NIC Robotics Project Progress Report Three

19th June 2015

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Your gas. Our network.

Contents

1 Document Control

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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 December 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 Weco seal 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 Project Progress Report 2 (PPR). A list of the key deliverables is shown below, a breakdown of each can be found throughout this report.

Elements 1&2

- Creation of Detailed Fabrication and Manufacturing Documentation for the Launch Tube
- Initial Parts Fabrication of the Robotic Platform
- Robotic Platform and Joint Repair Module Assembly
- Robotic Platform and Joint Repair Module Preliminary Functional Test
- Launch System Testing

Element 3

- Initial Electrical Schematic Design and Parts Selection
- Creation of Detailed Fabrication and Manufacturing Documentation
- Procurement and Testing of Sensor Package
- Design and Procure Tether
- Initial Parts Fabrication and Assembly

The project progressed successfully over the past six months from specification and design of the operating system through to the manufacture of fully operational systems for operational testing (Figure 1). The sensor selection and testing was a complex challenge to overcome and was achieved as part of the milestone for the procurement and testing of sensor package. To ensure that the sensors which were selected would achieve the required specification, test rigs were constructed to demonstrate how the sensors performed with help from the sensor vendor.

The manufacture of the robotic platform and the repair module has been a key aspect of developed under Element 1 (E1) & Element 2 (E2), shown in Figure 1.

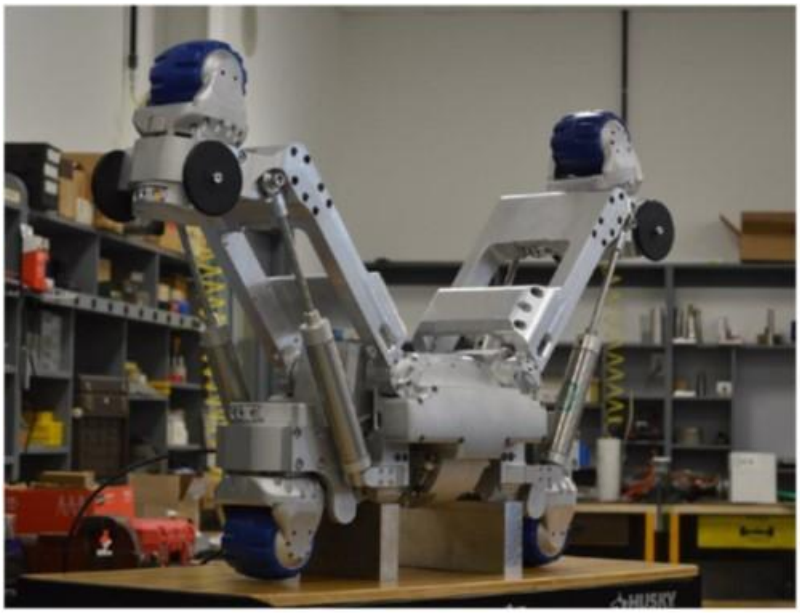


Figure 1 – Repair Robot Platform with the Wheels in the Driving Position

This progress report has been written in accordance with the Network Innovation Competition (NIC) guidance document.

2.1 Risks to Project Delivery

A summary of the associated risks highlighted in the guidance document are listed below with a short description of the mitigation methods used. All risks and their associated mitigation methods are listed in detail in the project risk register in Appendix C.

Recruitment Risk – There is no requirement to recruit customers to take part in the project until the field trial stage of Element 4. This stage presents no risk to project delivery. A customer engagement plan will be drafted and submitted to OFGEM for review as part of the field trial.

Procurement Risk – at this stage of the project, the risk associated with selecting a sensor vendor has been mitigated. There is however, a risk that the group will not be able to procure the tethers. This is due to the extended period of time required to specify the power requirements for the inspection robot tether. After a face to face meeting between ULC and SGN, it was decided that functional testing would be conducted using a CISBOT tether to mitigate any delay to the schedule with additional wiring of an equivalent specification. This allows the functional testing milestones to be satisfied without any impact on the project schedule. The supply of the tether will be delivered prior to the "Integrate and Test Tether with Sensor/Data Acquisition System" milestone**.**

Installation Risks – Field trials will begin in November 2015 and work has begun as stated in PPR2 to mitigate any risk. This was achieved through the manufacture of a test rig used to simulate onsite conditions within a controlled environment. Pipe samples from the network have been provided to ULC for controlled testing of the launch tube and sensors. The testing carried out to date and the items still to be tested are listed in the project managers section of this report.

Other Risks

At this stage there are no risks to the successful delivery of the project.

2.2 Learning Summary

In line with previous PPR's, the project learning outcomes will be divided into two categories of dissemination: internal and external. The aim 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. Further detail can be seen on page 20 of this report.

Since the last progress report SGN have used a number of different methods to disseminate information on the project:

1. The 'robotics' website has had 586 hits since 1st January 2015
2. The robotic system has been named and as soon as the logo has been finalised, it will be used on all internal and external communication with stakeholders to give the systems a brand identity
3. Institute of Gas Engineers and Managers (IGEM) presentations
4. Gas Innovation Governance Group (GIGG) meeting updates
5. Presentations to key external stakeholders including the Scottish Water Executive, Scottish and Southern Energy Power Distribution (SSEPD)
6. Presentations to the Department for Energy and Climate Change (DECC) and the Health and Safety Executive (HSE)
7. Preparation for the 2015 LCNI Conference (this will include a demonstration of the robotic platform, a presentation at the break-out sessions and team members engaging with delegates)

3 Project Managers Report

Since the submission of PPR2, the project has progressed as planned with no variation to the schedule or the budget. The detailed design and manufacturing works reported previously have been completed successfully. Both the operating platforms and the repair and sensor modules have been manufactured and assembled ahead of the controlled testing phase of the project.

As we near the testing phase the quantity of critical milestones has started to increase as key areas of the project are reached. Since the last report the 'Procurement and testing of the sensor package', 'Robotic Platform and Joint Repair Module Preliminary tests' and 'Launch System Testing' have been reported on and approved by the technical consultants RPS and SGN resulting in the project progressing to the next stage. Over the next six months a further eight milestones will be reviewed and assessed against the performance criteria.

The first significant budgetary and scheduling challenge was faced in the earlier part of this year with the design and procurement of the tethers for each operating platform. It was reported in PPR2 that the repair and inspection functions should be separated on to two separate transport platforms to realise operational efficiencies. Both robots will use the Element 1 platform for manoeuvrability allowing a common specification to be used for approximately 75% of the components. The repair module and inspection module have different requirements; as such each robotic platform will require different tethers. ULC Robotics planned to complete the tether design and start tether procurement immediately after the mechanical design of the robotic systems was complete. In practice while the mechanical design of the system was complete, additional engineering was necessary to finalise the tether designs. In order to mitigate cost and schedule risk associated with the need to redesign and manufacture the tethers later in the project, a gap analysis determined that the appropriate action was to delay the order of the tethers per the original schedule to allow time to finalise the additional design requirements. The minor schedule change avoids any potential for the tether designs to fall short of the demands for each platform and any changes to the specification resulting in the tether being reordered.

The Sinclair motors electrical power requirements was a significant driver in determining the appropriate power capacity of the conductors in the tether. To characterise the power, the fully assembled custom motors and electronics were assembled and tested to finalise the power requirements. The change to the schedule was monitored by the project team and documented in the project risk register.

Preparation for Element four has also begun in advance of the scheduled start date of July 2015. A consultation period required to review the conceptual designs for the inline service replacement technique for tier 1 mains. SGN have made contact with the other networks and key stakeholders in preparation for the consultation period and plan to hold individual meetings and engagement events to disseminate the conceptual designs has begun.

The key achievements from the last six months and targets for the next six months are listed below with a description for each.

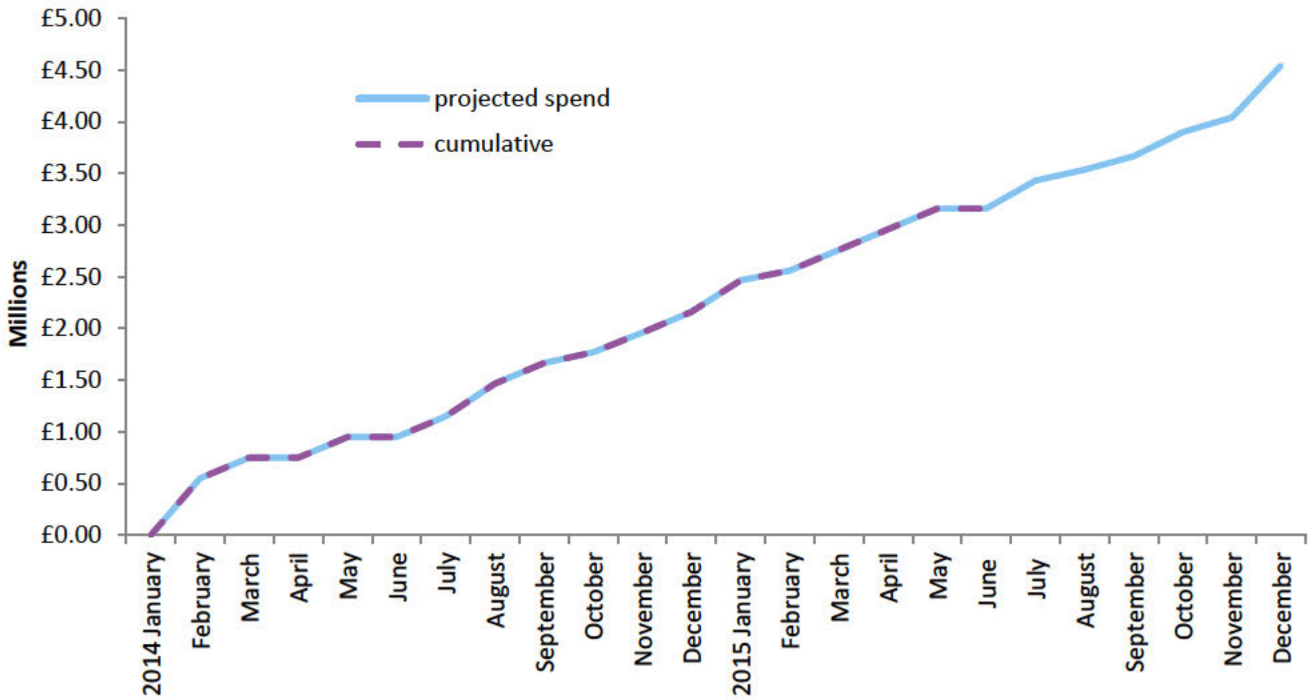


Figure 2 – Total project expenditure to 19th June 2015

3.1 Previous Six Months – 19.12.2014 – 19.06.2015

Key achievements since the submission of PPR2:

- Initial parts fabrication and assembly of robotic platform for E1 & E2 and full functional test
- Manufacture of the test rig to provide supporting evidence of the sensor technology and the procurement of the sensors required
- Development of the user interface, control system design and programming
- Creation of 3D design documentation for E3
- Detailed fabrication for the E3 sensor module
- Design and procurement of tethers
- Design and fabrication of the Launch Tube, including PED certification
- Identify how the data provided by the sensor payload can be integrated in to the Mains Prioritisation Risk Score (MRPS) package

Initial parts fabrication and assembly of robotic platform for E1 & E2 and full functional test

Over the past six months, significant progress has been made in the fabrication and assembly of the robotic platform. The design was completed in October 2014 and manufacturing started immediately after. The engineering team oversaw the assembly and post machining operations ensuring that the robot was assembled properly and the design specifications were met.

The mechanical assembly of the repair platform for a 24" diameter pipe has been completed on schedule and in accordance with the requirements. The design considered SGNs approved project specifications, relevant British standards and additional documentation.

Functional testing of all systems
The functional testing of all systems is a key step in project progression. This area has been heavily controlled by the project team with target specifications set for the tests. Each specification is linked to a respective milestone in accordance to the project plan. [redacted]

[redacted]

[redacted]

[redacted]

Finalise site trial locations

An investigation has been undertaken within SGN to source suitable sites to trial both the Repair and Inspection robotic platform. It is intended that over the 30 day trial period 2 different sites will be used, one 10 day trial will be carried out on an abandoned main still *in situ* on the network, and the rest of the period on a live gas main. Using the two different sites will allow different tests to be performed, reduce operational cost and the disruption caused by using an SGN controlled site instead of the public carriageway and allow demonstrations to be carried out in a safer, controlled environment.

