NIC Robotics
Project Progress Report Two

19th December 2014

Sam Wilson

NIC Robotics Project Manager

Your gas. Our network.

Contents

1 Document Control

Key Contributors

Name	Company	Contact Detail
Sam Wilson	SGN	sam.wilson@sgn.co.uk
Mike Passaretti	ULC Robotics	mpassaretti@ulcrobotics.com
David Phelan	RPS	david.phelan@rpsgroup.com
Angus McIntosh	SGN	angus.mcintosh@sgn.co.uk
SGN Robotics Team	SGN	robotics@sgn.co.uk

Version Control

Version	Status	Date	Owner	Action
V1.0	Draft	28.11.2014	Project Team	Initial draft
V1.1	PM Review	04.12.2014	Sam Wilson	Review
V1.2	Final Draft	08.12.2014	Sam Wilson	Final draft
V1.3	Project Director Review	16.12.2014	Angus McIntosh	Changes for approval
V1.4	Regulation Review	16.12.2014	Jenny Rogers	Changes for approval
V1.5	Director sign off	17.12.2014	Angus McIntosh	Sign off and approval

Reviewers

Name	Job Title
Sam Wilson	NIC Robotics Project Manager
Angus McIntosh	NIC Robotics Project Director
Jenny Rogers	SGN Regulation Team

Distribution List

Name	Company	Contact Detail
Angus McIntosh	SGN	angus.mcintosh@sgn.co.uk
Jenny Rogers	SSE	Jenny.1.rogers@sse.com
Keavy Larkin	Ofgem	Keavy.larkin@ofgem.gov.uk
Networks Innovation	Ofgem	Networks.innovation@ofgem.gov.uk

2 Executive Summary

The purpose of this document is to report on the progress the project has made since the last submission on the 19th June 2014 and the key deliverables over the next six months of the project. The report contains a summary of the progress made from SGN, with subsequent reports from ULC Robotics as the principle project partner, and RPS as the technical consultant.

The aim of the Robotics project is to develop a robotic system to be used in a live gas main to perform the following functions:

- Element 1 - Development of a robotic 'platform' and launch system to enable deployment of modular repair and inspection devices for tier 2 and tier 3 pipe
- Element 2 - Development of an internal mechanical joint installation module and Keyseal repair method for tier 2 and tier 3 pipe
- Element 3 - Robotic visual and non-visual inspection
- Element 4 - Automated live asset replacement for distribution services and mains for tier 1 mains

The project aims to realise the benefits of these methods on certain gas operations (tier 2-3 gas mains) in an attempt to reduce traffic congestion, overall excavation foot print, inspection time and general inconvenience to customers.

Since the last project progress report was published the project has progressed as planned in line with the project plan and budget, successfully delivering each milestone and targets listed in PPR1. A list of the key deliverables is shown below, a breakdown of each can be found throughout this report.

- Successful delivery of SDRC9.3 – Source Vendor for Sensors (E3)
- Creation of detailed design and fabrication specification for the robotic tool head (E1 & E2)
- Creation of both the initial conceptual designs, and subsequent 3D design of the launch tube
- The project website has been published and contains all project detail, a document library, animations and blog facility
- Promotion of the project at the 2014 Low Carbon Network and Innovation Conference (LCNI Conference)
- Manufacture of a test rig and pipe samples sourced from the live network for controlled testing

The past six months have seen the project progress from the initial research and conceptual design phases, identifying key suppliers and the requirements of the system, through to the exciting stage of defining the design of the operating system. One of the most critical aspects of the project to date was to identify appropriate vendors who are capable of supplying the types of sensors required in line with agreed specifications and the target price. This has been achieved successfully and within the projected timescales laid out in the project plan. Multiple vendors were identified following a worldwide search, and a number of leading companies have been brought in to the project.

Another key area has been the development from conceptual designs through to the final fabrication design of the robotic platform and the repair module developed under E1 & E2, shown in Figure 1 below.

2.2 Learning Summary

In line with PPR1, the project learning outcomes will be divided into two categories of dissemination: internal and external. The goal of the project dissemination plan is to ensure accessibility to, and dissemination of the project results and methods. The plan details the format and timescales of the internal and external dissemination modes, ensuring transparency and effective communication with all stakeholders. A plan demonstrating the way knowledge is disseminated between these two groups can be see on page 20.

Notable dissemination activities since PPR1 include the creation and publication of the website, containing detail on all aspects of the project, a blog facility and links to contact the project team with any queries. Internal sharing with key contacts including the stakeholder team and key department heads throughout the business through bimonthly steering group meetings. Attendance at the LCNI Conference (http://www.lcniconference.org/) and presentation of the project in the Customer Impacts session at the event.

3 Project Managers Report

The project has entered in to an extremely exciting and important stage where the theory and research conducted during the first stages of the project are being put in to practice. The operating platform and associated supporting equipment designs are being finalised and moved through the manufacturing process in preparation for the build of the first prototype. This is an extremely important time for any project, amplified by the intricacies of the robotic systems under development and the potential for the operating costs to escalate unless consideration is given to how the system will function when in operation.

The system will operate across a wide variety of pipe diameters from 12" to 46", and slight alterations to the design will be required dependant on the diameter range the system is operating in to allow it to function efficiently. There was a risk that designing a solution for all of the diameters at the same time could result in slippage in the project schedule and over spend on the detailed design phase. To mitigate this risk once the replicable design for the entire diameter range had been selected, the group decided to focus the initial detailed design for manufacture on the 24" diameter system. This will allow us to develop, manufacture and test the prototype, exposing any issues in a common diameter range. A fully operational 24" transport platform and repair module will be ready for controlled testing in April 2015. Any improvements to the design which are identified as a result of the testing will be incorporated in to the final designs for the other diameter ranges.

Another key development that emerged through the detailed design phase regarding the practicalities of operating the system is the method in which the transport platform will be utilised. One approach being explored initially was that the modular system would allow for the same transport platform to be used for both the sensor and repair modules, with the central payloads being 'swapped' out on site depending on the operational requirements at the time. We have opted to utilise the modularity in the design differently, with the long term vision of how the system will operate in a commercial sense. The result will be two separate operating systems, with the same transport module design utilised for both independent of each other to allow the use of each function at the same time. This will reduce the complexity of the design and allow improved functionally of each module and the associated support equipment. Further detail is given in the design summary below on page 9.

To date the project has progressed as planned, with no variation to the project schedule or budget and no variance to the project scope in the original bid submission. Figure 5 shows the financial spend on the project to date.

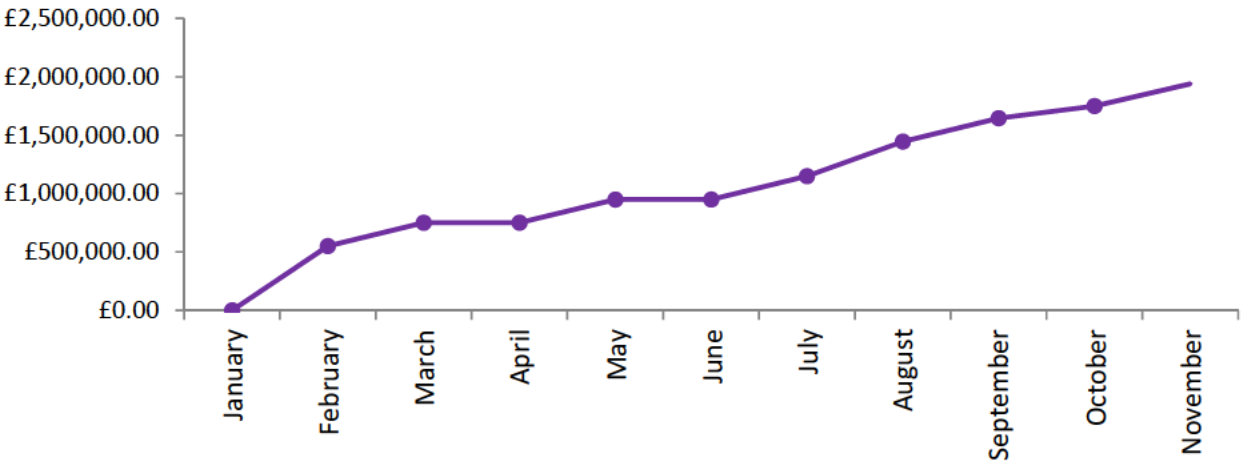

Figure 5 – Total project expenditure to 2nd December 2014

Identify how the data provided by the sensor payload can be integrated in to the Mains Prioritisation Risk Score (MRPS) package

A key outcome of the project is to determine how the data being produced by the sensor module can be utilised to provide a true reflection of asset condition. A method of integrating the data in to an asset management process similar to the MRPS (Mains Risk Prioritisation Score) used for Tier 1 (2" to 8" metallic) mains across GB will need to be created. Figure 19 shows the key factors that currently contribute to the MRPS Risk Model.

