GAS NIC Interrogation Report

In Line Robotic Inspection of High Pressure Installations

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Compiled By : Duncan Livingston

Verified By : Harry Scott-Dempster

Approved By : Richard Underhill

Signed : *Signed on Original*

Distribution :

Copy	Recipient	Organisation
1	Andrew White	Ofgem
2	Jonathan Hedgecock	PPA Energy
3	Project File	Frazer-Nash Consultancy

1. PROJECT SUMMARY

National Grid Gas Transmission (NGGT) proposes to develop a new system to inspect pipe work at Above Ground Installations (AGIs). Together with two Small Medium Enterprises (SMEs), Synthotech and Premtech, NGGT proposes to design and develop a new type of Pipeline Inspection Gauge (PIG) to perform this task.

PIG's are routinely used for pipeline inspection. However, the partners propose a new design of device that can operate in pipe work at high pressure (100 barg) and cope with the complex geometry of pipes at AGIs.

The stated key benefit of the project is that the development of such a device would allow the adoption of a risk based maintenance and replacement scheme for the pipe work. This would result in environmental, safety and financial benefits, while avoiding disruption caused by unneeded excavations, premature asset replacement and unplanned events.

The project has 4 key objectives:

- To accurately and reliably determine the condition of high pressure below ground pipe work at AGIs using an internal inspection robot.
- To generate a proactive, rather than reactive, risk based approach to the management and maintenance of aging assets, based on the knowledge of the actual condition of pipe work.
- Minimise the occurrence of annual unnecessary excavations and eradicate premature replacement of assets reducing significant carbon emissions and generating cost savings of circa £58m over 20 years.
- Minimise the likelihood of asset failure through proactive asset management, thereby significantly reducing the risk of a high pressure gas release into the atmosphere and the consequential financial, environmental and reputational impact.

2. ASSESSMENT AGAINST CRITERIA

The criteria against which each submission will be assessed are outlined in the NIC Governance Document as follows:

(a) Accelerates the development of a low carbon energy sector and/or delivers environmental benefits & has the potential to deliver net financial benefits to existing and/or future customers;

(b) Provides value for money to electricity/gas customers;

(c) Generates knowledge that can be shared amongst all (relevant) Network Licensees;

(d) Is innovative and has an unproven business case;

(e) Involvement of other partners and external funding;

(f) Relevance and timing;

(g) Demonstration of a robust methodology and that the project is ready to implement.

2.1 CRITERION (A): ACCELERATES THE DEVELOPMENT OF THE LOW CARBON ENERGY SECTOR AND/OR DELIVERS ENVIRONMENTAL BENEFITS

2.1.1 Key statements

A successful implementation of the project would:

- Minimise the requirement to excavate buried pipe work, resulting in a direct reduction of 1,036 CO_2e per annum.
- Reduce the unnecessary replacement of pipe work, resulting in a direct reduction of 1,109 CO_2e per annum.
- Reduce accidental releases of natural gas, resulting in an equivalent reduction of 6,800 CO_2e per release.
- Result in cost savings of more than £30m.

2.1.2 Challenges and Potential Shortfalls

Criterion (A) – Accelerates the development of the low carbon energy sector and/or delivers environmental benefits and has the potential to deliver net financial benefits to existing and/or future customers;	
Sub-criterion (a.i) – Ability to facilitate the Carbon Plan through GB wide roll out	**Challenge 1:** The submission states that it "Unequivocally accelerates the development of a low carbon energy sector", but then does not provide any evidence that this is the case.
	Answer 1: The requirement for the NIC is that the project accelerates the development of a low carbon energy sector and/or delivers environmental benefit. Through reducing the number of excavations, delaying replacement and reducing the likelihood of a high pressure gas release there are clear environmental benefits. Ultimately this will therefore aid in the transition to a lower carbon energy sector. Specifically, the project would directly reduce the carbon emissions by ~2,000 tonnes per year. The gas transmission network will be essential in delivering the UK energy needs in the transition to a low carbon economy, yet it is approaching the end of its design life. In order to facilitate the Carbon Plan the network needs to be inspected and maintained in a manner accounting for the ageing asset profile as well as expected future requirements.
	Conclusion 1: The case for the role of this project in advancing inspection techniques and moving to condition based asset management is well made, and accepted. The environmental case presented does not include the carbon impact of increased pigging operations, nor the does it present a watertight case based on avoiding large scale accidental releases, as no data is available on the likelihood of these events. However, these failings are relatively minor.

Sub-criterion (a.ii) – Network Capacity released by the project	**Challenge 1**: No statements are made regarding network capacity.
	Answer 1: This project is not intended to impact network capacity, as such we do not believe that this section of the criteria is applicable to this project.
	Conclusion 1: The answer presented is clear.
Sub-criterion (a.iii) – Environmental benefits delivered to customers	**Challenge 1:** The environmental benefit identified is based on the reduction of unnecessary pipe excavations. The submission assumes 15 excavations at AGIs per annum. What is the reference for this? What is the reason for these excavations today? If it is a suspected leak, then better inspection will not reduce this number of excavations. If it is external corrosion, then internal inspection may not detect this. It is possible that better inspection may increase the number of excavations.
	Answer 1: AGIs are only now reaching the end of their asset life and as such require effective asset management, to that end there is no empirical evidence on which to predict future asset condition. In order to determine the true asset condition of the 200 unpiggable AGIs on the NTS we need to instigate a plan of inspection and have suggested that we would conduct 15 excavations per year in order to inspect all AGIs within a 15 year period. Based on experience of pipeline pigging and professional engineering judgement, of the excavations approximately half are assumed to be in no need of urgent repair or replacement. There have been no recorded leaks on AGIs due to pipe failure. There have been high pressure incidents and these are referred to in section 3.3b of the NIC submission. Internal inspection can detect external corrosion using wall thickness measurements, it is hoped that this will be incorporated onto our robot throughout the stages of development. It is entirely feasible that better understanding of asset condition will result in more excavations. These will however be targeted excavations rather than 'unnecessary' excavations and it is anticipated that these will not only allow for intelligent and determined replacement or re-lifing of assets but importantly will prevent a high pressure incident due to a pipe break or similar.
	Conclusion 1: As discussed above, the environmental case presented does not include the carbon impact of increased pigging operations, nor the does it present a watertight case based on avoiding large scale accidental releases, as no data is available on the likelihood of these events. However, these failings are relatively minor.
	Challenge 2: Pigging operations involve venting of natural gas during launch and recovery operations. The amount of gas involved could be considerable, given the high pressures involved. The negative environmental impact has not been