The abandoned mains in the SGN site will allow sections to be cut out and the results from the survey to be compared against samples sent for laboratory testing using conventional methods. If we used live mains still in operation this wouldn't be possible without extensive and costly flowstopping [redacted] Pre-site surveys will be performed ensuring the mains are suitable for the trial to confirm the robots performance.

Develop test criteria for field trial and demonstrations

The criteria for the field trial are critical for the success of the project and have been extensively discussed amongst the project team. This has been documented, given references with respect to the project plan and a "Classification of technical assurance position score". The critical points that have been addressed are listed in the table below (Figure 43) with the testing requirements described.

Consideration	Testing Requirements
Pipe Loading	The forces imparted on the pipe at the excavation site should be quantified.
Wall Press Vs. Free Weight	Both the dead weight of the robot and the opposing force produced should be measured.
Size/Launching	The ability to launch the robot through the launch tube. The robot must be able to launch and be retrieved vertically.
Wheel Torque	The maximum torque produced by the wheels should be measured. This will play a role in determining the overall travel distance of the robot.
Traction	The resulting traction should be measured in various robot configurations.
Power Transmission	The type of power transmission chosen should be tested to determine its effectiveness and reliability.
Pneumatics	Any pneumatic elements used in the design should be tested to ensure that they are effective and reliable.
Electronics	Any electronic components should be adequately tested to ensure that they are up to specification and capable of carrying out the required tasks. This will also involve testing of the sensor systems and repair module.
Form Factor	The overall design and shape of the robot will be known prior to testing; however the way in which the robot's shape influences its capabilities should be noted during testing. For example, certain elements of the robot may snag on certain pipe elements or going around bends.
Manoeuvrability	The ability of the robot to launch and transverse various obstacles likely to be encountered in gas pipelines should be tested.
Travel Distance	The travel distance of the robot should be measured as this will form an important element of the robots capabilities. The effect that pipe seals, bends, tee's etc. have on the travel distance should be determined to allow for the travel distance of the robot in any particular pipe to be calculated in advance of deployment (if the existing pipe details are known).
Negotiate Bends	The ability of the robot to negotiate varying bends should be tested.
No Power Extraction	No power extractions should be carried out to ensure that the robot can be fully extracted, even when the robot is experiencing power loss.
Scalability	The robot must be tested under various Tier 2 and Tier 3 pipes to ensure that it is scalable.
Negotiating Weco Seals and Obstacles	The robot will be required to transverse Weco seals and obstacles in the pipe without causing damage to the seals or the pipe.
Negotiating Tees's	The robot must be able to travel through a tee without turning into one.
Position of Repair Module	The repair module must be capable of performing a suitable repair with accuracy.
Robustness	It is expected that the robustness of the design will be determined during the overall testing process. Any weaknesses should be noted and rectified.
Circumferential Motion	The robot should be tested in various situations where it is required to manoeuvre around the circumference of the pipe. This should include situations where the robot is required to negotiate obstacles and perform repairs.
Obstruction of Gas Flow	The overall cross section of the robot in the pipe should be noted in different situations to ensure that gas flow will not be substantially reduced. These situations should include the robot during launch, normal operation, negotiating bends and obstacles.
Ability to Pull Tether	The ability for the robot to overcome the forces on the tether system should be tested.
Quality of Repair	Pipe repairs performed by the robot should be carefully tested to ensure that they are sufficiently repaired.

Figure 43– Testing requirements as agreed within the project group for the live field trail for Elements 1, 2 and 3

Creation of technical assurance documentation and SGN/PM/G/23 field trial procedure

The procedure will contain all technical assurance documentation and operational procedures to facilitate safe operation on a live network. Once compiled the procedure is submitted to the SGN Engineering board for review and approval prior to any operational works taking place. It will assist in meeting the requirements, principally, of the Pipeline Safety Regulations and will facilitate a consistent approach to ensure the integrity of the network is maintained.

From experience of using the Large CISBOT system and use of intelligent PIGs on transmission lines, SGN has determined that the robotic platform does not need to be (Explosive Atmosphere) ATEX certified. Mitigation measures will be specified in the operating procedures to avoid any potential exposure to a gases (explosive gas and air mixture) atmosphere using inert gases in the purging process. This has also been confirmed by RPS, who will be carrying out an independent electrical assurance assessment.

Any operations that take place using the NIC systems will be reviewed by the G/23 steering group before it is used on the network and will comply with the controls in place in the procedure.

Create report documenting the learning taken from E1, 2 and 3

The learning taken from the development of elements 1, 2 and 3 will be collated in a report to support the consultation period for the element 4 conceptual designs. The report will be written by ULC robotics and SGN with RPS providing a report documenting their views as an independent technical consultant. The report will be written by the project team to support the SDRC9.2 'Development of conceptual designs for E4' report which will be in the same style as SDRC9.1. Both reports will be published on SGN's robotics website.

Development of conceptual designs for Element 4 and the respective consultation period

The intended plan for the development of Element 4 of the project over the next six months is to work on the conceptual design. All the conceptual designs will be put together as part SDRC 9.2 and will be presented to the other UK Gas Distribution Networks and the wider stakeholder groups during the consultation period.

SGN has created a draft consultation document which includes a capture form to record written feedback from stakeholders. Once the conceptual design has been finalised, the capture form will be populated with questions relating to the design suitability, the benefit of the technique to the industry and any areas where they feel improvements can be made to the design or the delivery method.

Two separate forms will be created; one for industry stakeholders who have a technical understanding of the environment the system will operate in, and one for third parties who are focused on the impacts this type of system will have on the general public.

Presentations will be made to each stakeholder by a member of the Robotics project team on the development process to date and the objectives of Element 4. Once all stakeholders have been contacted the final report will be submitted to OFGEM containing a summary of the feedback received and SGN's intentions for the progression of Element 4.

Submission of SDRC's 9.2, 9.4, 9.6 and 9.7

Within the next six months there are a number of SDRC's scheduled for submission. SDRC 9.4 will be submitted on the 28th August 2015 detailing the Configuration Testing with Robotic Platform. SDRC 9.6 and 9.7 will be submitted by the 4th December 2015 detailing the Launch of the Robot for both the repair and inspection module and SDRC 9.2 on the 14th December 2015 is to present the conceptual designs for Element 4 and the consultation period carried out by SGN.

Learning Dissemination

The project team are focused on the dissemination of the learning development of the project date and as we move in to the key areas of testing and field trial of the system. The Low Carbon Network and Innovation (LCNI) conference as a key event to share any learning across the gas and electricity networks. This flagship conference which is held annually offers a great opportunity to disseminate information on each of our innovation projects and gather feedback from key stakeholders. The conference also provides an opportunity to take learning from other gas network innovation projects with a key focus on how the initiatives will be transferred into business as usual.

As part of the conference, SGN will be holding breakout sessions whilst live demonstrations of the NIC platform will be performed on the SGN stand. Members of the project team will be present throughout the event to disseminate all information and learning from the project with interested stakeholders and colleagues from other GDNs.

During the field trial the other GB GDNs, local councils and press will be invited to observe the operation of the robotic system as well as be provided with the information gained during the development period to ensure that all the learning gained is disseminated. SGN will also continue to update the robotics website to provide the information to a wider stakeholder groups.

As mentioned above a report will be created containing a summary of all of the learning from the project to date for dissemination to key stakeholders and for publication on the project website. Meetings will also be held with key stakeholders to gather feedback on the conceptual designs for Element four of the project.

4 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. Once the controlled testing and live field trial have taken place a commercial appraisal of the process and the potential impacts the system can have against the original bid submission will be carried out.

5 Progress against Plan

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

The RPS report summarises the PPR from an independent technical consultant perspective and highlights any concerns or areas of interest in the project they feel needs to be monitored closely. ULC Robotics has also provided a 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).

6 Progress against Budget

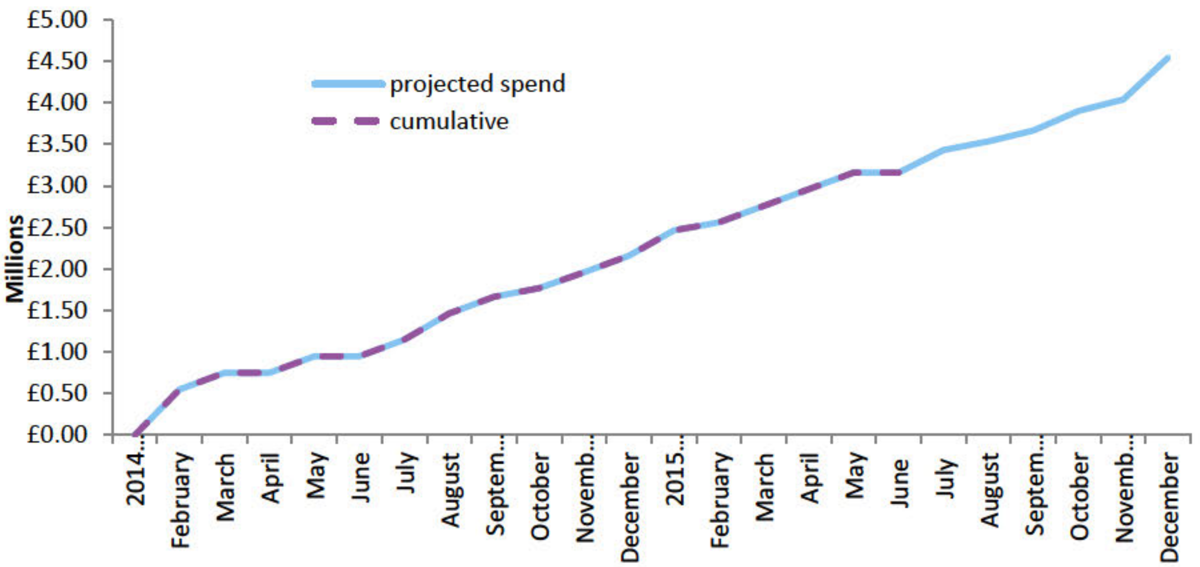


Figure 50 – total project expenditure at the date of submission (also included here is the projected spend for the field trial costs).

7 Bank Account

				Projected variance (at project conclusion)	
	Budget (£000s)	Expenditure ITD (£000s)	Comparison with expected expenditure (%)	(£000s)	%
See note			1		
LABOUR	**5566.9**	**2567.5**	**-6.0%**	**0**	**0.0%**
EQUIPMENT	**716.3**	**385.8**	**0.0%**	**0**	**0.0%**
CONTRACTORS	**163.9**	**75.2**	**0.0%**	**0**	**0.0%**
IT	**59.2**	**34.4**	**0.0%**	**0**	**0.0%**
IPR	**39.6**	**15.7**	0.0%	**0**	**0.0%**
TRAVEL AND EXPENSES	**583.9**	**196.6**	**0.0%**	**0**	**0.0%**
CONTINGENCY	**276.9**	**0**	**-100%**	**0**	**0.0%**
Total	**7406.8**	**3275.1**	**-8.2%**	**0**	**0.0%**

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

Figure 51 – Total project expenditure against budget

The variance in labour costs is the result of reduced expenditure on the technical service aspect of the project against the projected spends on the project spreadsheet. The fixed price and agreed payment milestone structure with RPS are lower than the projected budget as a result of the tender process conducted by SGN.

Additional works will be carried out by another technical service provider, DNV GL over the next reporting period focusing on the integration of the sensor output from the element three platform which will incur cost in to the expenditure category which is currently under spent. Further detail on the scope of works can be found in the *'Identify how the data provided by the sensor payload can be integrated in to the Mains Prioritisation Risk Score (MRPS) package'* section of this report.

Bank account extracts for each month since the last project report are included in the appendices of this document, reference D.

8 Successful Delivery Reward Criteria

There have not been any SDRC's due in this reporting period.

9 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].

10 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,

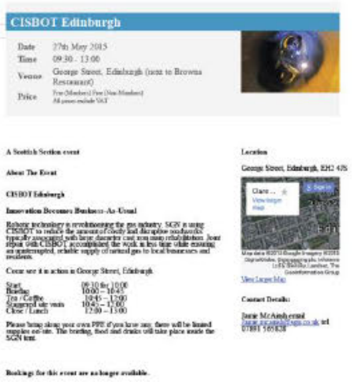
[1]https://www.ofgem.gov.uk/ofgem-publications/84774/gasnicsubmissionfromscotiagasnetworks-robotics.pdf

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.

As of the 1st May 2015, ULC Robotics have confirmed that key aspects of the commercial design of the system is protected for the GB Gas consumer by a patent. This allows SGN to share the technical and engineering knowledge whilst protecting the commercialisation of the system.