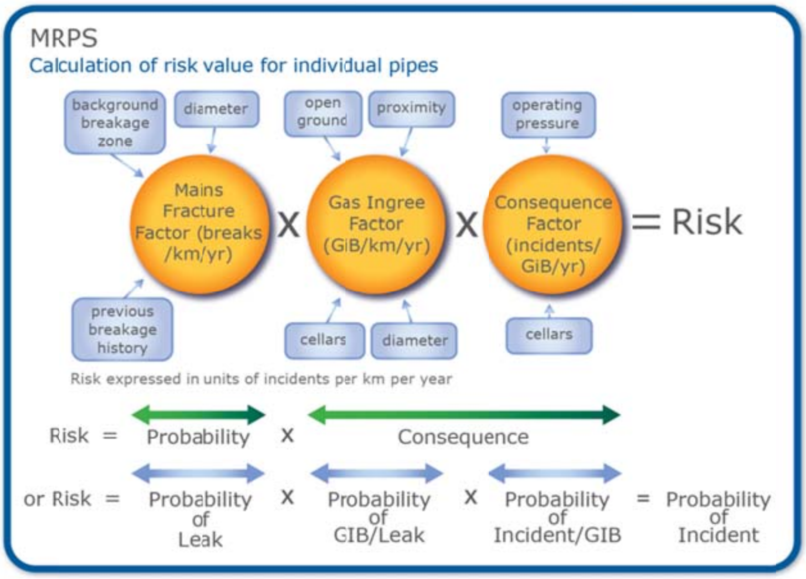

Figure 19 – Graphical summary of the main MRPS risk model for Tier 1 pipes

To ensure the project team have a firm understanding of how the existing risk model works, SGN have arranged a workshop with key asset integrity engineers from SGN and its external consultants to discuss how the types of data currently, and where the data captured by the sensor package can influence a similar model for Tier 2 & 3 mains. The model will need to give a clear indication of the level risk associated with the asset, if any immediate action is required to remediate pipe barrel, and the frequency of future surveys to prolong the asset life.

4 Consistency with Full Submission

At this stage of the project there are no variances to the Full Submission document published on the Ofgem website[1].

5 Risk Management

At this stage of the project there are no risks above the green, low risk category on the project risk register. A number of changes have been made since the last PPR submission, a summary of the main changes are listed below:

Selection of vendors for sensors – **Original Score 10** – **Current Score 5**

One of the highest risks to the project at its commencement was the ability to identify a technology to be used remotely in the challenging environment of a live gas main, to the agreed target price. The research conducted by ULC in to the available technology and suppliers, and the subsequent selection of primary and secondary vendors has resulted in satisfactory mitigation of the risk and a reduction in its score. Detail of the selection process and the chosen technology can be found in the Project Managers Report section.

Capabilities of the tether for E1, E2 & E3 – **Original Score 5** – **Current Scores 5**

One of the most challenging aspects of the tether design is combining all of the required power, communication, consumable supply and functional strength to cover the functionality of the repair module and the sensor module in one tether. The complexity of the tether design was a key factor when deciding to separate the operation of the repair module and sensor module to two separate transport platforms, allowing a specialised tether for each function which share key characteristics to be developed. To cover the change, the design of each tether has been divided in to two separate items on the register, item 22 for E2, and 23 for E3 operations. Both remain low risk items.

Operation of the Robot in a live gas main – **Original Score 8** – **Current Score 8**

As mentioned above, the decision to separate the operation of the repair and sensor module between two platforms has resulted in changes to the complexity of the design and the operation of each process. This change has been documented in the risk register, but no change has been made to the risk score which is at its lowest rating.

Launch tube development – Original Score – Risk not listed as a standalone item – **Current Score 4**

For early versions of the risk register the launch tube specification was covered by the design capabilities for Elements 1, 2 & 3. For review v1.9 it was agreed that this item needed to be listed on the register as a separate item due to the criticality of the launch tube on the system operation. The experience gained by both SGN and ULC from the large CISBOT operation, and the delivery of the 3D design for the launch tube by ULC has provided confidence that the final design will operate effectively. As a result; a low risk level has been calculated. The next key review of the launch tube will be conducted when the detailed manufacturing documentation has been produced in January 2015.

[1] https://www.ofgem.gov.uk/ofgem-publications/84774/gasnicsubmissionfromscotiagasnetworks-robotics.pdf

6 Successful Delivery Reward Criteria

The SDRC 9.1 report was successfully submitted on 25th April 2014 and SDRC 9.3 was successfully submitted to Ofgem on 27th July 2014. A summary of the content of SDRC9.3 can be found in the Project Managers Report section of this report.

The next SDRC due, report 9.4 will be submitted in August 2015 (see Figure 20) and covered in the next project progress report. At this time there are no outstanding risks which could impact on the delivery of this report or any of the remaining SDRC's.

SDRC	Due	Description	Status
9.1	28/03/2014	Development of conceptual designs (Element 1&2)	**Submitted**
9.2	14/12/2015	Development of conceptual design (Element 4)	On target
9.3	27/08/2014	Source vendor for sensor (Element 3)	**Submitted**
9.4	03/08/2015	Configuration of testing with robotic platform (Element 3)	On target
9.5	17/04/2017	Tapping and fitting tool validation (Element 4)	On target
9.6	04/12/2015	Launch robot (Element 1&2)	On target
9.7	04/12/2015	Launch robot (Element 3)	On target
9.8	13/10/2017	Launch robot (Element 4)	On target

Figure 20 – Table of SDRCs

The full SDRC breakdown can be viewed using this link below:

https://www.ofgem.gov.uk/ofgem-publications/85427/projectdirectionforroboticsincl.projectplanv2.pdf

7 Learning Outcomes

The main outputs of this project are the technical and engineering knowledge gained whilst researching new methods to assess and remediate the existing gas distribution network. Therefore it is essential that learning opportunities generated by this project are successfully disseminated for GB GDN's, the wider gas community, national and international standard bodies, academia, local authorities and other key stakeholders. Learning will be disseminated so that the technology can be incorporated by all GB GDNs upon successful completion of the project.

At present a large proportion of the design work and specification can't be shared with external parties due to the IPR conditions concerning the design. Dissemination of this information prior to patent approval could jeopardise the commercial aspects of the system, and impact on the financial return to the GB gas consumer and SGN. This has been factored in to the Stakeholder engagement plan, with the majority of key events planned after the expected approval date of the patents. An update on the IPR conditions of the project can be found in section 12 of this report.

Figure 21 summarises the key learning outcomes to date, and how they have been disseminated both internally and externally.

Key Learning Outcomes
Development of launch tube conceptual design
Research into sensor suppliers and application of equipment and technology in a live gas main
Development of a tether guide and incorporation into the launch tube design
Separation of the sensor and repair modules into distinct operations with their own tether
Practical testing of a transport platform to transport a 'payload' inside a live gas main

Internal Dissemination
Naming competition – engaging with all members of the business to submit a name for the robot
Steering group meetings – to obtain support from all areas of the business
Publication of robotics website – so members can access information
Provision of robotics email address – to provide a direct line of communication to the project team
Innovation piece in company team brief to inform the wider business

External Dissemination
LCNI Conference – promoting the progress of the project and making the project team available for inquiries to gas industry personnel
Publication of reports on Ofgem and SGN websites – highlighting the progress to date
Publication of robotics website – allowing anyone to access project detail and view progress
Provision of robotics email address – to provide a direct line of communication to the project team

Figure 21 – Key learning outcomes and the ways they have been disseminated

7.1 Dissemination

The project team attended the LCNI conference along with the rest of the Innovation team. This event was hugely successful and allowed the Robotics team to showcase a project overview and an info-film to reach out to a wide range of stakeholders. The project team received positive and constructive feedback from GDNs and the general response to the project was one of enthusiasm and interest. Figure 22 shows the Project Manager presenting the Robotics concept at the conference.

Figure 22 Project Manager presenting the Robotics project at the LCNI Conference.

Naming Competition

The Robotics team have engaged staff across the business in hope that staff may have suggestions to name the robot. The competition was a success with 72 suggestions - the team are currently going through the entries to determine if there are any that would be commercially robust.

Project Website

The project website has now been published both internally and externally. The release of the new website was delayed slightly so that it could be included to conform to SGNs new brand. Some of the items that will be included on the new website are as follows:

- Overview of the project – drive behind it, element breakdown and 'meet the team'.
- LCNI Conference 2014 video – this is shows an overview of some of the objectives and reasons for the project.
- Redacted versions of all key reports.
- Blog facility with regular updates on project progress.

