Scotia Gas Networks

Gas Network Innovation Competition Full Submission Pro-forma

Robotics

August 2013

Project Code/Version No: SGN_GN_01/v1

Gas Network Innovation Competition Full Submission Pro-forma

Section 1: Project Summary

1.1 Project Title:
Robotics

1.2 Funding Licensee:
Southern Gas Networks (SGN)

1.3 Project Summary:

This innovative and world-leading project has the potential to allow extensive work to be carried out on the gas network without the associated disruptive road works.

It's objective is to develop new robotic technologies which operate inside the live gas main which can not only remotely repair leaking joints, but support our pipe fracture risk management process through enhanced inspection in larger our diameter pipes.

The project scope will cover:

- Detailed design and manufacture of modular robotic platforms
- Development of management and operational procedures
- Full testing to ensure the robots can be operated safely inside a live gas pipe
- A detailed commercial appraisal

If our project is accepted, we believe the development of these robotic technologies could fundamentally change the way the UK gas industry operates in the maintenance of gas distribution pipes, enhancing safety at the same time.

The primary participants in the project will be SGN and ULC Robotics. Other smaller suppliers will be selected through our established procurement processes and of course subject to competitive tender.

The project duration is two years, with a proposed start date of 6 January 2014.

1.4 Funding

1.4.2 NIC Funding Request (£): £6,640,000

[redacted]

1.4.4 External Funding - excluding from NIC/LCNF (£): 0

1.4.5 Total Project cost (£): £7,378,000

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Section 1: Project Summary continued

1.5 Cross industry ventures: If your Project is one part of a wider cross industry venture please complete the following section. A cross industry venture consists of two or more Projects which are interlinked with one Project requesting funding from the Gas Network Innovation Competition (NIC) and the other Project(s) applying for funding from the Electricity NIC and/or Low Carbon Networks (LCN) Fund.

1.5.1 Funding requested from the LCN Fund or Electricity NIC (£k, please state which other competition):

1.5.2 Please confirm if the Gas NIC Project could proceed in absence of funding being awarded for the LCN Fund or Electricity NIC Project:

☐ **YES – the Project would proceed in the absence of funding for the interlinked Project**

☐ **NO – the Project would not proceed in the absence of funding for the interlinked Project**

1.6 List of Project Partners, External Funders and Project Supporters:

There are two key project participants; ULC Robotics (ULCR) and SGN.

ULCR specialises in the development of unique solutions for energy industry technical challenges, from the creation of simple tools to complex electromechanical systems.

The company is based in Long Island, USA.

Further details of the project participants are in Appendix B.

1.7 Timescale

1.7.1 Project Start Date:	**1.7.2 Project End Date:**
6 January 2014	31 December 2015

1.8 Project Manager Contact Details

1.8.1 Contact Name & Job Title: Angus McIntosh Innovation & New Technology Manager	**1.8.3 Contact Address:** Scotia Gas Networks Axis House 5 Lonehead Drive Newbridge Edinburgh EH28 8TG
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Section 2: Project Description

This section should be between 8 and 10 pages.

All gas network operators aim to operate their networks in a safe and efficient manner. Despite an ongoing transformation to plastic pipe, we still have over 80,000km of GB gas distribution mains are metallic and subject to aging and deterioration. They are costly to operate and require continuous inspection, repair or replacement.

There are three key drivers for intervention in relation to these assets. (i) leakage; (ii) risk management and (iii) third party damage.

(i) Leakage – the largest proportion of network leakage occurs from joints on metallic gas mains. This is the gas transporters' biggest impact on the environment and is reflected in the networks' shrinkage declarations. Methane, the primary component of natural gas, is around 21 times more harmful than CO_2 and lost gas per annum across all the distribution networks has a carbon equivalent of 4.56Mtonnes of CO_2e (carbon dioxide equivalent).The current method of repairing gas main joints requires a separate excavation on each joint which is both costly and causes considerable disruption to the public, particularly road users. Our robotics proposal will eliminate the need for the overwhelming majority of these excavations as the joints will be repaired invisibly and internally.

(ii) Risk Management - A common risk model is used by all the gas distribution networks to manage their replacement programmes. Today the recognised method of risk removal for small diameter pipes is full replacement. Under RIIO, there is an opportunity to explore alternative methods of risk reduction for both Tier 2 and 3 pipes, and our development of robotics to measure stress and strain in pipe walls will allow alternative risk removal techniques to be applied.

(iii) Third Party Damage – Robotics will allow the accurate mapping of gas pipes to be undertaken. Sharing is important and this information will be of use to other utility companies as well as local and highway authorities excavating in the roads. This could also reduce the risk of accidental damage to gas pipes and accurate mapping would also reduce the number of aborted excavations undertaken when making service connections to our pipes.

There are therefore four key areas of potential benefit if our project is successful:

1) Reduction in repair costs
2) Reduction of third party damage
3) Improved risk management of metallic mains
4) Reduction in leakage from the gas distribution network

As we said in the summary, this innovative and world-leading project will potentially allow extensive work to be carried out on the gas network without the need for disruptive roadworks. Having new robotic technologies operating inside the live gas network, repairing leaking joints, support the risk management of pipe fracture through accurate empirical inspection.

The outcome from this project were it to proceed would be several commercial ready prototype devices which could be deployed across the whole UK gas network, for the benefit of all companies, people and communities. At the completion of this project ULC Robotics will be ready to provide commercial level services utilising the field commercial prototype devices to all UK gas network licensees.

In order to address this broad scope, the work has been divided into specific Elements which represent sub-projects under the greater project scope. A description of each Element along with a description of the means being developed to solve each problem, are as follows.

Note: Element 1 and 2 have been grouped together since they will be performed as a single development by one team of engineers.

- *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*

Element 1 and Element 2: Description of problem

The Problem(s) that needs to be resolved

In GB, gas distribution companies have a considerable amount of post war spun cast iron mains which utilise mechanical joints at their connection points. Mechanical joints generally comprise two parallel backing rings held together using bolts and nuts. A rubber gasket is forced into the space between the bell and spigot of a cast iron joint by the two parallel backing rings, which provide a seal. Over time, gaskets can dry out and shrink or bolts and nuts corrode; creating leak paths for pressurised gas.

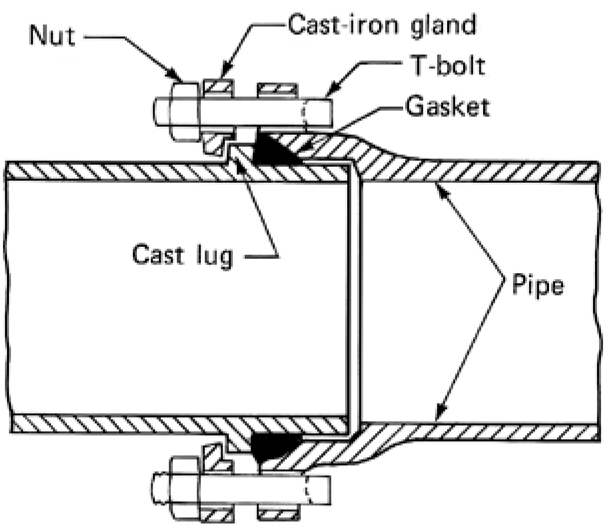

Figure 1 - Mechanical Joint Design Example

Project Description continued

The Weco sealing process was popular in the past in some areas of the country and was used for performing repairs on mechanical joints in ≥24" diameter mains. Weco seals are mechanical seals comprised of a rubber ring and a mechanical support. These are installed on the inside of the pipe directly over cast iron joints.

Repair by Weco sealing requires multiple excavations, the gas main to be taken out of service and for a person to enter the main to physically install the seals by hand. Because this person must enter the pipe to install the seals, there were associated health and safety risks, so much so, this method is no longer employed in Britain.

Figure 2 - Weco Seal Installed In Pipe

In order to perform repairs to leaking mechanical joints on tier 2 and tier 3 gas mains, distribution operators are forced to excavate over each joint. These excavations represent significant civil engineering works, generally involving shoring of the excavation walls, access and egress.

Once exposed, the joint as well as a portion of the pipe on both sides of the joint, must be sand blasted to clean the metal. In a process called encapsulation, a flexible semi-rigid fabric mould is installed around the joint. The mould is filled with an expanding urethane compound which quickly sets to form a gasket around the exterior of the joint (see Figure 3).

Figure 3 - Encapsulation Kit

The Method(s) being trialled to solve the Problem (see conceptual drawings in Appendix C)

A means of performing live, internal sealing on non-Weco sealed mechanical joints, along with a method of internally repairing previously installed Weco seals, from inside the pipe, would alleviate considerable costs, while providing substantial environmental and customer benefits.

In order to internally seal mechanical joints and to perform repairs on previously installed Weco seals, it is proposed to develop a robotic platform capable of vertically launching into live Tier 2 and tier 3 gas pipes. The platform will accommodate a module capable of installing internal mechanical seals and for repairing Weco seals in situ.

The system is anticipated to operate with minimal disruption to the public. Multiple joints will be repaired internally from one excavation point, with a minimum target travel distance of 150m in each direction (300m total) from the point of entry. 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 Trial(s) being undertaken to test that the Method(s) works

Once the robot, launch tube, and repair module have been developed, prototyped and off site testing complete, field testing will be performed in the UK. Field testing will focus on proving the technology and ensuring that the goals of the project have been met.

Expected outcomes of the trials are as follows:

1. Proof-of-concept demonstration of an internal pipeline robotics system.

2. Internal repair of multiple mechanical joints and failed Weco seals from a single excavation point.

3. Successful operation in pipelines within tiers 2 and 3 and ability to negotiate up to 90 degree horizontal bends.

The Solution(s) that will be enabled by solving the problem.

The robotic system developed under Element 1 & 2 will be capable of internally sealing mechanical joints and also repairing failed Weco Seals with significantly less excavation and disruption to customers than traditional methods. 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 point for retrieval.

Advantages of this internal robotic joint repair system, when compared with encapsulation or direct burial replacement include:

- Reducing the need for street opening permits
- Reducing the amount of excavation and restoration required
- Reducing public disruption to both gas service and roadways

- Providing a much smaller carbon footprint than conventional repair methods

Element 3 – Robotic visual and non-visual inspection

The Problem(s) which need resolving

Metallic pipelines are typically iron or steel. Steel and ductile iron pipes are more susceptible to corrosion and cast iron pipes are more susceptible to stress cracking. Stress cracking leads to failure of the pipeline below the expected yield stress of the material.

In order to locate and quantify the levels of corrosion, wall loss and stress in pipes, without significant excavation or taking the main off line and generating disruptions for customers, a means of live, in pipe assessment is needed.

The Method(s) being trialled to solve the problem

ULCR 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.

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.

To determine the type of sensor equipment which will provide the most effective measurement of corrosion level, pipe stresses and wall loss, ULCR will work with sensor manufacturers and research various inspection techniques and methods.

The Trial(s) being undertaken to test that the Method(s) works

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 pipeline failures.

Expected outcomes of the trials are as follows:

1. Demonstration of internal robotic pipeline inspection technology

2. Live data collection on pipe wall thickness, stress cracks, joint integrity, and other information

3. Custom reporting of pipeline structural integrity data to the distribution network

4. Identification of critical locations at high risk of leak or rupture

The Solution(s) that will be enabled by solving the problem

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.

Advantages of this method of internal robotic inspection include:

- Assessing the integrity of the main without turning gas off to customers
- Minimising the costs and disruptions associated with excavations or other conventional inspection methods
- Identifying locations for preventative maintenance and repair

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

The Problem(s) that needs to be resolved

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

Pipe insertion can be further broken down into two commonly applied methods, dead insertion and live insertion.

For dead insertion a pipe is temporarily disconnected from the existing gas distribution network. Typically, an excavation is made at suitable access points on the existing gas main. A cut-out of an excavated section of main is created and a new polyethylene (PE) pipe is pulled or pushed into the section of existing main.

For dead insertion methods, typically used for insertion lengths of under 200m, customers are interrupted for the duration of these works. For live insertion, a pipe is inserted into a live gas main and services replaced using specialist foam off technique developed by Steve Vick™.

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

In order to eliminate the need to excavate over each service an in situ means of connecting newly inserted PE pipe to service lines is needed.

The Method(s) being trialled to solve the Problem

This project proposes to develop a system capable of remotely reconnecting service lines to inserted pipe without the need to perform excavation over each service connection. The robotic device will enter and travel down the gas main between the gas 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" – 8" gas mains, the most common diameters in tier 1.