Since the patents have been approved SGN have taken steps to share project detail externally through two IGEM (Institute of Gas Engineers and Managers) presentation evenings, and through the Gas Innovation Governance Group (GIGG) attending by all GB GDN's (Figure 44).

Over the next six months, SGN will conduct a number of stakeholder engagement activities such as the LCNI Conference (held in November 2015), the IGEM conference (held in September 2015), regular updates at the GIGG meetings and invitations to the live field trial. Figure 49 lists the key stakeholders who will be invited to the field trials.



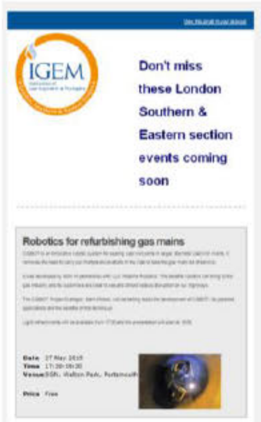


Figure 44 - These emails were circulated to all members of IGEM in the Edinburgh and South East district. The Robotics team provided an overview of Robotics for refurbishing gas mains.

Target Audience	Date	Description
Scottish Water Executive Board	6th January 2015	Innovation and SGN update
Department of Energy and Climate Change (DECC)	27th January 2015	General SGN and Innovation portfolio update
Scottish and Southern Energy Power Distribution (SSE PD)	13th February 2015	Innovation project progress update
HSE (Andrew Cooke)	Monthly update	Regular meetings to provide progress repost

Figure 45 – a table showing dissemination activities carried out by SGN in the last six months

Element 4.

As determined in the project direction; prior to developing Element 4 beyond the conceptual design stage, SGN must submit a report to Ofgem which contains the following information:

- The learning from Elements 1, 2 and 3 and how it can be applied to the development of the E4 system. RPS will act as an independent technical consultant and will submit their views in the form of a report.
- The learning gained through the conceptual design stage (internal stage gate 13 in the SDRC) for Element 4, including any technical and functional specifications and designs for Element 4
- A proposed methodology for the development of Element 4. This must include a description of the technologies that will be used in Element 4. It must also include an explanation and justification of why these technologies have been chosen, based on the learning described above.

SGN will disseminate these reports on the external website and will hold a workshop with each key stakeholder to present the developments and conceptual designs. The feedback from these workshops will be captured in a question and answer format. SGN will provide forms for each stakeholder to complete, enabling individuals to present their ideas and suggestions. The key stakeholders for the consultation period are listed in figure 49.

The key learning outcomes from the project to date are summarised in figure 46 and the methods used to disseminate information bother internally and externally are shown in figures 47 and 48.

Key Learning Outcomes		
	Reported Previously	Update
Launch tube	Development of launch tube conceptual design	The design has been finalised and constructed as per the Pressure Equipment Directive (PED) (97/23/EC)
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
Transport platform	Practical testing of platform to transport a 'pay-load' inside a live gas main	All aspects of the platform have been tested and learning outcomes recorded by ULC including: Sinclair drives, pneumatic system, video and lighting system and the drilling system
[redacted]	[redacted]	[redacted]
System Brand Identity	Developing a trademarked logo and brand for the system to give it an identity	The project team have worked to develop recognisable brand to give any engagement activities more impact and build an identity for the system

Figure 46 – a table to show the updated key learning outcomes

Internal Dissemination		
	Reported Previously	Update
Naming Competition	Engaging with all members of the business to submit a name for the robot	An attorney has been contacted to conduct a legal search for the selected name. SGN has learnt the importance of ensuring that the name is not already in use as well as the legal process involved with finding a name.
Steering Group Meetings	To obtain support from all areas of the business	Feedback provided from different departments within the business. For example, guidance on how safety can inform the design.
Robotics website	So members can access information	Still ongoing. Will be updated in the next few months.
Robotics email address	To provide a direct line of communication to the project team	Still available
Innovation piece	In company team brief to inform the wider business	Updates via SGNmail and on SGNnet with designs (which are now patent protected)

Figure 47 – showing the updated internal dissemination activities

Figure 48 – shows the updated external dissemination activities

External Dissemination		
	Reported Previously	**Update**
LCNI Conference	Promoting the progress of the project and making the team available for inquiries to gas industry personnel	This year, the project team will be able to disseminate the system and hope to have a functioning prototype on display. The LCNI conference will also serve as an opportunity for SGN to hold a Q&A session for Element 4.
Publication of reports	On Ofgem and SGN websites to highlight the progress to date.	Ongoing
Publication of robotics website	Allowing anyone access to project detail and to view progress	Ongoing – will be updated with designs (which are now patent protected)
Provision of robotics email address	To provide a direct line of communication to the project team	Still available
Communication with external institutes and bodies to capture a wider industry audience	SGN have given presentation on the project to IGEM and NJUG (National Joint Utilities Group) as well as the Innovation Institute, Construction News and Utility Week to promote the project.	Ongoing – As we get closer to the live field trial and demonstration activities we will increase the level of engagement to ensure profile of the project is raised and the benefits can be seen by all relevant stakeholders and our customers.

Stakeholders	Knowledge base and interests	Importance	Type of Engagement Activity
Transport for London (TfL)	External – focused on the benefits to road users	High	Invite to LCNI and field trial. Separate presentation direct to TfL.
GDN's – includes WWU, NGN, NG Distribution and Transmission	Internal – knowledge of the industry and technical challenges faced.	High	Engagement at LCNI. Individual visits to each GDN's network to present and answer any questions, invite to trials for E1, E2 and E3.
MPs/MSPs	External – focused on the benefits the general public	Low	Engagement through existing channels within SGN, invite to field trials.
Water companies	Internal – knowledge of the industry and technical challenges faced.	Low	Water companies face similar challenges whilst maintaining their networks. Invite to LCNI conference and field trials.
Replacement contractors – Southern and Scottish	Internal – knowledge of the industry and technical challenges faced.	High	Considered interested Third Parties. Contractors carry out a large proportion of tier 1 mains replacements works across the country. Communication through existing channels.
Universities/ independent consultants	External – focused on the benefits the general public	High	Engagement at LCNI conference. Potential for an independent view on the impacts of the new technology on the general public.
Health and Safety Executive (HSE)	Internal – knowledge of the industry and technical challenges faced.	High	Regular interface meetings, unlikely to issue written support.
Environment Agency (EA)	External – focused on the benefits to the environment	Low	Contact will be made to discuss the outputs of the project and the reduction in the carbon footprint of the works if the proposed solution is developed further.
Local press	External – focused on the benefits the general public	Low	Invitations to field trials as evidence of benefit and public opinion of robotic 'no dig' techniques. Unlikely to complete capture forms

Figure 49 – List of primary stakeholders

11 Intellectual Property Rights

In accordance with the Gas Network Innovation Competition Governance Document, ULC Robotics will report on intellectual property rights (IPR) being pursued on the project to SGN. In this period, ULC Robotics has the following filings to report on. Additional filings may be pursued as several key parts of the system are finalised.

- [redacted]
- [redacted]
- [redacted]

[redacted]

12 Risk Management

A summary of the associated risks highlighted in the guidance document are listed below with a short description of the mitigation methods used. All risks and their associated mitigation methods are listed in detail in the project risk register in Appendix C.

Procurement of Tether (Ref 22and23) - Original Score 10 – Current Score 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 and inspection 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 in to two separate transport platforms, allowing a specialised tether for each function to be developed.

A risk assessment and gap analysis was undertaken to defer finalising the design specification of the tether until further testing had been conducted on key components to ensure it would meet the requirements and avoid the need to reorder at a later date. If the tether was ordered as scheduled, there was the potential for a significant impact on the schedule and budget if it had to be re-ordered due to a specification change.

[redacted]

A progress report documenting progress to date and the specification of the tether will be submitted by ULC on the 03/07/15 for the repair module and 10/07/2015 for the sensor module. Due to the mitigation methods put in place, both remain low risk items in the risk register.

PED Certification for Launch Tube (Ref 35) - Original Score 12 – Current Score 3

For early versions of the risk register the launch tube specification was covered by the design capabilities for Elements 1, 2 and 3. For review v1.9 this item has been listed on the register as a separate item due to the criticality of the launch tube on the system operation.

To ensure the successful operation of the robotic platform on the UK gas network, it was vital that the launch tube has PED certification. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

13 Other

[redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]

[redacted]

14 Accuracy Assurance Statement

The same steps that were taken in the previous PPR's have been followed for this report (Figure 53). The aim of these measures is to ensure accuracy and to comply with governance provided.

Figure 53 – Accuracy assurance procedure

Appendix A - ULC Project Progress Report

ULC PIPELINE ROBOTICS

NIC ROBOTICS

Project Progress Report

Prepared for SGN PPR #3

SUBMITTED ON: June 17, 2015
PREPARED BY: Mike Passaretti, Program Manager, ULC Robotics

Contents

Revision History

Revision No.	Revision Date	Author(s)	Revision Description
--	15 JUN 2015	MP, et al.	Initial release

Referenced Documents

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

1.0 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 greatly support pipe fracture risk management processes by providing unprecedented inspection capabilities. After sixteen months, ULC Robotics is excited to report that a new, innovative and commercially viable robotic technology has been matured from concept to in-house functional testing. 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.

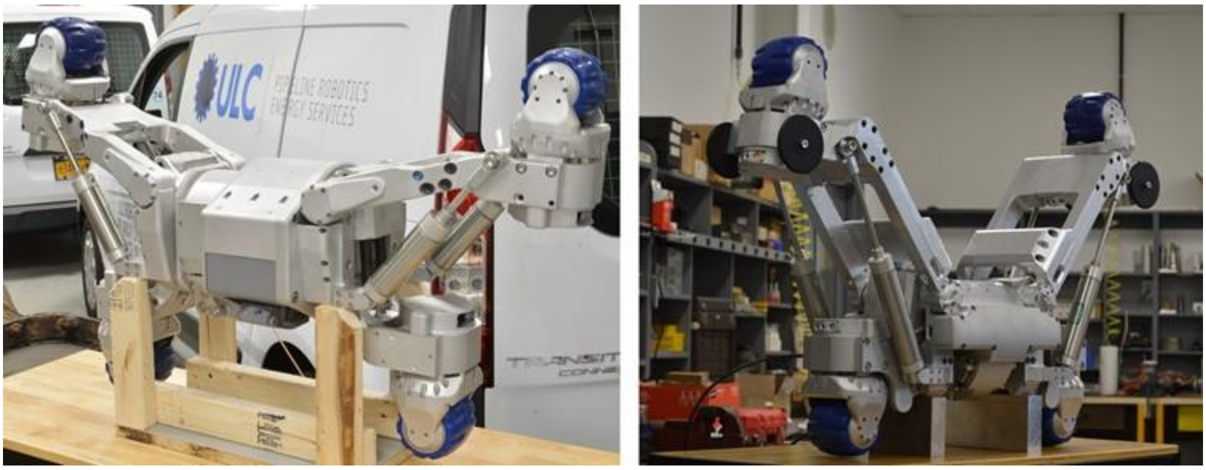


Figure 1 – The assembly of the Inspection Robot (Element 1 &3) (Left) and the Repair Robot (Element 1&2) (Right) were completed on-schedule are currently undergoing testing.

ULC Robotics has been under contract since February 2014. Since the submission of the last project progress report (December 2015) all milestones were achieved on schedule including two (2) Go/No-Go milestones. Since the start of the project, and as of the date of this report, twenty six (26) milestones have been submitted on schedule which includes two (2) SDRC's and five (5) Go/No-Go's. There are fourteen (14) project milestones remaining for Element 1,2&3. The milestones that were successfully completed since the submission of the previous progress report reflect several significant project accomplishments. The assembly and functional testing of the repair robot (Element 1 & 2) have been completed and the prototype system for 24" diameter mains is currently being readied for launch and travel testing. The design of the inspection robot (Element 1&3) has been completed.

The project is fully staffed with dedicated engineering and management personnel. The team consists of a total of eight engineers and one manager. All team members are full-time and dedicated to the NIC Robotics project. 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.

2.0 Project Managers Report

2.1 Element 1&2

The development of the repair robot (i.e. the transport platform and repair module) is currently on schedule with no major problems or areas of concern. In the previous reporting period (PPR No. 2: June – December 2014), the design of the repair robot was finalized and manufacturing began. The manufacturing of the system was completed on schedule without any major issues or delays.