Figure 23 shows screen shots of the Robotics webpage which is currently available in the public domain (https://www.sgn.co.uk/Innovation/Innovation-NIC-Robotics/)

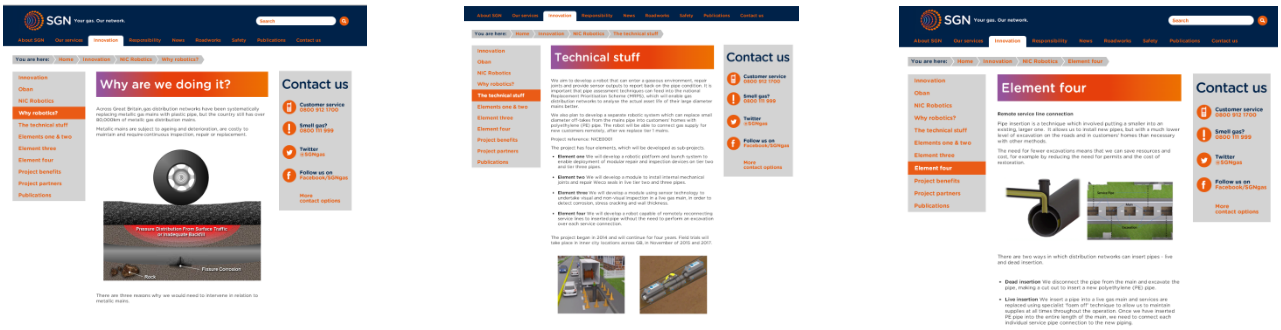

Figure 23 – the Robotics website

National Joint Utility Group (NJUG) Awards

The 2014 NJUG street works awards ceremony was held at the House of Commons in November and SGN were awarded the prestigious Outstanding Contribution to Street Works award for previous and on-going works with robotics technology (Figure 24).

Figure 24 – NJUG Awards

Prior to the start of the NIC Robotics project, SGN worked with ULC on the NIA Large CISBOT project and carried out the first live field trial of the system. The aim was to remediate 370m of 24" Cast Iron pipe from two excavations in Woolwich, London. The success of the trial led to a 9.1km commercial package starting in July 2014 utilising the Large CISBOT system on Cast Iron main sizes from 18" to 30" across SGN's network. Learning from the trial and the commercialisation of a robotic platform which shares operational similarities to the systems which are being developed under the NIC project has been extremely beneficial and learning will be incorporated whenever possible in the design of the system. All of the knowledge has been shared with the other networks to assist with use of the system.

Speaking at the NJUG Awards, Robert Goodwill MP, the Parliamentary Under-Secretary of State at the Department for Transport, described robotics as a 'game-changer'.

This view was echoed by Bob Gallienne, NJUG CEO who said: "Between 2010 and 2040, traffic on our roads is expected to increase by 43 per cent, so the challenge facing utilities, local authorities and their contractors will be to find new ways of minimising disruption to road users. The only way the industry will meet this challenge will be through innovation and collaboration, and I believe SGN's CISBOT system will deliver the step-change that is needed to do this."

Review and Support of National Grid Transmission 2014 NIC Bid

For the 2014 Network Innovation Competition National Grid Transmission (NGT) submitted a proposal to develop a robotics solution to perform the survey and maintenance of high pressure transmission pipelines. Given the success of SGN with robotics previously, and in winning funding for this project for the 2013 NIC bid, NGT asked our company to review their proposal and ensure there is no duplication with funding for the two projects.

The SGN NIC robotics team reviewed the proposal document and issued written support for the NGT's project, highlighting there will the potential for some shared learning, particularly in relation to the sensors used to determine asset integrity and our willingness to share this information when appropriate.

A copy of the letter sent to NGT can be found in the appendices of this report (Appendix D).

8 Business Case Update

At present there are no changes to the business case that was submitted in the full submission pro-forma report, or the target prices set. The Robotics team believes that over the next six month reporting period; no changes will be required.

9 Progress against Plan

At present the project is progressing in line with the project schedule agreed as part of the project direction. Reports from both RPS and ULC Robotics confirm the successful progression of the project to date.

The RPS report condenses and summarizes the PPR from their point of view as our technical consultants and highlights any concerns or areas of interest in the project they feel needs to be monitored closely. ULC Robotics has also provided a condensed report as the principal project partner.

Both of these reports can be found in Appendix B (RPS PPR Summary Report) and Appendix A (ULC Robotics PPR Summary Report).

10 Progress against Budget

There is currently no variance in the budget. The project expenditure can be viewed graphically in Figure 25.

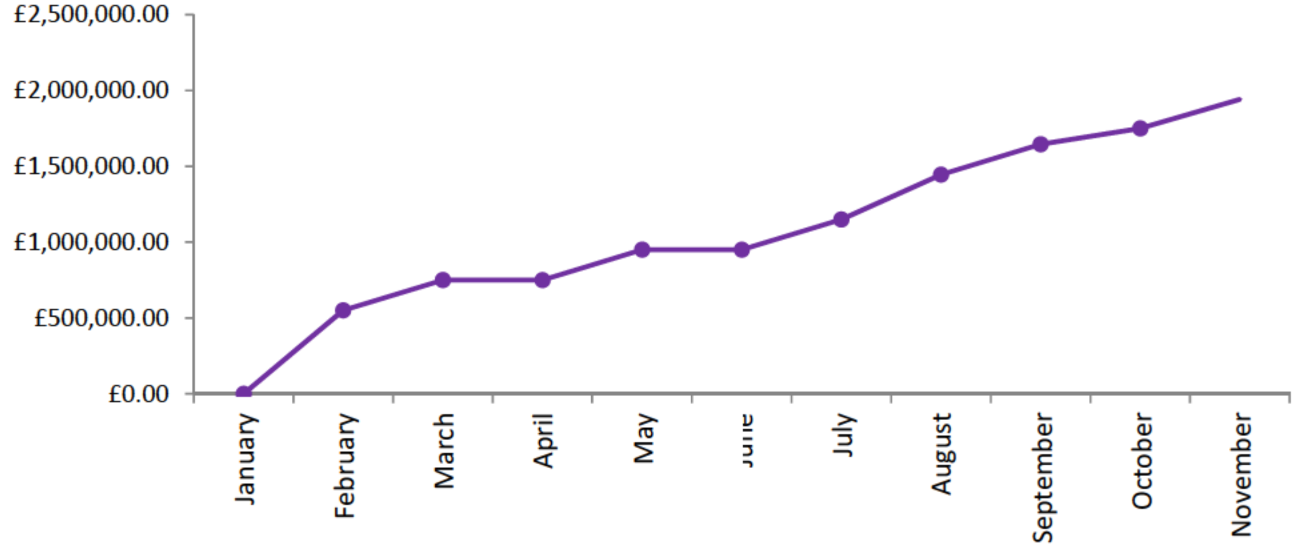

Figure 25 – Total project expenditure to 02.12.2014 (payment for the launch tube 3D design document is scheduled to be made after delivery of this report and therefore has not been included).

11 Bank Account

Figure 26 summarises the total spend as of 2nd December 2014 for the project against the agreed headings in the project direction. The project is currently on budget, with the only variance outside of the allowed 5% variance being the contingency fund.

				Projected variance (at project conclusion)	
	Budget (£000s)	Expenditure ITD (£000s)	Comparison with expected expenditure (%)	(£000s)	%
See note			1		
LABOUR	**5566.9**	**1621.9**	**-0.7%**	**0**	**0.0%**
EQUIPMENT	**716.3**	**248.9**	**0.0%**	**0**	**0.0%**
CONTRACTORS	**163.9**	**38.3**	**0.0%**	**0**	**0.0%**
IT	**59.2**	**12.6**	**0.0%**	**0**	**0.0%**
IPR	**39.6**	**5.2**	**0.0%**	**0**	**0.0%**
TRAVEL AND EXPENSES	**583.9**	**12.8**	**0.0%**	**0**	**0.0%**
CONTINGENCY	**276.9**	**0**	**-100%**	**0**	**0.0%**
Total	**7406.8**	**1939.7**	**-2.5%**	**0**	**0.0%**

1 – Actual expenditure to date is compared with phased projected spend over the same period.

Figure 26 – Total project expenditure against budget

Bank Statements

Figures 27 and 28 show the current standing of the project bank accounts.

BARCLAYS

Account Statement

Printed On:04/12/2014 11:40

Search Criteria
Account Number: [redacted] Statement Date: Absolute From: 16/06/2014 To: 29/08/2014
Search Result

Account Number	Account Name	Currency	Account Type / Status	
[redacted]	ROBOTICS INTERES	GBP	Deposit / OPEN	
IBAN	Bank Identifier	Bank Name		
[redacted]	[redacted]	BARCLAYS BANK PL		
Address				
Leicester,Leicestershire,UNITED KIN , LE87 2BB				
Opening Ledger	Total Payment Amount/Payment Count	Total Receipt Amount/Receipt Count	Transaction Count	Latest / Closing Ledger
843,380.01 As At: 16/06/2014	391,054.06/5	1,528,399.04/3	8	1,980,724.99 As At: 29/08/2014

	Entry Date	Transaction Details	Transaction Type	Payment Amount	Receipt Amount	Ledger Balance
		Balance Brought Forward				843,380.01
	01.07.2014	SG N PLC - ROBO * 004166 * * TFR	Transfer		544,287.06	1,387667.07
	01.08.2014	SG N PLC - ROBO * 004334 * * TFR	Transfer		439,803.98	1,827411.05
	04.08.2014	EX1408041360330 1 * 011093 * ROBOTICS A* TFR	Transfer	95,511.68		1,731959.37
	11.08.2014	EX1408111376964 9 * 633003 * ROBOTICS A* TFR	Transfer	7.00		
	11.08.2014	EX1408081375963 1 * 581329 * ROBOTICS A* TFR	Transfer	95,519.68		1,636432.69
	15.08.2014	SOUTHERN GAS NET 844914 * REF/CLUSIVE TFR	Transfer		544,308.00	2,180740.69
	22.08.2014	956309 * CLM * 2000009 7369864 TFR	Transfer	104,496.52		2,076244.17
	29.08.2014	921666 * CLM * 2000009 7369864 TFR	Transfer	95,519.18		1,980724.99
		Balance Carried Forward				1,980,724.99