It is anticipated that ULC will work closely with manufacturers of PE piping to acquire or develop a PE pipe capable of being pushed down existing steel services and into the main. This piping will be flexible enough to negotiate bends, without exceeding the rated minimum bend radius of the material, but will also be rigid enough to travel from the customer gas meter location to the gas main.

The Trial(s) being undertaken to test that the Method(s) works

Once the remotely operated devices, repair methodology and tooling have been developed, prototyped and off site tested, field testing will be performed in GB. Field testing will focus on proving the technology and ensuring that the goals of the project have been met.

Expected outcomes of the trials are as follows:

1. Demonstration of a remotely controlled robotic system to reconnect PE service lines
2. Robotic installation and reconnection of multiple PE services from a single excavation point
3. Operation with minimal disruption as compared to traditional methods

The solution(s) which will be enabled by solving the problem.

A remotely operated tool capable of reinstating service lines following a main being inserted would provide the following advantages when compared with traditional methods:

- Reduced customer service downtime
- Reduction in the amount of excavation required
- Reduced costs of resources, permitry and restoration

Element 1 and Element 2: Technical Description

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:

Project Description continued

- 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

Module development will be focused on providing solutions that will lengthen pipe asset life, reduce carbon footprint, minimise excavation and ultimately provide a cost saving to gas customers.

Development of the robotic transport platform is anticipated to include the following steps:

Mechanical Design:

- Mechanical specification document development
- Development of conceptual designs
- 3D Design of mechanical components
- Selection and procurement of motors, gears and bearings for propulsion system
- Creation of detailed fabrication and manufacturing documentation
- Parts fabrication and assembly

Electrical Design:

- Electrical specification document development
- Electrical and software system block diagram development
- Electrical schematic design and parts selection
- Circuit card layout and fabrication
- Microprocessor firmware programming
- User interface and control system design and programming
- Tether design and procurement
- Bench testing of electrical system
- Integration of electrical system into mechanical prototype

Element 3 – Robotic visual and non-visual inspection

Anticipated engineering work required for sensor package development include:

- Electrical specification development
- Electrical and software system block diagram development
- Electrical schematic design and parts selection
- Modification or adaptation of existing off-the-shelf sensor equipment
- Circuit card layout and fabrication
- Microprocessor firmware programming
- User interface and control system design and programming
- Tether interface and data transmission
- Bench testing of electrical system
- Integration of electrical system into modular package for deployment

Project Description continued

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

After off-site testing has been completed, minor modifications are expected to prepare the sensor package for field testing. The sensor package will be integrated with the robotic transport platform developed for Element 1 & 2 and shipped to Britain for field testing. The test plan developed as an outcome of off-site testing will be used as guidance for field testing. Field testing will be performed at sites provided by us and will determine the:

- Ability to successfully deploy the sensor package via the robotic transport platform
- Maximum useful travel distance for relaying sensor data to the operator
- Fidelity and clarity of data that can be used to assess pipe integrity in the field
- Ability to locate and assess leaks or other damaged areas
- Modifications required prior to system commercialisation
- Estimated Unit Pricing for Commercial Work Performed

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

It's anticipated complete robotic system will include:

- Robotic transport mechanism, capable of:
  - Entering the annular space between the newly inserted PE Pipe and the existing main or inside of the newly inserted PE pipe
  - Traversing to a service location
  - Utilizing Integrated Camera and LED Lighting or other sensor to locate a service requiring reinstatement
  - Transporting a fitting to the location

- An equipment package carried by the robotic transport mechanism, capable of:
  - Tapping a hole in the PE mains pipe
  - Attaching a PE fitting at the hole location, and providing a means of permanently installing the fitting
  - Connecting the inserted PE service pipe to the fitting
  - Inspecting the new service-mains connection to assess its integrity

- Control System with integrated video displays, robot controls, power supplies and data acquisition equipment (as required)

- Additional support equipment

Field testing will be performed at sites provided by us and will determine:

- Engineering and planning steps necessary prior to deployment

Project Description continued

- Maximum travel distance and ability to remotely reconnect service lines
- Impact on customers
- Ability for system to operate and remotely install service connection on newly inserted PE pipelines
- Deployment methodology
- Modifications prior to system commercialization
- Estimated unit pricing for commercial work performed

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Section 3: Project Business Case

This section should be between 3 and 6 pages.

Our project is aimed at developing methods to minimise cost of mains repair and replacement by delivering multiple solutions and benefits. These developments are necessary to demonstrate new business models for mains activity to ensure UK gas network companies can play a role in the future low carbon gas system, efficiently and economically.

Business case context

The latest gas distribution price control (RIIO) is the first price control to be conducted under the new RIIO (Revenue = Incentives + Innovation + Outputs) model. The objective of RIIO is to encourage gas distribution network owners like ourselves, to play a full role in the delivery of a sustainable energy sector and to do so in a way that delivers value for money for customers.
In relation to network safety outputs, consistent with the new Health and Safety Executive (HSE) iron mains policy (which provides greater flexibility for GDNs in managing the risk associated with iron mains) we, as distribution network owners, are tasked to reduce the safety risk by 40 to 60 per cent during RIIO. We're also expected to reduce gas transport losses, which comprise approximately 95% of our carbon footprint, by 15 to 20 per cent by the end of the period.
On top of this, we are committed to delivering improvements in customer service which this project will help with.
Finally, reliability output measures will require us to maintain the integrity of network assets, as well as meet the current network capacity and security of supply standards.
The Government's Carbon Plan sets the UK's progress towards and framework for meeting carbon targets. Currently, greenhouse gas (GHG) emissions caused by leakage from the UK's gas network, although relatively low in terms of units of energy lost, are the most significant source of GHG emissions from the UK network. Far greater than our operational emissions. We see an enduring role in the future for the gas network, transporting many sources of new unconventional and low-carbon gas while being utilised for different purposes including innovative heating solutions and transport. Reducing leakage and cutting GHG emissions from the network is therefore a very important aspect of increasing our sustainability and we recognise this project will help us towards this goal.
The use of internal repair and replacement methodologies on the gas distribution system offers a solution to both these problems allowing accelerated leakage reduction and minimising highway disruption while securing safe supplies to customers at least cost.
The project consists of four progressive elements that combine to create substantial environmental, customer and financial benefits when compared with business as usual methods of working.

Within the context of the project scope, each element will entail:

- Detailed design and manufacture of modular robotic platform or devices
- Development of management and operational procedures
- Full testing to ensure the robots can be operated safely inside a live gas pipe
- A detailed commercial appraisal

Benefits of the project

Element 1: A robotic 'platform' to enable deployment of modular repair, inspection and location data acquisition devices.

The first Element will facilitate the creation of a universal platform on which to base each of the specific method solutions, rather then pursuing siloed solutions for each problem. This releases an economy of scale recognised in the suite modules that will be developed and reduces the general operating costs of the units for the gas distribution network operators. Typical benefits of pursuing this approach are:

- A universal launch/retrieval system and method
- Unification of the control and support systems on which the modules operate, allowing a plug and play solution
- Minimal unique parts allowing greater production at reduced cost
- Reduced specialist training requirements, reducing unit costs

The specific benefits of each of the modules to be developed to run from this platform are described below.

Element 2: An internal mechanical joint installation module and internal seal repair method.

Due to changing engineering methodology and the time frame in which the gas distribution networks have evolved, various jointing methods and systems have been developed and accepted as fit for purpose or 'standard' on the metallic gas distribution systems. These range from Cast Iron Lead yarn joints, Spun cast iron elastomeric joints and on to screwed or mechanical joints.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

There may still be the requirement to replace the mains due to pipe barrel risk, however the leakage history indicates that joints have been the only recorded mode of failure.

This project represents a typical example of a large diameter project submitted to the Condition Review Group where this new system could provide the means of enabling us to meet our Pipelines Safety Regulation [PSR] obligations at a significantly reduced cost, compared with traditional remediation methods.

The first of the modular robots addresses the leakage issues relating to the joints in metallic gas distribution systems. The module will perform two functions, utilising both mechanical seal and repair methods to manage leaking joints and returning maximum environmental, customer and financial benefits.

Element 2 – Environmental benefits

The development and delivery of this module will bring multiple environmental benefits which include:

- The reduction of leakage and gas emissions
  - As an example, if full remediation of 1km of a 24" CI gas pipe within a 30mbar network was achieved, the saving in gas emissions would be 5.55 tonnes of Natural gas, or 116.5 tonnes of CO_2e per annum. In addition, the procedure releases no gas during the live operation.

- Reduced excavation and reinstatement requirements in the highway
  - The breaking up and removal of the existing highway and the replacement of it with new material during reinstatement of the excavation produces significant waste. This is multiplied for each joint that requires encapsulation. By employing this technology we will hugely reduce the requirement to excavate and it's likely we can reduce waste to landfill.

- Reduced gas main replacement activity
  - By effectively reconditioning and remediating the existing gas main we no longer need to replace it with a new polyethylene one. As an example, if full remediation of 1km of a 24" CI gas pipe within a 30mbar network was achieved, the saving in polyethylene of the replacement pipe would be 5.2 tonnes or 8.84 tonnes of CO_2e.

Element 2 – Customer Benefits

- Reduced excavation requirements in the highway which will reduce costs and minimise disruption to road users
  - Once deployed at a discreet location, the module will be able to internally seal up to 300m of infrastructure through one network entry point that allows both deployment and retrieval. This potentially reduces traffic management measures considerably.

- Reduced gas mains repairs as a result of fewer public reported gas escapes
  - By using proactive repair methodology we are no longer reliant on the customer for reporting leaks on this infrastructure. We can also remove the short term disruption the remediation of the leak traditionally causes.

- Reduced gas main replacement activity

Project Business Case continued

- Similar to the benefit regarding escapes, as we will have remediated the main we no longer need to replace it, removing all the disruption that comes with a replacement project.

[redacted]

Element 3: A robotic visual and non-visual inspection module incorporation sensors for the collection of corrosion, cracking, wall thickness, stress and pipe condition data.

In metallic networks, the pipe wall itself is a common failure mode. This can occur through various mechanisms depending on which metal the pipe is made from and what environmental factors are affecting it.

The metallic gas distribution system is primarily constructed of four metals, Cast Iron (CI), Spun Iron (SI), Ductile Iron (DI) and Steel (ST). Steel mains within low pressure distribution networks are generally unprotected. Steel is the primary metallic material for service pipes connecting the mains supply to the customers meter. It is also used for higher pressure transmission systems, which are outside of this scope.

Generally three mechanisms can act on a pipe (or pipe wall) to allow gas to leak for the system; corrosion, fracture due to stress and joint failure.
Pipes made from Steel and Ductile Iron are susceptible to through wall corrosion and are generally replaced on the grounds of condition.

For Cast Iron pipes though, the primary mechanism for failure is joints, however the highest risk posed is through fracture, which is the primary determinant of risk with the Mains Risk Prioritisation System (MRPS) model (see appendix D for summary of risk model principles).

The MRPS model has been adopted as a common risk model by all GB distribution networks and is the recognised basis for replacement programmes.

Under RIIO, there is an opportunity to explore alternative methods of risk reduction for Tier 2 and 3 pipes, and our development of robotics to measure stress, strain, defects and corrosion in pipe walls will allow alternative risk removal techniques to be applied, realising a broad range of benefits. For tier 1 pipes, which are more prone to fracture, replacement is

the only option at this time.
Element 3 – Environmental benefits

- The reduction of leakage and gas emissions
  – Not all leakage from a distribution network will get reported as a public reported escape (PRE). Using its suite of sensors this module will detect all leaking joints and fractures which can then be remediated.

- Proactively identifying fracture failures before they happen
  – Currently, one of the inputs for the prioritisation of mains replacement in the risk model is the recording of a fracture, and therefore a leak. By surveying the prioritised mains before replacing them we can target the ones shown at greatest risk from fracture based on empirical data, rather than statistical analysis.

Element 3 – Customer benefits

- Reduced excavation and reinstatement requirements in the highway will reduce costs and minimise disruption to road users

- Accelerated removal of actual risk from the distribution system
  – By surveying the tier two and tier three mains first, rather than just replacing them through the top down output of the risk model, an objective assessment of risk can be obtained. This allows prioritised replacement of at risk mains and the remediation of those not at imminent risk of fracture.

[redacted]

[redacted]

Element 4: An automated live asset replacement module for distribution services and mains.