[redacted]

The completion of the mechanical assembly phase in March 2015 marked the beginning of the repair robot functional testing phase. Following the mechanical assembly of the robot, wiring and pneumatic routing were completed to enable functional testing. Each of the functional tests performed during this phase (See Learning Outcomes) were successfully completed.

[redacted]

Throughout the duration of the project, ULC Robotics has been providing weekly updates to SGN and RPS via teleconferencing. These meetings also serve as a forum to discuss technical developments and project planning to ensure milestones are met on schedule. As needed, in-person meetings are also held. An in-person meeting was held with SGN and ULC the week of the 6th of April in the US to thoroughly update the project team about various parts of the project. At this meeting, SGN toured ULC facilities, observing the functional testing detailed in this report, as well as testing of the inspection sensors, and launching system mechanisms.

[redacted]

2.2 Launch System

The development of the launch system is currently on schedule with no major problems or areas of concern. After completing the manufacturing documentation (January 2015) for the launch system, manufacturing began. As of the date of this report the launch tube has passed both ASME and PED testing and has met all quality and material documentation requirements. The launch tube has been stamped ASME compliant, and upon final acceptance of the technical construction file, the PED stamp will be installed. The final review and placing of the stamp will take place prior to shipping the launch system to the UK. See Learning Outcomes for additional details.

[redacted]

Element 1&2 Milestones Completed This Report Period	Go/No-Go No.	SDRC No.	Completion Date
Creation of Detailed Fabrication and Manufacturing Documentation (Launch Tube)			16 JAN 2015
Initial Parts Fabrication (Robotic Platform)			13 FEB 2015
Robotic Platform and Joint Repair Module Assembly			13 MAR 2015
Robotic Platform & Joint Repair Module Prelim. Functional Test	2		10 APRIL 2015
Launch System Testing	3		22 MAY 2015

Remaining Element 1&2 Milestones	Go/No-Go No.	SDRC No.	Due Date
Robotic Platform Launch, Retrieval and Travel Testing	4		03 JUL 2015
Seal Robot Tool Testing	5		03 JUL 2015
Procure Spares & Material for Field Testing			25 AUG 2015
Launch Robot	6	9.6	04 DEC 2015
Perform 20 Days of Field Testing			06 NOV 2015
Generate Final Report			18 JAN 2016

Table 1 – Remaining Element 1&2 Project Milestones

2.3 Element 3

The development of the sensor module is currently on schedule with no major problems or areas of concern. In the previous reporting period (PPR No. 2: June – December 2014), the 3D design of the inspection robot was completed. Following this milestone, ULC Robotics finalized the detailed design of the system and created the manufacturing documentation. Fabrication of the inspection robot started shortly thereafter and was completed on schedule. The inspection robot was successfully assembled in May 2015.

The design of the final custom sensors and required sensor electronics were finalized during this reporting period. The next iteration of (final) custom sensors are expected to be completed before the 10 July 2015 "Integrate & Test Tether with Sensor/Data Acquisition System" Go/No-Go milestone; the custom electronics are expected before the 28 August 2015 "Configuration Testing w/ Robotic Platform" SDRC & Go/No-Go milestone. [redacted]

[redacted]

Figure 6 - Inspection Robot Assembled (22 May 2015)

[redacted]

[redacted]

[redacted]

Element 3 Milestones Completed This Report Period	Go/No-Go No.	SDRC No.	Completion Date
Initial Electrical Schematic Design and Parts Selection			09 JAN 2015
Creation of Detailed Fabrication & Manufacturing Documents			30 JAN 2015
Procurement & Testing of Sensor Package	2		06 MAR 2015
Design and Procure Tether			03 APR 2015
Initial Parts Fabrication and Assembly			22 MAY 2015

Remaining Element 3 Milestones	Go/No-Go No.	SDRC No.	Due Date
Integrate and Test Tether With Sensor/Data Acquisition System	3		10 JUL 2015

Configuration Testing with Robotic Platform	4	9.4	28 AUG 2015
Sensor Data Validation	5		31 JUL 2015
Develop Test Plan for the Field			04 SEP 2015
Incorporate Improvements Discovered During Testing			23 OCT 2015
Perform 20 Days of Field Testing			06 NOV 2015
Launch Robot	6	9.7	04 DEC 2015
Generate Final Report			18 JAN 2016

Table 2 – Remaining Element 3 Project Milestones

2.4 Element 4

ULC Robotics is excited to start development of a system for performing automated live asset replacement for distribution service and mains on tier 1 mains. The preliminary specifications are on-schedule to be completed and submitted by 6 July 2015. Following the completion of the specifications, ULC Robotics will begin the conceptual design process with the goal of selecting a design, with input from SGN by 14 December 2015. See Table 3 for a list of the remaining Element 4 milestones.

Remaining Element 4 Milestones	**Go/No-Go No.**	**SDRC No.**	**Due Date**
Delivery of High Level, Preliminary Specs. Document			06 JUL 2015
Development of Conceptual Designs	1	9.2	14 DEC 2015
Initial Electrical Schematic Design and Parts Selection			29 JAN 2016
Review of Conceptual Design by OFGEM			04 MAR 2016
Circuit Card Layout and Fabrication			11 MAR 2016
Initial 3D Design of Mechanical Components			27 MAY 2016
Microprocessor Firmware Programming			03 JUN 2016
Selection and Procurement of Motors, Gears and Bearings			22 JUL 2016
User Interface and Control System Design and Programming			29 JUL 2016
Creation of Detailed Fabrication & Manufacturing Docs.			19 AUG 2016
Initial Parts Fabrication			23 DEC 2016
Robot Assembly			20 JAN 2017
Robot Preliminary Functional Test	2		17 FEB 2017
Integration Of Electrical System into Mechanical Prototype			31 MAR 2017
Service Installation Validation	5		14 APR 2017
Pipeline Travel Testing	3		12 MAY 2017
Tapping & Fitting Tool Validation	4	9.5	12 MAY 2017
Develop Test Plan for the Field			23 JUN 2017
Incorporate Improvements Discovered During Testing			04 AUG 2017
Perform 20 Days Field Testing			15 SEP 2017
Launch Robot	6	9.8	13 OCT 2017
ULCR Generate Final Report			27 NOV 2017

Table 3 – Remaining Element 4 Project Milestones

3.0 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.

4.0 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.

5.0 Learning Outcomes

In this section of the report ULC Robotics will present a summary of the key learning outcomes that resulted from the progress made during this reporting period.

[redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]

[redacted]

5.2 Repair Robot (Element 1&2)

5.2.1 Creation of Manufacturing Documentation & Functional Testing of the Launch Tube

A detailed overview of functional testing of the launch system, as well as the lessons learned throughout the process of manufacturing, certifying and assembling were included in the 22 May 2015 "Launch System Testing" report. A brief summary of this report in included here. An overview of the current design of the launch system is shown in Figure 10. The key features of the design are shown and explained in detail later in this section. The details associated with the design process for each feature is included in the subsequent sections. The overall goal of the NIC launch system design is to increase the efficiency of safe operations, minimize the size of the site footprint and minimize the cost of operations.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

5.2.2 Initial Parts Fabrication & Robotic Platform and Joint Repair Module Assembly

As mentioned in the manufacturing documentation report, a large amount of knowledge will be gained through the process of building, assembling and testing the first prototype system. Many factors that could affect the design of the system can only be learned through fitting and testing of the actual hardware – these include launching, retrieving, drilling, injecting, rounding bends and traversing obstacles. It is anticipated that minor design and functionality changes will be determined through testing and minor adjustments will be made to fine tune the system. Throughout the assembly phase the project team has been documenting the lessons that were learned to inform future design tasks. As it relates to the assembly process, the following was learned thus far:

1. In preparation for the manufacturing of the repair robot, the NIC project team took the opportunity to reevaluate the design finalization steps, manufacturing documentation generation, approval, checking and general configuration management processes. These were prepared and instituted per the project timeline and the results thus far have been very positive. To date there have been no errors or need for major modifications identified. In the future, ULC will continually evaluate these processes to ensure efficiency and quality is maintained.

2. [redacted]

3. [redacted]

    a. [redacted]

    b. [redacted]

[redacted]

c. [redacted]

d. [redacted]

5.2.3 Robotic Platform & Joint Repair Module Prelim. Functional Test

Functional testing is a valuable step that enables the project team to ensure individual components are working appropriately prior to integrating additional hardware, software systems and conducting more sophisticated tests such as launch, travel and seal test operations. Some parts of the system are first tested individually before being tested as a whole. This allows for better control over potential variables and increases the efficiency of debugging and fine-tuning operations. An explanation of the functional tests and results is given below. Overall, the team at ULC is very encouraged by the outcome of the functional testing and looks forward to more advanced and extended testing of the system leading up to the upcoming milestones.

[redacted]

5.3 Inspection Robot (Element 1&3)

5.3.1 Initial Electrical Schematic Design and Parts Selection

The initial electrical schematic design and parts selection of the inspection robot was completed as schedule on 9 January 2015. The design was informed by all relevant project documentation and specifications. Each design was completed through direct collaboration with the sensor vendors who are experts in their respective areas of NDT (non-destructive testing) sensor technology. The details of the initial designs as well as supporting information that describes the design process were described in the report.

5.3.2 Creation of Detailed Fabrication and Manufacturing Documentation

The design of the inspection robot and the appropriate manufacturing documentation was completed by 30 January 2015. There were several key considerations that were assessed leading up to this milestone. [redacted]

[redacted]

5.3.3 Procurement & Testing of Sensor Package

The inspection robot utilizes specialized sensors, mechanisms and supporting electronics to support direct assessments on the pipelines. Since down-selecting, in July 2014, to the most appropriate technology for the purposes of this project, ULC Robotics has procured, evaluated and characterized several iterations of the sensors and the corresponding hardware [redacted]

[redacted]

- [redacted]
    - [redacted]
    - [redacted]
    - [redacted]
    - [redacted]
    - [redacted]

- [redacted]

[redacted]

- [redacted]

[redacted]

- [redacted]
- [redacted]

5.3.4 Design and Procure Tether

As it relates to the original project schedule, ULC Robotics planned to complete the tether design and start tether procurement immediately after the mechanical design of the robotic systems was complete. In practice it was learned that while the mechanical design of the system was complete, additional engineering was necessary to finalize the tether designs. This has been detailed in the Project Managers Report of the milestone report submitted 3 April 2015. As a result of the project meetings the week of 6 April, ULC and SGN have discussed a revised plan for the tethers. The plan is as follows:

- [redacted]
- [redacted]

5.3.5 Initial Parts Fabrication and Assembly

The mechanical assembly of the inspection robot for 24" diameter pipe was completed on schedule and in accordance with the requirements set forth in the project specifications. The design takes into consideration the SGN approved project specifications, relevant British standards and additional documentation approved by SGN. The completion of the fabrication period and receiving of the inspection robot parts marked the beginning of the assembly phase. Following receiving, all parts required for the assembly were quality checked, test fit, and post-machined as planned. After multiple inspections and fit checks, the assembly was completed as scheduled [redacted]

As mentioned previously, a large amount of knowledge has and will be gained through the process of building, assembling and testing the first prototype system. Many factors that could affect the design of the system can only be learned through fitting and testing of the actual hardware. It is anticipated that minor design and functionality changes will be determined through testing and minor adjustments will be made to fine tune the system. Throughout the assembly phase the project team has been documenting the lessons that were learned to inform future design tasks. As it relates to the assembly process, the following was learned thus far:

1. As with the repair robot, in preparation for the manufacturing of the inspection robot, the NIC project team took the opportunity to reevaluate the design finalization steps, manufacturing documentation generation, approval, checking and general configuration management processes. These were prepared and instituted per the project timeline and the results thus far have been very positive. To date there have been no errors or need for major modifications identified. ULC has been, and will continually evaluate these processes to ensure efficiency and quality is maintained.

2. [redacted]

[redacted]

[redacted]

[redacted]

4. The ease of assembly of the inspection robot was continually evaluated during the design, fabrication and assembly processes. The following features or areas of the design were noted as having potential for improvement:

a. [redacted]

[redacted]

b. As with the repair robot, the team is also considering installing small removable plastic caps to cover counter bores and prevent ingress of contaminants that may foul or otherwise inhibit access and insertion or removal of the fasteners.

c. The width of wire pathways were increased where possible to increase the ease of wiring and routing based on learning from the repair robot assembly and functional testing phase. See Figure 17.

[redacted]

6.0 Progress Against Plan and Budget

The project is progressing on schedule and on budget. A summary of the successful delivery reward criteria milestones are shown in Table 4 below.

