgem, no later than 3 months after the end date (26th February 2019). Since the previous report '**Project_GRAID_SDRG_9.5 & 9.7_Report-End_of_Stage4**' dated 24th October the GRAID robot has officially been handed over, new connection locations have been summarised, the data model work has concluded and a review of the documentation has been carried out internally at National Grid.

14. The Project GRAID hand over pressure test occurred on the 25th October 2018 at the National Grid Pipeline Maintenance Centre (PMC) depot in Ambergate, Derbyshire. The 2 hour, 77 bar(g) nitrogen test was passed successfully and signified the handover of the platform and all associated equipment from Synthotech to National Grid.

15. A large proportion of the GRAID work in the latter stages revolved around the creation of the condition model by Pipeline Integrity Engineers (PIE). This condition model aimed to take existing data from archives and new data from the GRAID robot and visualise the areas of site that have a high susceptibility to corrosion and the likely growth rate. The acceptable failure frequency limit is derived and shows the expected number of failures per m². To help visualise this the 3D models for site have been split into sections of similar pipework and given a colour coding depending on the results. This 'heat map' of the site allows a quick view of a given site, with the model behind it providing more detailed information. The end of Stage 5 report from PIE has been included within this report (**GRAID PIE Model Report.pdf**)

16. The Stage 5 duration has not been amended following the change in timelines for the Online trials and as such covers the final 3 months of the project – September through to closure on the 26th November 2018. The planned spend for Stage 5 was £266,132.48 with the expected current spend at £323,471.45. This increase can be attributed to:

- Project partner payments pushed back from Stage 4
- The Bacton Terminal inspection costs
- Handover pressure test
- Adhoc expenses that had not been invoiced in earlier stages.

17. The final payment for Stage 5 has been made showing the total payments to be £6,305,005.59 which matches the Ofgem funding and National Grid compulsory contribution.

Period	Bank Payment
Stage 1	£1,340,910.46
Stage 2	£1,780,612.80
Stage 3	£2,796,830.66
Stage 4	£306,232.00
Stage 5	£80,419.67
	£6,305,005.59

Since Stage 2 of the project it was reported and agreed with Ofgem that there would be an additional voluntary contribution of roughly £243,000 to cover the Offline test rig. This over spend has been carried through the project and as agreed will be covered by National Grid Gas Transmission (NGGT). Efforts have been made to reduce the impact of this for the business and is discussed in greater detail in the End of Project Closure Report.

18. Communications channels have continued throughout Stage 5 updating those that are interested in the project via the usual newsletter, website and LinkedIn channels. During the Low Carbon Networks & Innovation (LCNI) the team revealed an updated video to signify the end of the NIC project, this video has now been uploaded externally.

19. The patent applications have progressed throughout Stage 5 have been filed accordingly, and are currently pending.

20. Now that the NIC project is concluded for GRAID the existing Risks and Issues log has been updated and any outstanding risks have been closed. Any relevant risks from the log which refer to the ongoing use of GRAID have been transferred to internal risk logs in NGGT. Similarly, the project plan which was maintained throughout the course of GRAID has been updated to signify all tasks completed and has been closed. Any outstanding actions relating to creating the End of Project Closure Report and the SDR Application will be completed by the NGGT Innovations team.

Summary

21. Project GRAID has been a hugely successful NIC, achieving all its ambitious milestones resulting in a platform that can collect reliable integrity data of the high-pressure pipework on a 'live' gas site.

Milestone	Status
Design and develop a robotic platform	
Build a robotic platform capable of testing	
Perform Offline Testing programme	
Navigate the complex pipework (90° bends, Tees, inclines/declines)	
Carry out Online trials at Pannal and Bacton	
Complete Enhanced NDT analysis	
Implement Delta changes to the robot	
Update relevant National Grid documentation	

Table 2 – Summary of Project GRAID achievements

Although the project finishes in November the team are very keen to maintain the momentum within National Grid and ensure that the robot is utilised to its full potential. We are attending future conferences on unpiggable pipelines and are looking to use GRAID to inspect a variety of other installations in the next few years and onwards into RIIO T2. Focus is also on how we can adapt and improve the platform in a variety of ways such as:

- Travel further, around more bends
- Lighter, smaller body leading to a smaller connection footprint
- Improve the quality and quantity of data collected

22. The project will officially conclude on the 26th November 2018 and referring to the NIC Guidance document the End of Project Closure Report will be produced, peer reviewed and provided to Ofgem no later than the 26th February 2019.

Appendices:

GRAID Synthotech G01-NGGT-R-0012 Rev 1.1.pdf

GRAID Synthotech Training Plan v1.0.pdf

GRAID Synthotech G01-SPC-010v2.0 - General Specification.pdf

GRAID G01-SPC-010v2.0 - General Specification Confirmation.pdf

GRAID Premtech PREM128-REP-0000-0502 Rev 02.pdf

GRAID PIE Model Report.pdf

GRAID SCT-001-SBS Set up and Install Robotic Platform.pdf

GRAID SCT-002-SBS Remove Robotic Platform and decontaminate.pdf

GRAID Process Flow Diagram v1.pdf

Project GRAID_SDRC_9.8_Report-End_of_Stage5 Senior Signoff.pdf