The replacement of gas distribution pipe requires the excavation of trenches, into which the pipe is laid. However, a technique known as pipe insertion provides a means for the installation of distribution pipe with reduced excavation, resources, permitry and reinstatement costs. Pipe insertion is the process of inserting a smaller pipe into an existing, larger one. It currently provides a means for gas companies to cost effectively replace large sections of main.
Pipe insertion can be further broken down into two commonly applied methods, dead insertion and live insertion.
For dead insertion a pipe is temporarily disconnected from the existing gas distribution network. Typically, an excavation is made at suitable access points on the existing gas main. A cut out of an excavated section of main is created and a new Polyethylene (PE) pipe is pulled or pushed into the section of existing main.
In order to eliminate the need to excavate over each service an in situ means of connecting

newly inserted PE pipe to service lines is needed.
Within the context of Element 4 we intend to develop a module capable of remotely reconnecting service lines to inserted pipe without the need to perform excavation over each of the connection points.

The module will enter and travel down the gas main between the old main and the inserted PE pipeline or inside the newly inserted PE pipe to perform a remote reconnection of the service.

Element 4 – Environmental Benefits

- Reduced excavation and reinstatement requirements
  - The breaking up and excavation of the existing driveways, pathways and highways and the replacement of it with new material during reinstatement of the excavation produces significant waste. This is multiplied for each customer service pipe that requires replacement to the new mains supply. By utilising this new methodology we will reduce the requirement to excavate.

Element 4 – Customer Benefits

- Reduced excavation and reinstatement requirements in the highway, pathway and driveways of our customers' homes
  - Excavations are a visible and disruptive element of our service work. This module will greatly reduce the requirement to excavate which we believe is of great importance to our customers.

[redacted]

Under the Final Proposals for RIIO-GD1, the Information Quality Incentive provides for efficiency savings made against expected expenditure during the price control to be shared with the relevant GDN's customers. For SGN customers in our Scottish and Southern licence areas, 36% of savings on total expenditure are returned to customers, via a reduction in allowed revenue. [redacted]

[redacted]

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Section 4: Evaluation Criteria

This section should be between 8 and 10 pages.

The Government's Carbon plan sets the UK's progress towards and framework for meeting carbon targets. Currently, greenhouse gas (GHG) emissions caused by leakage from the UK's gas network are, although relatively low in terms of units of energy lost, the most significant source of GHG emissions from the UK network, far greater than our operational emissions. We see an enduring role for the gas network, transporting many sources of new unconventional and low-carbon gas whilst being utilised for different purposes including innovative heating solutions and transport. Reducing leakage and cutting GHG emissions from the network is a very important aspect of increasing our sustainability and we hope that this project will help us towards this goal.

At present the total leakage across all UK distribution networks is approximately 4.56Mtonnes of CO_2e per annum. If pipe remediation through robotics is successful then leakage can and will be prevented. As an example, if full remediation of 1km of a 24" CI gas pipe within a 30mbar network was achieved, the saving in gas emissions would be 5.55 tonnes of Natural gas, or 116.5 tonnes of CO_2e per annum.

All Gas Distribution Network's are engaged in a multi-million pound mains replacement programme. This project will demonstrate the viability of remediating some of these mains rather than replacing them, accelerating leakage reduction as well as removing the cost, disruption and environmental impact of the unnecessary replacement.

It should be noted that the UK gas networks represents the most efficient energy distribution network available.

The expected environmental benefits the Project can deliver to Customers

The main environmental benefit this project delivers is the accelerated reduction in leakage (often termed as shrinkage) from the gas distribution network. For the purposes of demonstrating environmental benefit, this can be expressed in terms of Carbon Dioxide equivalent, or CO_2e.

In terms of process, elements two and three will combine to release the following benefits:

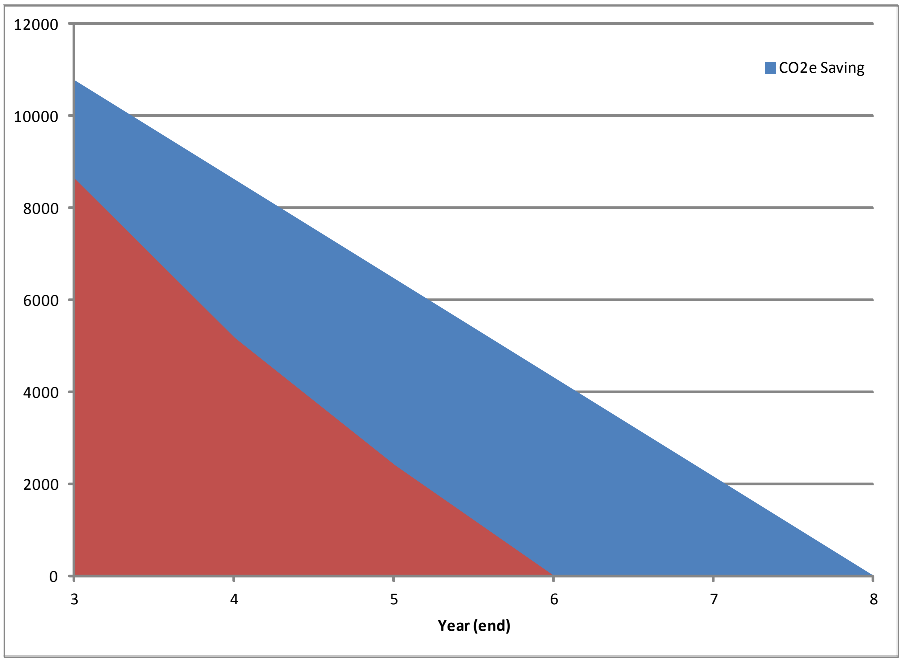

Figure 4: New method CO2e saving over the remainder of the PCR

In total, Figure 4 represents a saving of 16,441 tonnes of CO2e over the remaining (post project completion) RIIO period. If applied to all the other GDNs as is the intention, then the UK benefit would be somewhere in the order of 65,764 tonnes of CO2e.

A secondary benefit realised as a consequence of using the module developed in element 2/3 would be the reduction in the use of replacement polyethylene pipe. This would realise savings in emissions of 215 tonnes of CO2e per year or 1,290 tonnes of CO2e over the remainder of the period. If applied to all the other GDNs as is the intention, then the GB benefit would be somewhere in the order of 5160 tonnes of CO2e.

The final environmental benefit, applicable to all the modules developed as part of the project concerns the reduction in the need to excavate. Although this is harder to accurately quantify, it represent a reduction in the quantity of material excavated and of course sent to landfill, for SGN, who are a particularly efficient GDN in this respect.

[redacted]

[redacted]

Evaluation Criteria continued

[redacted]

Provides value for money to gas Customers

The development of this robotic technology has the potential to fundamentally change the way in which the routine activities involved with securing the supply of gas through the distribution system. Starting the shift away from external management of the infrastructure to an internal approach is only now possible though recent advances in precision manufacturing techniques being used in robotic technology and offers multiple Customer and Environmental benefits as well as reducing the operating costs of the activities.

We believe the time is right to advance the industry understanding of the use of internally deployed robotics that will allow us to counter the often disruptive nature of our routine gas distribution network activities on our customers. At first glance, the cost and scale appear significant, but in the context of the benefits that will be realised actually represent a sound industry changing investment.

The project utilises a tried and tested project management methodology with the scope and project plan clearly defined up front with four main elements:

1. Project Element 1 & 2 - Develop Modular Robotic Inspection & Repair Platform
2. Project Element 3 - Robotic Visual & Non-Visual Inspection
3. Project Element 4 - Live Asset Replacement

Each of these elements has then been broken down further in to specific deliverable tasks with defined dates that influence the realistic but challenging project deadline. As shown in the project plan (see appendix F) we have set a number of payment trigger stage gates in line with the project plan and will be finalised prior to project commencement.

Prior to commencing the project a mobilisation payment will be made to ULC Robotics, see project plan task - SDRC 9.1.a - Publish Project Reporting Structure Document. At any point throughout the project, and with reasonable notice, we have the ability to put the project on hold and revise its status or tombstone the project if they believe that the project will fail to deliver its outputs.

100% of the benefits will accrue to the gas consumers through more efficient network operation, reduced public disruption and customer supply interruption.

At the heart of the project engineering is the consideration for the capability of the robotics to be developed. A feasibility study was undertaken to assess a range of companies and products in the market and ULC were identified as being at the forefront of pipeline robotics. They are the only specialised pipeline robotics company with successful and demonstrable experience of robotic solutions in the world. Until now this Small Medium Enterprise (SME) has been solely based in North America, primarily the USA.

The project is designed to reduce leakage and failure of gas distribution networks through inspection, repair and replacement of assets from inside the gas main using robotic techniques. These are high cost areas for gas distribution networks, which justify the scale of the project proposed.

The field of robotics is highly specialised. ULC Robotics has been selected for their unique experience and competence in this area to support this project and many of the concepts and ideas has contributed to the development of the project requirements and proposal. The prices submitted within the project have been benchmarked against previous work and based on projected daily rates.

Additional suppliers will be required to support elements 3 and 4 of our project. Specifically, technologies including microwave, acoustics, radiography, magnetic flux leakage, pulsed eddy current, and ultrasonics, will all be researched and analysed for use in performing in situ integrity assessment of the pipe wall. This will include the detection of corrosion, wall loss, cracking, pitting and locating of unknown features. This aspect will be subject to competitive process and an estimated cost has been included in the funding requested.

Further support will also be required by PE pipe and manufacturing suppliers to develop either electro fusion, compression, or push fit fittings for application in the annulus of the pipe by the robotic solution. This has been estimated as part of the funding assessment, but will be subject to our internal competitive process.

The cost benefit analysis (in appendix D) clearly demonstrates that the method proposed offers improved efficiency over the current base, allowing tangible financial benefit to be passed back to the customer. All the potential benefits from the project will be realised through increased efficiencies in the operation and management of the gas distribution network.

Evaluation Criteria continued

There are aspects of the project that will require external technical assurance, such as an ATEX analysis. We plan to use suppliers on our technical services agreement, who have been through a recent procurement event at the beginning of this year.

A procurement event was completed to support this and a number of UK based industry expert suppliers were included. Innovation delivery was a key factor used as part of the assessment process. In total, there were 80 applicants and from this a total of 26 were short listed as potential suppliers. Through further rigorous review, the final award was made to 8 suppliers, all providing good evidence of their capability in supporting projects at this level.

Generates knowledge that can be shared amongst all relevant Network Licensees

As laid out in the project plan, while progressing each element of the project we will be capturing and demonstrating learning. A learning dissemination table is detailed in appendix G.

If the project is successful, it is our intention to immediately implement the use of the first production modules based on these prototypes and the other gas distribution network owners will also have full and equal access to this technology to do the same.

The prototypes at the end of the project will belong to SGN, but with an unrestricted licence for ULC to commercialise in GB, with no royalty due from any other GB GDN to utilise under a commercial agreement.

It is proposed in additon the Gas Distribution Networks will have first refusal up to one month in advance, subject to a first come first serve basis. Where more than one network wishes to use the robotic solution, it will be offered in sequence or subject to agreement.

As a means of rollout across all GDNs a free demonstration of a 300m section will be offered upon successful completion by ULC, this is a benefit in kind. This is intended to share knowledge, assuage engineering concerns and engage with other distribution networks.

In terms of maintenance and operation, ULC will perform required maintenance to ensure ready for deployment within a month for a period of a year following completion of the project without additional cost.

Is innovative (i.e. not business as usual) and has an unproven business case where the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness

The project seeks solutions to industry challenges from the field of cutting edge robotics. Due to the novelty of the robotics application, the project has particular technical challenges, specifically the engineering and operational aspects that require to be controlled in order to operate complex electronics in a live gas environment. It is not feasible for such a technology to be developed to an operational standard without support and operational field trialling from a gas distribution network. Although some robotic solutions exist in the market they rarely perform more than one specific function and are limited in terms of adaptability regarding the sizes of infrastructure they can operate in. This project aims to provide an integrated and consistent modular solution to the common problems the gas distribution networks face when undertaking mains management activities.

Involvement of other partners and external funding

There are two key project participants; ULC Robotics and SGN.

ULC Robotics (ULCR) specialises in developing unique solutions for energy industry technical challenges; from the creation of simple tools to complex electromechanical systems. ULCR has a proven track record of success in robotics and routinely executes multiple complex robotics R&D projects simultaneously. They have expertise in project management, mechanical engineering, electrical engineering, sensor development and application, programming, user interface development as well as manufacturing, assembly and testing. ULCR has unique experience in the commercial deployment of live gas pipeline robotics are considered the ideal partner to commercialise and deploy the technologies developed under the project.

Additional suppliers will be sought at various stages of the project. The cost for this aspect has been estimated as part of the funding assessment, but will be subject to a competitive process.

