NIC Robotics SDRC 9.2 Report

Development of Conceptual Designs & Element 4 Consultation

14th December 2015

Sam Wilson

SGN

Your gas. Our network.

Contents

1 Document Control

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Version Control

Version	Status	Date	Owner	Action
V1.0	Draft	09/12/2015	James Heywood	Initial draft
V1.1	PM Review	10/12/2015	Sam Wilson	Review
V1.2	Final Draft	11/12/2015	Sam Wilson	Final draft
V1.3	Project Director Review	11/12/2015	Angus McIntosh	Changes for approval
V1.4	Regulation Review	14/12/2015	Paul Mitchell	Regulation Review
V1.5	Project Director Approval	14/12/2015	Angus McIntosh	Final Approval

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2 Executive Summary

The purpose of this document is to satisfy the deliverables which form the SDRC 9.2 milestone, document the learning gained from the development of Elements 1, 2 & 3 and present the outcome of the consultation for the conceptual design developed under Element 4 of SGN's NIC Robotics project.

The objective of the NIC Robotics project is to develop new, cutting edge robotic repair, inspection and remediation technology which can operate inside live gas distribution mains. The project was designed with four key elements to deliver the outputs listed in the original bid submission.

- Element 1 – Development of a robotic 'platform' and launch system to enable deployment of modular repair and inspection devices for metallic 12 to 48" gas mains
- Element 2 – Development of an internal metallic joint sealing module and Weco seal repair method for metallic 12 to 48" gas mains
- Element 3 – Robotic visual and non-visual inspection
- Element 4 – Automated live asset replacement for distribution services for tier 1 mains

Elements 1, 2 & 3 of the project are almost complete with only the final reports to submit to Ofgem on the 18th January 2016. The CIRRIS XR & XI systems shown in figure 1 below were successfully field trialled under live gas conditions on SGN's south London network with all testing and SDRC criteria met.

Figure 1 – CIRRIS XR™ - The Repair Robot (Left), CIRRIS XI™ - The Inspection Robot (Right)

In the initial NIC bid submission, Element 4 of the project was designed to run concurrently with the first three elements of the project. When the funding was awarded, it was stipulated in the project direction that element 4 should have a delayed start date to enable the learning to be taken from the development of the first three elements and for the chosen conceptual design to be shared with SGN's key stakeholders to gather feedback before progressing to the detailed design phase.

Since the start of element 4 on the 6th July 2015 ULC have investigated in detail four different design concepts for the robotic platform and have assessed them against the key form factors identified. The key learning from the research and design of each concept has been recorded as part of this report, with consideration given to the use of the robot in practice, the ease of duplication and the commercialisation of the system. The report clearly highlights the reasons behind the selection of the chosen conceptual design and the potential benefits the system could deliver.

The selection of insertion and connection techniques to be progressed highlights the importance of ULC's experience in the research and development of robotic solutions for the utility industry. The learning gained through the development of the Elements 1, 2 & 3 provided significant benefits allowing ULC to assess the theory behind the design principles by utilising a number of cutting edge technologies including rapid prototyping, 3D modelling and in house prototype testing. Consideration has been given to key aspects such as deployment, retrieval, surveying and live connection operations to ensure the final solution can be practically applied across the GB gas distribution networks.

As stipulated in the project direction document, once research had been carried out to identify a viable technique and a conceptual design had been developed a consultation period must be held to share it with

SGN's key stakeholders. The consultation was designed to determine if there was a place for the technology in the GB market and support from SGN's key stakeholders for the continuation of the project through to field trial. SGN have used a number of methods to engage stakeholders throughout the consultation period, with an animation created detailing the potential benefits of the system and how it will operate.

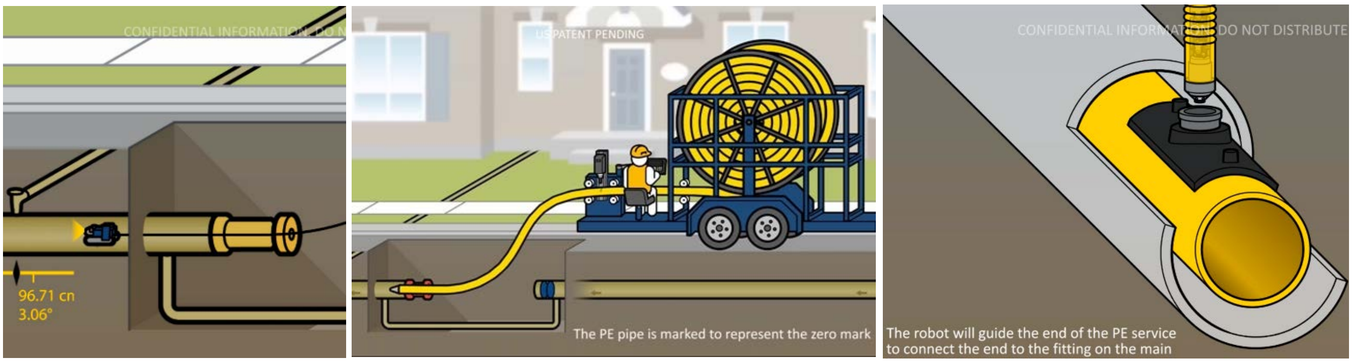


Figure 2- Preliminary concept for remotely connecting service lines proposed by ULC. Robotics platform is inserted into the main to map the location of all features (left). Custom fittings are installed on to a section of PE pipe to be live inserted (centre). Service lines are inserted using ULC designed adaptor to create connection (right).