Figure 27 – Project bank statement

BARCLAYS

Account Statement

Printed On:04/12/2014 11:13

Search Criteria
Account Number: [redacted] Statement Date: Absolute From: 01/09/2014 To: 02/12/2014
Search Result

Account Number	Account Name	Currency	Account Type / Status	
[redacted]	ROBOTICS INTERES	GBP	Deposit / OPEN	
IBAN	Bank Identifier	Bank Name		
[redacted]	[redacted]	BARCLAYS BANK PL		
Address				
Leicester, Leicestershire, UNITED KIN , LE87,2BB				
Opening Ledger	Total Payment Amount/Payment Count	Total Receipt Amount/Receipt Count	Transaction Count	Latest / Closing Ledger
1,980,724.99 As At: 01/09/2014	460,786.64/8	1,633,883.42/5	13	3,153,821.77 As At: 02/12/2014

	Entry Date	Transaction Details	Transaction Type	Payment Amount	Receipt Amount	Ledger Balance
		Balance Brought Forward				1,980,724.99
	08/09/2014	INTEREST PAID GROSS FOR PERIOD 2JUN/7SEP	Credit		514.70	1,981,239.69
	16/09/2014	SOUTHERN GAS NET* 866834*/RFB/CLMGVF TFR	Transfer		544,308.00	2,525,547.69
	23/09/2014	CHARGES 683648 ULBB GTXQ ADV	Advice	11.60		
	23/09/2014	ELINE ROB*583648*UA DV	Advice	104,496.62		2,421,039.67
	30/09/2014	947555 CLM200000933369854 TFR	Transfer	1,052.57		2,419,987.10
	01/10/2014	690046 CLM200000933369854 TFR	Transfer	95,519.18		2,324,467.92
	06/10/2014	852272 CLM200000933369854 TFR	Transfer	104,504.02		2,219,963.90
	15/10/2014	SOUTHERN GAS NET* 851902*/RFB/CLMGVF TFR	Transfer		544,308.00	2,764,271.90
	06/11/2014	851370 CLM200000933369854 TFR	Transfer	95,519.18		2,668,752.72
	12/11/2014	860103 CLM200000933369854 TFR	Transfer	0.32		2,668,752.40
	17/11/2014	SOUTHERN GAS NET* 866788*/RFB/CLMGVF TFR	Transfer		544,308.00	3,213,060.40
	25/11/2014	INTEREST REFUND LGC10 XT	Advice		444.72	3,213,505.12
	02/12/2014	CLMGVP17000069359 856432* ROBOTICS A* TFR	Transfer	59,683.35		3,153,821.77
		Balance Carried Forward				3,153,821.77

Figure 28 – Project bank statement

12 Intellectual Property Rights

In accordance with the Gas Network Innovation Competition Governance Document, ULC Robotics will report on intellectual property rights (IPR) being pursued for the project. In this reporting period, ULC Robotics does not have any IPR to report on. Additional filings are anticipated in early 2015 when the final design of several key parts of the system is completed.

As reported in the previous period, a provisional patent application for the selected concept of the transport platform (Element 1), repair module (Element 2) and sensor module (Element 3) has been filed with the USPTO on the 30th of April 2014. In accordance with the NIC Project Agreement, the non-provisional patent will be assigned to SGN.

SGN are committed to protecting the IPR of the project which will potentially be of great benefit to the GB gas consumer. With this in mind we are controlling the level of detail released in to the public domain to ensure the IPR is not at risk. This has been built in to the Stakeholder Engagement plan, and as soon as patents are registered, SGN will proactively disseminate detail where appropriate.

13 Other

13.1 Company Rebranding

The business has begun the rollout of the new brand which will be ongoing over the next couple of years. These rebranding guidelines formed the basis for the project logo development. This can be seen by comparing the logos shown in Figure 29

Figure 29 – The SGN and Robotics new branding logos

The robotics project team is working with the business to ensure that all communication material is in-keeping with the new brand to provide a clear, consistent message for our stakeholders. The publication of the project website was delayed to allow it to be launched with the rebranded SGN website in November 2014.

14 Accuracy Assurance Statement

The same steps that were taken in the first PPR have been followed for this report (Figure 30). The aim of these measures is to ensure accuracy and to comply with governance provided.

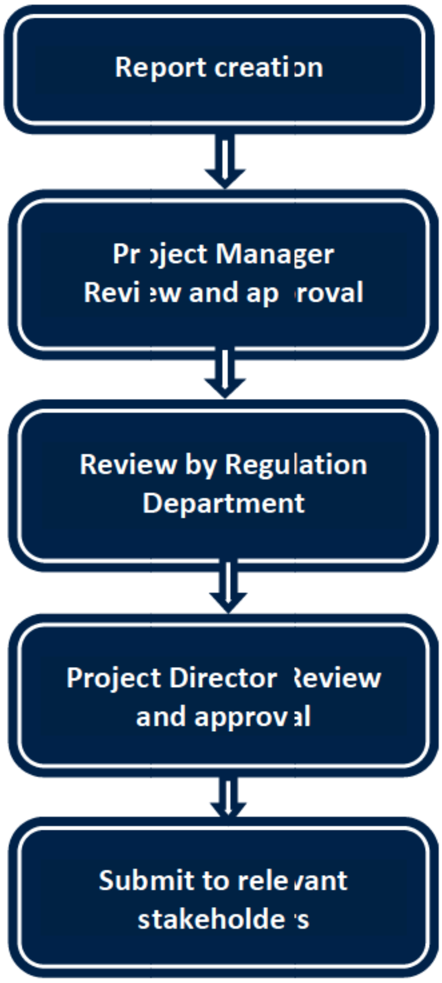

Figure 30 Accuracy assurance procedure

Appendix A - ULC Progress Report

NIC ROBOTICS

Project Progress Report

Prepared for SGN PPR #2

SUBMITTED ON: December 9, 2014
PREPARED BY: Mike Passaretti, Program Manager, ULC Robotics

CONFIDENTIAL INFORMATION – PLEASE DO NOT DISTRIBUTE BEYOND NIC PROJECT TEAM

Contents

Revision History

Revision No.	Revision Date	Author(s)	Revision Description
--	09 Dec 2014	MP, et al.	Initial Release

Referenced Documents

1. NIC Project Plan (schedule)
2. NIC Project Agreement
3. Gas Network Innovation Competition Governance Document

Executive Summary

The objective of the NIC Robotics project is to develop new, cutting edge robotic repair and inspection technologies which can operate inside live gas distribution mains. This new technology will not only remotely repair leaking mechanical joints and failed Weco seals, but will also support the pipe fracture risk management processes by providing enhanced inspection capabilities. In the first nine months of this project, ULC Robotics is excited to report that a new, innovative and commercially viable robotic technology has been matured from concept to prototype manufacturing. The success and achievements of the project to date are a direct result of an excellent level of collaboration and attention to detail from all project stakeholders, namely SGN, the project sponsor and RPS, the project technical service provider.

[redacted]

ULC Robotics has been under contract since February 2014. Since the submission of the last project progress report (June 2014), all milestones were achieved on schedule, including SDRC 9.3 (Source Vendor for Sensor). Since the start of the project and as of the date of this report, all fourteen milestones have been submitted on schedule, which now includes two SDRC milestones. There are two more milestones for 2014 that are due following the submission of this report. Including the SDRC, several significant technical achievements were accomplished in this reporting period. The detailed design of the transport platform (Element 1) and repair module (Element 2) have been completed and the prototype system for 24” diameter mains is currently being manufactured. The research for the sensor module (Element 3) was completed, several rounds of sensor testing has taken place, vendors were selected and the sensor robot design is currently being finalized. The manufacturing of the sensor robot will begin as scheduled in early 2015. ULC has also completed the initial design of the launch system which is responsible for safely and efficiently launching and retrieving the robotic system from the live gas mains during normal daily operations. The manufacturing of the launch system will also start in early 2015.

The project is fully staffed with dedicated engineering personnel. Since the submission of the last progress report, an additional engineer was added to the team, which now consist of a total of six engineers and one manager. All team members are full-time and dedicated to the NIC Robotics project. An additional senior electrical engineer should be joining the team soon. Additional resources such as sensor consultants are being utilized as well on an as needed basis. A detailed summary of the project’s progress and upcoming objectives are given in this report. What we've learned, our development approach and the intricate details of the designs have been detailed in all project milestone reports.

Summary of Progress by Element

Element 1&2

The development of the transport platform and repair module is currently on schedule with no major problems or areas of concern. The conceptual design of the repair robot (Element 1&2) presented in April 2014 was matured, reviewed and finalized. The manufacturing documentation for a robotic system that is designed to enter 24" diameter gas mains has been completed. Through scaling of key parts and effective use of the modular features of the system, the robotic system can be configured to accommodate 12 to 48" diameter gas mains. Manufacturing of the repair robot is currently in rogress. Purchase orders have been placed for all critical long lead components. Many custom and off the shelf components have already been received. All fabrication of manufactured parts will be completed, and all off the shelf parts will be received on schedule by 13 February 2015.