ULCR are currently working with us develop an NIA project to field trial and demonstrate CISBOT, an existing ULC commercial product. This will be a precursor to this project and the learning from it will be utilised.

Further to a period of comprehensive stakeholder engagement we have set out an innovation strategy to do a number of things:

- Improve the way in which we work to be more efficient, more customer focussed, less disruptive while carrying out road works and reduce our carbon footprint
- Support entry into the network from renewable sources of gas and support the low carbon economy
- Open up competition in gas distribution through provision of alternative entry points

To support our innovation strategy, we adopt both a proactive and reactive approach to idea generation. We run a suggestions scheme, called Ignite (Ignitescheme@sgn.co.uk), for our staff, our project partners, suppliers and anyone else who wishes to make a suggestion, offer a new product or share an idea. We are also proactive in seeking new innovations and project partners, through our industry watch; our external memberships with greater access to SMEs; and most successfully through challenging our ever increasing array of project partners to come up with solutions to our industry issues.

This proposal from ULC Robotics is a good example of this proactive approach in action. We provided detailed problem statements and definitions, to address which, they have proposed this project. Our problem statements are available externally on both on the EIC and ENA websites and soon on our own external website.

We continually prioritise the ideas and develop projects for both the NIA and NIC based on their scale, feasibility, potential to add value to the UK gas consumer and support our outputs under RIIO GD1. The project proposals are subject to a challenge and review at our Innovation Board, which reports to our Executive. Having followed this process, we believe the Robotics project to be of significant scale and potential to be considered under the NIC.

Relevance and timing

The relevance and timing of this project is all the more pertinent given where we are in RIIO, at the beginning of the GD1 price control. The project offers a multitude of benefits to our customers, efficiency and cost to the gas distribution network owners and also environmentally at a time when the government is actively seeking industry solutions and participation in reducing and controlling CO2e emissions. The project is designed to deliver environmental benefits to UK gas customers through:

- The accelerated reduction of leakage and gas emissions
- Reduced excavation requirements in the highway
- Reduced gas mains repairs as a result of less public reported gas escapes
- Reduced gas main replacement activity

The Government's Carbon plan sets the UK's progress towards and framework for meeting carbon targets. Currently, greenhouse gas (GHG) emissions caused by leakage from the GB's gas network are, although relatively low in terms of units of energy lost, the most significant source of GHG emissions from the GB network, far greater than our operational emissions.

We see an enduring role for the gas network, transporting many sources of new unconventional and low-carbon gas whilst being utilised for different purposes including innovative heating solutions and transport. Reducing leakage and cutting GHG emissions from the network is a very important aspect of increasing our sustainability and we hope that this project will help us, and the other gas distribution network owners, towards this goal.

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Section 5: Knowledge dissemination

This section should be between 3 and 5 pages.

☐ Please cross the box if the Network Licensee does not intend to conform to the default IPR requirements.

Learning Dissemination

The main outputs of this Project are the technical and engineering knowledge gained in using new methods to assess and remediate the existing natural gas network. It may also support any future directive or ordinance in this field.

Therefore it is essential that learning opportunities generated by this project are successfully disseminated for GB GDNs, the wider gas community, national and international standards bodies, academia, local authorities and other key stakeholders such as the ENA, DECC, IGEM and Ofgem. Learning will be coordinated through the Project in such a way to ensure that all knowledge generated is disseminated effectively and that, if successful, the trial can be translated to business-as-usual solutions – a table detailing the plan can be found in Appendix G.

We have already gained positive interest regarding the project from the other gas distribution owners during the regular Gas Innovation Group (GIGS) meetings.

In order to ensure that learning is effectively disseminated, a specific workstream, lead by SGN has been established for this purpose: Workstream 4 'Learning Dissemination'. The learning dissemination will focus on both internal and external learning and knowledge dissemination activities.

Target Audience

The target audience for dissemination activities will include both internal and external parties. The audience is anticipated to include but not be limited to:

- All our employees
- GB GDNs;
- The Energy Networks Association (ENA);
- Ofgem;
- DECC;
- IGEM;
- Academic Institutions;
- Local Authorities;
- Local Communities;
- Relevant Trade Associations

Internal Dissemination

Sharing knowledge with all our employees is considered a vital activity of all innovation projects to ensure the ongoing engagement of staff so that the outcomes of the project are adopted for future application. We will be adopting a similar approach to knowledge dissemination for this project to help build awareness and knowledge of the project around our business. Methods for internal dissemination will include, but not limited to, the following:

Knowledge dissemination continued

- Project briefing presentations for all employees at project start and end using our *teamtalk* briefing session
- An article outlining the project will be produced for our in-house newspaper 'SGN*mail*'
- An article outlining the project will be produced for our in-house intranet site 'SGNnet'
- Training key members of staff before, during and after the project
- Inclusion of our graduate trainees in project delivery as part of their accredited training scheme
- Identifying project champions and points of contact within each business area that can be kept updated of developments to ensure customer experience is effectively managed.
- An annual internal innovation and technology conference
- Knowledge transfer 'in' to the project for previous projects
- Operational workshops

The development of this technology along with the new methods and techniques to use it is likely to require new working procedures to be developed and further training of staff to be conducted. We will use the expertise of the project members to contribute to the training of Project staff. This will complement our existing in-house training team and facilities which we already have in SGN.

This project has strong links to a number of business directorates including Operations, Customer Service and Network through our Innovation Board. Principal points of contact are established within this body to ensure all information on the project is exchanged to manage the internal process as well as for learning dissemination.

In addition to our Innovation Board, we will also be identifying project champions from each of the other business areas who will act as ambassadors and lead engagement within their business unit. This will involve providing updates, *teamtalks* and making other presentations as appropriate to keep staff informed of developments.

Recently we have started planning an annual innovation and technology conference for our staff attend to find out about the various developments which are ongoing across business. This will be ideal forum to raise knowledge and awareness of the project. A broad range of staff will be in attendance.

We believe that this broad range of activities will provide comprehensive sharing of the learning from this project, and that the learning will be embedded into day to day practices. Many of these processes for internal dissemination are building upon existing activities and experiences from other innovation projects.

We have planned to undertake a workshop with the operational and design staff who are engaged with these projects. We recognise that over and above the wide variety of material available in relation to this project, some of the less tangible learning is best shared in a workshop environment where people can talk about their experiences. This event has already been agreed to be undertaken prior to the commencement of the project. We will also be looking to undertake a similar activity with other GDNs where we believe there to be merit.

Knowledge dissemination continued

External dissemination

We are intending to build upon our successful dissemination approach already used for all our innovation projects. For this project, this will include, but not limited to, the following:

- Project presentations at learned bodies such as IGEM and the Pipeline Industries Guild throughout the project life cycle to share lessons learned
- Updating of the NIC portal website which will provide access for any interested party to understand more about the project
- Articles outlining the project and its progress will be produced for our external website site 'www.sgn.co.uk' at various key stages
- An article with be produced for the monthly IGEM magazine 'Gas International'
- Innovation workshops
- The NIC and other industry conferences
- Six monthly progress reports to Ofgem
- Influencing the updating of policies and standards
- Partner dissemination
- Engagement with media and trade press
- Engagement with the local authorities

The Project will identify areas of existing technical and regulatory standards which are impacted by the trials or where the implications of a UK wide roll-out will have such an impact. These areas will be documented in reports and presented to other GDNs.

From the experience of undertaking this project, key learning points will be fed into the relevant national policies and standards to ensure all parties can benefit. One of the principal learning points which will help with the dissemination will be the recommendations to use the new technology, methods and techniques as standard.

Knowledge dissemination plan

A knowledge dissemination plan is detailed in appendix G. The goal of this dissemination plan is to ensure accessibility to, and dissemination of, the project results and methods. The knowledge dissemination plan details the format and timescales of the internal and external dissemination modes – we would wish for this plan to work both ways, gaining thoughts and ideas back in as well as knowledge and information flowing out.

IPR

The project complies with the default IPR clauses.

All parties involved in the project will have the freedom to discuss work undertaken as part of the project in seminars or presentations, give instruction on questions related to such work and publish results obtained during the course of the work undertaken as part of the Project.

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Section 6: Project Readiness

This section should be between 5 and 8 pages.

[redacted]

[redacted]

We are confident of the readiness of this project due to the preparation that has taken place pre-proposal, having already initiated an Innovation Funding Incentive (IFI) project in 2011 that was linked to the early developments of robotic technology introduced by ULC Robotics. In addition, we have taken encouragement following the Initial Screening Process and the interest made known by the other Gas Distribution Networks. Furthermore, we are also currently in the process of registering a smaller scale Network Innovation Allowance (NIA) project with ULC Robotics to evaluate their existing robotic commercial product. Through applying proven project management methods, effective planning and engaging with our experienced project participants we have a high degree of confidence of delivery and success.

This section will provide evidence of why the Project can start in a timely manner, how the costs and benefits have been estimated and measures in place to minimise the cost of overruns or shortfalls in direct benefits. Furthermore, this section will explain the verification process for information provided, how the Project Plan would still deliver learning if take up is lower than anticipated and the processes in place to suspend the project if necessary. This is explained in more detailed under the following headings:

- Project plan
- Programme management and governance
- Project team
- Procurement
- Risk mitigation and contingency strategy
- Key performance indicators
- Quality assurance
- Stakeholder engagement
- Previous studies
- Accuracy if project costs and benefits
- Verification process
- Project learning (if take up is lower than anticipated)

Project Plan

The project plan sets out the best approach and timescales that the project team has determined to bring the highest likelihood of success. The Plan identifies the 4 main Project elements, including additional work tasks broken down under each. This detailed Project plan can be found in Appendix E. The plan will be revised an updated again before the start of the Project.

Project Readiness continued

Programme Management and Governance

This project will employ the standard programme management and governance approach used by SGN as described in our Project Management Procedures. The project governance structure will ensure that the Project meets the delivery criteria and milestones identified. Ultimate Project direction will come from the Project Director, Angus McIntosh, Innovation & New technology (SGN). Key decisions and sign off will however be managed by a Project Steering Group, consisting of key representatives from both SGN and ULC Robotics. The Steering Group will have access to the day to day running of the Project enabling them to make key informed decisions as to the strategic direction of the Project.
The Project Manager shall maintain the planning system and monitor the progress of the project and be responsible for updating the accepted programme on a regular basis. Coordination meetings will be held to maintain during the design and construction phases a coordinated approach between all parties throughout all phases of the project.
Protocols shall be put in place by the Project Team to ensure regular contacts are established through a meeting schedule and that information is shared between all parties throughout the duration of the project. As a minimum, the following meetings shall be held:

- Pre-start meeting
- SGN / participant meetings
- Progress meetings
- Construction meetings
- Commercial meetings
- Quality meetings
- Health, safety and environmental meetings

Project Team

The Project team will comprise of the following (May be subject to changes in personnel):

Designation	Company	Name
Project Director Head of Innovation & New Technology	SGN	Angus McIntosh
Project Manager	SGN	Oliver Machan
Finance Manager	SGN	Rob Hetherington
Engineering Policy Manager	SGN	Malcolm Green
Distribution Asset Manager	SGN	Tony Hughes
Engineering Manager	SGN	Steve Harger
Engineering Team manager	SGN	Winston Alphonse
Engineering Team	SGN	TBC
Reinstatement Team	SGN	TBC
Commercial Solicitor	SGN	Alistair Scragg
Innovation Delivery Manager	SGN	David McLeod
Regulation Manager	SGN	Beverley Grubb
Communications Manager	SGN	Anne Neilson

Project Readiness continued

Procurement manager	SGN	Michael Okosodo
Administrative assistant	SGN	TBC
Technical assurance	TBC/SGN	TBC
President	ULC Robotics	Gregory Penza
Director of Research & Development	ULC Robotics	Robert Kodadek
Engineering Project Manager	ULC Robotics	Ryan Dubose
Mechanical Engineer x 3	ULC Robotics	TBC
Electrical Engineer x 3	ULC Robotics	TBC
Sensor designer	ULC Robotics	TBC
Sensor manufacturer	TBC/ULC Robotics	TBC
PE Pipe manufacturer	TBC/ULC Robotics/SGN	TBC

The project team's organisation structure, showing lines of reporting can be found in Appendix H.

One of the key criteria for building a robust Project Plan was in the selection of the relevant project participants and the forming of a competent project team. Our preferred participants were identified after an undertaking review of skill sets required and competence levels. ULC Robotics provides a highly skilled, specialised workforce.