The results of the consultation period were extremely positive, with wide support for the conceptual design from a variety of key stakeholders including the GDN's, Highways Agencies, Local Council's and industry experts.

Following the success of elements 1, 2 & 3 of the project, the quality of the conceptual design developed by ULC and the support shown by SGN's stakeholders, SGN recommends element 4 of the project continues in line with the project plan in the project direction. This report contains details the relevant learning from E1, 2 & 3 and how it will be applied, the conceptual design process and the results of the consultation. An independent appraisal by RPS technical consultants supporting the continuation of the project and the viability of the conceptual design can also be found in the appendices.

3 Background

Across the GB gas distribution networks, network operators are required to replace specified lengths of metallic mains under the RIIO price control. Over the next 6 years (until 2021) across both its Scottish and Southern networks, SGN will replace approximately 6,800km of 4”-8” Tier 1 Iron mains and relay 389,000 metallic services with new PE pipe.

Due to the GB GDN (gas distribution networks) sizes being approximately 4:2:1:1 with SGN being the second largest, it’s possible to estimate a total length of 27,200km of 4”-8” Tier 1 Iron main and 1.56 million metallic services will be replaced under the current price control. The significant volume of replacement work still to be carried out over this price control period alone presents an opportunity to develop and introduce new techniques to lower the cost, environmental impact and disruption caused whilst carrying out replacement activity.

The current replacement of gas distribution service piping requires the excavation of trenches into which the pipe is laid. However, a technique known as pipe insertion allows for the installation of distribution piping with reduced excavation, resources, permitry and restoration costs.

Pipe insertion is the process of inserting a smaller pipe into an existing, larger one as seen in Figure 3. The process currently provides a means for gas companies to cost effectively replace large sections of main. Pipe insertion is a good option in situations where a lower capacity of gas would satisfy the needs of a given area or where the network pressure can be increased in order to match or exceed the existing network capacity.

Pipe insertion can be further broken down into two commonly applied methods, dead insertion and live insertion. For dead insertion a pipe is temporarily disconnected from the existing gas distribution network. Typically, an excavation is made at suitable access points on the existing gas main. A cut-out of an excavated section of main is created and a new polyethylene (PE) pipe is pulled or pushed into the section of existing main. This method is typically used for insertion lengths of under 200m, customers are interrupted for the duration of these works.

Figure 3 - A new PE main inserted within a parent metallic main with the service reconnected

For live insertion, a pipe is inserted into a live gas main and services replaced using a specialist foam off technique developed by Steve Vick™.

Once the entire length of main has a new PE pipe inserted inside of it each individual service pipe connection must be connected to the new piping. The customer’s service is the pipe which extends from the main in the street to the customer’s emergency control valve, just upstream of their gas meter. In order to connect the newly inserted PE main to the customer’s service, excavations are created at the point in which each customer service line meets the existing main. The connection between the new main and the existing service is performed manually by a skilled operative. The requirement for excavating over each service creates significant planning and execution costs and increases supply interruption and disruption to customers.

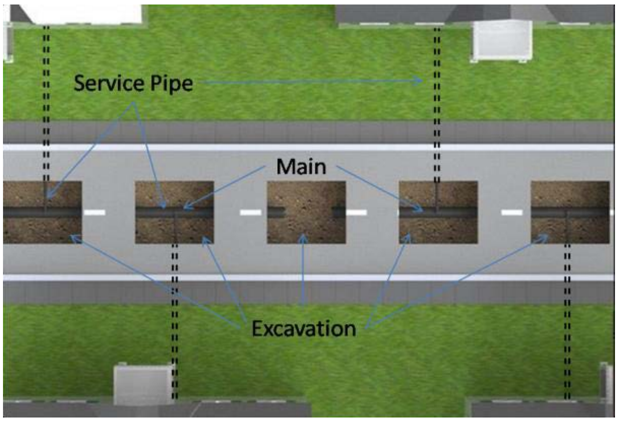


Figure 4 - Service Excavations Plan View

In order to eliminate the need to excavate over each service an in situ means of connecting newly inserted PE pipe to service lines is needed. Research has been carried out under element 4 of SGN's NIC Robotics project and a viable conceptual design has been developed which has the potential to be a disruptive technology in the market.

Once Element 4 of the project had begun one of the first actions was to develop a preliminary high level specification which was subsequently approved by the project team in line with the original bid document. The key criteria from the document have been listed below. For clarity the specifications in this section have been separated by their respective areas of the overall system design. These areas have been further broken out by what are considered general and detailed specifications.