Launch System

The development of the launch system is currently on schedule with no major problems or areas of concern. After completing the launch system specification document in August 2014, ULC Robotics completed the conceptual design for an efficient and robust launching system that will provide a means of dispatching and retrieving the robotic system. Potential concepts for the supporting machinery and equipment necessary to facilitate operations was also completed. The conceptual design was presented to SGN & RPS in London on September 8th 2014. Following the acceptance of the conceptual design work, ULC immediately began to explore and improve the concepts until an initial design for the system was completed in November 2014. The initial design for the launch system was been completed in accordance with the requirements set forth in the project specifications and was matured through design, analysis and testing. ULC is currently finalizing the details of the launch system design in preparation for completing the necessary manufacturing documentation that is due on the 16th of January 2015.

Summary of Element 1&2 Milestones This Period (includes Launch System):

- Initial Electric Schematic Design and Parts Selection, 27 June 2014
- Initial 3D Design of Transport Platform, 18 July 2014
- Mechanical Specification Document Development (Launch Tube), 1 August 2014
- Development of Conceptual Designs (Launch Tube), 29 August 2014
- Creation of Detailed Fabrication & Mfg. Documentation (Robotic Platform), 10 October 2014
- 3D Design of Mechanical Components (Launch Tube), 21 November 2014
- User Interface and Control System Design and Programming, 26 December 14 (on-schedule)

Element 3

The development of the sensor module is currently on schedule with no major problems or areas of concern. The conceptual design of the sensor robot (Element 1&3) presented in April 2014 was matured, reviewed and is currently being finalized. Through scaling of key parts and effective use of the modular features of the system, the robotic system can be configured to accommodate 12 to 48" diameter gas mains. After several months of research, into sensor technology areas for Element 3, a down-selection process was carried out to

[redacted]

[redacted]

Summary of Element 3 Milestones This Period:

- Final Report on Sensor Research w/ Sensor Recommendations, 20 June 2014
- Source Vendor for Sensor, 18 July 2014 **(SDRC 9.3)**
- Electrical & Software System Block Diagram, 22 August 2014
- Sensor Module Specification, 5 September 2014
- Initial 3D Design of Mechanical Components, 19 December 2014 (on-schedule)

Consistency with Full Submission

The contents of this report are consistent with the original NIC Robotics proposal document. Any variances to the proposal will be clearly captured as part of the report structure to ensure the learning outcomes can be assessed and disseminated. There are no variances to report at this time.

Risk Management

In accordance with the Gas Network Innovation Competition document risks are being tracked and monitored throughout the duration of the NIC Robotics project. ULC Robotics, along with RPS and SGN have been periodically reviewing the project risk register and collaboratively making appropriate updates to it.

Progress Against Plan & Budget

The project is progressing on schedule and on budget. A summary of the successful delivery reward criteria milestones are shown in Table 1.

SDRC No.		SDRC Description	Status	Due Date
9.1	Element 1&2:	Development of Conceptual Designs	**Completed**	25 APR 2014
9.2	Element 4:	Development of Conceptual Designs	On-schedule	6 NOV 2015
9.3	Element 3:	Source Vendor for Sensor	**Completed**	25 JUL 2014
9.4	Element 3:	Configuration Testing with Robotic Platform	On-schedule	28 AUG 2015
9.5	Element 4:	Tapping & Fitting Tool Validation	On-schedule	12 MAY 2017
9.6	Element 1&2:	Launch Robot	On-schedule	7 DEC 2015
9.7	Element 3:	Launch Robot	On-schedule	6 NOV 2015
9.8	Element 4:	Launch Robot	On-schedule	15 SEP 2017

Table 1 – SDRC Milestone Schedule & Status

In accordance with the Gas Network Innovation Competition Governance Document, ULC Robotics will report on intellectual property rights (IPR) being pursued on the project. In this period, ULC Robotics does not have

Ofgem Project Progress Report Update 2

Document Control Sheet

Client:	SGN
Project Title:	Network Innovation Competition (NIC) Robotic Solutions
Document Title:	Project Progress Report Update 2
Document No:	MDR1025Rp013

Text Pages:	15	Appendices:	0

Rev.	Status	Date	Author(s)	Reviewed By	Approved By
F02	Final	11th December, 2014	Ian MacHugh David Phelan	Mark Phelan David Phelan	Ciarán Butler PJ Rudden

TABLE OF CONTENTS

LIST OF TABLES

- Finalising the design of the sensor module followed by parts fabrication, assembly and integration with the robotic platform.
- Carry out the internal testing of the launch system testing including retrieval & travel testing and seal repair tool testing.
- Identify and select suitable live gas mains for use as field trial sites.

1 INTRODUCTION

This project progress report provides an update of work completed since the last progress report submitted to Ofgem. The key areas to which RPS is providing an update on are as follows:

- Progress of each element against plan and budget;
- Key learning outcomes,
- Consistency with full submission,
- Risk management,
- Key objectives for the next six months.

RPS input towards robotics innovation development
RPS was appointed by SGN in February 2014 to provide a range of services including on the project such as:

- Technical review and gap analysis of conceptual designs and manufacturing design against SGN, UK and European Standards and legislation.
- Due diligence and project appraisal
- Strategic development planning
- Provision of technical assessments and advisory services
- Provision of support and assistance for the provision of field trial testing.
- Assist on technical input for Mains Risk Prioritisation System (MRPS)
- Risk management
- Multidisciplinary engineering design

2 PROGRESS SUMMARY

Since the previous project progress report, ULC has delivered nine milestone reports to which RPS has contributed technical input and assessment. A welcome addition to RPS reporting structure is the inclusion of queries raised and responses into the assessment reports for each ULC milestone report. This enables essential capturing of information shared amongst the project team. In addition, this process enhances the review of queries and feedback. ULC has recently included a current status comment table which further improves milestone review and evaluation. This process has also provided an opportunity for potential improvements to be suggested.

The following table shows the level of reporting to date by RPS.

Table 2-1: Table of Reports by RPS [1]

Report	Date of Issue	Report Name	Report size	Comments / Key Outcomes
1	23/04/2014	Assessment of SDRC 9.1 Report – Element 1&2 Conceptual Design Report	15 Pages	13 separate concepts were compared against each other using a range of considerations. Final concept was selected.
2	09/06/2014	Project Progress Report Update 1	3 Pages	Update of progress for the first six months. Key areas described; progress against plan and achievements for the first six months, risk management, key targets and objectives for the next six months and potential areas of concern.
3	02/07/2014	Assessment of SDRC 9.3 Report – Sensor Research & Recommendations	17 pages	Assessment report on Sensor Research & Sensor Recommendations. Six additional pages were included showing a potential means of incorporating the sensor data into the MRPS [redacted]
5	23/07/2014	Assessment of Source Vendor for Sensor Report	8 Pages	Overview of potential vendors, selected sensor technologies (EMAT & Barkhausen)
6	14/08/2014	Initial 3D Design of the Transport Platform	18 Pages	The Initial 3D Design of the Transport Platform Report is a development of the preliminary design outlined in the conceptual design report. The proposed areas of focus such as the design of mechanisms and sub systems have been addressed.

[1] Reports in grey font represent reports shown in the previous Project Progress Report. Reports in black font represent reports within the last six months.

Report	Date of Issue	Report Name	Report size	Comments / Key Outcomes
7	16/09/2014	Electrical and Software System Block Diagram Development Assessment	7 pages	This report outlines the various preliminary electrical and software system block diagrams associated with the sensor module.
8	26/09/2014	Launch Tube Conceptual Design Assessment	18 pages	The Development of Conceptual Designs (Launch Tube) Report presents the conceptual design for an efficient and robust launching system. It also provides insight into the conceptual design process and key learning outcomes. RPS provided a suggestion for improving the launch tube design.
9	Submitted to SGN on 13th Nov 2014, however, it requires an additional update. ETA – 19th Dec 2014	Sensor Module Specification Document Development	7 pages	The Sensor Module Specification Document Development Report presents the preliminary specifications for the sensor module. A number of parameters are still under examination. Further testing and discussions with manufacturers and suppliers in the coming months will further define the specifications and full capabilities of the sensor module.
10	Currently under final review ETA – 19th Dec 2014	Creation of Detailed Fabrication and Manufacturing Documentation	TBC	This report indicates ULC's readiness to commence manufacturing of the repair robot for 24" diameter pipes. The final design of the robotic platform is presented.
11	Currently under final review ETA – 19th Dec 2014	3D Design of Mechanical Components (Launch Tube)	TBC	The 3D Design of Mechanical Components Report presents details of the inaugural 3D design of the launch tube which has developed from the proposed conceptual designs through several design iterations, modelling, testing and analysis. The launch tube provides the mode by which the NIC robot can enter / exit the live gas distribution main and the initial 3D design produced by ULC

There have been an additional two successful face to face meetings since the previous project progress report submitted on 19th June 2014. They have facilitated very useful discussions, clarifications, provided direction and brainstorming sessions.