As part of the proposal, SGN have ensured that the Project Team is in a position where all our members can commence Project work come the 6th January 2014, are aligned to the specific project deliverables and are able to commit to and meet their scope of work and defined outputs. The work schedules have been developed together with ULC Robotics to ensure the Project will start in a timely manner as detailed in the project plan.

Procurement

SGN's procurement of services and operational equipment and materials will be carried out in accordance with SGN's standard Procurement Procedures.
Following the initial site investigations and preliminary works, the Project Manager will procure the equipment and materials to undertake the field testing. At this point, all long lead items / critical items will be identified to ensure this does not influence the proposed Project Plan. All equipment, spares and materials will be documented within an Equipment/Materials Control Register which will be maintained throughout the duration of the Project to record and track the following detail:

- Description of equipment, material and specification to be purchased against;
- Identifies suppliers;
- Quantities required;
- Programme delivery dates, order by date, and expected lead times; and
- Outstanding information e.g. sufficient information to prevent procurement;

The Equipment/Material Control Register will be updated on a regular basis by the Procurement Manager.
Equipment and materials will be procured at site level by the Project Manager in consultation with the Procurement Manager who will be responsible for the placement of large orders.

Project Readiness continued

Regular review meetings shall be held to coordinate material delivery dates, highlight any special requirements e.g. unloading arrangements and establish material storage requirements.

Risk Mitigation and Contingency Strategy

Hazard and Risk Assessments of network mains will be undertaken by Asset Management before any on site operational activities take place, using recognised HAZID and HAZOP methodology. This is recommended in order to assess the condition of the network prior to inserting CISBOT into a live gas environment. Such risk assessments will consider the historical data behind each individual pipe and environmental factors.

Embedded within our project management methodology is the capability to manage risks and issues. This project will adopt the existing risk management process currently in operation within SGN.

The Risk and Issues Model employed considers risks and issues that are business-as-normal and those specifically related to the project all of which will be articulated in a common format. Appendix I outlines the risks that have been identified prior to the start of the project and the corresponding contingencies put in place. Within the risks model, likelihood and consequences will each be given a score from 1 to 5, and the resulting product of these two ratings used to score and rank the risks on the project. The model has been used and refined for many years and has been found to be both robust and recognised as an exemplar approach.

The format of the SGN scoring matrix is presented in Appendix I. The scoring matrix will be used by the Project Manager, Project Director and Project Steering Group to continually review Project risks, their mitigating action(s) and controls, and to ensure that risks are managed in priority order. The risk model describes the Methodology for determining an `uncontrolled' risk score. However, if control measures are applied, aimed at reducing the hazard and/or mitigating the risk, it should be possible to produce a `controlled' risk score that is lower than the `uncontrolled' risk.

The risk register will be re-visited in greater detail prior to project start and further problematic or opportunistic areas together with risks identified will be analysed and mitigation measures agreed and implemented.

Also in place is a risk escalation process which documents how certain risk types are escalated up through the Project team. The governance processes to be operated across the Project Participants, will regularly review risks and issues and either remove these if agreed mitigation has occurred and/or bring new issues or risks to the attention of the Project Steering Group. The Group will agree management actions, which may lead to the Project being halted until such time as sufficient mitigation has occurred to enable on-going management of the risk or issue, or to halt the Project and defer further commitment until agreement has been reached with Ofgem on how to proceed.

Mitigation and contingency management will form a key part of the risk strategy. When a risk is raised the Project team will be responsible for creating a mitigation action that can be brought into play should the risk be realised.

During the project, the method of identifying hazards and controlling the risks will be by performing Risk Assessments by competent and experienced persons, both across SGN and ULC Robotics who will implement the relevant control measures if necessary. Activities will also be controlled by issuing Method Statements for any operation as required. The assessment shall be subject to ongoing review and shall be reissued to take into account any changes in circumstances or new hazards.

Over and above the foregoing and prior to the start of the Project, we will facilitate a necessary Hazard Identification (HAZID) meeting to ensure we fulfil our duty to manage and mitigate identified and foreseeable risks encountered during the works and those identified during the planning phase.

Stakeholder Engagement

Throughout the bid preparation process we will discuss and plan our stakeholder engagement strategy for the project in much the same way as we would in conventional business as usual repair and replacement activity. See typical stakeholder communication material in appendix J.

Key Performance Indicators

We shall develop Key Performance Indicators (KPIs) as a mechanism to identify critical measurements and to capture performance information in these specific areas on site:

- Health and Safety
- Environment
- Delivery

The detail of these KPIs shall be communicated to all Project personnel and external consultants at the project induction meeting.

It is envisaged that a reporting system will need to be implemented to ensure the required statistical data is captured. This will enable an updated project Monthly Report to be compiled and circulated to all relevant participants.

Quality Assurance

We are fully committed to achieving high standards with regard to engineering, safety, health and environment. Throughout this Project we will adopt a strict quality control procedure in accordance with our existing Safety Management Framework (SMF) which enshrines our approach to managing our activities safely. It also protects and enhances our reputation by defining the standards we will apply in relation to how we manage risks, the engineering of our assets, protection of the public, the well-being of our workforce and contractors, and the protection of the environment.

All necessary equipment and materials for operational activities will be ordered to the required specification and the Procurement Manager and Project Manager will be responsible for obtaining and collating all quality assurance documentation.

All on site activities, including Non Routine Operations (NRO) will be undertaken by competent engineers and all documentation appropriately logged by the Programme Manager in the Project folder.

Project Readiness continued

SGN and where applicable ULC Robotics will carry out visual inspection of all equipment materials at the point of receipt into the storage areas during unloading in accordance with SGN procedures.

Previous Studies

While the gas industry worldwide are gradually waking up to the potential for robotics to improve transmission and distribution operations, GB will take some warming up to the concept and at present seem happy to view it as a long-term trend that will have a gradual rather than a sudden effect. However, we understand the importance and focus in relation to safety, environmental impact, cost efficiency and increased production and believe that the potential for a more extensive use of robotic technology is evident and imminent.

The most significant challenge that ULC Robotics have faced in selling their technology to the gas industry is the difficulty in engagement with the GDN due to the complexity of the technology, but the proven resilience and performance standard assuages many concerns in this regard. In November 2011 we internally approved an IFI project to develop an innovative solution for the repair of leaking lead yarn joints within our cast iron population. This was the first time we began working alongside ULC Robotics and there cast iron joint sealing robot (CISBOT). The aim of this project was to insert CISBOT technology directly into 6”-12” diameter cast iron mains to seal leaking joints with an anaerobic sealant, without disrupting service, and with minimal excavation. Whilst this project did not progress we learned a great deal about the feasibility of the technology and the capabilities of ULC Robotics.

Having explored early developments introduced by ULC Robotics and understood the level of experience they had with regards to robotic technology, a detailed problem definition was provided. ULC have proposed a more advanced CISBOT commercial product that would potentially aid us in delivering our future outputs. This technology is referred to as large CISBOT and has already sealed more than 3000 cast iron joints for Con Edison and gas companies throughout the Northeast of America. It uses the same anaerobic sealant that has been used throughout the UK gas industry for over 15 years. However, the most significant advantage is that the method employed has allowed the repair process to be remediated and offers a 50 year extension to asset life, as tested and verified by Cornell University.

We are looking to carry out an assessment of this commercial product separately under the NIA mechanism and trial the large CISBOT technology on a large diameter main on our network. Whilst proven in the US it is currently limited in its capability for GB application to straight lengths of pipe with lead yarn joints. This NIC project is designed to develop a more comprehensive robotic solution to distribution mains management focusing on the GB gas distribution network needs.

In addition to the previous studies that have taken place with ULC Robotics, we are also in the process of finalising another transitional IFI to NIA project with Synthotech Limited. The purpose of this project was to carry out a technical feasibility study to investigate the technical potential to extend the capability of the prototype SynthoTrax architecture to enable remote internal joint sealing of gas pipes that:

- Are between 18” and 48” diameter metallic mains

Project Readiness continued

- Can operate at low pressure (≤75mbar) and medium pressure (>75mbar, <2bar)
- Can remediate up to 400m of main from one excavation
- Potentially drill if required

The feasibility also looks into the individual system components, including a review of all other globally available technology:

- Access Fitting
- Access System
- In-pipe robotic platform
- Sealant Application System
- In-pipe CCTV
- External Support Systems

Initial draft versions of the final research report have now been submitted and have provided us with a fundamental understanding of the feasibility of introducing robotic technology into a live gas environment for the purpose of joint repair and remediation.

Accuracy of Project Costs and Benefits

The Project costs have been calculated using input from ULC Robotics and a finance resource from SGN.

This is a highly complex and technically challenging project. The potential financial benefits if successful are compelling, however this is an unproven technology, therefore we will continuously review the probability of success and any changes to the financial benefits.

We have allowed for the default cost overrun.

The overall budget will be managed by a Finance Manager embedded in the Project team. They will be responsible for managing all costs and constructing and delivering the reporting requirements as part of the Project.

SGN will run a robust financial tracking and reporting system in line with our current internal policies and frameworks. As per the Ofgem requirements the Project finances will be held in a separate Project Bank Account which will meet the following requirements:

- Show all transactions relating to (and only to) the Project;
- Be capable of supplying a real time statement (of transactions and current balance) at any time;
- Accrue expenditures when a payment is authorized (and subsequently reconciled with the actual bank account);
- Accrue payments from the moment the receipt is advised to the bank (and then subsequently reconciled with the actual bank account);
- Calculate a daily total; and
- Calculate interest on the daily total according to the rules applicable to the account within which the funds are actually held.

SGN will engage with our financial auditors, to alert them of their potential responsibilities should this Project be awarded the funding.

Project Readiness continued

Verification Process

Throughout the whole process SGN has carried out a strict internal verification process. The process firstly started with NIC project suggestions being shortlisted at Novembers 2012 Innovation Board, in anticipation that the bill would be passed through Parliament to allow the NIC to take place this year. This Board is made up of the Heads of each function across SGN and its purpose is to engage in delivering Innovation throughout SGN and provide the overall executive level control and guidance required. Furthermore, it:

- Decides on innovation areas to pursue in order to significantly reduce SGN's operating costs and promote effective working and management of risk.
- Spreads innovation throughout the Company
- Supports evaluation of ideas and suggestions
- Ensures Innovation projects are being properly progressed
- Ensures any "best practice" is spread across SGN as standard practice
- Removes any blockages or barriers to implementation
- Supports implementation and tracking of initiative effectiveness

The Board meet on a monthly basis initially to review progress against the budget and plan, support major deliverables and provide input to risk and issue management. Particular importance will be placed on managing the key dependencies between the different business streams to minimise the delays.

Following recommendations at the Board meeting this Project was identified and it was agreed by all members that this would significant value to network licensees throughout GB. The next step was to present a proposal paper to the investment committee, which consists of Directors and provides Executive sponsor.

Following approval the initial screening submission was undertaken with support from members of the Innovation Board. The Executive were also informed of developments fortnightly and following the success of the initial screening process the executive agreed to provide additional resources from out with the Innovation department to support and manage the expectations of the Final Submission.

To ensure the final submission was to the required standard a steering group was created consisting of a variety of experiences and competencies across SGN. Each member of the group had a specific role to play and weekly meetings took place to ensure that all data and supporting information was provided. In addition, weekly teleconference meetings have taken place throughout the year between SGN and ULC Robotics to ensure that not only all technical information is shared but also to finalise all contractual documentation in support of the Project being successful. Our Regulation team have also been involved throughout the whole process with frequent discussions and guidance provided to ensure full compliance with the governance criteria.

Project learning if take-up is lower than anticipated

Regardless if the take-up from the other Network Licensees is lower than anticipated there will still be sufficient scope to use the learning generated from this Project in the future if they wish. From SGN’s perspective we believe that this will not influence the outcome of the Project and the cost benefit targets set will still largely be achieved, along with learning and improvement in the following areas:

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Section 7: Regulatory issues

This section should be between 1 and 3 pages.

☐ Please cross the box if the Project may require any derogations, consents or changes to the regulatory arrangements.

This project does not require derogation, licence consent, licence exemption or a change to the current regulatory arrangements in order to execute it.

If the project is successful, however, we will look to raise a UNC modification through the Shrinkage forum in accordance with our licence condition special condition(s) 1F; Part E; 1F.17 & 1F.18 in order to reflect changes to remediated pipe.

The relevant extract is in appendix K.

Section 8: Customer impacts

This section should be between 2 and 4 pages.

The project will impact on customers within the demonstration projects for asset replacement only. The impact will be positive as we will be field trialling on a project where we are intending to replace the asset anyway and the method proposed is designed to be less disruptive than the current method.