Robotic Transport Mechanism & Equipment Package

- The system will be designed to operate under live conditions.
- All or parts of the system may enter the annular space between the newly inserted PE pipe and the existing main or it may enter inside the newly inserted PE pipe.
- The system will provide a means of performing live, internal asset replacement for distribution services and tier 1 mains.
- The system will provide an appropriate means for lighting and obtaining video feedback of the operations while inside the pipe.
- It is anticipated the system will enter live gas mains via a SGN approved fitting as appropriate.
- It is anticipated that the robotic system may provide the ability to:
  - Traverse to a service location
  - Transport a fitting to the service location
  - Tap multiple holes in the PE mains pipe
  - Permanently install and connect PE fittings at the hole locations to the inserted PE service pipe from a single excavation point
  - Inspect the new service-mains connection to assess its integrity
- The system will be informed by relevant British standards.
- The system will be tested to ensure safe operation inside live gas pipes. Each component of the robot, including drive systems, repair tools, electronics and pneumatic components will be tested individually to ensure that all systems function as designed.

Support & Control Equipment

- Provide a means for remotely powering, monitoring and controlling the robotic transport mechanism, its associated equipment and the launch system.
- The system will operate within an appropriately sized site footprint.

ULC researched a number of concepts and rated them against the agreed specifications above. The outcome of the research are detailed throughout this report. Once the chosen conceptual design had been identified an animation was developed to support the consultation process and allow SGN to gather feedback from its key stakeholders. This report contains detail of the learning taken from the successful development and field trial of E1, 2 & 3 of the project, the chosen conceptual design developed by ULC and the results of the consultation carried out by SGN.

4 Project Direction Funding Criteria – Element 4

In the initial NIC bid submission from SGN, Element 4 of the project was designed to run concurrently with the first three elements of the project. Unlike the first three elements which all relate to a shared robotic platform, element four is designed for a very different task and environment with significant technical challenges that will need to be overcome.

When the funding was awarded, it was stipulated in the project direction that element four should have a delayed start date to enable the learning to be taken from the development of elements one to three, and for the chosen conceptual design to be shared with SGN's key stakeholders to gather feedback before progressing to the detailed design phase.

A summary of the key criteria set in the project direction document has been listed below with the actions taken by SGN to satisfy each provided on the right of the table. SGN believe all of the criteria have been successfully met, with the associated evidence contained within this report.

Criteria	Evidence Produced
(i) The progress and development, including learning to date, of Modules 1, 2 and 3, as described in the Full Submission (Project Description).	A report documenting the learning from E1, 2&3 and how it can be applied to the development of the Element 4 system has been written by ULC robotics and SGN. This can be found in Appendix A and summarised in Section 5 of this report respectively. Further details of the design, manufacturing and testing processes and the learning developed has been documented in the PPR (Project progress reports) and 38 deliverable reports submitted to SGN and RPS by ULC throughout the project. The PPR's are available on SGN's dedicated project webpage. All of the deliverable reports are saved in the project file and are available on request.
(ii) The learning gained through the Conceptual Design Stage (internal stage gate 13 in the SDRC) for Module 4, including any technical and functional specifications and designs for Module 4.	ULC have extensively researched a number of different concepts that could have been used and assessed them against the agreed specifications. A design has been chosen and researched in depth using 3D modelling and prototyping techniques. Details of each design and their technical specifications can be found in ULC's SDRC9.2 report in Appendix A. RPS and SGN have conducted a gap analysis against the specifications identified in the original bid submission. A preliminary controlled testing plan has been created to ensure that the product developed achieves the requirement defined in the Bid Document. This can be found in Appendix C and Section 5 respectively.
A proposed methodology for the development of Module 4, as described in the Full Submission (Project Description). This must include a description of the technologies that will be used in Module 4. It must also include an explanation and justification of why these technologies have been chosen, based on the learning described in (i) and (ii).	ULC's SDRC9.2 report contains the specifications and performance criteria of the chosen design and the reasons behind the selection of it over the other technologies researched.

A description of the process and steps taken by the Funding Licensee to consult with other Network Licensees and interested third parties on whether, based on the information provided in (i), (ii) and (iii), proceeding past the Conceptual Design Stage and thus further developing Module 4 would provide the learning outlined in the Full Submission pro-forma. This must include a written consultation.	Dissemination was achieved through a number of different avenues to ensure that the relevant stakeholders were given the opportunity to provide both verbal and written feedback to the project team. This was carried out using a number of different methods: • A detailed animation of the conceptual design was distributed to all key stakeholders explaining the proposed conceptual design, the benefits the system can provide and the key performance characteristics. A copy of the animation has been submitted with this report. • Monthly GIGG (Gas Innovation Governance Group) presentations since the selection of the chosen design with updates as to the projects progress between the GB GDN operators. • SGN presented a copy of the animation on its NIC robotics stand at the LCNI conference held in November 2015. The event was attended by over 1000 delegates with discussions held with a number of interested parties. The display also provided information about the technology developed in Elements 1, 2 & 3 including a 3D printed model with information on the outputs of the project and its anticipated impact for asset management, and the CIRRIS XI inspection system available on ULC's stand. A presentation was given in the network resilience breakout session, with an explanation of the E4 conceptual design presented. • During the field trial period for Elements 1, 2 & 3, SGN and ULC invited all GB GDN's and key stakeholder groups to attend its Kennington depot field trial site. A presentation was given to the GDN's who attended providing information regarding the technology developed under Elements 1, 2 & 3, the learning taken from the development process, and the expected outputs. The CIRRIS XI™ system was operated with full access to the control vehicle and one to one discussions with the project team to answer further questions. A presentation and discussions were held on the Element 4 of the project and SGN's intentions for the next steps. • The animation was redistributed with the questionnaire to provide an easy platform for the GDN Network Licensees and wider stakeholder group to provide written feedback to the project team. This questionnaire has been distributed out to 160 recipients across the UK with ULC distributing it further to their global network. A full list of the stakeholder groups who were sent the animation and questionnaire is available on request.