Table 2-2: Face to Face Project Team Meetings [2]

	Date	Meeting Purpose	Attendee's	Comments / Key Outcomes
Meeting 1	Friday 21st March, 2014	Project Kick-Off	SGN & RPS	Initial Face to Face Meeting between SGN & RPS. Presentation on RPS experience and project team.
Meeting 2	Tuesday 22nd April, 2014	Conceptual Design Overview	SGN, ULC & RPS	Introduction to ULC and presentation on Conceptual Design
Meeting 3	Tuesday 13th May, 2014	Sensor Technology Overview	SGN, ULC & RPS	Identification of potential sensors and key pipe defects (graphitic corrosion, stress & strain and wall thickness) to be considered.
Meeting 4	Monday 9th & Tuesday 10th Sept, 2014	Project Up-Date and Launch Tube Conceptual Design	SGN, ULC & RPS	Project update and discussion on Launch Tube designs
Meeting 5	Tuesday 21st October, 2014	Project update and discussion on Detailed Fabrication and Manufacturing Document	SGN, ULC & RPS	ULC will focus on preparing a robot for 18" and 24" mains. A separate robot of the 12" main will need to be developed at a later time. A similar approach is being carried out for 36-48" robot configuration. A separate robot for the sensors will be used.

All project elements are reported to be currently on-schedule and within budget. It is noted that key delivery dates have been modified from the Full Submission (See Appendix H) and adjusted accordingly in Ofgem's Project Direction. For example, procurement & testing of sensor package is due on 6th March 2015 as opposed to 6th February 2015.

2.1 ELEMENT 1

Element 1 involves the development of a robotic 'platform' and launch system to allow the insertion and movement of a repair module and inspection module inside a live gas mains. This Element is closely linked with Elements 2 & 3 as the design of the robotic platform and the launch system depends on the requirements of the payload systems (e.g. repair and inspection modules) designed under these elements.

The robotic platform has progressed from the conceptual design phase, through the initial design phase and is currently in the final design phase. The manufacturing of this system is due to begin shortly, with the fabrication of the robotic platform, which is due for completion in February 2015. The launch tube system is in the initial 3D design phase and is working towards User Interface and Control System Design and Programming. While working on the launch tube design, RPS has suggested potential improvements which ULC is considering.

It is clear that ULC has been thorough in the design of the launch tube and the development is progressing well. The key target over the next six months is to develop a launch tube system for the Tier 2 & 3 mains. The robotic platform and joint repair module preliminary functional test is due in April, 2015. Launch system testing will begin in May, 2015. These are both 'Go/No-Go' Stage

[2] Meetings in grey font were reported in the previous project progress report. Meetings in black font represent the previous six months.

- Extensive consideration has been given to all specifications associated with the sensor module, with parameters requiring additional research and testing being identified.
- Existing sensor technologies are being researched in detail and that there is communication with component manufacturers.

[redacted]

SGN has sourced pipe samples and shipped them to United States for testing by ULC. Analysis of the tests carried out will inform the project team of what can/cannot be done including the level of detail (i.e. extent of survey required versus 'value proposition') that can be used to inform the MRPS.

Overall, it appears that ULC is progressing well with Element 3. They are managing the sourcing of possible sensor vendors and are currently on schedule. There are a number of key areas the development of the Element 3 must achieve in order to progress:

1. ULC must successfully be able to design a sensor module using the selected sensor technologies that can be commercially reproducible. There are currently a number of unknowns regarding the sensor module mechanical specification that need to be confirmed.
2. Operation of the sensor module will be relevant to SGN's operational objective with respect to pipe risk management. The overarching goal is to devise a practical sensor module that can identify primary pipe defects that will provide the most informative and meaningful set of measurements to assess mains integrity while meeting the cost target outlined in the Full Submission Pro-forma.

A key risk regarding the sensor module development is to make sure that there is no delay in the project programme as there are a number of reporting milestones to be achieved and the sensor package is due for procurement and testing in March 2015. This is an important Go/No-Go Milestone.

2.4 ELEMENT 4

Element 4 involves automated live asset replacement for smaller distribution pipes. Work is due to begin on this Element in July 2015.

6 KEY TARGETS AND OBJECTIVES FOR THE NEXT 6 MONTHS

The key targets for the next six months involve:

1. Fabrication of parts for the robotic platform and joint repair module.
2. Assemble the robotic platform and joint repair module and carry out preliminary functional testing.
3. Develop and assemble the launch system prototype, including completing the final design and parts fabrication stages.
4. Finalise the design of the sensor module.
5. Parts fabrication and assembly of the sensor module and integration with the robotic platform.
6. Carry out the internal testing of the launch system, robotic platform launch including retrieval & travel testing and seal repair tool testing.
7. Identify and select suitable live gas mains for use as field trial sites. This will involve obtaining the necessary permits to conduct the field trials and the meeting the required health & safety criteria.
8. A MPRS workshop will be held to determine how sensor data can be incorporated into the risk model.
9. Structural assessments to be performed to determine the risks associated with installing the launch tube on the gas mains.
10. While no SDRC milestones are scheduled over the next 6 months, there are a number of SDRC milestones in the following 6 month period and consideration will be given to these during the next 6 months to ensure that these are adequately prepared for.

7 CERTIFICATION

It has been decided to seek CE marking for both the robotic systems and launch tube developed under this project. This decision was made on the basis that obtaining this marking is a form of quality assurance whereby independent testing confirms that the systems comply with the various applicable European Standards. It will greatly aid the integration of these robotic systems onto the market should this project be successful. The applicable Directives include:

- Pressure Equipment Directive (Directive 97/23/EC),
- Machinery Directive (Directive 2006/42/EC),
- Electromagnetic Compatibility Directive (Directive 2004/108/EC),
- Low Voltage Directive (Directive 2006/95/EC),
- ATEX Directive (Directive 94/9/EC).

Investigation is currently underway into the Directives to check if the conformity tests are required to be carried out by an independent Notified Body or whether they can be done by the manufacturer. This varies for different Directives. Depending on these requirements, the UK Conformity Assessment Bodies (notified bodies, recognised third party organisations and user inspectorates) will be assessed for each applicable Directive to assess who can best provide the relevant conformity assessment tests.

Appendix C - Risk Register – v2.2 - 11.12.2014

ROBOTICS
Reducing cost through innovation

Definition	Explanation	Probability	Score
Almost certain	event is expected to occur in most circumstances	>90%	5
Likely	event will probably occur in most circumstances	50-90%	4
Possible	event should occur at some time	30-50%	3
Unlikely	event could occur at some time	10-30%	2
Rare	event may occur only in exceptional circumstances	<10%	1

Responsibility Key:
AM - Angus McIntosh (SGN)
SW - Sam Wilson (SGN)
SG - Susan Gray (SGN)
DP - Dave Phelan (RPS)
MP - Mike Passaretti (ULC)

Scoring Key

16-25	10-15	1-9

Ref No	Risk	Business Risk	Inherent Risk			Controls & Mitigation	Owner	By When	Project Plan Ref	Residual Risk		
			Likelihood	Impact	Score					Likelihood	Impact	Score
1	**Insufficient Resources** Insufficient resources assigned to the NIC Project Manager and/or ULC's Director of Research and Development. SGN unable to resource personnel for on-site management and management of SCO procedures.	Time / Financial	3	3	9	A - Regular resource review at monthly innovation group meeting. B - Implement and maintain a project programme to monitor deliverables against the timescales and ensure that any shortage of resources impacting delivery of the overall project are clearly identified. Review programme at monthly progress meetings. C - ULC Robotics to contract additional staff to the project. D - SGN to identify dedicated resources to undertake site management and management of SCO procedures. E - RPS has assigned committed resources to carry out technical advisory of the NIC Robotics Project.	A- SW B - SW C - AM D - AM E - DP	Ongoing	N/A	1	3	3
2	**Local Authorities Communication for E1,2&3** SGN unable to obtain notices from Local Authorities to allow work on the highway.	Time / Financial	2	4	8	A - SGN to liaise with Local Authorities as early as possible to expedite the process. B - Input from the SGN Regulation and Corporate Communications Officer where necessary to support engagement with customers.	A - SW B - SW & SG	10/04/2015	54	1	4	4
3	**Local Authorities Communication for E4** SGN unable to obtain notices from Local Authorities to allow work on the highway	Time / Financial	2	4	8	A - SGN to liaise with Local Authorities as early as possible to expedite the process. B - Input from the SGN Regulation and Corporate Communications Officer where necessary to support engagement with customers.	A - SW B - SW & SG	17/02/2017	228	1	4	4
4	**Stakeholder Opposition for Elements 1,2&3** Has the potential to influence the public's perception of the project. This could lead to a negative response if not handled appropriately; conversely can result in a very positive response.	Reputation	1	4	4	A - Implement and maintain a stakeholder management plan. B - Input from the SGN Regulation and Corporate Communications Officer to ensure high level engagement with customers as early as possible. This will allow our stakeholders to understand exactly what we are aiming to achieve and what the benefits are.	A - SW & SG B - SW & AM & SG	Ongoing	N/A	1	4	4
5	**Stakeholder Opposition for Element 4** Has the potential to influence the public's perception of the project. This could lead to a negative response if not handled appropriately; conversely can result in a very positive response.	Reputation	1	4	4	A - Implement and maintain a stakeholder management plan. B - Input from the SGN Regulation and Corporate Communications Officer to ensure high level engagement with customers as early as possible. This will allow our stakeholders to understand exactly what we are aiming to achieve and what the benefits are.	A - SW & SG B - SW & AM & SG	Ongoing	N/A	1	4	4
6	**Technical Issues with Robotic Platform for Elements 1,2&3** Any technical issues when developing the robotic platform could delay the Project and lead to increased costs. Further issues may arise if the project timeline begins to slip.	Time / Financial	4	4	16	A - ULC Robotics to divert staff from other aspects of the business to support the project. B - Go / No Go Stage Gate at early stages of the project.	A - ULC B - SW & RPS	10/04/2015	54	1	4	4