Any failure of the system would require us to revert back to known techniques with no additional disruption to the customer. An example of our communication material is in appendix J.

We will work within and meet our internal obligations to our customers as well as all our obligations to the guaranteed standards of service (GSOS) as laid out by the regulator.

Link to relevant GSOS standards in appendix L.

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Section 9: Successful Delivery Reward Criteria

This section should be between 2 and 5 pages.

This section sets out our proposed Successful Delivery Reward Criteria (SDRC), each under a subsection labelled 9.1 to 9.8.

Our SDRC are genuine actions linked to outputs of the Project with a realistic and challenging deadline. In the following subsections we set out each criterion then clearly state the evidence we propose Ofgem should use to assess performance against the criterion.

9.1 Selection and Procurement of Motors, Gears & Bearings for Propulsion System (Element 1 & 2) by 15th August 2014

- Global search to investigate possible suppliers of motors, gears and bearings to be used in fabrication process.
- Carry out credit check on potential suppliers, review parts prices and evaluate logistical constraints and costs.
- Confirm and secure parts from suppliers for fabrication commencing on the 9th September 2014.
- Establish arrangements for the fabrication of parts.

9.1.1 Evidence:

- Commercial contracts are already in place with ULC Robotics and a number of part suppliers, however if already not in place they will be completed ahead of purchase.
- Procurement records for the purchase of motors, gears and bearings.
- All specifications, designs and supporting documentation for parts to be documented in project file.

9.2 Identify potential live mains suitable for trial on SGN Network (Referenced in all Elements) by 13th February 2015

- Engage with Asset Management, Network Planning, Operations, Safety Health and Environmental Teams to discuss Project proposal and potential field trial sites.
- Ensure ULC Robotics is involved in all field trial location meetings that take place.
- Select a variety of field trial locations to pass on to Asset Management for further Hazard and Risk Analysis review.
- Receive sign on / authorisation of field trial locations from all parties.

9.2.1 Evidence

- Minutes of meetings documented in project file.
- Email Correspondence documented in project file.
- All Network Planning analysis and designs to be documented in project file.
- Potential field trial site photographs and site plans to be documented in project file.

9.3 Robot Assembly (Referenced in all Elements) by 13th February 2015

- Purchase of all necessary parts and equipment.
- Installation of parts and equipment.

Successful Delivery Reward Criteria continued

9.3.1 Evidence

- Parts and equipment purchase orders documented in project file and controlled by ULC.
- All invoices and transactions documented in project file and controlled by Finance Manager.
- Robot Assembly method statements documented in project file.
- Photographic evidence of robot assembly stages documented in project file.

9.4 Hazard and Risk Analysis of Network Mains by Asset Management (Referenced in all Elements) by 10th April 2015

- Identify and understand the risks associated with our cast iron mains population and the selection of mains that has been selected as part of the field trial.
- Create inventory of potential hazards, their likelihood, and consequences assessed by comparison against defined criteria.
- Show that risks are identified and controlled to an acceptable level.
- Make reference to existing approval of G/23 requirements as completed by 27th March 2015 for guidance.

9.4.1 Evidence

- Minutes of Project team/Asset Management team meeting documented in project file.
- Hazard and Risk Analysis Assessment documented in project file.
- Approval for field trial document (G/23)

9.5 Site Management and CDM Requirements (Referenced in all Elements) by 3rd July 2015

- Site Management and CDM Requirements will be coordinated by SGN's Project Manager and ULC Robotics Engineering Project Manager.
- Ensure compliance with SGN policies and procedures as referenced in the Safety Management Framework.
- Traffic Management to be set up in compliance with NRSWA 1991.
- Ensure site welfare facilities and temporary project offices are delivered on time and positioned in the correct location as discussed at site selection and planning stage.
- CDM Pack to be compiled and located on site. This folder will contain all site drawings, utility drawings, log in/out registers and any other necessary information required to ensure compliance with CDM Regulations 1994.

9.5.1 Evidence

- Purchase Order of Welfare Facilities and Temporary Offices.
- Purchase Order for Traffic Management.
- Copy of CDM Pack to be saved in Project file, including scanned copy of site log in/out register.
- Photographs of site set up, including traffic management, welfare facilities and offices to be documented in project file.

Successful Delivery Reward Criteria continued

9.6 Prepare and authorise NRO's and PTW's under SCO (As per Element 4) by 28th August 2015

- Only competent SGN employees will prepare and authorise NRO's and PTW's that are raised throughout the duration of this project.
- The Project Manager along with the Engineering Manager will oversee all activities undertaken on site.

9.6.1 Evidence:

- Competent SGN employees will be registered on the SCO database.
- Copy of authority to proceed document
- All signed and dated NRO's and PTW's to be documented in Project file.

9.7 Launch Robot (Referenced in all Elements) by 9th October 2015

- Method statement to be written by ULC Robotics and approved by SGN.
- Prior to task a site meeting will take place to discuss the operation to be performed.
- Operation to be controlled by ULC Robotics with support provided from SGN.
- ULC Robotics Engineering Project Manager and SGN's Project Manager are to coordinate the entire operation.

9.7.1 Evidence

- Method statement and approval to be documented in Project file.
- Photos will be taken during the launch both externally and internally (by the robot). These will be filed in the Project folder.

9.8 ULC Robotics/SGN Generate Final Report (As per Element 3) by 23rd November 2015

- Report on final finance.
- ULC/SGN Robotics draft final report.
- ULC Robotics to send draft final report to Project Director ahead of deadline for review. This report will then be circulated to Project Steering Group and comments made.
- ULC Robotics to take on board any comments and necessary amendments and circulate final report by proposed date.
- SGN Project Director to sign off report.

9.8.1 Evidence

- Minutes of meeting between ULC Robotics and SGN to be documented in Project file.
- All versions of report to be documented in Project file.
- Final report will be one of the key aspects of the project to be disseminated to the other Network Licensees.

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Section 10: List of Appendices

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Appendix B – **About SGN and ULC Robotics**
This appendix contains information about each of the companies involved in this project.

Appendix C – **Project Conceptual Drawings and Detailed Descriptions**
This appendix illustrates the project conceptual drawings and provides a detailed description of the process.

[redacted]

Appendix E - **MRPS Risk Model**
This appendix provides a summary of MRPS principles

Appendix F – **Project Plan**
This appendix shows our detailed project programme in Microsoft Project which identifies key stages and milestones for the project

Appendix G – **Knowledge Dissemination Plan**
This appendix shows what, how, when and to whom we will disseminate the learning generated form this Project

Appendix H – **Project Team Organograms**
This appendix shows our suggested project team structure

Appendix I – **Risk Register and Mitigation**
This a ppendix s hows o ur m ain P roject r isks a nd m itigations identified. This a ppendix also explains h ow our risk r egister is scored

Appendix J – **Typical Stakeholder Communication Examples**
This appendix identifies examples of typical s takeholder communication material previously undertaken by SGN

Appendix K – **Extract fr om L icence c ondition regarding m odifications t o the leakage model (LRMM)**
This appendix outlines the terms with our license conditions

Appendix L – **Guaranteed Standards of Services**
This appendix outlines areas of our Standards of Service which are applicable to this project

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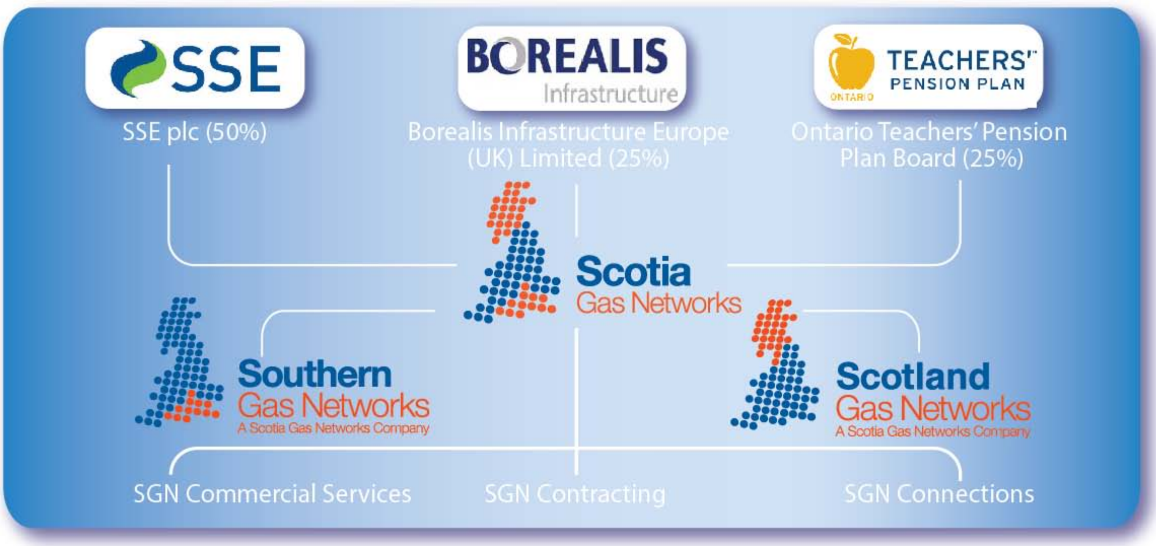
Appendix B – About SGN and ULC Robotics

Scotia Gas Networks (SGN) operates two of the UK's largest gas networks through 74,000km of gas mains and services. Scotland is served by Scotland Gas Networks and Southern Gas Networks encompasses the south and south-east of England. We provide a safe and secure supply of natural gas to 5.8 million customers and are the second largest gas distribution company in the UK.

Formed in June 2005, we have three shareholders who are the UK-based SSE plc (50%) and two Canadian pension funds: Borealis Infrastructure Management Inc (25%) and Ontario Teacher's Pension Plan Board (25%).

By actively engaging with and helping our customers, our environment and our communities, and by demonstrating the highest standards of safety, reliability and efficiency, we aim to become the UK's leading gas network operator.

Our people take pride in making a real difference, continuously improving and innovating. We are committed to delivering excellent customer service in all areas of our business and aim to be the leading operator of gas distribution networks in the UK.



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ULC Robotics is a pipleine robotics energy service, research and development organisation. Their aim is to work closely with their customers to develop novel solutions to their infrastructure operations and maintance needs.

Based in New York, United States of America ULC Robotics thrives on creating and implementing a range of devices from simple tools to complex electromaechanical systems and robotics. Their staff includes highly experienced field operations personnel, mechanical and electrical engineers, automation specialists and master machinists and technicians.

At ULC Robotics their values are based around the partnership built with their customers and the capability to produce value. They believe customer relationships are built on integrity, innovation, value and safety, these are the underlying principles that they ULC Robotics deliver.

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Appendix C – Project Conceptual Drawings and Detailed Descriptions

Element 1

1.1 Robot Deployment

Figure 1 shows a street-level view showing the deployment of the modular robotic platform developed for elements 1, 2 & 3. Under this concept, the robot is able to travel along the pipe up to 150 meters in either direction from the point of insertion. The vertical launch tube shown minimizes the size of the required excavation needed to perform the operation.

Figure 1 Robot Deployment

The inserted robot has a live video feed which is directly streamed to the robots operator in the vehicle. The entire system is capable of operating without the release of any gas from the main whilst minimising the disruption which can be caused from conventional excavations, thus resulting in an overall reduction in the impact to the customers and the environment.

1.2 Launch System

Figure 2 is a conceptual cross-section explaining the proposed method of deployment for the tethered modular robot to be launched in the down a gas main using a hydraulically controlled winching system in to the vertical no-blow launch tube attached to the gas main.