	considered.
	Answer 2: It is expected that the robot launch and receive vessels will be smaller and of less internal volume when compared with traditional pipeline pig traps. The robot vessels will not require a large bridle (bypass) connection; the robot will drive itself from and into the robot vessel. The robot vessel will also not require a pressure equalising bridle as the robot will operate with no or minimal differential pressure across the robot. The operation will be designed to minimise venting, by minimising the robot vessel's internal volume. At present we have not calculated the volume that will be vented as it will be dependent on many factors, e.g. the robot design, which has yet to be decided. However, we do not believe it will have a material impact on the benefits quoted.
	Conclusion 2: The concept robots presented have a small internal volume in order to minimise the impact of operations on network flow and presumably to minimise drag on the robot. One consequence of this is that there is a significant amount of space around the robot in the launch/receive vessel. For full pressure operations at 100 barg this volume would contain a significant quantity of gas that would be vented. There are ways of minimising this release, especially if the robot is able to collapse itself into a smaller diameter pipe for launch and recovery. . It would have been useful to see a discussion of this in the submission, but this is a not a serious omission.
Sub-criterion (a.iv) – Financial benefit delivered to customers	**Challenge 1**: A case is presented, but the rationale for the argument is weak for the reasons given above (a.iii).
	Answer 1: Based on the answers above and our submission, the monetised value of the environmental benefit, using a non- traded central price of carbon of £58 per tCO_2e, would equate to £124k per annum for avoided excavations and delayed replacement. In addition, based on this approach, the monetised value of avoiding a one-off high pressure gas release would be **£394,400**.
	Conclusion 1: These values are presented in the original submission and are accepted. The weakness in the argument is in the probability of one-off event, and the number of excavations that will potentially be avoided. It is accepted that there is a net benefit for this project, but the case is not presented in a robust manner.

2.2 CRITERION (B): PROVIDES VALUE FOR MONEY TO APPLICABLE CUSTOMERS

2.2.1 Key Statements

Gas customers would benefit from the project from incentives to optimise network operation. Value for money for gas customers will be achieved through:

- Improved asset condition assessment, knowledge and understanding resulting in better planning and focussed expenditure.
- Extending asset life.
- Reduced disruption through asset failure
- Reduced excavations.

2.2.2 Challenges and Potential Shortfalls

Criterion (B) – Provides value for money to applicable customers;	
Sub-criterion (b.i) – Potential direct impact on Network licensee's network	**Challenge 1**: The submission assumes 15 excavations at AGIs per annum. What is the reference for this? What is the reason for these excavations today? If it is a suspected leak, then better inspection will not reduce this number of excavations. If it is external corrosion, then internal inspection may not detect this. It is possible that better inspection may increase the number of excavations.
	Answer 1: Please see answer to Challenge 1 in sub-criterion (a.iii).
	Conclusion 1: Please see conclusion to Challenge 1 in sub-criterion (a.iii).
Sub-criterion (b.ii) – Justification that the scale/cost is appropriate	**Challenge 1**: The submission provides no evidence of requirements capture. Better inspection of pipes is beneficial. However, it is unclear what the 'threats' to pipe work are and how they might be mitigated. There is therefore no clear argument presented for the benefits of a new in line inspection technique. Other techniques are being investigated in industry. Has a cost/benefit analysis been undertaken that demonstrates the expenditure is justified?
	Answer 1: The requirement for the project is clear and is captured within the success criteria, which is to develop a robot that can travel 100m and navigate two bends, taking visual and wall thickness measurements. Combining this information with condition modelling algorithms, will enable us to obtain an overall view of the condition of the below ground pipework on an AGI. In terms of inspection techniques, In Line Inspection is fundamentally the best way, both financially and environmentally to inspect below ground pipework. There are no other methods at this time which provide the same level of accuracy regarding true asset condition. We have already established that it is not possible to use commercially available pigging technology on below ground pipework on AGIs due to the geometries, complex pipework (size and scale) and flow rate. Therefore we are proposing to use an in line inspection robotic platform which will utilise some technology which is similar to that found on a PIG, however it will

	importantly negotiate its own route throughout complex pipe geometries, adjusting its size accordingly and will withstand pressures of up to 100Barg. It will provide asset health measurements as well as visual data concerning the actual condition of below ground pipework at AGIs, targeting threats to asset condition such as corrosion and external interference. There are a variety of 'threats' to pipework ranging from corrosion (CP not working effectively), corrosion (external interference/rock damage), corrosion (disbondment, CIPS not collecting data) and pipe deformation (dents/ gouges).
	Conclusion 1: This is a good, robust, response and the points raised are accepted. However, the original challenge has not been addressed. A formal requirements capture process would allow a much better understanding of the case being made. In particular what is missing here is a quantitative breakdown of the types of pipe failure that are currently being observed and precisely what kind of failure would be detected by different inspection techniques. Ideally this would be based on experience of operations, but "good engineering judgement" could be presented as an alternative.
	Challenge 2: The business case presented for the project is not robust. It does not include the risks and costs of pigging operations compared to other inspection techniques. Furthermore, it is written on the basis that there will be a saving because the total number of excavations will be reduced. This is based on a number of assumptions that are not justified, for example; ▸ Inspection does not remove the requirement to replace a pipe; it allows an extension to the life of the pipe before it must be replaced. ▸ Better inspection does not replace existing techniques it augments them.
	Answer 2: The business plan assumes that one robotic platform is delivered as part of the project and this unit is used to inspect our AGIs. In terms of inspecting AGIs we will use existing infrastructure on the AGIs, such as valves and filters, through which we will insert the robotic platform. It is therefore anticipated that the cost of the operation will be largely limited to the manpower for the inspection period and the post analysis. With regard to the risks of pigging we have undertaken 156 pigging runs over the past 14 years with no reported incidents. As with all high pressure operations there are risks involved, however with good processes and a strong safety culture these can be effectively mitigated and managed. The business case assumes the total number of excavations will be reduced because there will be fewer excavations that are 'unnecessary' as the true condition of the asset has been assessed as acceptable through the use of an inline robotic solution. In extending the operational life of existing assets, the requirement for new projects and associated expenditure can be reduced, removed or delayed. Reducing planned or unplanned asset replacement will provide cost benefits to the gas customer. ILI through a robotic solution would be performed in addition to the current techniques however crucially the additional data captured through ILI would remove the risk associated with current reliance on cathodic protection which fails to account for corrosion due to external interference or on areas where