7	**Technical Issues with Robotic Platform for Element 4** Any technical issues when developing the robotic platform could delay the Project and lead to increased costs. Further issues may arise if the project timeline begins to slip	Time / Financial	4	4	**16**	A - ULC Robotics to divert staff from other aspects of the business to support the project. B - Go / No Go Stage Gate at early stages of the project.	A - ULC B - SW & RPS	09/01/2017	253	1	4	**4**
8	**Repair Module (Element 2)** Issues that may occur when developing the Repair Module has the potential to delay the project.	Time / Financial	4	4	**16**	A - ULC Robotics to divert staff from other aspects of the business to support the project. B - Go / No Go Stage Gate at early stages of the project.	A- ULC B - SW & RPS	10/04/2015	48	1	4	**4**
9	**Sensor Module (Element 3)** Issues that may occur when developing the Sensor Module has the potential to delay the project. Selection of optimum Sensor. Sensor Accuracy, Processing Time, Interface & Usefulness. Sensor Module proposed puts pipe safety at risk	Time / Financial	4	4	**16**	A - ULC Robotics to investigate optimum solution to satisfy the needs of the project. B - Go / No Go Stage Gate at early stages of the project.	A- ULC B - SW & RPS	23/10/2015	160	2	4	**8**
10	**Repairing Leaking Joints** There is a risk that a solution for remotely repairing leaking Weco seals and mechanical joints will not be determined.	Financial	1	5	**5**	A - Develop sealing methods and conceptual designs early in the project schedule to ensure that a method is determined. B - Shop testing will be performed to ensure that the methodology provides an adequate seal. C - Go / No Go Stage Gates added into the project plan in case a solution has not been determined.	A - ULC B - ULC C - SW & RPS	03/07/2015	79	1	5	**5**
11	**Sensor Manufacturer Not Found** There is a risk that a sensor manufacturer will not be found which meets the requirements i.e. functioning and transmitting data accurately over a long distance, providing accurate measurement of pipe wall loss, measurements in varying pipe diameters etc.	Time / Financial	2	5	**10**	A - Generate a report outlining options for sensors and the pros/cons of each will be performed early in the project. B - A collaborative decision relative to the sensor selected for the project will be performed. C - Go / No Go Stage Gates added into the project plan in case a manufacturer is not found.	A - SW B - SW & ULC C - SW & RPS	06/03/2015	142	1	5	**5**
12	**Sensor Manufacturer** Delays from the sensor manufacturer could affect the overall schedule.	Time / Financial	3	4	**12**	A - ULC Robotics to divert staff from other aspects of the business to support the project. B - Review project plan if required for sourcing sensor vendor	A - SW B - SW	06/03/2015	142	2	4	**8**
13	**Technical Issues with Service Replacement** Any unforeseen technical issues with service replacement could hamper the effectiveness of the robotic system and delay the Project. For example; identifying custom flexible PE tubing to insert in the service line, identifying custom fittings for service replacement and ensuring a reliable and gas tight seal on the newly connected service.	Time / Financial	4	4	**16**	A - ULC Robotics to divert staff from other aspects of the business to support the project. B - Test robot in mock up main. C - Go / No Go Stage Gates at early stages of the project.	A - SW B - SW C - SW & RPS	14/04/2017	247	1	4	**4**
14	**Field Trial Challenges** The mains selected for the field trial are not suitable for the robotic operation.	Time / Financial	3	3	**9**	A - Network Analysis undertaken. B - Familiarity with site location and mains. C - Pre inspection of main using camera.	A - SGN B - SGN & ULC C - SW & RPS	23/06/2017	267	1	3	**3**
15	**Launch Robot for Elements 1,2&3** SGN / ULC Robotics are unable to launch the robot into the main.	Time / Financial	1	5	**5**	A - Ensure entry tee compatible with launch tube and manufacturer requirements. B - Design parameters well defined. C - Go / No Go Stage Gate at early stages of the project.	A- ULC B - ULC C - SW & RPS	18/01/2016	80	1	5	**5**
16	**Launch Robot for Element 4** SGN / ULC Robotics are unable to launch the robot into the main.	Time / Financial	1	5	**5**	A - Ensure entry tee compatible with launch tube and manufacturer requirements. B - Design parameters well defined. C - Go / No Go Stage Gate at early stages of the project.	A- ULC B - ULC C - SW & RPS	27/11/2017	253	1	5	**5**

17	**Robot Manoeuvrability E1,2&3** There is a risk that a motor drive system capable of transporting the robotic system for each element cannot be developed.	Financial	2	4	**8**	A - ULC have significant experience developing and deploying complex electromechanical systems in live natural gas mains and other inaccessible locations. B - Ability to apply past engineering knowledge along with computer modelling and simulation to guide the conceptual design of the robotic platform drive system. C - Go / No Go Stage Gates added into the project plan in case a solution has not been determined.	A- ULC B - ULC C - SW & RPS	06/02/2015	74	1	4	**4**
18	**Robot Manoeuvrability E4** There is a risk that a motor drive system capable of transporting the robotic system for each element cannot be developed.	Financial	2	4	**8**	A - ULC have significant experience developing and deploying complex electromechanical systems in live natural gas mains and other inaccessible locations. B - Ability to apply past engineering knowledge along with computer modelling and simulation to guide the conceptual design of the robotic platform drive system. C - Go / No Go Stage Gates added into the project plan in case a solution has not been determined.	A- ULC B - ULC C - SW & RPS	09/09/2016	241	1	4	**4**
19	**Structural Assessment** Risk associated with the Launch Tube and the structural integrity of the pipe condition to take loads.	Time / Financial	1	4	**4**	A - RPS to carry out assessment with review from Structural Engineers. Structural Assessment takes into account maximum loads in ideal scenarios and then provides assumptions that affect maximum loads (for example wall thickness & unsupported pipe lengths). B - ULC to agree and be satisfied with assumptions.	A- RPS B - ULC	09/01/2015	N/A	1	4	**4**
20	**Robotic Functionality For E1,2&3** There is a risk that the technology developed cannot be operated at the target length of 150 meters or manoeuvre around debris, obstacle and bends.	Financial	2	4	**8**	A - Utilise 3D modelling and simulation techniques throughout the design to determine the estimated travel distance and ability to manoeuvre within the pipe (launch, retrieve, avoid or travel over/through debris and obstacles, etc.). B - Once the manoeuvrability and the overall travel distance for each pipe size has been determined a decision can be made to pursue one concept, modify the design to meet the specifications of the project or modify the project criteria to meet the design limitations. C - Go / No Go Stage Gates added into the project plan in case a solution has not been determined.	A- SW / ULC B - SW & ULC C - SW & RPS	25/09/2015	74	1	4	**4**
21	**Robotic Functionality for E4** There is a risk that the technology developed cannot be operated at the target length of 150 meters or manoeuvre around debris, obstacle and bends.	Financial	2	4	**8**	A - Utilise 3D modelling and simulation techniques throughout the design to determine the estimated travel distance and ability to manoeuvre within the pipe (launch, retrieve, avoid or travel over/through debris and obstacles, etc.). B - Once the manoeuvrability and the overall travel distance for each pipe size has been determined a decision can be made to pursue one concept, modify the design to meet the specifications of the project or modify the project criteria to meet the design limitations. C - Go / No Go Stage Gates added into the project plan in case a solution has not been determined.	A- SW / ULC B - SW & ULC C - SW & RPS	17/02/2017	245	1	4	**4**
22	**Capabilities of the Tether for Elements 1 & 2** There is a risk that a tether capable of carrying power and data connections meeting the distance and bend radius requirements cannot be developed. For example; transmitting data over a long distance, providing sufficient bend radius, manufacture lightweight and robust tether to the desired length. As a result of the design process, it has been determined that the best course of action is to develop two tethers (one for the sensor module and one for the repair module).	Financial	2	5	**10**	A - Deliver a list of conceptual design requirements to cable manufacturers for quotations early in the project to mitigate against technical and schedule risk. B - Experience working with several industrial cable manufacturers to develop custom, highly specialised tethers for powering and controlling robotic systems. C - Conceptual Design Go / No Go Stage Gate added into the project plan at an early stage in case a solution cannot be determined. D - ULC are aware of the issue of gas leakage at the gland arrangement of the large CISBOT launch tube.. This will be factored into conceptual design E - Developing two tethers will avoid complications with dual functionality and will be proven through the controlled testing phase of the project	A - SW B - SW C - SW & RPS D - ULC E - ULC	22/05/2015	71	1	5	**5**