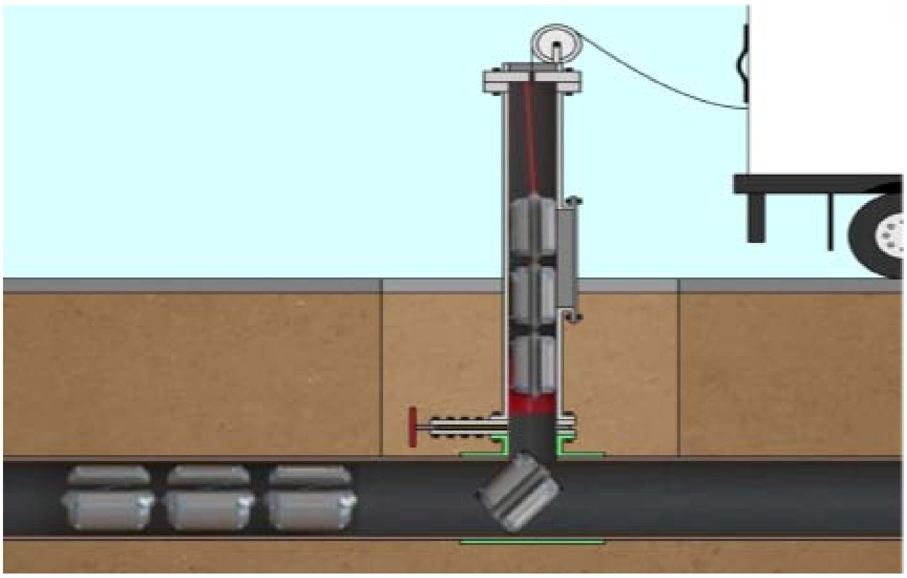

Figure 2 Launch tube

1.3 Expand to fit

The expanding modules at the front and the back would have powered wheels to drive the robot along the pipe. A camera and lighting system mounted in the forward module would provide the operator with live video images of the interior of the pipe. The module in the middle is a conceptual joint repair module.

The tethered robotic system is controlled and monitored by an operator in a vehicle. After the robot has been inserted into the gas main it will then expand to fit the inner diameter of the pipe as required, as shown in Figure 3.

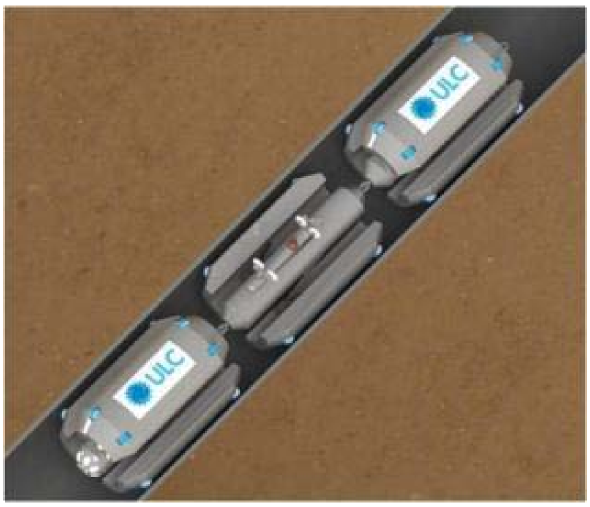

Figure 3 Expanding to fit main size

The ability to expand allows this system to operate in a variety of pipe diameters. The ability to expand will allow the robot to launch into a small tap hole and to operate in a variety of pipe diameters.

The expanding modules at the front and the back have powered wheels to drive the robot along the pipe. A camera and lighting system mounted in the forward module would provide the operator with live video images of the interior of the pipe. The module in the middle is the joint repair module. (See Element 2)

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Element 2

2.1 Repair Module

Figure 4 is conceptual drawing of the repair module developed for element 2. After locating a joint that requires a repair, the repair module is positioned and a tool is deployed to seal the joint. The process involves an expanding sealant being injected directly in to the joint; the secondary conceptual repair method would be the deploying a mechanical seal at the joint.

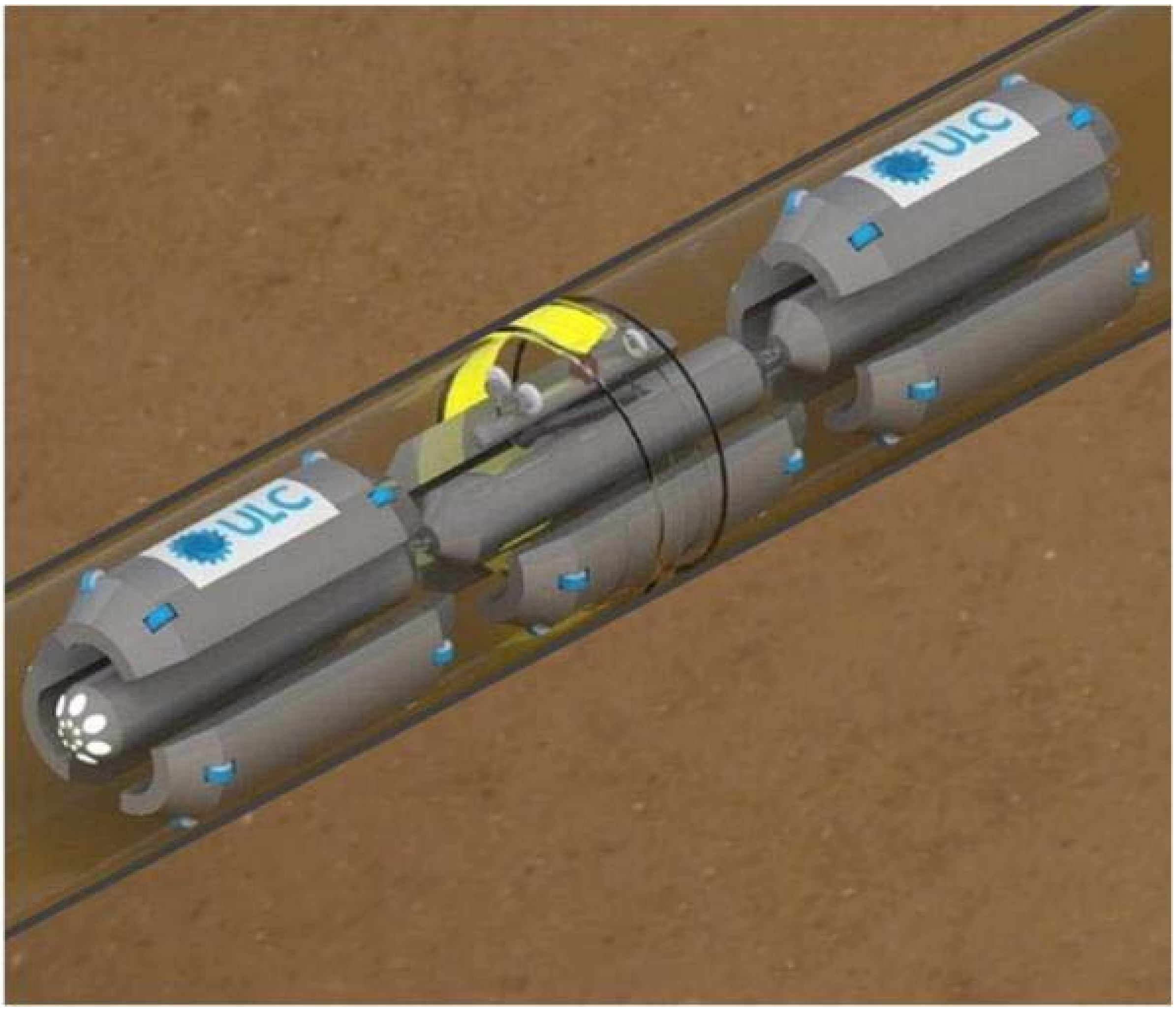

Figure 4 Repair Module

After completing the first sealing operation, the robot continues along the main, locating the next joint and repeats the joint sealing operation. Using the robotic platform and launch tube described in element 1, multiple joints could be inspected and repaired from a single insertion point, eliminating the need for costly and disruptive excavations at each joint.

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Element 3

3.1 Sensor Module

Figure 5 is a conceptual drawing of the modular robot developed for elements 1 & 2 with the sensor module developed for element 3. This module shown in the middle could be installed on the same robot and deployed for different applications.

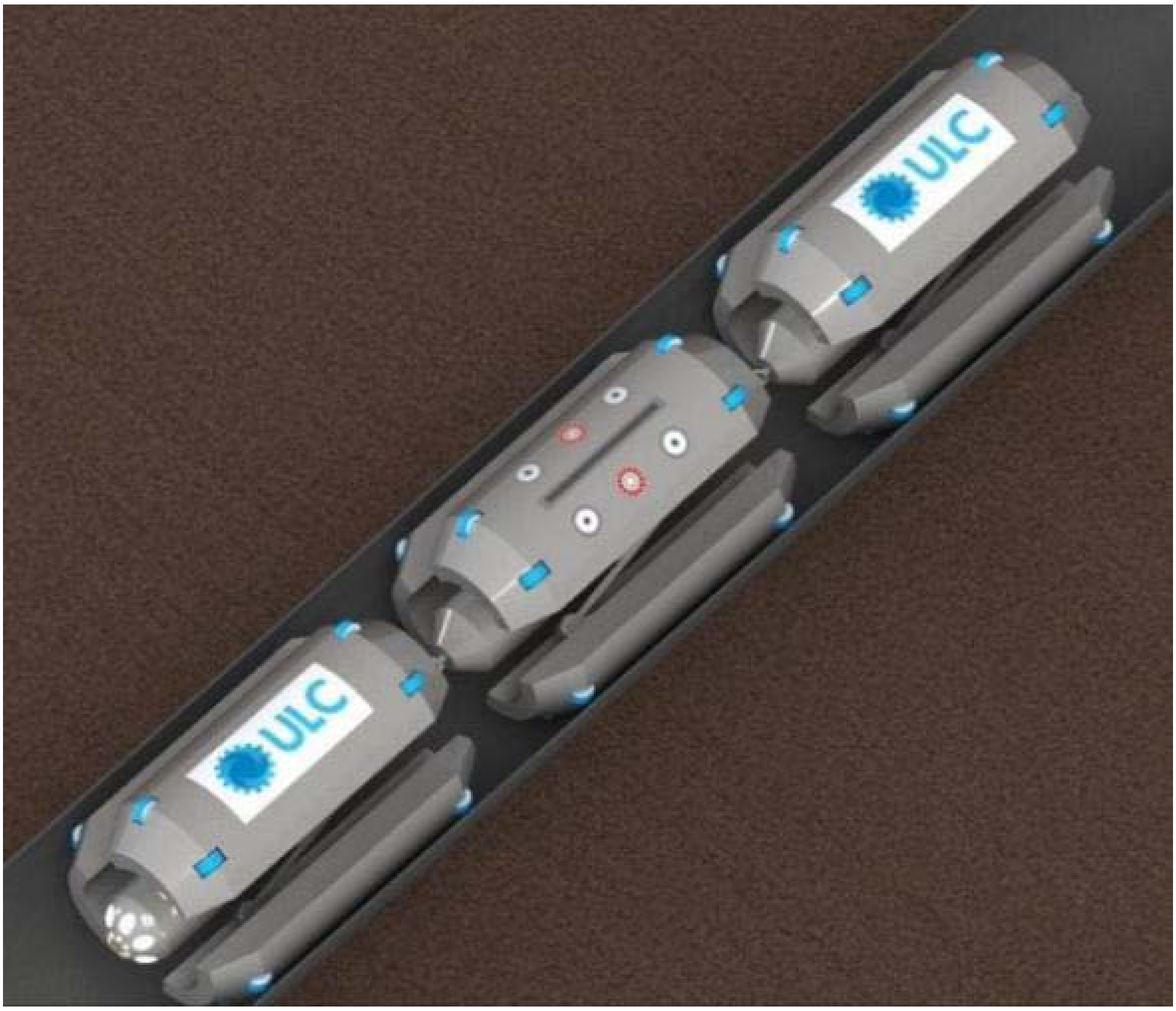

Figure 5 Sensor Module

The sensor module added on to the robot would carry instruments capable of measuring wall thickness, detecting corrosion, cracks, pipe stress data and potentially other types of data. The robot is designed to travel along the inside of the pipe to assess its structural integrity from a single insertion point, again minimising the disruption from excavations.

4.1 Service Excavations

Figure 6 below is a plan view of a traditional 'insertion' replacement operation. Each home is connected to the gas main via a small diameter service pipe leading from the main to the customers Emergency Control Valve. To insert a replacement PE pipe inside the existing gas main, large excavations are created along the main, as shown below.