	• All elements of the NIC robotics project have been presented at a number of industry wide conferences including the Asset Infrastructure Conference, Safe and Efficient Street Works workshops held by SGN that were attended by over 70 key industry stakeholders, National Joint utilities group functions and IGEM. SGN have been requested to present at a number of international conferences in 2016 where E4 of the project will be presented to the wider gas industry.
The written responses to the written consultation described in (iv) together with summaries of all other feedback received. The Funding Licensee must describe the consideration it has given to the feedback provided by other Network Licensees. It should explain how the feedback has informed its approach to delivering Module 4 and how this feedback supports its request to either proceed with Module 4 or suspend the project.	Following on from the presentation of the conceptual design at various industry events, SGN distributed the conceptual design animation with a questionnaire to key stakeholders to gather written feedback. The feedback received can be found in Appendix E of this report. The results of the questionnaire issued to key stakeholders including industry experts, local councils, highways authorities as well as interested gas customers have been analysed and presented in section 7 of this report. The feedback received as a result of the stakeholder engagement activities carried out has been extremely positive. The amount of research carried out by ULC resulting in an advanced conceptual design being chosen provides real confidence that the concept will deliver the benefits identified in the bid document if the investment in the next phases of the project is received. SGN recommends the funding to be provided in line with the project plan in the project direction.

5 SDRC 9.2 Criteria

Element 4 – Automated live asset replacement for distribution services and mains for tier 1 mains

Development of Conceptual Designs (Element 4) by 14th December 2015

The criteria below has been extracted directly from the project direction document for reference. SGN confirm that all criteria have been met.

Criteria

- Research and conceptual design will have been performed into methods of performing no-dig service replacement with a robotic system.
- Various tools and methods will be considered, with judgment criteria based on effectiveness, ease of deployment, technical feasibility and cost in line with the target price. ULC Robotics will have drawn upon its past experience performing field service work related to gas services and will have referred to performance specifications provided by SGN.
- Considerations for the robot design will have included size requirements for maneuvering inside the pipe or annular space, form factor, drive system and power transmission, pneumatic systems, electronic power requirements, tapping and fitting tools to be carried by the robot, service line testing, and travel distance.
- A report outlining these findings and suggestions will be delivered by ULC Robotics to SGN.
- SGN will review the proposed replacement method, carry out a risk assessment and gap analysis against the identified specifications (for example relevant sections of GIS/LPL22) in order to determine what the offsite and on site testing success criteria will be. This will include an independent assessment by one of SGN's technical service providers.
- Provided the method identified has the potential to be deemed an acceptable means of no-dig service replacement, the project will progress.

Evidence:

- Delivery of technical report that looks to provide a means of robotic no-dig service replacement.
- Approval and sign off by Project Director depending on the outputs of the report.
- All specifications, designs and supporting documentation to be documented in the Project file.

5.1 Summary Table

The table below summarises the evidence produced against each milestone heading. A summary of the key developments is shown in the Project Managers section of this report and in ULC's report in Appendix A.

Criteria Defined	Evidence Produced
The supplier will research and a conceptual design will have been performed into methods of performing no-dig service replacement with a robotic system.	ULC has conducted research and a conceptual design has been developed for performing no-dig service replacement with a robotic system. The mission requirements and capabilities were used to guide the conceptual design. The conceptual design presented in this report is intended to provide an effective means for robotic no-dig service replacement. Details of the chosen design and the other concepts researched can be found later in this report and in the Learning Outcomes section of ULC's report in the Appendices.

The Supplier's will research various tools and methods will be considered, with judgment criteria based on effectiveness, ease of deployment, technical feasibility and cost in line with the target price.	ULC has researched various tools and methods for remote service replacement. The judgment criteria for each was based on effectiveness, ease of deployment, technical feasibility and anticipated operations cost. The relevant performance specifications were used to inform the conceptual design process. Details can be found in the Learning Outcomes section of ULC's report in the appendices.
Considerations for the robot design will have included size requirements for maneuvering inside the pipe or annular space, form factor, drive system and power transmission, pneumatic systems, electronic power requirements, tapping and fitting tools to be carried by the robot, service line testing, and travel distance.	The conceptual design takes into consideration size requirements, form factor, drive system and power transmission, pneumatic systems, electronic power requirements, tapping and fitting tools to be carried by the robot, service line testing, and travel distance.
A report outlining these findings and suggestions will be delivered by supplier to SGN.	ULC has submitted a full technical report detailing the research carried out and various conceptual designs to provide a means of robotic no dig service replacement. Comprehensive design details have been provided to SGN supported by an animation showing how the system will work in practice. The full report can be found in Appendix A.
SGN will review the proposed replacement method, carry out a risk assessment and gap analysis against the identified specifications (for example relevant sections of GIS/LPL22) in order to determine what the offsite and on site testing success criteria will be. This will include an independent assessment by one of SGN's technical service providers.	SGN have reviewed the proposed design with the project steering group. A gap analysis has been carried out using the specifications identified in the original bid document by RPS. The full gap analysis can be found in the appendices of this document in RPS's SDRC9.2 report.
Provided the method identified has the potential to be deemed an acceptable means of no-dig service replacement, the project will progress.	SGN, ULC and RPS believe the chosen conceptual design developed by ULC has the potential to deliver significant benefits to gas consumers and the general public and the project should be progressed through the design process leading to the field trial of the system.