	CIPS cannot collate data (i.e. disbondment). This additional intelligence will enable the most cost effective and timely approach to asset replacement.
	Conclusion 2: This is a good, robust, response. The points made are accepted.
Sub-criterion (b.iii) – The project is delivered at competitive cost	**Challenge 1:** The submission does not include evidence to demonstrate that costs have been minimised. For example, a significant proportion of the cost is related to testing. Facilities exist in the UK for testing high pressure pipe work and fittings. What aspects of the testing could be subcontracted and what aspects of the testing require a bespoke test rig?
	Answer 1: NGGT is committed to minimising costs wherever possible. The programme has been designed to provide a comprehensive development and testing plan that will deliver the overall ambition at an efficient cost, whilst mitigating operational risks. In terms of the test rig, this is an essential element of the testing programme. There is no existing facility that can provide both the required pipe configurations, lengths and required pressures of up to 150barg in the UK. The facility required must operate at up to 150 barg so that it may allow safety testing of the robotic platform and accompanying devices of 1.5 x their operating pressure. Our bespoke facility is critical to ensure that the robotic platform is suitably tested prior to being deployed on a live AGI. It is also critical to the project remaining on time and to budget. Eakring for example is the largest training establishment used by Network Licensees but is fairly simple in terms of pipework configuration. We require complex pipework comprising of multiple bends and vertical rise and fall.
	Conclusion 1: This is a good response and project costs presented are reasonable estimations for the scope of work presented.
Sub-criterion (b.iv) – The proportion of the benefits that accrue to other parts of the supply chain	**Challenge 1**: The submission briefly discusses applicability to other network licensees, but no arguments are presented discussing how a successful project would benefit other parts of the supply chain.
	Answer 1: The project is naturally focussed on delivering benefits on the gas transmission network and we have outlined that significant benefits should accrue to distribution networks, which is substantiated by the letters of support we have received. In terms of the wider supply chain, if the project is successful the robotic platform may also be of interest to the offshore oil and gas industry. However, at this stage we may have not undertaken any studies to determine its potential outside of the initial application.
	Conclusion 1: The answer presented is clear, but a more developed concept for how the project will benefit the supply chain would be preferable.

Sub-criterion (b.v) – How project partners have been identified and selected	**Challenge 1**: The submission discusses a competitive process at NGGT whereby the project was selected from seven potential projects, based on a proposal from Synthotech and Premtech. However, assuming that better in line inspection is a worthwhile project, no evidence is presented why these two companies are the best partners to deliver this project.
	Answer 1: As stated National Grid evaluated all of the NIC ideas and proposals that we received both internally and externally. The in-line inspection of high pressure installations was evaluated as providing the greatest potential benefits and was suitably advanced for a NIC submission. Part of his evaluation involved an assessment of the project partners to ensure that they had the appropriate capabilities and track record to deliver the project. From our own experience of Premtech and through industry references and back ground research of Synthotech, we determined that our partners were capable of delivering this project. In our submission we provide a brief profile of both companies. See question 28 for further detail but if more is required it can be made available upon request.
	Conclusion 1: The original comment stands. NGGT has selected good partners with relevant skills. The concept for the project originates with the partners and it is appropriate that they should be the ones to take the project forward. However, evidence of a skills gap analysis would be preferred to demonstrate that all the required skills are available within the partners.
Sub-criterion (b.vi) – Costs associated with protection from incentives	**Challenge 1**: No information provided regarding protection from incentives.
	Answer 1: No protection from incentives is required.
	Conclusion 1: Satisfactory response.

2.3 CRITERION (C) GENERATES KNOWLEDGE THAT CAN BE SHARED AMONGST ALL RELEVANT NETWORK LICENSEES

2.3.1 Key Statements

The project would generate knowledge through;

- Improved knowledge about the condition of assets.
- Improved knowledge of the design of flanged connections.
- Improved understanding of available technology.

2.3.2 Challenges and Potential Shortfalls

Criterion (C) – Generates knowledge that can be shared amongst all relevant Network Licensees;	
Sub-criterion (c.i) – The level of incremental knowledge to be provided by the project	**Challenge 1**: The project is novel and involves development of a considerable amount of new technology. No challenge.
	Answer 1: N/A
	Conclusion 1: Satisfactory response.
Sub-criterion (c.ii) – Applicability of new learning to other Network Licensees	**Challenge 1**: The benefit to other network licensees is not clear. There may be a general improvement in knowledge about the general condition of pipe work underground, but how is this to be communicated to Licensees? In the finished prototype available to Network Licensees, the design of the prototype, or intellectual property without the design itself.
	Answer 1: As stated in our submission, Gas Distribution Networks (GDNs) are also faced with similar problems of unpiggable pipelines and pipework on AGIs. Therefore if this project is successful, GDNs will be able to benefit through adapting, where necessary, this technology for their own needs. In addition the algorithms developed by PIE for ascertaining the condition of AGIs based on the pipe condition data should also be applicable to GDNs. At the presentation to the NIC panel on 26 August, we informed the panel that we intended to modify the intellectual property (IP) arrangements. All foreground IP will be owned by NGGT. This will then be licensed to project partners or any other interested party. In addition the robotic solution would also be commercially available to other network licensees on the same terms as NGGT. With regard to GDN communications, NGGT meets every month with the GDNs to discuss projects and progress. We will use these opportunities to understand how each GDN wants to receive information and be involved in the project, e.g. witnessing testing etc. This will form part of the comprehensive communications plan, which will be developed if the project is approved.