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	14 DEC 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	04 DEC 2015
9.7	Element 3:	Launch Robot	On-schedule	04 DEC 2015
9.8	Element 4:	Launch Robot	On-schedule	15 SEP 2017

Table 4 - SDRC Milestone Schedule

7.0 Intellectual Property Rights (IPR)

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 has the following filings to report on. Additional filings may be pursued as several key parts of the system are finalized.

- [redacted]
- [redacted]
- [redacted]

[redacted]

[redacted]

Appendix B - RPS Project Progress Report

Ofgem Project Progress Report Update Three

Document Control Sheet

Client:	SGN
Project Title:	Network Innovation Competition (NIC) Robotic Solutions
Document Title:	Ofgem Project Progress Report Update Three
Document No:	MDR1025Rp020

Text Pages:	28	Appendices:	0

Rev.	Status	Date	Author(s)	Reviewed By	Approved By
F02	Final	17th June 2015	Ian MacHugh David Phelan	Ciarán Butler Mark Phelan	David Phelan PJ Rudden

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EXECUTIVE SUMMARY

The objective of this project is to develop new robotic technologies to operate inside live gas mains. This new technology will 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.

RPS were appointed to provide technical services to SGN in supporting an industry leading innovation project in developing robotic platforms and solutions for the gas industry in partnership with a robotics manufacturing & utility company – ULC. This innovation project will potentially allow extensive work to be carried out on the UK's gas network without the need for disruptive road works, reduce repair costs, reduce third party damage, improve the risk management of metallic mains and reduce leakage from gas distribution mains.

This Project Progress Report - Update Three provides a concise update of work completed since the previous progress report issued to SGN on 11th December, 2014.

Progress Summary

- The project is currently progressing well and is within budget;
- Five key Milestone reports (three in the last six months) have been provided by ULC and assessed by RPS to date;
- ULC has provided 12 reports on Elements 1&2 to date (six in the last six months);
- ULC has provided 10 reports on Element 3 to date (six in the last six months);
- The repair robot parts were fabricated and assembled. Functional testing has been carried out.
- The launch tube design and manufacturing has been finalised. Hydro testing has been carried out and pressure equipment testing has been certified in accordance with the EU Pressure Equipment Directive on the physical examinations for the launch tube;
- The inspection robot has undergone detailed design, manufacturing and testing of the sensors. It has recently been fabricated and assembled. The tethers are going through final design. Most of the inspection robot has been fabricated and assembled.
- In addition to assessing ULC reports, RPS has developed two separate reports that are of significant importance to this NIC project for this project progress report milestone.
    - A Structural Assessment Report on 5th February, 2015 on four pipe sizes of interest to SGN. A revised report was delivered on 12th March, 2015 which included spun cast iron calculations;
    - A preliminary MRPS Interpretation Report was developed on 28th May, 2015 to showcase how the data from the inspection robot can impact on the current risk management system in SGN and other GDNs.

Key Learning Outcomes

- The past six months has seen the detailed design progressed and development of two independent robotic systems to carry out the repair (Element 2) and inspection (Element 3) services. They will share common, interchangeable components including the transport platform and launch system (Element 1);
- Both systems have different tether requirements and therefore separate individual tethers.
- The launch tube has also been fully designed, manufactured and assembled;

- Another very encouraging outcome is that the launch tube has passed all physical tests regarding EU Pressure Equipment Directive (PED) for certification. ULC will now have to provide the paperwork and calculations to finalise the process;
- Testing of the robotic systems and launch tube will provide significant learning outcomes over the next six months.
- Functional testing has provided individual learning outcomes on key components.

Consistency with Full Submission Pro-Forma
The project development to date is consistent with the SGN Full Submission Pro-forma to Ofgem.

Risk Management
The risk register is discussed and regularly updated with all members of the project team. Key project risks are then identified. Controls are then put in place to mitigate these risks. There were three risks over the past six months that were marked as completed. There are six key risks over the next six months that are of critical importance to the project and require due attention to make sure that they are sufficiently controlled.

Intellectual Property Rights
There is very significant value in the IPR developed under this project to GB gas consumers. Techniques used in this project for the launching process, robotic platforms, repair and inspection are at the forefront of robotic technology to inform risk and asset management especially in a live gas main.

This robotics project has the potential to transform the way the UK gas industry maintains its gas distribution pipes. The use of robotic technology to repair and inspect mains may lead to significant benefits, both for customers and our environment.

Key targets and objectives for the next six months
The following are key deliverables over the next six months from ULC and RPS:

ULC Report Deliverables
Elements 1 & 2
Perform testing on the launch tube, retrieval and travel
Perform testing on the repair robot
Procure spare parts and material in preparation for field testing
Launch repair robot and begin field tests (4th December, 2015)
Element 3
Integrate and test tether with sensor/data acquisition system
Configuration testing with Robotic Platform
Sensor data validation
Develop test plan for the field testing and incorporate improvements discovered during testing
Launch inspection robot and begin field tests (4th December, 2015)
Element 4
Delivery of High Level, Preliminary Specification Document By ULC To SGN
Development of Conceptual Designs
RPS Report Deliverables
Electrical Safety Technical Assurance Report
MRPS Interpretation Report

1 INTRODUCTION

The aim of the project is to develop robotic techniques that will allow Gas Distribution Networks (GDNs) to repair leaking joints and inspect mains providing sensor outputs of mains condition in a 'live' gas environment from a remote location.

RPS were appointed as the technical service provider to SGN in supporting an industry leading innovation project in developing robotic platforms and solutions in partnership with a robotics manufacturing & utility company – ULC.

This Project Progress Report - Update Three provides an update of work completed between December, 2014 and June, 2015. The key areas to which RPS will discuss in this progress update report are:

- RPS Company Profile,
- Progress update and summary of each element including overview of RPS Structural Report and Preliminary RPS MRPS Interpretation Report;
- Key learning outcomes,
- Progress against target price,
- Consistency with Full Submission Pro-Forma,
- Review of high level performance specification
- Risk management,
- Intellectual Property Rights
- Key objectives for the next six months.

2 RPS PROFILE

RPS is a global energy company with a long track record in utilities including gas, water and power engineering. For information on the range of services which RPS provides, please visit our webpage at http://www.rpsgroup.com/Ireland/Services/A.aspx

RPS currently provides ongoing energy and consultancy services to a number of public and private sector companies in the Gas industry.

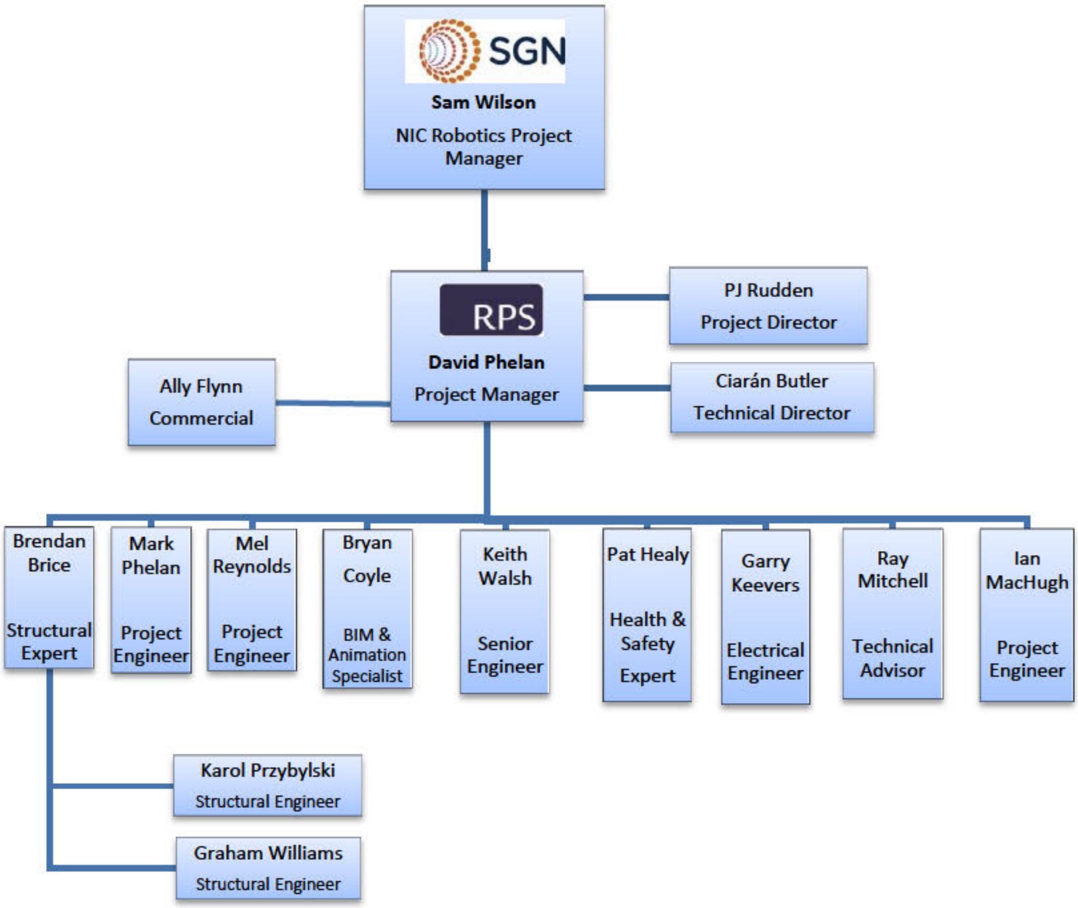
2.1 NIC PROJECT TEAM

RPS was appointed by SGN in February, 2014 to provide a range of technical services for the NIC project as follows:

- 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;
- Review of the data gathered against the Mains Risk Prioritisation System (MRPS);
- Risk management;
- Multidisciplinary engineering design;
- Structural assessment;
- Imagery and 3D animations;
- Electrical safety technical assurance.

The RPS project team is led by David Phelan and consists of a number of specialist staff with various backgrounds and experience. An overview of the RPS project team can be viewed in Figure 2-1 overleaf.

Figure 2-1 Overview of RPS NIC Project Team



3 PROGRESS SUMMARY

Since the previous progress report in December, 2014, ULC has delivered 12 progress development reports to which RPS has contributed technical input and assessment. Upon receiving each report, RPS carries out a thorough review of project/element developments at each stage. A number of queries are raised and recommendations are provided by RPS. All information discussed on each ULC report is captured in the RPS assessment reports. This allows for an efficient and transparent process of knowledge transfer within the project team. There are also weekly teleconference calls on progress updates and items about upcoming events are discussed. It is worth noting that the success of this process to date is a product of SGN's excellent project management capabilities, which has helped to create an excellent project team dynamic.

In addition to assessing ULC reports, RPS has developed two separate reports that are of significant importance to this NIC project for this project progress report milestone.

1. Structural Integrity Report
2. Preliminary MRPS Interpretation Report.

These reports are discussed in more detail later in this section, along with a summary of the progress made with each Project Element during this period.

As mentioned previously, RPS has contributed to project team meetings and completed a number of assessment reports.

Table 3-1 Update on Meetings and Reports since previous Project Progress Report

	No. since December, 2014
Project Team Face-to-Face Meetings	2
RPS Reports	7

The following two tables' show the meetings and reports carried out since the project commenced. Note the text in grey font was reported in the previous project progress report. Text in black font represents meetings and reports carried out over the last six months.

It is worth noting that there were a number of ULC reports grouped together in Milestone 2 for Elements 1&2 and 3. This facilitated a more efficient reporting process for RPS.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

3.1 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 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.

3.1.1 Project Progress Update

There were two ULC reports that provided updates on the development of the launch system.

1. 'Creation of Detailed Fabrication and Manufacturing Documentation (Launch Tube)' Report
2. 'Launch System Testing' Report

The 'Creation of Detailed Fabrication and Manufacturing Documentation (Launch Tube)' Report by ULC in December, 2014 presented the final design for a launch tube to facilitate safe and easy access and removal of the robotic systems developed to work in live gas conditions. The report describes the design of the launch system from the conceptual design and initial design stages to the final design stage.

The 'Launch System Testing' Report by ULC in May, 2015 provided a summary of the manufacturing, certification, assembly and testing of the launch system. [redacted] This is an important step in that functional testing enables the project team to ensure individual components are working appropriately. The launch tube has successfully passed each of the tests to-date.

3.2 ELEMENT 2 - DEVELOPMENT OF AN INTERNAL MECHANICAL JOINT INSTALLATION MODULE AND WECO SEAL REPAIR METHOD FOR TIER 2 AND TIER 3 PIPE

Element 2 involves the development of a repair module for repairing internal joints and Weco seals inside a live gas main. The repair module has been designed in conjunction with the robotic platform in Element 1.