Evidence Required	Evidence Produced
Delivery of technical report that looks to provide a means of robotic no-dig service replacement.	ULC have submitted a full technical report providing a number of conceptual designs to provide a means of robotic no dig service replacement. Using the agreed criteria ULC have identified a primary design. The full report can be found in Appendix A
Approval and sign off by Project Director depending on the outputs of the report.	As with all NIC Robotics reports, the Project Director has reviewed the content of this report and approved the proposed approach and report content.
All specifications, designs and supporting documentation to be documented in the Project file.	All specification, design and supporting documentation has been submitted to the project team, reviewed and documented. All additional documentation is available upon request.

5.2 Proposed Conceptual Design for Element 4

Executive Summary

The SDRC9.2 report submitted by ULC Robotics to SGN and subsequent assessment and supporting documentation supplied by RPS demonstrates a thorough understanding of the challenges posed by the environment this system will need to operate in. The chosen design meets all of the key criteria highlighted in the NIC bid document with the varying types of designs investigated demonstrating a number of different design concepts have been thoroughly reviewed prior to the selection of the chosen concept.

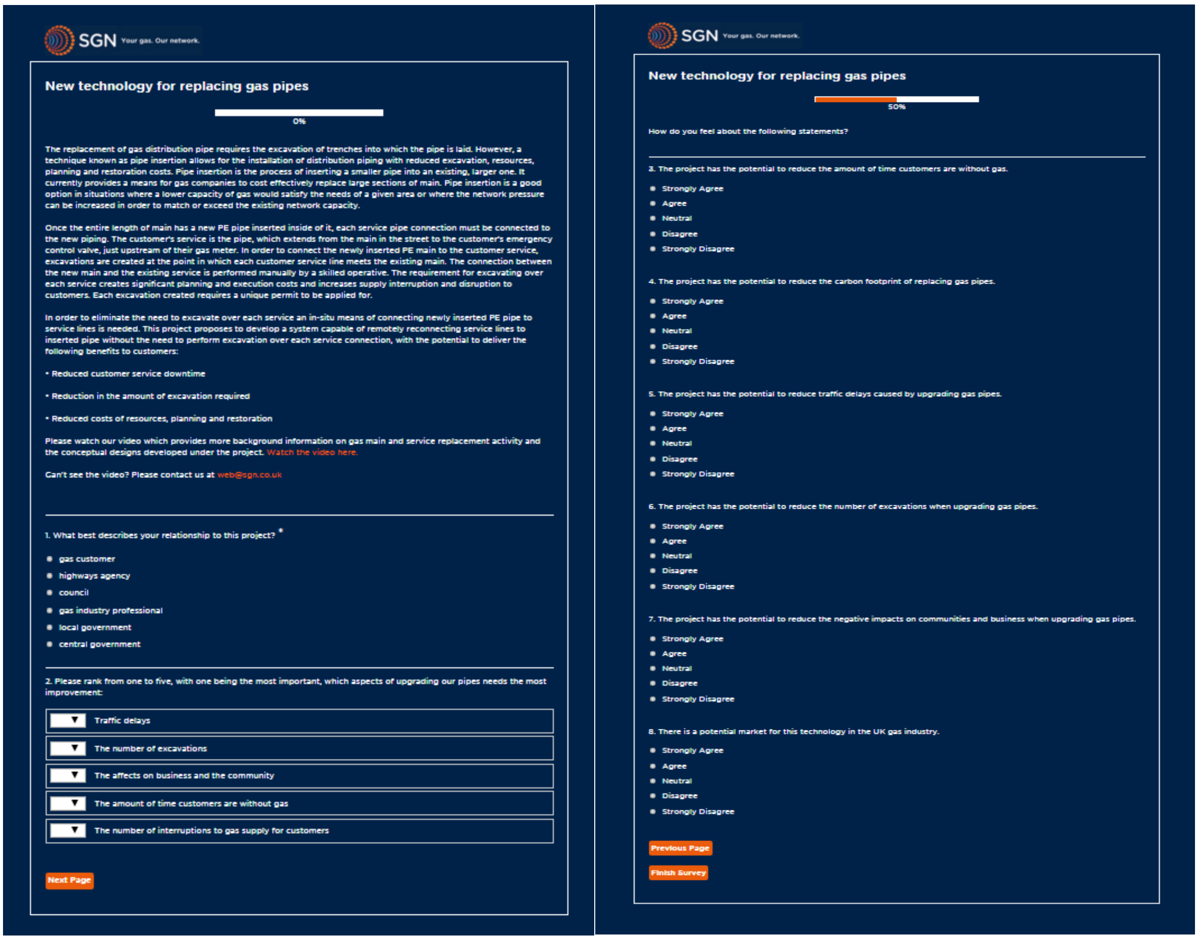
ULC have investigated in detail four different design concepts for the robotic platform and have assessed them against the key form factors identified. The key learning from the research and design of each concept has been recorded as part of the report, with consideration given to the use of the robot in practice, the ease of duplication and the commercialisation of the system. The report clearly highlights the reasons behind the selection of the chosen conceptual design and the benefits it presents as well as the areas where there's an opportunity to stretch the goals set at the start of the project.