	Conclusion 1: This is a good response, and the modification to the IP arrangement provides more clarity. All GDNs can potentially benefit from a better understanding of pipe condition and the case made in the answer is well made. The missing element is the nature of the delivery of this benefit. For example, the answer makes the case that algorithms developed by PIE are applicable to others. Does this mean that anything developed with PIE will be freely distributable to GDNs?
Sub-criterion (c.iii) – Plans to disseminate learning	**Challenge 1**: Many routes are identified in the submission to disseminate learning. However, the submission must clarify what learning it expects to disseminate.
	Answer 1: Section 5.1.a of the submission breaks the knowledge which we expect to gain from this in line robotics project into three distinguishable categories: technical knowledge, operational knowledge and data analysis. Each are described in some detail and are listed again below: ▸ **Technical Knowledge**: The technology and systems integration which are being developed throughout the course of this project regarding in line inspection robotics is something which all network licensees both domestic and abroad will benefit from. The Tech Watch at Appendix G highlights the range of available technology and importantly the fact that the technology sought for this project is simply not available. Several areas of technical knowledge which will be disseminated as appropriate will involve design, installation, commissioning and asset management. ▸ **Operational Knowledge**: Important knowledge regarding implementation including maintenance, repair procedures, risk management, safety processes and data collection. **Data analysis:** The knowledge gained as a result of the robotic inspection will allow certain algorithms to be developed in order to predict asset condition across any given network. The way in which this is collected, processed and analysed will be shared to enable the robotic technology to transcend across distribution networks.
	Conclusion 1: This response is copied from the original submission and does not advance the case made. The discussion in the original submission correctly detailed the knowledge generated and some routes for dissemination of that learning. However, the submission needs to be more explicit about the nature of the knowledge generated. For example, the discussion above regarding pipe condition algorithms developed with PIE is a good example of a specific knowledge generation deliverable. Other deliverables could be the robot design or other enabling technologies.
Sub-criterion (c.iv) – Robustness of the methodology to capture learning	**Challenge 1**: No information is presented regarding a methodology to capture learning.

	Answer 1: As stated in the submission, reports will be produced as the project progresses through each stage. Technical and operational knowledge with these reports will be captured by the PM in conjunction with the project support partners and will be formally recorded in a knowledge capture document which will be available for other network licensees to view. The data analysis knowledge will be captured and interpreted by our third party consultants Pipeline Integrity Engineers (PIE). They will then provide the knowledge to the PM who will include it in the knowledge capture document.
	Conclusion 1: Satisfactory response.
Sub-criterion (c.v) – Treatment of IPR	**Challenge 1**: The IPR section is not clear. Who owns the PIG design at completion of the project? Who owns the test rig? Who owns any patents generated by the project? What is the rationale behind the IP arrangements set out in Section 5.2?
	Answer 1: At the presentation to the NIC panel on 26 August, we informed the panel that we intended to modify the intellectual property (IP) arrangements. All foreground IP will be owned by NGGT. This will then be licensed to project partners or any other interested party. In addition, the robotic solution would also be commercially available to other network licensees on the same terms as NGGT.
	Conclusion 1: This modification clarifies the IPR arrangements.

2.4 CRITERION (D) IS INNOVATIVE AND HAS AN UNPROVEN BUSINESS CASE

2.4.1 Key Statements

The project is innovative because:

- No robotic device exists that can inspect pipe work at over 2 barg. The project will develop a device that can operate up to 100 barg.
- Novel techniques to launch and recover the device at this pressure will be developed.
- High pressure glanding arrangements will be developed.
- Tethered and/or wireless systems will be developed.
- Geo-location and tracing capabilities will be developed.

2.4.2 Challenges and Potential Shortfalls

Criterion (D) – is innovative and has an unproven business case;	
Sub-criterion (d.i) – Justification why the project is innovative	**Challenge 1**: No equivalent device currently exists and new technologies would need to be developed. No challenge.
	Answer 1: N/A
	Conclusion 1: Satisfactory response.
Sub-criterion (d.ii) – Why the Network Licensee will not fund through price control	**Challenge 1**: The submission does not make a case for why NGGT would not fund the project through a price control allowance or other funding route.
	Answer 1: The project is a good fit with the NIC criteria as it has the potential to deliver environmental and financial benefits to consumers, it will create knowledge that will be of use to the other gas networks and it is innovative. In terms of the business case, the project does have a significant level of risk and due to the scale of the project, it would be unlikely to be funded by the business at this time without the NIC funding. In addition, the majority of the benefits accrue in future price controls whereas the expenditure would be within this price control.
	Conclusion 1: Satisfactory response.
Sub-criterion (d.iii) – Why the project can only be undertaken with the support of the NIC	**Challenge 1**: The submission does not make a case for why this project could not progress without NIC funding.
	Answer 1: The project is a good fit with the NIC criteria as it has the potential to deliver environmental and financial benefits to consumers, it will create knowledge that will be of use to the other gas networks and it is innovative. In terms of the business case, the project does have a significant level of risk and due to the scale of the project, it would be unlikely to be funded by the business at this time without the NIC funding. In addition, the majority of the benefits accrue in future price controls whereas the expenditure would be within this price control.
	Conclusion 1: Satisfactory response.

2.5 CRITERION (E) INVOLVEMENT OF OTHER PARTNERS AND EXTERNAL FUNDING

2.5.1 Key Statements

- Synthotech and Premtech were chosen following an internal tendering process at NGGT.
- Other partners are available to provide support.