3.2.1 Project Progress Update

ULC has completed the manufacturing and assembly of the 24” repair robot prototype. Functional Testing on a number of parts and mechanisms have been carried out.

Over the past six months, there were four ULC reports that provided updates on the development of the robotic platform and repair system. These were:

1. User Interface, Control System & Programming Report;
2. Initial Parts Fabrication (Robotic Platform);
3. Robotic Platform and Joint Repair Module Assembly;
4. Robotic Platform and Joint Repair Module Preliminary Functional Test.

The ‘User Interface, Control System & Programming’ Report by ULC in December, 2014 provided an update on the various software components which will make up the final robotic system. An outline was provided of the architecture and concepts which make up the programming code that will ultimately ensure the robotic system operates as intended. ULC began developing the computer system behind the robotic system which will allow the final robotic design to be developed.

The ‘Initial Parts Fabrication (Robotic Platform)’ Report by ULC in February, 2015 provides an update on the fabrication stage for parts needed to assemble the repair robot. The report follows on from the ‘Creation of Detailed Fabrication and Manufacture Documentation’ Report which outlined the final design of the repair robotic system. The successful completion of the fabrication of all parts for the repair robot has been undertaken and described in this report. The fabricated robotic parts were shown through a number of images with accompanying descriptions. In preparation for this stage, the robotic system parts were post-machined and treated, particularly the mating parts. This allowed for the preparation of the full system functional test in April 2015.

The ‘Robotic Platform and Joint Repair Module Assembly’ Report by ULC in March, 2015 illustrated the process of assembling the repair robotic system. The report also follows on from the ‘Initial Parts Fabrication – Robotic Platform’ and ‘Creation of Detailed Fabrication and Manufacture Documentation’ reports. The report outlines the successful assembly of the repair robot and outlines some of the lessons learned from this stage. The next step milestone for this element was the full system functional test for the repair robot, which was scheduled for 10th April 2015. The project team prepared for this stage by readying the support equipment for the robot, including the software, electronics, pneumatic systems, cabling, tubing and wiring.

The ‘Robotic Platform and Joint Repair Module Preliminary Functional Testing’ Report by ULC in April, 2015 outlined the preliminary functional testing of four critical components of the repair robotic system – Sinclair drives, Pneumatic system, Video & Lighting system and drilling system. A prototype graphical user interface was developed to allow the user to interact with these developments. The report follows on from the previous Element 2 reports which outlined the final design, sourcing of parts and assembly of the repair robot. This report outlined the successful completion of the functional testing phase of the repair robot configured for 24” gas mains.

3.3 ELEMENT 3 - ROBOTIC VISUAL AND NON-VISUAL INSPECTION

[redacted]

3.3.1 Project Progress Update

The inspection robot has completed final design and fabrication and is almost fully assembled.

Over the past six months, there were six ULC reports that provided updates on the development of the inspection robotic system:

1. Initial 3D Design of Mechanical Components Inspection Robot;
2. Initial Electrical Schematic Design and Parts Selection;
3. Creation of Detailed Fabrication and Manufacturing Documentation;
4. Procurement & Testing of Sensor Package;
5. Design and Procurement of the Tether;
6. Initial Parts Fabrication and Assembly.

The 'Initial 3D Design of Mechanical Components' Report by ULC in December, 2014 presented the initial design of the inspection robot and sensor module. The report outlines the testing carried out in order to inform the initial design and the large amount of consideration which was given to the practicality of the sensor module. The initial design of the inspection robot was covered and the consideration given to the sensor modules and how these will tie into the transport platform was outlined. The report summarised the initial design requirements, an overview of initial design, a summary of robotic deployment, all concepts evaluated and the testing performed to date.

[redacted]

The 'Creation of the Detailed Fabrication and Manufacturing Documentation' Report by ULC in January, 2015 presented a variety of information associated with the inspection robot [redacted]

The 'Procurement & Testing of Sensor Package' Report by ULC in March, 2015 provided a summary of the procurement of the sensor hardware and the testing which had been completed to date. [redacted]

The 'Design and Procurement of the Tether' Report by ULC in April, 2015 provided an update on the design progress for the repair and inspection robots. Both robotic systems share a number of common components and therefore some components of the tether will be the same also. It is noted that the primary purposes of the two robotic systems are different and therefore they each will require their own separate tether. Information on tether sealing, tether cores, physical characteristics, tether manufacturers and tether terminations were discussed.

The 'Initial Parts Fabrication and Assembly' Report by ULC in May, 2015 illustrated all the parts of the inspection robot and the assembled robot itself. It provided an update on the custom sensor developments, sensor data validation, sensor module mechanical specification, an overview of the assembly process and lessons learned during the assembly process.

3.4 ELEMENT 4 - AUTOMATED LIVE ASSET REPLACEMENT FOR DISTRIBUTION SERVICES AND MAINS

This element proposes to develop a system capable of remotely reconnecting service lines to inserted pipe without the necessity of performing excavation over each service connection. The robotic device will enter and travel down the gas main between the main and the inserted PE pipeline or inside the newly inserted PE pipe to perform a remote reconnection of the service line. It is anticipated that the system will work in 4” to 8” gas mains, the most common diameters in Tier 1.

Work on this element is due to commence in July 2015.

3.5 RPS STRUCTURAL REPORT

RPS carried out structural assessments of cast iron, spun cast iron and ductile iron pipes in the Tier 2 and Tier 3 categories. Finite Element Analysis was undertaken to analyse stresses induced locally within the pipe cross section by imposed loads. Analyses were carried out on selected pipe sizes based on a number of pipe diameters. A 24” diameter pipe was also analysed as this had previously been identified as a key pipe size within the SGN network. Analyses were also completed with and without corrosion of the pipe wall resulting in reduced pipe wall thicknesses of various amounts.

3.6 RPS PRELIMINARY MRPS INTERPRETATION REPORT

The MRPS Interpretation Report is a working draft currently in development by RPS. The first issue for review was issued to SGN in May, 2015. The purpose of the report is to seek an understanding of current MRPS (Mains Risk Prioritisation System) being utilised in SGN and other GDNs and how the inspection robot can positively influence and inform asset risk. [redacted]

[redacted]

- Distribution mains characteristics
- Overview of previous relative risk reports on cast iron

- Failure modes of gas pipes
- The existing MRPS Model
- Influencing categories for the inspection survey
- Integration of sensor data from inspection robot
- Probability of detecting a defect
- Various inspection strategies

[redacted]

4 KEY LEARNING OUTCOMES

The past six months has seen enhanced detailed design and development of two independent robotic systems to carry out the repair (Element 2) and inspection (Element 3) services. They will share common, interchangeable components including the transport platform and launch system (Element 1).

Both robotic systems will have different tether requirements and therefore separate individual tethers.

The launch tube has also been fully designed, manufactured and assembled.

Another very important and encouraging outcome is that the launch tube has passed all physical tests regarding EU Pressure Equipment Directive (PED) for certification. ULC will now have to provide the paperwork and calculations to finalise the process.

Testing of the robotic systems and launch tube will provide significant learning outcomes over the next six months.

5 PROGRESS AGAINST TARGET PRICE

It is noted in each ULC report that there has been no variation in the progress against the target price.

6 CONSISTENCY WITH FULL SUBMISSION PRO-FORMA

The Gas Network Innovation Competition Full Submission Pro-Forma covers the entire summary of the project and describes the design process and various milestones in detail. The overall objectives of the project are described in detail throughout the document.

The Pro Forma is broken down into 9 sections:

1. Project Summary
2. Project Description
3. Project Business Case
4. Evaluation Criteria
5. Knowledge Dissemination
6. Project Readiness
7. Regulatory Issues
8. Customer Impacts
9. Successful Delivery Reward Criteria (SDRC)

The final design of the robotic system has undergone significant change since the initial and conceptual design stages. At each milestone, the Full Submission Pro-forma is checked for compliance by the RPS Project Team. It has been deemed compliant at each milestone to-date. It has been established by ULC that the optimum design approach for this project will involve a modular robotic system that shares common components such as the transport platform, launch system and other support and control elements, which will create the economies of scale specified. It is proposed to use two independent robotic systems onsite to maximize operational efficiency and prolong hardware performance, rather than interchanging the modules between the inspection and repair services.

A potential area for uncertainty arose through the use of two different robotic systems to perform the repair (Element 2) and inspection (Element 3) services. While it is not stated in the Full Submission Pro-forma that two independent robotic systems will be developed under this project, it is not explicitly stated that the robot will be limited to one system. It is stated that a launch tube, robotic platform, repair module and sensor module will be developed. The repair module is to be developed with the robotic platform and launch tube. The sensor module *"will be deployed in conjunction with the robotic transport platform and launch system developed under Element 1".* The final design of the robotic systems use the same transport platform and launch tube system for each payload module, and as such has been deemed compliant.

6.1 ELEMENTS 1 & 2

For the purposes of reporting and checking compliance against the Full Submission Pro-forma upon each ULC development report for Elements 1 & 2, a number of statements from the initial bid document were identified as being areas which should be closely monitored as the design of the launch system & platform progresses. These are assessed overleaf:

1. *"A launch tube system will be designed to prevent gas from escaping during the setup, operation and removal of the device, while keeping the mains live and without disrupting gas service to customers."*

The current design has been developed to satisfy this criterion. Extensive design works and testing will ensure that the launch tube performs as required. Operational procedures will be implemented to allow the gas mains to remain live throughout the operation.

Estimated timeframe for technology to be defined: July, 2015 following 'Robotic Platform Launch, Retrieval and Travel Testing' Report. This is Milestone 4 on the Element 1 & 2 schedule and is a go/no go milestone.

2. *"This robotic system will be able to enter the gas mains via a launch tube, travel down the pipe making repairs, and then return to the launch pipe for retrieval."*

The current design has been developed to satisfy this criterion. Extensive design works and testing will ensure that the equipment used and procedures associated with the robotic system and launch tube will allow the system to perform as required.

Estimated timeframe for technology to be defined: July, 2015 following 'Seal Robot Tool Testing' Report. This is Milestone 5 on the Element 1 & 2 schedule and is a go/no go milestone.

3. Under Element 3 – *"It is anticipated that the device will utilise the same or a similar launch tube as the platform developed under Element 1."*

This will be achieved with the current design of the launch tube. The system has been designed to utilise the same launch tube to serve both the inspection and repair robots for the same diameter mains.

Estimated timeframe for technology to be defined: July, 2015 following 'Robotic Platform Launch, Retrieval and Travel Testing' Report. This is Milestone 4 on the Element 1 & 2 schedule and is a go/no go milestone.

The technical description of the project under Element 1 & 2 has not varied as a result of the proposed designs presented in this report:

"ULC Robotics proposes to develop a tethered robotic system capable of vertically launching into live gas pipes within tiers 2 and 3 with pressures up to 29psi. It is anticipated that the modular robotic system will include:

- *Robotic Transport Platform – Capable of entering live gas mains via the launch system, performing internal video inspection, transporting the sensor modules through the gas main.*
- *Interchangeable modules (mechanical joint repair module, Weco seal repair module, sensor modules).*
- *Gas tight (no release of gas during operation) launching system.*
- *Control system.*

- *Additional support equipment."*

RPS do not currently foresee any reasons why the above statements cannot be achieved. The current robotic system has been developed with consideration to these aspects of the design.

Estimated timeframe for technology to be defined: July, 2015 following 'Robotic Platform Launch, Retrieval and Travel Testing' Report. This is Milestone 4 on the Element 1 & 2 schedule and is a go/no go milestone.

6.2 ELEMENT 3

Similarly, for Element 3, the following key items from the Full Submission Pro-forma were identified which should be closely monitored as the design of the inspection robot progresses.

1. *"ULC Robotics proposes to research and develop a suite of sensors, which can be mounted, pushed, pulled or transported into live gas mains via the robotic transport platform developed under Element 1. This modular sensor package will be utilized to evaluate internal corrosion, wall thickness, stress cracks and pipe condition in cast iron and steel pipe as appropriate*."

[redacted]

Estimated timeframe for technology to be defined: September, 2015 following Configuration Testing with Robotic Platform (Milestone 4 for Element 3)

2. *"Internal robotic inspection of the mains will provide an accurate means of pipeline assessment without disrupting gas supplies to customers, incurring large engineering costs or performing oversized excavations. It is anticipated that the device will utilise the same or a similar launch tube as the platform developed under Element 1."*

The current design has been developed to satisfy this criterion. The same launch tube will be utilised to serve the inspection and repair robots for the same diameter mains. ULC are currently finalising the pipe inspection procedure.