The selection of insertion and connection techniques to be progressed highlights the importance of ULC's experience in the research and development of robotic solutions for the utility industry. The learning gained through the development of the Elements 1, 2 & 3 provided significant benefits allowing ULC to assess the theory behind the design principles by utilising a number of cutting edge technologies including rapid prototyping, 3D modelling and in house prototype testing. Consideration has been given to key aspects such as deployment, retrieval, surveying, connection operations and repeatability of the operation to ensure the final solution can be practically applied across the GB gas distribution networks.

In light of the report content, and supported by RPS as an independent technical consultant, SGN recommends that funding is awarded for the continuation of the project past the conceptual design phase.

Research and concept development

After an expansive and intense conceptual design phase, which included meeting with vendors and visiting various SGN replacement projects, the team at ULC Robotics arrived at a conceptual design for the live asset replacement robotic system. This primary concept was selected through a process that included evaluating a wide variety of other concepts generated by not only the project team, but the entire ULC engineering staff and the wider NIC robotics project team. All of the concepts researched have been detailed in ULC's report with additional supporting information available on request.



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New technology for replacing gas pipes

0%

The replacement of gas distribution pipe requires the excavation of trenches into which the pipe is laid. However, a technique known as pipe insertion allows for the installation of distribution piping with reduced excavation, resources, planning and restoration costs. Pipe insertion is the process of inserting a smaller pipe into an existing, larger one. It currently provides a means for gas companies to cost effectively replace large sections of main. Pipe insertion is a good option in situations where a lower capacity of gas would satisfy the needs of a given area or where the network pressure can be increased in order to match or exceed the existing network capacity.

Once the entire length of main has a new PE pipe inserted inside of it, each service pipe connection must be connected to the new piping. The customer's service is the pipe, which extends from the main in the street to the customer's emergency control valve, just upstream of their gas meter. In order to connect the newly inserted PE main to the customer service, excavations are created at the point in which each customer service line meets the existing main. The connection between the new main and the existing service is performed manually by a skilled operative. The requirement for excavating over each service creates significant planning and execution costs and increases supply interruption and disruption to customers. Each excavation created requires a unique permit to be applied for.

In order to eliminate the need to excavate over each service an in-situ means of connecting newly inserted PE pipe to service lines is needed. This project proposes to develop a system capable of remotely reconnecting service lines to inserted pipe without the need to perform excavation over each service connection, with the potential to deliver the following benefits to customers:

• Reduced customer service downtime

• Reduction in the amount of excavation required

• Reduced costs of resources, planning and restoration

Please watch our video which provides more background information on gas main and service replacement activity and the conceptual designs developed under the project. Watch the video here.

Can't see the video? Please contact us at web@sgn.co.uk

1. What best describes your relationship to this project? *

- gas customer
- highways agency
- council
- gas industry professional
- local government
- central government

2. Please rank from one to five, with one being the most important, which aspects of upgrading our pipes needs the most improvement:

- Traffic delays
- The number of excavations
- The affects on business and the community
- The amount of time customers are without gas
- The number of interruptions to gas supply for customers

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New technology for replacing gas pipes

50%

How do you feel about the following statements?

3. The project has the potential to reduce the amount of time customers are without gas.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

4. The project has the potential to reduce the carbon footprint of replacing gas pipes.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

5. The project has the potential to reduce traffic delays caused by upgrading gas pipes.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

6. The project has the potential to reduce the number of excavations when upgrading gas pipes.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

7. The project has the potential to reduce the negative impacts on communities and business when upgrading gas pipes.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

8. There is a potential market for this technology in the UK gas industry.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

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Finish Survey

Figure 18 – image of the questionnaire sent to key stakeholders

Survey Results

1. What best describes your relationship to this project?			Response Percent	Response Total
1	gas customer		20.83%	15
2	highways agency		12.50%	9
3	council		20.83%	15
4	gas industry professional		37.50%	27
5	local government		6.94%	5
6	central government		1.39%	1
Analysis	Mean: 3.01; Std. Deviation: 1.32; Satisfaction Rate: 40.28		answered	72
	Variance: 1.74; Std. Error: 0.16		skipped	0