23	**Capabilities of the Tether for Elements 1 & 3** There is a risk that a tether capable of carrying power and data connections meeting the distance and bend radius requirements cannot be developed. For example; transmitting data over a long distance, providing sufficient bend radius, manufacture lightweight and robust tether to the desired length. As a result of the design process, it has been determined that the best course of action is to develop two tethers (one for the sensor module and one for the repair module).	Financial	2	5	**10**	A - Deliver a list of conceptual design requirements to cable manufacturers for quotations early in the project to mitigate against technical and schedule risk. B - Experience working with several industrial cable manufacturers to develop custom, highly specialised tethers for powering and controlling robotic systems. C - Conceptual Design Go / No Go Stage Gate added into the project plan at an early stage in case a solution cannot be determined. D - ULC are aware of the issue of gas leakage at the gland arrangement of the large CISBOT launch tube. This will be factored into conceptual design E - Developing two tethers will avoid complications with dual functionality and will be proven through the controlled testing phase of the project	A - SW B - SW C - SW & RPS D - ULC E - ULC	22/05/2015	71	1	5	**5**
24	**Capabilities of the Tether for Element 4** There is a risk that a tether capable of carrying power and data connections meeting the distance and bend radius requirements cannot be developed. For example; transmitting data over a long distance, providing sufficient bend radius, manufacture lightweight and robust tether to the desired length.	Financial	2	5	**10**	A - Deliver a list of conceptual design requirements to cable manufacturers for quotations early in the project to mitigate against technical and schedule risk. B - Experience working with several industrial cable manufacturers to develop custom, highly specialised tethers for powering and controlling robotic systems. C - Conceptual Design Go / No Go Stage Gate added into the project plan at an early stage in case a solution cannot be determined. D - ULC are aware of the issue of gas leakage at the gland. This will be factored into conceptual design	A - SW B - SW C - SW & RPS D - ULC	17/02/2017	243	1	5	**5**
25	**Tapping and Fitting Tools** There is a risk that a tapping and fitting tools capable of being carried and operated by the service replacement robot cannot be developed.	Financial	2	5	**10**	A - Tools for service replacement will be identified early in the development stage of the robotic system. B - Experience developing a prototype service replacement robot which performed tapping and fitting of a new service connection on inserted PE pipe. C - The entire system will be shop tested at ULC to ensure it performs prior to being deployed in the field. D - Tapping and Fitting Tool Validation Go / No Go Stage Gate added into the project plan in case a solution cannot be determined.	A- ULC B - ULC C - SW & ULC D - SW & RPS	12/05/2017	250	1	5	**5**
26	**Cost Escalation** Costs may escalate due to unforeseen circumstances and / or unknown delays in Programme, procurement, shipping, field trials etc.	Financial	2	5	**10**	A - Build sufficient float into Project plan B - Project has built in Go/No Go Stage Gates to ensure an opportunity to halt Project at anytime.	A- SW / ULC B - SW & RPS	Ongoing	N/A	1	5	**5**
27	**SME Cash flow** There is a risk that ULC may not have the required cash flow to complete each task defined on the project plan.	Financial	2	5	**10**	A - Up front mobilisation payment. B - Project has built in payment milestones to ensure steady cash flow. C - Go/No Go Stage Gates added into the project plan at critical points.	A - SW B - SW & ULC C - SW	Ongoing	N/A	1	5	**5**
28	**Timetable Slippage** Timetable may slip due to unforeseen circumstances and / or unknown delays in procurement, custom and shipping to the UK.	Time / Financial	2	4	**8**	A - Build sufficient float into Project plan B - Regular steering group reviews to monitor progress against the programme C - If required there is an opportunity to halt programme at Go/No Go Stage Gates	A - SW & AM B - SW & AM C - AM	Ongoing	N/A	2	4	**8**
29	**Operation of Robot in a Live Gas Main For Elements 1,2&3** Safety risk - pollution risk from gas leakage and potential for anaerobic sealant to contaminate moving parts of the robot as well as debris from inside the main to be spread when removing the robot. Due to operation in the carriageway, potential risk of impact from vehicles in the event of a road traffic accident.	Time / Financial	2	4	**8**	A - Spillage kits available at trial sites B - Monitor level of debris being removed from main visually using robot camera C - ULC to consider the impact of anaerobic contamination on moving/functional parts of the robot and the associated cleaning that is required. D - The operation of E2 & E3 will be performed using two seperate transportation platforms, reducing design complexity and the possibility of anerobic contamination to one system.	A - SW & RPS B - ULC C - ULC D - ULC / SGN	25/09/2015	72	2	4	**8**

30	**Operation of Robot in a Live Gas Main For Element 4** Safety risk - pollution risk from gas leakage and potential for debris from inside the main to be spread when removing the robot	Time / Financial	2	4	**8**	A - Spillage kits available at trial sites B - Monitor level of debris being removed from main visually using robot camera	A - SW & RPS B - ULC	09/01/2017	253	1	4	**4**
31	**Structural Integrity of Pipe Wall** The impact of the pressure applied by the robotic wheels when operating inside the main could have a detrimental affect on the integrity of the pipe wall.	Reputation / Time / Financial	1	4	**4**	A - A Structural Assessment will be carried out to mitigate this risk B - Launch tube operational weight design parameters set for ULC C - Coupon sample taken from main at initial survey to confirm main material prior to the launch tube being fitted	A - RPS B - SW & RPS C - SW & ULC	10/04/2015	52	1	4	**4**
32	**Launch tube development for Elements 1, 2 & 3.** A launch tube design needs to be developed to facilitate a gas free operation and ease of use on site. Considerations need to be given to its manoeuvrability, functionality and the excavation footprint.	Time / financial	1	4	**4**	A - ULC and SGN to utilise experience gained from Large CISBOT trial and incorporate improvements into the new design B - SGN and RPS to assess designs against UK legislation C - Maximum operating weight of launch tube to be identified as a result of structural integrity pipe wall report conducted by RPS (30)	A - ULC & SGN B - SGN & RPS C - SGN & RPS	16/01/2015	59	1	4	**4**
33	**Communication of Project Team** Due to geographical split of team across UK, Ireland and the USA, there is a risk that effective communication channels may not be maintained efficiently.	Time / Financial	1	4	**4**	A - Face-to-face meetings for key stage gate deliverables B - Use of virtual meeting centre and secure file share	A - SW B - SW	Ongoing	N/A	1	4	**4**
34	**Impact of UK legislation/HSE acknowledgement of remediation technique.**	Time / Financial	3	4	**12**	A - SGN to set up regular progress meetings with HSE B - RPS and SGN to check legislative requirements for system operation and outputs	A - SW & AM B - RPS	Ongoing	N/A	2	4	**8**

Appendix D - Letter to NGT

SGN
St. Lawrence House
Station Approach
Horley
Surrey
RH6 9HJ

National Grid Transmission
National Grid House
Warwick Technology Park
Gallows Hill
Warwick
CV34 6DA
16 December 2014

Dear Sir/Madam,

Re: Network Innovation Competition

Thank you for the opportunity to comment on your NIC project 2014.

Having successfully implemented robotics into low pressure gas distribution pipework, we have seen at first hand the potential financial, operational and environmental benefits associated with this type of in-pipe technology. As you are aware, we have been recently awarded (2013) NIC funding for our own innovative robotics project, and have undertaken this in partnership with ULC Robotics, so can see similarities in the approach taken by National Grid Transmission in their partnership with Synthotech and Premtech. We have ourselves worked with Synthotech on a robotics and other innovation & technology projects under NIA.

It appears that this project will need to develop robotic technology which is, at present, unavailable across the NTS and all distribution networks both in the UK. The development of a robotic inline inspection device capable of inspecting complex pipework, operating at up to 100barG will face a number of unique and complex challenges. If successful however, it will potentially allow the network to operate at full capacity whilst conducting proactive and efficient asset management.

We do not think that this project conflicts with the above mentioned NIC awarded to our network for the following reasons:

1) Designed for Unpiggable pipeline configuration
2) Designed for significantly higher pressures (100barg)
3) Targeting inspection of asset condition only not remediation or replacement

We believe that there may be an opportunity to share some learning between both projects in relations to asset condition measurement methods. Although the pipeline operating environment will be very different due to the pressures involved, the sensors we are developing as part of our NIC project may be applicable, or there may be some learning from the sensor review we have completed. We will be submitting our SDRC 3 report in the coming months and will share the relevant outcomes.

We would also be happy to support technical peer review at the end of the project, and would invite you to do the same for ours.

Similar to the NTS, our transmission network is nearing the end of its design life and as such the requirement to conduct inspection to validate asset health is critical to maximising asset life and extending this asset life by demonstrable data.

Yours Sincerely

Angus McIntosh
Innovation & New Technology Manager
SGN