3. **Estimated timeframe for technology to be defined:** September, 2015 following Configuration Testing with Robotic Platform (Milestone 4 for Element 3) *"To determine the type of sensor equipment which will provide the most effective measurement of corrosion level, pipe stresses and wall loss, ULC Robotics will work with sensor manufacturers and research various inspection techniques and methods."*

[redacted]

Estimated timeframe for technology to be defined: August, 2015 following Sensor Data Validation (Milestone 5 for Element 3)

4. *"The sensors will be field tested in the UK. The module will be deployed in conjunction with the robotic transport platform and launch system developed under Element 1. The sensors will be used to assess the condition of the pipe. Testing will be aimed towards the demonstration of the technology with the goal of providing useful data on pipe condition and in minimizing the risk of pipe failures."*

ULC is currently working towards field testing the robotic transport platform, launch system in conjunction with the inspection robot. Tests will be carried out to demonstrate that the technology meets the required goals set out above.

Estimated timeframe for technology to be defined: September, 2015 following Configuration Testing with Robotic Platform (Milestone 4 for Element 3)

5. *"Data provided by the sensors will identify defects in the pipe wall which have caused or will likely cause a leak, crack or rupture in the pipeline. This information will reduce the safety risk and environmental impact associated with leaking gas."*

[redacted]

Estimated timeframe for technology to be defined: August, 2015 following Sensor Data Validation (Milestone 5 for Element 3)

6. "A report outlining the results of off-site testing will be provided to us. The following outcomes would be included in the report.
   - Ability for sensors to operate down full tether length
   - Ability for sensors to measure wall thickness
   - Accuracy of data collected
   - Overall assessment capability of sensors
   - Concerns and lessons learned during testing
   - A test plan which will guide the selection field testing sites and which will ensure that field testing is executed as efficiently and effectively as possible."

ULC is currently working towards these testing outcomes.

Estimated timeframe for technology to be defined: September, 2015 following Configuration Testing with Robotic Platform (Milestone 4 for Element 3)

7 REVIEW OF HIGH LEVEL PERFORMACE SPECIFICATION

A review of the high level performance specification was put together by RPS and discussed by the project team. It outlines key testing criteria for the general specification, detailed specification, support & control system and the launch tube including RPS conceptual design considerations. Progress on testing is reported to the project team using the following classifications:

Fully tested/ Criteria satisfied
Partially complete / Further testing required
Not tested / To be completed

There are a number of items already functionally tested. ULC will be reporting on further testing in July, 2015 through their reports on key achievements of the robotic platform launch, retrieval, travel and seal testing stages. This is an ongoing review process with the project team to make sure all testing is adequately carried out on the robotics development to ensure smooth operation during the field trials.

8 RISK MANAGEMENT

Risk Management has been used by the project team throughout as a tool to identify, monitor and implement measures to reduce risks to various aspects of the project. The project specific Risk Register has been formulated using inputs from SGN, ULC and RPS and is discussed regularly on an ongoing basis between all members of the project team. The Risk Register is a dynamic model that has been revised a number of times to account for new risks which are identified as the project progresses or to adjust the likelihood or impact scores of existing risks as the associated constraints develop.

RPS considers the Risk Register as part of the assessment process of ULC reports and identifies any areas of concern which may require attention. This is typically followed by a discussion of any potential risks during a teleconference between the project team using WebEx to determine the extent of these risks and the best control and mitigation measures to implement.

Currently there are three risk categories used to distinguish the type of impact a risk will have, there are; Time, Financial and Reputational. Risks are given an estimated date by which they can be eliminated, mitigated or avoided. A number of risks have been satisfactorily mitigated during this progress report period.

Table 8-1 Risks completed to date

	Risk	Reason for risk marked as completed
11	Sensor Manufacturer Not Found	Sensor manufacturers were identified and contracted to meet the requirements of this project. i.e. functioning and transmitting data accurately over a long distance, providing accurate measurement of pipe wall loss, measurements in varying pipe diameters etc.
31	Structural Integrity of Pipe Wall	The impact of the pressure applied by the robotic wheels when operating inside the main was calculated by ULC.
32	Launch tube development for Elements 1, 2 & 3	The launch tube design was developed and has been manufactured to facilitate a gas free operation and ease of use on site. Considerations were given to its manoeuvrability, functionality and the excavation footprint.

For the next six months, the following risks will require adequate attention:

Table 8-2 Risks that require attention over the next six months

Risk No.	Risk	Residual Risk Score
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	**8**

12	**Sensor Manufacturer** Delays from the sensor manufacturer could affect the overall schedule.	**8**
28	**Timetable Slippage** Timetable may slip due to unforeseen circumstances and / or unknown delays in procurement, custom and shipping to the UK or Potential slippage identified due to Launch tube manufacture or insertion of the robotic systems.	**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.	**8**
34	**Impact of UK legislation/HSE acknowledgement of remediation technique.**	**8**

It is worth noting that the highest Residual Risk score currently is at level 8 which is within the low scoring key range. All other risks that arise over the next six months are scoring between 3 and 5.

Table 8-3 Scoring key range

(red)	(orange)	(green)
16-25	10-15	1-9

9 INTELLECTUAL PROPERTY RIGHTS (IPR)

There have been significant developments with the IPR since the previous progress report. This mainly involves techniques used in this project for the launching process, robotic platforms, and repair & inspection robotic systems. These innovations are at the forefront of robotic technology to inform pipe risk especially in a live gas main. This robotics project has the potential to transform the way the UK gas industry maintains its gas distribution pipes. The use of robotic technology to repair and inspect mains will lead to significant benefits, both for customers and our environment through the following:

- Enhancing the ability of GDNs to inspect their assets leading to a significantly improved risk management system, thus reducing leakage from the network.
- Ability to obtain better information on the integrity of Tier 2 and Tier 3 mains, the ability to prioritise the replacement of mains of highest risk, and remediate those which are at less risk of fracture.
- Ability to share more information about the exact location of mains pipes with stakeholders, which leads to reduced risk of third party damage.
- Ability to lower the likelihood of leaks and third party damage, robotic solutions will reduce greenhouse gas emissions to the environment, and the costs of repairing these issues.
- Ability to reduce the necessity for road excavations - GDNs will be reducing or removing a range of costs e.g. purchasing permits, restoring roads and properties. This will also include fewer excavations leading to less disruption and dissatisfaction for the public.
- In the final stage of the project, the ability to connect customers' services remotely if successful will reduce disruption for those customers. Connections should be faster and remove the necessity to excavate pathways and driveways.

Patents for the platform design, repair module and sensor design were registered on 1st May, 2015. This was critical to make sure the designs and concepts developed by the project team were secured in order to progress the project going forward and mitigating the risk of intellectual property infringement on the project from a third party.

As discussed previously, there will also be various testing carried out on the launch tube, robotic platform, repair and inspection modules over the next six months. [redacted]

10 KEY TARGETS FOR THE NEXT SIX MONTHS

The following are key deliverables over the next six months from ULC and RPS:

Elements 1 & 2

- Perform testing on the launch tube, retrieval and travel
- Perform testing on the repair robot
- Procure spare parts and material in preparation for field testing
- Launch repair robot and field trials

Element 3

- Integrate and test tether with sensor/data acquisition system
- Configuration testing and robotic platform
- Sensor data validation
- Develop test plan for the field testing and incorporate improvements discovered during testing
- Launch inspection robot and field trials

Element 4

- Delivery of High Level, Preliminary Specification Document By ULC To SGN
- Development of Conceptual Designs

RPS will develop an Electrical Safety Technical Assurance Report and finalise the MRPS Interpretation Report.

Appendix C - Risk Register – v2.9 – 29.05.2015

On Going Risk Register

Responsibility Key:
AM - Angus McIntosh (SGN)
SW - Sam Wilson (SGN)
ST - Stakeholder Team (SGN)
DP - Dave Phelan (RPS)
MP - Mike Passaretti (ULC)

Scoring Key: 16-25 | 10-15 | 1-9

Ref No	Risk	Business Risk	Inherent Risk Likelihood	Inherent Risk Impact	Inherent Risk Score	Controls & Mitigation	Owner	By When	Project Plan Ref	Residual Risk Likelihood	Residual Risk Impact	Residual Risk 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 & ST	03/07/2015	75	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 & ST	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 & ST	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 & ST	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	03/07/2015	75	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	03/07/2015	76	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	Completed											
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	26/06/2015	146	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	03/07/2015	75	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	03/07/2015	75	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 - Alignment of the tether design reports with Go / No Go stage gates C - Developing two tethers will avoid complications with dual functionality and will be proven through the controlled testing phase of the project D - The project team have agreed to move the 'Design and procure Tether' deliverable to align with the 'Robotic platform and repair module preliminary functional test' to allow learning from the final assembly of the robotic platform be conducted prior to finalising the tether specification. A progress report documenting progress to date and the specification of the tether will still be submitted by ULC on the 03/04/15.	A - ULC B - SW C - ULC D - ULC / SW / RPS	03/07/2015	75	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 - Alignment of the tether design reports with Go / No Go stage gates C - Developing two tethers will avoid complications with dual functionality and will be proven through the controlled testing phase of the project D - The project team have agreed to move the 'Design and procure Tether' deliverable to align with the 'Integrate and test tether with sensor/data acquisition system' to allow learning from the final tests of the sensor hardware to be conducted prior to finalising the tether specification. A progress report documenting progress to date and the specification of the tether will still be submitted by ULC on the 10/7/15.	A - ULC B - SW C - ULC D - ULC / SW / RPS	10/07/2015	145	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. Potential slippage identified due to Launch tube manufacture - control D	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 D - Potential slippage in schedule identified due to launch tube manufacture. RPS & ULC focused on defining the required specification in preparation for manufacture. *Expanded in Risk Register Ref no.35*	A - SW & AM B - SW & AM C - AM D - SGN, ULC, RPS	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 separate transportation platforms, reducing design complexity and the possibility of anaerobic 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	Completed											
32	Completed											
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
35	**European Pressure Equipment Directive (PED) for Launch Tube** It has been identified that PED compliance may not be possible for the manufacture of the prototype launch tube due to additional time required for the Conformity Assessment Body to certify the manufacture and design.	Time	4	3	12	[redacted] B - Prototype for site trial monitoring and data gathering phase to be operated on Low Pressure (<75mBar) only unless full PED certification can be obtained. Final PED certification to be finalised prior to use on Medium Pressure network. C - Verification of ASME standards for operation on Low Pressure System [redacted] E - Welders to be trained, examined and certified to EU PED standards in parallel to avoid unnecessary delays for manufacture of future launch tubes.	A - ULC B - SGN, ULC, RPS C - RPS D - ULC E - ULC	23/10/2015	157	1	3	3

Completed Risk Register

Ref No	Risk	Business R	Likelihood	Impact	Score	Controls & Mitigation	Owner	By Whe	Project Plar	Likelihood	Impact	Score
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
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 - ULC 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. Review of manufacture specification and process to be aligned with delivery of Robotic Platform and Joint Repair Module Assembly	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) D - Additional review date added to monitor progress of launch tube manufacture	A - ULC & SGN B - SGN & RPS C - SGN & RPS D- SGN, ULC, RPS	22/05/2015	74	1	4	4

Appendix D - Bank Account References

BARCLAYS

Account Statement

Printed On:30/01/2015 16:50

Search Criteria:
Account Number: [redacted] **Statement Date:** Absolute **From:** 01/01/2015 **To:** 30/01/2015
Search Result

Account Number	Account Name	Currency	Account Type / Status	
[redacted]	ROBOTICS ACCOUNT	GBP	Current / 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**
0.00 As At: 02/01/2015	745,389.76/8	745,389.76/6	14	0.00 As At: 30/01/2015