2. Please rank from one to five, with one being the most important, which aspects of upgrading our pipes needs the most improvement:		
Item	Total Score [1]	Overall Rank
Traffic delays	273	1
The number of excavations	243	2
The affects on business and the community	217	3
The amount of time customers are without gas	200	4
The number of interruptions to gas supply for customers	147	5
[1] Score is a weighted calculation. Items ranked first are valued higher than the following ranks, the score is a sum of all weighted rank counts.	answered	72
	skipped	0

3. The project has the potential to reduce the amount of time customers are without gas.			Response Percent	Response Total
1	Strongly Agree		43.06%	31
2	Agree		44.44%	32
3	Neutral		11.11%	8
4	Disagree		0.00%	0
5	Strongly Disagree		1.39%	1
Analysis	Mean: 1.72; Std. Deviation: 0.77; Satisfaction Rate: 18.06		answered	72
	Variance: 0.59; Std. Error: 0.09		skipped	0

4. The project has the potential to reduce the carbon footprint of replacing gas pipes.

			Response Percent	Response Total
1	Strongly Agree		41.67%	30
2	Agree		40.28%	29
3	Neutral		15.28%	11
4	Disagree		1.39%	1
5	Strongly Disagree		1.39%	1

Analysis	Mean:	1.81	Std. Deviation:	0.84	Satisfaction Rate:	20.14	answered	72
	Variance:	0.71	Std. Error:	0.1			skipped	0

5. The project has the potential to reduce traffic delays caused by upgrading gas pipes.

			Response Percent	Response Total
1	Strongly Agree		59.15%	42
2	Agree		35.21%	25
3	Neutral		4.23%	3
4	Disagree		1.41%	1
5	Strongly Disagree		0.00%	0

Analysis	Mean:	1.48	Std. Deviation:	0.65	Satisfaction Rate:	11.97	answered	71
	Variance:	0.42	Std. Error:	0.08			skipped	1

6. The project has the potential to reduce the number of excavations when upgrading gas pipes.

			Response Percent	Response Total
1	Strongly Agree		65.28%	47
2	Agree		29.17%	21
3	Neutral		4.17%	3
4	Disagree		0.00%	0
5	Strongly Disagree		1.39%	1

Analysis	Mean:	1.43	Std. Deviation:	0.7	Satisfaction Rate:	10.76	answered	72
	Variance:	0.5	Std. Error:	0.08			skipped	0

7. The project has the potential to reduce the negative impacts on communities and business when upgrading gas pipes.

			Response Percent	Response Total
1	Strongly Agree		45.83%	33
2	Agree		41.67%	30
3	Neutral		9.72%	7
4	Disagree		1.39%	1
5	Strongly Disagree		1.39%	1

Analysis	Mean:	1.71	Std. Deviation:	0.81	Satisfaction Rate:	17.71	answered	72
	Variance:	0.65	Std. Error:	0.1			skipped	0

8. There is a potential market for this technology in the UK gas industry.				
			Response Percent	Response Total
1	Strongly Agree		45.83%	33
2	Agree		43.06%	31
3	Neutral		8.33%	6
4	Disagree		0.00%	0
5	Strongly Disagree		2.78%	2
Analysis	Mean: 1.71	Std. Deviation: 0.84	Satisfaction Rate: 17.71	answered 72
	Variance: 0.71	Std. Error: 0.1		skipped 0

[redacted]

Appendix C - RPS Element 4

SDRC Report 9.2
Assessment of Element 4 Conceptual Design

Document Control Sheet

Client:	SGN
Project Title:	Network Innovation Competition (NIC) Robotic Solutions
Document Title:	SDRC 9.2 Report – Assessment of Element 4 Conceptual Design
Document No:	MDR1025Rp0031

Text Pages:	18	Appendices:	-

Rev.	Status	Date	Author(s)	Reviewed By	Approved By
F01	Final	14th December 2015	Feargal Fanning Ian MacHugh	Ian MacHugh Ciarán Butler	Ciarán Butler

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EXECUTIVE SUMMARY

The latest gas distribution price control (RIIO) was introduced in Great Britain in April 2013. The objective of RIIO is to encourage the gas distribution network owners to play a full role in the delivery of a sustainable energy sector and to do so in a way that delivers value for money to customers.

In pursuit of these objectives in August 2013, SGN (formerly Scotia Gas Networks) in partnership with ULC Robotics of New York USA submitted the Robotics Project to Ofgem for funding consideration through the Gas Network Innovation Competition (NIC). This was approved for funding in December 2013 subject to Project Direction by Ofgem. RPS was appointed by SGN as Technical Service Provider to all of the Elements of the Robotics Project.

The Robotics Project Submission for the NIC to Ofgem was an ambitious and innovative project to enable SGN and other network operators to manage the gas distribution network in a safer more economical manner. Despite the ongoing transformation to polyethylene pipe, over 80,000 km of Great Britain's distribution system is metallic and subject to aging and deterioration.

The objectives of Elements 1, 2 & 3 were to develop new robotic technologies to operate inside live metallic gas mains. This new technology would have the ability to remotely repair leaking mechanical joints, failed Weco seals and also support pipe fracture risk management processes by providing enhanced inspection capabilities. This involved the development of two robotic systems; CIRRIS XI™, the inspection robot, and CIRRIS XR™, the repair robot. Both systems have undergone field trials and are awaiting final reports before these Elements will be closed out.