2.5.2 Challenges and Potential Shortfalls

Criterion (E) – Involvement of other partners and external funding;	
Sub-criterion (e.i) – Collaborators involved in the project	**Challenge 1**: The submission discusses a competitive process at NGGT whereby the project was selected from seven potential projects, based on a proposal from Synthotech and Premtech. However, assuming that better in line inspection is a worthwhile project, no evidence is presented why these two companies are the best partners to deliver this project.
	Answer 1: As stated National Grid evaluated all of the NIC ideas and proposals that we received both internally and externally. The in-line inspection of high pressure installations was evaluated as providing the greatest potential benefits and was suitably advanced for a NIC submission. Part of his evaluation involved an assessment of the project partners to ensure that they had the appropriate capabilities and track record to deliver the project. From our own experience of Premtech and through industry references and back ground research of Synthotech, we determined that our partners were capable of delivering this project. In our submission we provide a brief profile of both companies. See question 28 for further detail but if more is required it can be made available upon request.
	Conclusion 1: Evidence of a skills gap analysis or other de-risking process would be welcome. It is accepted that the partners have a wide variety of relevant skills.
Sub-criterion (e.ii) – Steps taken to identify potential partners and ideas	**Challenge 1**: A wide variety of potential partners have been identified, including industry bodies, academia and other suppliers. However, while this is welcome, it is not clear how each partner would contribute. For example, do the partners have all the skills required to deliver the project and where are the skills gaps? How are potential partners to be engaged commercially and how are does that impact the IP arrangements?

	Answer 1: This project can feasibly be delivered with the skills provided by the two central support partners (Synthotech and Premtech) and the third party consultants (PIE) alone. The additional collaborative working with academia (Leeds University), industry bodies (e.g. IGEM, UKOPA) and other suppliers serves to strengthen the project and improve dissemination. For example, NGGT has been invited to utilise Leeds University's facilities as well as its students. It is a partnership based on mutual trust and learning. Our project will allow Leeds University to be involved in the development of innovative world leading technology, thereby allowing its students insight and experience into areas where they would previously have been unable to explore. If it would be beneficial to procure services or technology from one of the other suppliers, this will be done on a contractual basis through one of our central support partners and the IP arrangements, as explained above, would be applied.
	Conclusion 1: This is a good response, however as discussed earlier a skills gap analysis at an early stage would go a long way to de-risking the project.
Sub-criterion (e.iii) – Control of project partners	**Challenge 1**: The submission adequately discusses control of the principal project partners, but not how any of the wider supply chain will be managed to deal with any technology gaps.
	Answer 1: As stated above, if it would be beneficial to procure services or technology from one of the other suppliers, this will be done on a contractual basis through one of our central support partners and the IP arrangements, as explained above, would be applied.
	Conclusion 1: The original comment stands. The submission discussed a wide supply chain, but does not provide details on how additional serviced would be procured.
Sub-criterion (e.iv) – External funding for the project	**Challenge 1**: The submission is clear. No challenge.
	Answer 1: N/A
	Conclusion 1: Satisfactory response.
Sub-criterion (e.v) – How secure external funding is	**Challenge 1**: The submission is clear. No challenge.
	Answer 1: N/A
	Conclusion 1: Satisfactory response.

2.6 CRITERION (F) RELEVANCE AND TIMING

2.6.1 Key Statements

No relevant statements made.

2.6.2 Challenges and Potential Shortfalls

Criterion (F) – Relevance and Timing;	
Sub-criterion (f.i) – The relevance of the solution to the move to a low carbon economy	**Challenge 1**: No information provided, and this is an important omission.
	Answer 1: The timing of this project is ideal. Robotic technology has only recently reached a point of maturity which enables us to consider it for this project, at the same time as the need case is emerging with our assets approaching the end of their design life. Therefore from a cost and risk perspective this is the perfect point at which to undertake this project. As stated in answer 1 above, this solution will lower the carbon intensity of operating and maintaining the gas transportation system, which is an essential component in the move to a low carbon economy.
	Conclusion 1: This is a good response and it is accepted that new technologies are available that make the project feasible. However, the original comment stands as the issue of relevance to the move to a low carbon economy has not been addressed.
Sub-criterion (f.ii) – How the method will be used as part of future business planning	**Challenge 1**: No information provided, and this is an important omission.
	Answer 1: The outcome of the project will have a direct impact on our RII0-T2 business plan. Within the asset health and maintenance expenditures the level of replacement and excavation will be adjusted based on the initial inspection results and the continued use of the technique moving forward.
	Conclusion 1: The original comment stands. The project may impact asset maintenance, but the submission does not provide detail on what the impact will be.

2.7 CRITERION (G) DEMONSTRATE A ROBUST METHODOLOGY AND THAT THE PROJECT IS READY TO IMPLEMENT

2.7.1 Key Statements

The project will

- Design a new robotic device
- Test the device using a bench test, off-line and on-line testing program.

2.7.2 Challenges and Potential Shortfalls

Criterion (G) – Demonstrate a robust methodology and that the project is ready to implement;	
Sub-criterion (g.i) – Detailed project plan	**Challenge 1**: The submission does not include any plan for the design and development of the robotic device. The submission identifies many technologies that could be used on a device, but at the outset of the project, the power, locomotion, instrumentation, control, guidance, construction, insertion and retrieval are all undefined. It is not credible that a robot can be designed in the 40 days allowed for a "Concept Study" and 110 days to construct the "Alpha prototype". The submission provides a good overview of a test plan, but provides no details on how suitable robotic concepts are to be identified, ranked, down-selected and how project risks are to be managed.
	Answer 1: The programme submitted as part of the bid is only a summary of the design tasks, in the more complex detailed program there is more clarity on the specific activities and durations of each element. As such the focus of the Global Technology Watch and Patents search have been used to support the conceptual designs for the power, locomotion, instrumentation, control, guidance, construction, insertion and retrieval, each method or technique has been considered using a Matrix and its applicability to this project, this information is defined in the more detailed documents that could not be included in this submission due to submission space restrictions. The 40 days stated for "Concept Study" is not related to number of man days (effort) during that period, this is purely a duration of the task, there will be a dedicated full time engineering design team (4+) and specialists/consultants for this project covering many engineering disciplines (Mechanical, Electronic, Software, Mechatronics), this programme of work will ensure that a detailed design scope and plan is in place prior to commencement of Alpha design phase. The 110 days for Alpha stage design do not relate to the amount of man days this is simply a duration namely 5 months. In the same way that the test plan has been detailed, the engineering team will use design reviews, assessment matrix, testing, and engagement with third parties (academic organisations) to rank solutions, this will be supported and controlled by a risk register for the project to ensure that where the risk is above a suitable threshold, clearly defined alternative solutions will be defined, this will be part of the risk mitigation process. [A copy of the full project plan is attached for information]