	Entry Date	Transaction Details	Transaction Type	Payment Amount	Receipt Amount	Ledger Balance
		Balance Brought Forward				**0.00**
	02/01/2015	SOUTHERN GAS NET * 671475*/RFB/CLMSW* TFR	Transfer		5.23	
	02/01/2015	INTEREST CHARGED FOR PERIOD 23SEP/ 7DEC	Debit	5.23		0.00
	09/01/2015	SOUTHERN GAS NET * 819454*/RFB/CLMSW* TFR	Transfer		1.46	
	09/01/2015	usd bank charges * 618197*SGNP-ROBOT* TFR	Transfer	1.46		0.00
	15/01/2015	National Grid PL * 533677*/ROC/3083 * TFR	Transfer		544,308.00	
	15/01/2015	CLMSWP1700109561 * 812336*ROBOTICS I* TFR	Transfer	544,308.00		0.00
	16/01/2015	SOUTHERN GAS NET * 824964*/RFB/CLMSW* TFR	Transfer		104,504.02	
	16/01/2015	CHARGES*525479* ULC Pipeline * TFR	Transfer	7.50		
	16/01/2015	CHARGES*525716* ULC Pipeline Rob * TFR	Transfer	7.50		
	16/01/2015	ULC Pipeline Rob * 525716*ULC PIPELI* TFR	Transfer	95,511.68		
	16/01/2015	ULC Pipeline * 525479*ULC PIPELI* TFR	Transfer	104,496.52		-95,519.18
	19/01/2015	SOUTHERN GAS NET * 680169*/RFB/CLMSW* TFR	Transfer		95,519.18	
	19/01/2015	COMMISSION FOR PERIOD 08Sep/07Dec	Debit	1,051.87		-1,051.87
	20/01/2015	SOUTHERN GAS NET * 833382*/RFB/CLMSW* TFR	Transfer		1,051.87	0.00

	Entry Date	Transaction Details	Transaction Type	Payment Amount	Receipt Amount	Ledger Balance
		Balance Carried Forward				**0.00**

BARCLAYS

Account Statement

Printed On:30/01/2015 16:41

Search Criteria:
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Account Number	Account Name	Currency	Account Type / Status
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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
3,603,606.49 As At: 02/01/2015	201,081.76/5	544,308.00/1	6	3,946,832.73 As At: 30/01/2015

	Entry Date	Transaction Details	Transaction Type	Payment Amount	Receipt Amount	Ledger Balance
		Balance Brought Forward				**3,603,606.49**
	02/01/2015	CLMSWP1700041628 * 671475*ROBOTICS A* TFR	Transfer	5.23		3,603,601.26
	09/01/2015	CLMSWP1700183411 * 819454*ROBOTICS A* TFR	Transfer	1.46		3,603,599.80
	15/01/2015	SOUTHERN GAS NET * 812336*/RFB/CLMSW* TFR	Transfer		544,308.00	4,147,907.80
	16/01/2015	CLMSWP1700220824 * 824964*ROBOTICS A* TFR	Transfer	104,504.02		4,043,403.78
	19/01/2015	CLMSWP1700343963 * 680169*ROBOTICS A* TFR	Transfer	95,519.18		3,947,884.60
	20/01/2015	CLMSWP1700174585 * 833382*ROBOTICS A* TFR	Transfer	1,051.87		3,946,832.73
		Balance Carried Forward				**3,946,832.73**

BARCLAYS

Account Statement

Printed On:02/03/2015 10:06

Search Criteria:
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Search Result

Account Number	Account Name	Currency	Account Type / Status	
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IBAN	**Bank Identifier**	**Bank Name**		
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Address				
Leicester,Leicestershire,UNITED KIN , LE87,2BB				
Opening Ledger	**Total Payment Amount/Payment Count**	**Total Receipt Amount/Receipt Count**	**Transaction Count**	**Latest / Closing Ledger**
0.00 As At: 02/02/2015	848,835.22/7	848,835.22/4	11	0.00 As At: 27/02/2015

	Entry Date	Transaction Details	Transaction Type	Payment Amount	Receipt Amount	Ledger Balance
		Balance Brought Forward				**0.00**
	06/02/2015	SOUTHERN GAS NET * 813931*/RFB/CLMSW* TFR	Transfer		104,504.02	
	06/02/2015	CHARGES*522176* ULC PIPELINE * TFR	Transfer	7.50		
	06/02/2015	ULC PIPELINE * 522176*ULC PIPELI* TFR	Transfer	104,496.52		0.00
	13/02/2015	SOUTHERN GAS NET * 818065*/RFB/CLMSW* TFR	Transfer		95,519.18	
	13/02/2015	CHARGES*524677* ULC Pipleine * TFR	Transfer	7.50		
	13/02/2015	ULC Pipleine * 524677*ULC PIPELI* TFR	Transfer	95,511.68		0.00
	16/02/2015	NGG PLC GAS MAIN LICENCES BGCFrom: 20-77-62 10872512	Bank Giro Credit		544,308.00	
	16/02/2015	CLMSWP1700045770 * 673881*ROBOTICS I* TFR	Transfer	544,308.00		0.00
	27/02/2015	SOUTHERN GAS NET * 914933*/RFB/CLMSW* TFR	Transfer		104,504.02	
	27/02/2015	CHARGES*539450* ULC PIPELINES * TFR	Transfer	7.50		
	27/02/2015	ULC PIPELINES * 539450*ULC PIPELI* TFR	Transfer	104,496.52		0.00
		Balance Carried Forward				**0.00**

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Account Statement

Printed On:02/03/2015 10:10

Search Criteria:
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Search Result

Account Number	Account Name	Currency	Account Type / Status	
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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**
3,946,832.73 As At: 02/02/2015	304,527.22/3	544,308.00/1	4	4,186,613.51 As At: 27/02/2015

	Entry Date	Transaction Details	Transaction Type	Payment Amount	Receipt Amount	Ledger Balance
		Balance Brought Forward				**3,946,832.73**
	06/02/2015	CLMSWP1700073309 * 813931*ROBOTICS A* TFR	Transfer	104,504.02		3,842,328.71
	13/02/2015	CLMSWP1700120214 * 818065*ROBOTICS A* TFR	Transfer	95,519.18		3,746,809.53
	16/02/2015	SOUTHERN GAS NET * 673881*/RFB/CLMSW* TFR	Transfer		544,308.00	4,291,117.53
	27/02/2015	CLMSWP1700360187 * 914933*ROBOTICS A* TFR	Transfer	104,504.02		4,186,613.51
		Balance Carried Forward				**4,186,613.51**

BARCLAYS

Account Statement

Printed On:01/04/2015 09:43

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Search Result

Account Number	**Account Name**	**Currency**	**Account Type / Status**	
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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**
0.00 As At: 02/03/2015	640,955.27/5	640,955.27/4	9	0.00 As At: 31/03/2015

	Entry Date	Transaction Details	Transaction Type	Payment Amount	Receipt Amount	Ledger Balance
		Balance Brought Forward				**0.00**
	16/03/2015	NGG PLC GAS MAIN LICENCES FEES BGCFrom: 20-77-62 10872512	Bank Giro Credit		544,308.00	
	16/03/2015	CLMSWP1700372025 * 829316*ROBOTICS I* TFR	Transfer	544,308.00		0.00
	17/03/2015	SOUTHERN GAS NET * 696524*/RFB/CLMSW* TFR	Transfer		95,519.18	
	17/03/2015	CHARGES*650785* ULC Pipeline * TFR	Transfer	7.50		
	17/03/2015	ULC Pipeline * 650785*ULC PIPELI* TFR	Transfer	95,511.68		0.00
	24/03/2015	SOUTHERN GAS NET * 708735*/RFB/CLMSW* TFR	Transfer		15.76	
	24/03/2015	INTEREST CHARGED FOR PERIOD 8DEC/ 1MAR	Debit	15.76		0.00
	31/03/2015	SOUTHERN GAS NET * 906496*/RFB/CLMSW* TFR	Transfer		1,112.33	
	31/03/2015	COMMISSION FOR PERIOD 08Dec/01Mar	Debit	1,112.33		0.00
		Balance Carried Forward				**0.00**

BARCLAYS

Account Statement

Printed On:09/06/2015 12:39

Search Criteria:
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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[redacted], LE87 2BB

Opening Ledger	Total Payment Amount/Payment Count	Total Receipt Amount/Receipt Count	Transaction Count	Latest / Closing Ledger
4,635,589.19 As At: 01/04/2015	435,287.10/7	1,754.44/1	8	4,202,056.53 As At: 09/06/2015

Entry Date	Transaction Details	Transaction Type	Payment Amount	Receipt Amount	Ledger Balance
	Balance Brought Forward				**4,635,589.19**
01/04/2015	CLMSWP1700118762 * 861555*ROBOTICS A* TFR	Transfer	20,364.86		4,615,224.33
02/04/2015	CLMSWP1700382083 * 861350*ROBOTICS A* TFR	Transfer	104,504.02		4,510,720.31
08/04/2015	BX15040822607435 * 595883*SGNF-ROBOT* TFR	Transfer	1.10		4,510,719.21
10/04/2015	CLMSWP1700096604 * 819834*ROBOTICS A* TFR	Transfer	95,519.18		4,415,200.03
01/05/2015	CLMSWP1700102182 * 659756*ROBOTICS A* TFR	Transfer	104,504.02		4,310,696.01
06/05/2015	CLMSWP1700338066 * 815574*ROBOTICS A* TFR	Transfer	95,519.18		4,215,176.83
03/06/2015	CLMSWP1700157747 * 707245*ROBOTICS A* TFR	Transfer	14,874.74		4,200,302.09
08/06/2015	INTEREST PAID GROSS FOR PERIOD 2MAR/ 7JUN	Credit		1,754.44	4,202,056.53
	Balance Carried Forward				**4,202,056.53**

You may have to adjust to a larger paper size and/or use a landscape paper orientation to have all the data found in summary grids appear on the printed paper

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Account Statement

Printed On:01/06/2015 12:22

Search Criteria:
Account Number:[redacted] **Statement Date:** Absolute **From:** 01/04/2015 **To:** 01/06/2015

Search Result

Account Number	Account Name	Currency	Account Type / Status
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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
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	Entry Date	Transaction Details	Transaction Type	Payment Amount	Receipt Amount	Ledger Balance
		Balance Brought Forward				**4,635,589.19**
	01/04/2015	CLMSWP1700118762 * 861555*ROBOTICS A* TFR	Transfer	20,364.86		4,615,224.33
	02/04/2015	CLMSWP1700382083 * 861350*ROBOTICS A* TFR	Transfer	104,504.02		4,510,720.31
	08/04/2015	BX15040822607435 * 595883*SGNP-ROBOT* TFR	Transfer	1.10		4,510,719.21
	10/04/2015	CLMSWP1700096694 * 819834*ROBOTICS A* TFR	Transfer	95,519.18		4,415,200.03
	01/05/2015	CLMSWP1700102182 * 659758*ROBOTICS A* TFR	Transfer	104,504.02		4,310,696.01
	06/05/2015	CLMSWP1700338068 * 815574*ROBOTICS A* TFR	Transfer	95,519.18		4,215,176.83
		Balance Carried Forward				**4,215,176.83**

You may have to adjust to a larger paper size and/or use a landscape paper orientation to have all the data found in summary grids appear on the printed paper

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Account Statement

Printed On:01/06/2015 09:25

Search Criteria:
Account Number: [redacted] **Statement Date:** Last 30 days

Search Result

Account Number	Account Name	Currency	Account Type / Status
[redacted]	ROBOTICS ACCOUNT	GBP	Current / 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
0.00 As At: 05/05/2015	95,519.18/2	95,519.18/1	3	0.00 As At: 01/06/2015

	Entry Date	Transaction Details	Transaction Type	Payment Amount	Receipt Amount	Ledger Balance
		Balance Brought Forward				**0.00**
	06/05/2015	SOUTHERN GAS NET * 815574*/RFB/CLMSW* TFR	Transfer		95,519.18	
	06/05/2015	CHARGES*514129* ULC Pipeline Rob * TFR	Transfer	7.50		
	06/05/2015	ULC Pipeline Rob * 514129*ULC PIPELI* TFR	Transfer	95,511.68		0.00
		Balance Carried Forward				**0.00**

You may have to adjust to a larger paper size and/or use a landscape paper orientation to have all the data found in summary grids appear on the printed paper

BARCLAYS

Account Statement

Printed On:01/06/2015 09:24

Search Criteria:
Account Number: [redacted] **Statement Date:** Last 30 days

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
4,310,696.01 As At: 05/05/2015	95,519.18/1	N/A/0	1	4,215,176.83 As At: 01/06/2015

	Entry Date	Transaction Details	Transaction Type	Payment Amount	Receipt Amount	Ledger Balance
		Balance Brought Forward				**4,310,696.01**
	06/05/2015	CLMSWP1700338068 * 815574*ROBOTICS A* TFR	Transfer	95,519.18		4,215,176.83
		Balance Carried Forward				**4,215,176.83**

You may have to adjust to a larger paper size and/or use a landscape paper orientation to have all the data found in summary grids appear on the printed paper