Pipe insertion is an established technique which involves pushing a polyethylene (PE) pipe into a larger metallic main as a means of replacement. This provides the benefit of reduced excavation costs during this main insertion. However, currently, each service line that ties into this section of main requires an individual excavation to connect it. Element 4 of the Robotics Project involves developing robotic techniques to integrate the pipe insertion method with a method of remotely connecting the service pipes without needing to carry out individual excavations. Successful completion of this project will result in further reductions in impacts to the public, reduced environmental impacts and cost savings to the gas distribution networks implementing the system.

The primary concept design, outlined by ULC in their “Element 4 Development of Conceptual Designs” Report, provides confidence that the goals of Element 4 of this Project can be achieved. This design has been assessed by RPS and high level criteria for testing have been outlined. These criteria will be addressed though testing within ULC’s facility, on dead test pipes and in live gas pipes during field trials as appropriate. As the design progresses further, more refined tests to be carried out will be determined amongst the project team.

A gap analysis of the conceptual design against relevant standards has been carried out. This is useful to inform the designers of any requirements from the relevant standards and possible conflicts. RPS has noted that the conceptual design does not appear to conflict with any of these standards, although the system will have to be regularly reviewed against these as the design progresses. The conceptual design conforms with SGN’s Pro-forma submission to Ofgem and Ofgem’s Project Direction. It is noted that the project is progressing as planned, on schedule and within budget.

1 INTRODUCTION

This report has been developed by RPS to assess the conceptual design of the Element 4 robotic systems, as outlined in ULC's "Element 4 Development of Conceptual Designs" Report and the animation produced to support this. Through conducting a review of the design against various relevant documents and standards, RPS has identified a number of high level testing requirements for the systems.

RPS has assessed ULC's Conceptual Design Report against the following documents:

1. The Full Submission Pro Forma by SGN to Ofgem.
2. The Project Direction from Ofgem to SGN.
3. The SGN, Industry and British Standards:

    a. ATEX 137
    b. ATEX 95
    c. GIS/ECE1:2008
    d. GIS/F10:2006
    e. GIS/F16:2006
    f. GIS/LC14:2009
    g. GIS/PL2-1:2008
    h. GIS/PL2-2:2008
    i. GIS/PL2-3:2006
    j. GIS/PL2-4:2008
    k. GIS/PL2-5:2006
    l. GIS/TE/E1.9:2006
    m. GIS/TE/P6.3:2007
    n. IGE/TD/3
    o. IGE/TD/4

This report also reviews the Successful Delivery Reward Criteria (SDRC) for this stage of the Project (9.2). This report serves as fulfilment of part of the SDRC.

Appendix E - Written feedback received from Field Trial attendees

The quotations below were received from key stakeholders who attended the field and provided feedback to the team on their experiences whilst on site.

Feedback Comments
I wanted to thank you and your team for being such fantastic hosts on Tuesday and Wednesday. I really enjoyed the demonstration and I was very impressed with the work that has been done to date to develop the robot. I have had great feedback from both the operational side of the business and our GDSPs and I look forward to trialling CIRRIS in Q1 next year.
I'd like to thank SGN for the hospitality and opportunity to see the device and some of its outputs. It was a very useful visit. Also we both noticed how the entire ULC site team from technical/software/electronics/operational staff worked so closely and effectively together, notably during the fault repair and re-testing processes. Mike and Greg can be very proud of them and we'd like to pass on our good wishes to them as well.
It was really good to see the CIRRIS Robot live and to have the technical and operational details of it explained.
I just wanted to say thanks for having us down for the demo event on Tuesday. It was great to see the progress you've made and meet the team.
Many thanks to you, to your team and the ULC team for CIRRIS demonstration today. The innovation, skill and enthusiasm was fantastic. It was good to get a first – hand sense of the challenges involved in delivering industry innovation. Please thank everyone involved today.
Thank you to you and your team for the demonstration today. It was an excellent opportunity to see the latest innovation coming out of the gas NIC, and great to see it in operation on the network assets. It is often only when you see the technology in practice you appreciate the scale of the challenges, both technically and physically! I was very pleased to hear developments are progressing to the planned timeline. I look forward to seeing the benefits of this technology being further developed and applied widely on the gas network.....and seeing the benefits of this technology feeding into RIIO 2. Many thanks again to your team and the team from ULC for taking the time to explain things so thoroughly.
Thanks again for arranging this afternoon - very impressive. I look forward to seeing you at LCNI.
Without doubt you, SGN and ULC, are to be congratulated on the significant technological development, learning and achievements your robotics project has delivered. Thank you also for sharing information on the final phase of your robotics project with us. Your concept for this phase is extremely strong, straight forward in principle yet challenging on a number of fronts. However, we are sure that through an innovative R & D trial process, direct and indirect solutions will be found to meet the deliverables and SGN's main business drivers:- network improvement, reliability and improved safety, significantly reduced jobsite environmental impact, reduced risk to your employees, customers, general public and your business. Reduced excavations, reinstatement and traffic delays, all generally improving your business efficiency and at the same time reducing your construction cost. Whilst challenging we can see this final phase opening up new innovation to make replacement of service connections very exciting.