	Conclusion 1: The development process was not clear in the original submission. Subsequent details provided, and the answer above, provide more detail. This is welcome and clarifies many elements of the design process. However, appropriate control of the design process is essential and a robust approach to risk mitigation will be required.
	Challenge 2: The submission provides no evidence of requirements capture. Better inspection of pipes is beneficial. However, it is unclear what the 'threats' to pipe work are and how they might be mitigated. There is therefore no clear argument presented for the benefits of a new in line inspection technique. Furthermore, there is no way of quantifying the benefit of a visual inspection against a Magnetic Flux Leakage (MFL) inspection, for example. The operating environment is also poorly defined. The project specifies a robotic device that can operate at up to 100bar, but at what flow rate and for what gas composition?
	Answer 2: The requirement for the project is clear and is captured within the success criteria, which is to develop a robot that can travel 100m and navigate two bends, taking visual and wall thickness measurements. Combining this information with condition modelling algorithms, will enable us to obtain an overall view of the condition of the below ground pipework on an AGI. We are proposing a package which combines visual, wall thickness and laser profiling measurements in order to create an inspection as robust as that of pigging and MFL. The operating environment is well understood by both NGGT and the project partners, details of flow rates, pressure and gas composition form part of the robotic platform specification requirement.
	Conclusion 2: The requirement for the device and the success criteria are very different things. The first is a formal understanding of why the device is required and what the benefit is. The latter is a definition of what success means. The original challenge is not answered.
	Challenge 3: The submission provides no evidence of risk identification, management or mitigation. This project is technically very high risk. A method by which the risk can be tracked and reduced is essential. The submission includes a short risk register (Appendix E) but this is very brief and does not include sufficient detail.

	Answer 3: In developing the NIC submission, the project team has met a number of times and discussed risks. Based on the tightly defined scope the project is rated as medium risk as documented with our submission. We have listened to the concerns of both the panel and taken on-board the feedback from the consultants' report and will undertake an externally facilitated risk exercise ahead of the final NIC presentation. This exercise is in addition to the risk policy and workshop that has been planned if the project is approved.
	Conclusion 3: This is a welcome addition. Satisfactory response.
	Challenge 4: The submission does not discuss the difficulties of the launcher and receiver. For example the submission mentions tethered devices, but the technical challenges of integrating an umbilical to the robot through a 100 barg pressure barrier and then retrieving the umbilical after deployment are very high. The upstream oil and gas industry has regular problems with launchers and receivers for the simplest hydraulic PIGs, including personnel injury, even at low pressures.
	Answer 4: National Grid has successfully conducted pigging operations on many high pressure pipelines without notable incident, the potential for an incident is fully recognised and controlled by design, training and procedures, site specific NRO (Non-Routine Operations) and RAMS (Risk And Method Statements) and also required to manage the operation and the risk. The difficulties associated with the robot launch and receive vessels are expected to be no greater than those associated with pipeline PIG traps (vessels). The robot vessels should be smaller and less complex with fewer connections such as bridles and bypasses. High pressure seals through the robot vessel are being considered, high pressure seals are used in other industries in similar high pressure applications, typically offshore. The seals including the different types / manufacturers of seals will be fully considered and evaluated (technical and safety) during the project. The seals will also be evaluated against not having the seal by having the umbilical device within the pressurised robot vessel, as the connection through the vessel would be far less complex. It is fully recognised that there is a significant technical challenge of integrating an umbilical to the robot and then retrieving the umbilical afterwards.
	Conclusion 4: Satisfactory response.
Sub-criterion (g.ii) – Resources to deliver the project	**Challenge 1**: It is very unclear whether the project partners have the resources to deliver the project. The lack of a plan, design methodology and risk appreciation in the submission mean that is difficult to assess whether the partners have the skills and experience to deliver the project.

	Answer 1: **Premtech** is a current National Grid framework Designer for the provision of gas design services, as part of the award of this framework Premtech was fully assessed and evaluated both technically and commercially by National Grid. This assessment and evaluation fully considered planning and delivery skills / capability, plus experience and resources necessary to deliver design projects to National Grid. It is noted that Premtech are also an SGN framework Designer for the provision of gas design services and therefore would have gone through similar assessments by SGN. Premtech is an ISO 9001, ISO 14001 and OHSAS 18001 certified company. Premtech is also certified by Achilles and is a registered UVDB (Utilities Vendor Data Base) supplier. Premtech have and are successfully delivering a number of innovation projects to National Grid, including Building Information Modelling (BIM), Direct Replacement Preheat Package (DRPP) and renewable power for installations. **Synthotech Ltd:** is a UK based Small Medium Enterprise (SME) specialising in the development of technologies for the utilities industry. Synthotech are innovative engineering company providing 'Turn Key solutions' with a proven track record for design, development, manufacture and supply of services. Synthotech have extensive experience of inventing and developing innovative solutions for the four UK Gas Distribution Network Operators under both the Innovation Funding Initiatives (IFI) and more recently under the Network Innovation Award (NIA). Since 2009 Synthotech have specialised in the development of robotic solutions for the 4" to 48" Pipes, focusing on providing in-pipe intelligence though visual and non-destructive assessment of the asset. Synthotech have undertaken and successfully delivered three robotics projects under IFI, and two under NIA focused on asset assessment during live gas working, ensuring gas supplies to consumers are not interrupted and ground excavations are minimised, reducing environmental impacts. Synthotech also recently won the prestigious innovations award at the Gas Industry Awards 2013 and was short listed for 'company of the year' and 'innovation' in 2014. Synthotech is an ISO 9001, 14001, 18001 and PAS99 certified company. Synthotech is certified by Achilles Link-up and is a registered UVDB (Utilities Vendor Data Base Supplier). Synthotech has also aligned its self with strategic partners such University of Leeds, The Technology Partnership (TTP), as well as the IMechE, IET and IGEM to provide additional expertise and support as well as sharing learning. Due to restrictions on the submission in terms of content, page count it has not been possible to include the detail behind the submission, this detail would clearly support and show that in the preparation of the bid that both partners (Synthotech and Premtech) have the experience, passion and capability to deliver this project and as such have through support from NGG, Rhead, PIE fully understood the design methodologies and risks associated, this is why the project is stage gated to ensure that clear target and objectives against the plan have been fully met and reviewed before commencing the next phase.

	Conclusion 1: This is a good, robust response. The partners have a broad set of skills relevant to this project and it is accepted that the format of the submission does not make it easy to communicate this. A formal skills gap analysis would help demonstrate the skills available.
Sub-criterion (g.iii) – Project can be started in a timely manner	**Challenge 1**: There is no indication that the project could not be started in a timely manner. No challenge.
	Answer 1: N/A
	Conclusion 1: Satisfactory response.
Sub-criterion (g.iv) – Customer impact and planned mitigations	**Challenge 1**: No specific claims are made in the submission regarding customer impact.
	Answer 1: The project will not have a direct impact on customer's premises nor is it planned to cause any interruptions to supplies. The project does not require any customer disconnections or interruptions during installation or operation of the in line robotic equipment. The safety and security of supply will have the highest priority throughout the project duration with existing safety precautions being maintained or improved during every operational change or engineering operation.
	Conclusion 1: Satisfactory response.
Sub-criterion (g.v) – Costs reasonably estimated	**Challenge 1**: A summary costing spreadsheet is supplied together with an outline plan in the form of a Gantt chart. However, there is insufficient detail supplied to form an opinion of the planning of project costs.
	Answer 1: An additional internal costs spreadsheet highlighting costs per partner by category (labour, eqpt, comms, 3rd party contractors and IT) was sent following initial proposal submission. This has been sent again with these responses.
	Conclusion 1: The additional information is welcome, together with the development plan. Satisfactory response.
Sub-criterion (g.vi) – Contingency funding for cost over-runs	**Challenge 1**: What contingency is planned for and what is outside of scope?
	Answer 1: In preparing the bid and costings, all partners and NGGT have assessed the risks involved and have built in an appropriate risk margin. No specific events e.g. the loss of a robot, have been built into the costings, this will be at the risk of NNGT and the partners.

	Conclusion 1: This response is clear, however it is important that this liability for major project event is reflected contractually.
Sub-criterion (g.vii) – Robustness of proposed methodology	**Challenge 1**: The methodology proposed is not well defined and not robust. For example the project plan appears to only allow for the construction of one prototype. Should this prototype fail or be damaged, then how would the project cope? More importantly, should the testing of the prototype show that the prototype is not suitable for the proposed task, what is the course of action? Given the high cost of the test facilities, would it not be best to plan for several competing prototypes, or a modular prototype that can test a range of technologies?
	Answer 1: The project allows for the construction of a robotic solution(s), the solution ultimately cannot be determined at this early stage in the project, the robotic platform will be modular in construction and therefore be flexible and adaptable and will have a number of tools to perform specific tasks. The project will deliver a working prototype, Synthotech would as an OEM and designer be able to repair, re-build and problem solve any issues that may arise during the course of the project. The test facility is key to the successful development and testing to provide a robust solution in a controlled environment, where issues can be simulated with no risk to the robot, personnel or plant. Synthotech will use a clearly defined road map for design and development, with robust project management principles (PRINCE2), staged gated to manage risk and increase success, during this whole process Synthotech will be supported by partners within the HUB as detailed in the appendix of this submission . If at any stage the specific deliverables are not being met, then through a robust governance, compliance and control process with NGGT decisions will be made to whether the project progresses to the next stage.
	Conclusion 1: This is a good response. The key aspect here is the appropriate choice of stage gates and success criteria.
	Challenge 2: The submission does not include any mention of operational risks. For example, what is the projected failure rate of the device? How is the PIG retrieved if it fails within a pipe? What is the consequence of a failure in the launcher/receiver and how is this to be managed?

	Answer 2: All operational risks will be highlighted in the risk workshop and recorded in the risk policy if the project is successful. However some thought has already been given to the issues highlighted in this question. For example, if the inspection robot is lost it can either be left in situ (if it does not have any impact or restriction on the future operation of the AGI), or will be removed. The removal of the robot may involve isolating the existing pipework section to allow a section of pipework to be removed for the recovery of the inspection robot. The inspection robot will be fitted with a tracker device, so its location will be known. Through the proposed design and testing (offline and online) of the inspection robot, plus detailed knowledge of the pipework system being inspected, the likelihood and risk of losing a robot is deemed low.
	Conclusion 2: Satisfactory response.
Sub-criterion (g.viii) – Quality of success criteria	**Challenge 1**: The submission includes firm, clear, milestones that agree with the project plan presented. However, these success criteria monitor progress of the project, not success. The submission defines ultimate success to be release of the robot into Business As Usual (BAU) service. However, it does not define the levels of reliability and availability that are acceptable for BAU. Acceptable performance in terms of how much pipe can be inspected per day, what type of inspection could be performed and at what cost, are not presented.
	Answer 1: The success criteria reflect whether the project is being managed well and we are making the progress that is anticipated. Each milestone is essential in terms of achieving the overall deliverable and therefore we believe these are appropriate milestones to monitor. In terms of overall success this will be measured by the release of a robotic platform into BAU which can travel 100metres and negotiate 2 bends whilst taking wall thickness and wall condition measurements. The exact percentage of AGI pipework which the robotic platform will be able to inspect is yet to be determined. Ultimately 0% is currently inspected so any increase, however minor, will be perceived as success. If 30% could be inspected for example, PIE will be able to utilise algorithms to provide an assessment as to the asset condition of the remaining pipework at the AGI. It is intended that internal inspection of wall condition and thickness should be achieved. Implementation costs are yet to be defined but they are expected to be low and will likely utilise the Pipeline Maintenance Company.

	Conclusion 1: This is a good response, and it is accepted that the current success criteria reflect project management. However, the aim of the project is not to demonstrate good management, but to deliver good engineering. A well managed project might still 'fail' if an engineering solution cannot be found for a particular problem. The final deliverable (a robot that can travel 100m around two bends) is good. What is missing is a gated process that controls the engineering development with meaningful milestones. This should be part of a formal risk mitigation process.
Sub-criterion (g.ix) – Verification of all information in the proposal	**Challenge 1**: No information supplied.
	Answer 1: In preparing the NIC submission the information and material have gone through a number of internal challenge and review procedures, before sign off from Neil Pullen, the Project Sponsor, who is the Director of Gas Transmission Asset Management, We can confirm that all information provided in this proposal is true to the best of our knowledge.
	Conclusion 1: Satisfactory response.
Sub-criterion (g.x) – Risk mitigation process	**Challenge 1**: The submission provides no evidence of risk identification, management or mitigation. This project is technically very high risk. A method by which the risk can be tracked and reduced is essential. The submission includes a short risk register (Appendix E) but this is very brief and does not include sufficient detail.
	Answer 1: See answer 26 above.
	Conclusion 1: See g(viii) above.
	Challenge 2: No consideration is given to personnel risk. Pigging operations do cause injury, especially during launch and recovery. This issue is specifically important given that a key aspect of the robotic device is capable of operating in live pipe work at 100 barg. Launch and recovery therefore require venting gas at 100 barg.
	Answer 2: Safety lies at the heart of how National Grid does business. NGGT has clear and robust safety processes which will be adhered to throughout the duration of the project. The project management plan highlights a number of occasions throughout the project where Formal Process Safety Assessments will be written and promulgated. These will be referred to throughout the risk policy and personnel risk will be discussed in detail during the risk workshop.

	Conclusion 2: Satisfactory response.
Sub-criterion (g.xi) – Processes for suspension of the project	**Challenge 1**: The submission discusses this in overview, but provides no specific processes or metrics for project suspension.
	Answer 1: If, using EVM techniques, it is perceived that the health of the project is poor an immediate Integrated Baseline Review will take place. The project sponsor will have access to all project material, projected health and will be given a number of courses of action by the project lead. The project will receive a series of corrective actions. The project may be suspended until such time as any corrective actions have been completed. There would be consequential overruns both in terms of budget and schedule. In which case a consequential change of that significance would need to be incorporated into the baseline as a formal change.
	Conclusion 1: See g(viii) above.

3. INITIAL RESPONSE SUMMARY

This section summarises the response to the initial review of the submission and the formation of the challenges.

NGGT propose to develop a new type of robotic inspection device. No comparable device exists and such a device could deliver a real benefit as the industry moves towards a condition based asset management strategy. It is likely that a range of supporting technologies would need to be developed to facilitate this project and as such, the project is very innovative.

The testing procedure is extensive and includes bench testing, off-line testing on a bespoke test rig and on-line testing. Although details of the test procedure are not supplied, it is likely that a successful test can be delivered for the time and cost allotted.

Several weaknesses in the submission have been identified as follows:

- Technical Risk. The submission does not include any plan to characterise the requirement, understand the impact of new inspection techniques, perform a robust cost/benefit analysis or manage development of the robot. The technical risks are therefore very high and the submission presents little supporting evidence to show that the project could be successfully delivered.

  The overriding concern is whether the technical challenge of developing this system is within the capability of the partners. The submission does not adequately demonstrate that the partners have appropriate skills or a plan to deliver a successful project.

- Environmental Benefit. The project does not advance a low carbon economy, but it does provide environmental benefits by potentially reducing unnecessary excavation. However, the case made for the environmental benefits is not well thought out and may overestimate the benefits. Negative environmental impacts have not been considered.

- Business Case. A successful project would give NGGT, and other Network Licensees, a valuable tool to enable pipeline inspection. This may result in cost savings for the Licensees and better value for money for gas customers. However the arguments presented in the submission are not robust.

- Knowledge Generation. The knowledge generated by the project is principally the design of a validated robotic device and any associated intellectual property (IP). While the submission discusses sharing of the IP with other Network Licensees, the principal product of the project is a design of robot. It is not clear how other Network Licensees would benefit from the robot itself, the robot design or the IP behind the robot. The knowledge sharing should be clarified.

4. FINAL RESPONSE SUMMARY

Following receipt of the answers to the challenges raised, comments have been prepared for each response. In general, the responses are positive and provide good argument and relevant additional information. These responses, together with the presentation by the partners have clarified many of the issues and reduced concerns raised. Other documentation, specifically a project plan, have been received and used as part of the review.

At initial review we identified four areas of concern. These concerns are addressed below.

- Technical Risk. This remains the principal concern, although further information has been supplied related to the skills available within the team, development process and some risk mitigation. It is recognised by all that this is a technically challenging project and the stated goal is both achievable and worthwhile.

  Most of the remaining concerns can be addressed by a revised project plan with realistic, but quantifiable milestones and agreed criteria for project termination in the case of insurmountable engineering challenges.

- Environmental Benefit and Business Case. There is no doubt that better inspection would allow better risk based management of ageing assets. However, more quantitative evidence of the environmental benefits and business case would make a stronger case.

- Knowledge Generation. Changes to the IP arrangements are welcome. A clearer understanding of how the project would benefit the wider industry directly and indirectly would be useful.