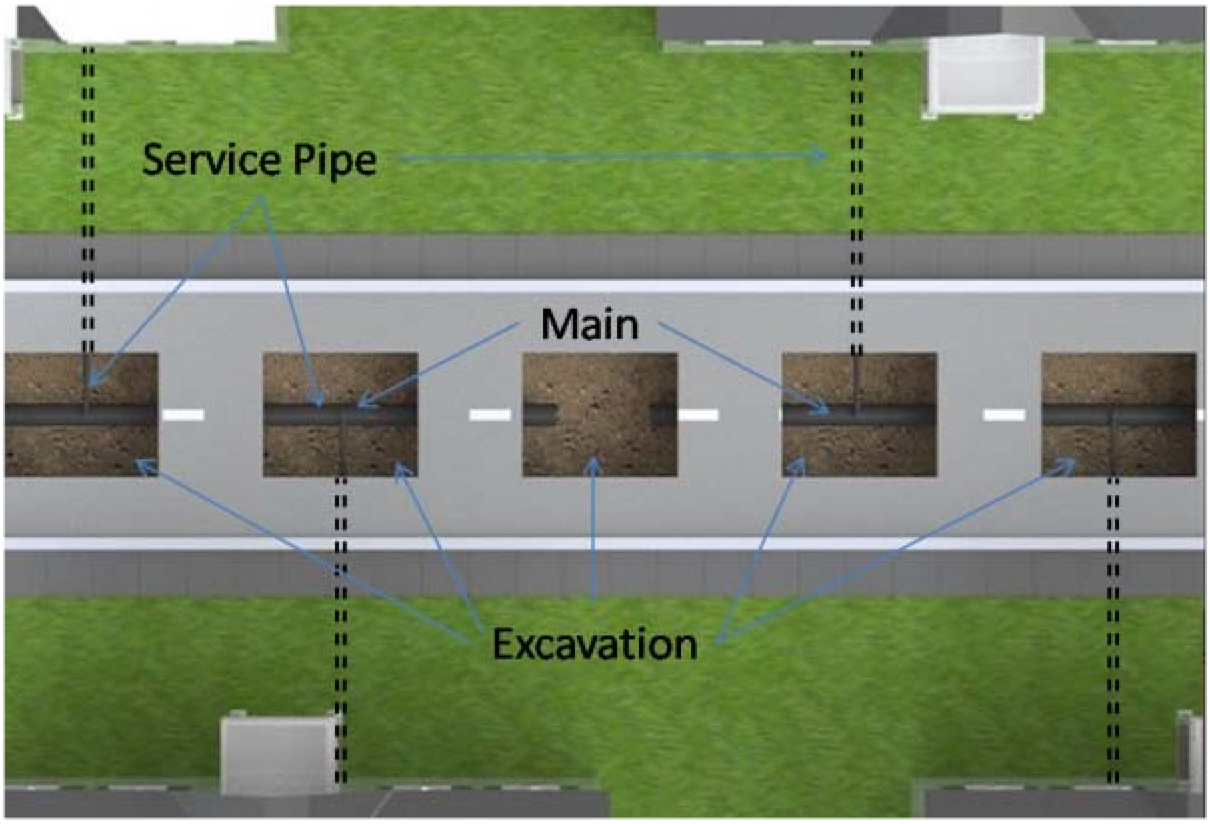

Figure 6 Service Excavations Plan View

The replacement PE main is inserted in the carrier main from one of these excavations. To connect new PE service pipe using traditional methods, additional excavations have to be created at each service connection point.

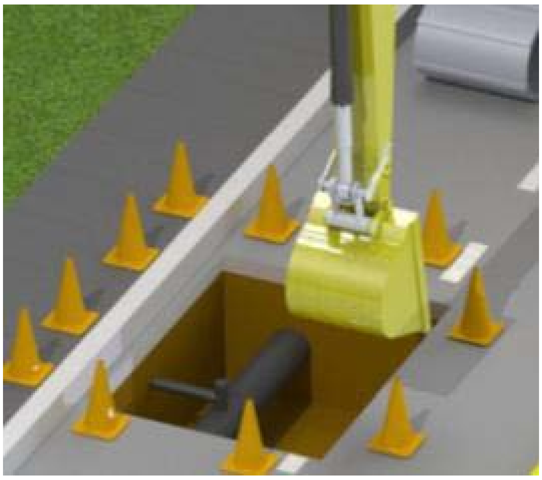

Figure 7 shows a 'street-level' view of a traditional service replacement operation. An excavation is required at each of the services connection point to the main to insert a new PE service into the existing service carrier pipe. This method is highly disruptive to the public and requires extensive street works.

Figure 7 Service Connection Excavation

4.2 Service Replacement

Figure 8 shows a cross-section of PE service replacement. The new PE main is inserted into the existing gas main and a new flexible PE service pipe is inserted into the existing service pipe.

Figure 8 Service Replacement

Both of the new PE pipes are joined at the service connection with a PE fitting. The robotic system developed for element 4 will be capable of making connections at multiple service lines from a single point of entry, (as described in section 4.1) minimizing the excavations required.

4.3 Robot Operation

Figure 9 is a conceptual drawing of the proposed robotic service replacement system developed under scope of element 4.

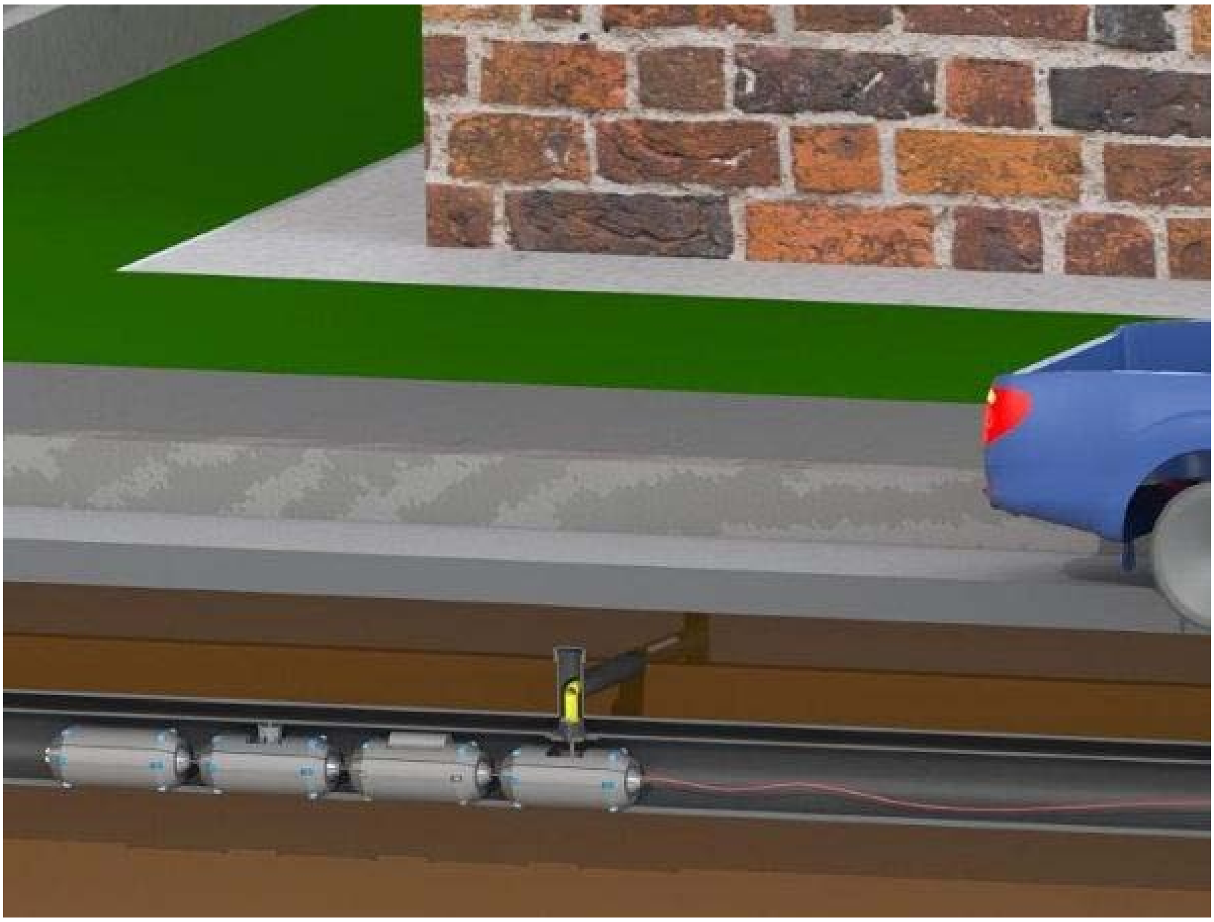

Figure 9 Robot Operation

Figure 9 shows a robot which is inserted into the replacement PE main. The robot travels along the main to each service connection. Tools carried by the robot drill a hole in the PE main, install a PE fitting, and connect the new PE service line to the main. Multiple services can be reconnected from a single insertion point using this method, eliminating the need for an excavation at each connection. As shown in the figure, this method greatly reduces the disruption to the public caused by service replacement.

4.4 Drilling, Fitting & Reconnecting

Figure 10 shows a conceptual cross-section of the robotic system developed for element 4 coving the three main steps in the operation of:

- **Internally drilling the PE main,**
- **Inserting a PE fitting for the service reconnection,**
- **Reconnecting the service.**

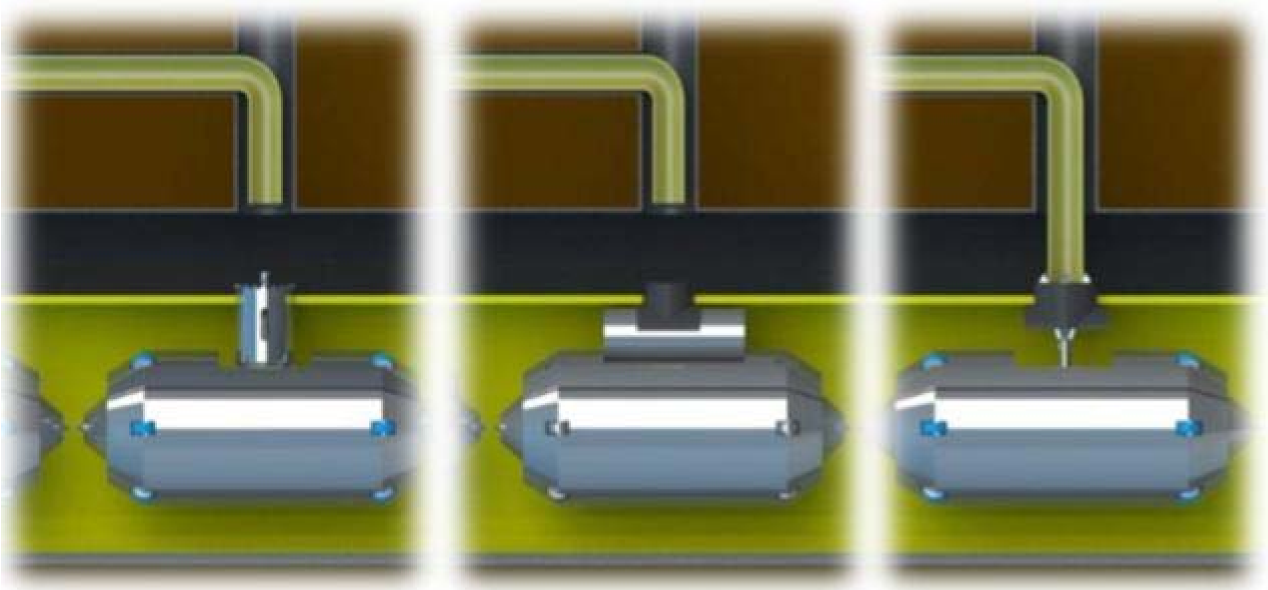

Figure 10 Drilling, Fitting & Reconnecting

The Drilling Process involves the robot travelling along the newly inserted PE main to the service connection point location. The drilling or cutting tool is then deployed to make a small hole in to the new PE main in preparation for service reconnection.

A new PE fitting is installed by the robot in the new hole that was cut in the main. The PE fitting can be electrically welded to the main from the inside.

The new PE service is inserted from the customer side and connected to the newly installed PE fitting. A tool on the robot could be used to position the new service line and insert it securely to the PE fitting. The new PE service connection would then be pressure tested to ensure its integrity before the gas supply is restored.

Following off site testing, minor modifications will be performed to prepare the system for field testing.

Once off site testing has been performed, the system will be packed and crated in preparation for shipping to the UK.

Field testing will be performed at sites provided by SGN and will determine:

- Engineering and Planning steps necessary prior to deployment
- Maximum Travel Distance and Ability to Remotely Reconnect Service Lines
- Impact On Customers
- Ability for system to operate and remotely install service connection on newly inserted PE pipelines
- Deployment Methodology
- Modifications prior to system commercialization
- Estimated Unit Pricing for Commercial Work Performed

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Appendix E – MRPS Risk Model

Advantica (now GL Noble Denton) developed a risk assessment model between 1997 and 1999, in order to assist in prioritising gas mains for replacement and optimising risk replacement in the gas distribution system. The Mains Risk Prioritisation Scheme (MRPS) is dependant on the material of the gas mains. Three models have been created taking into account the material of the mains, the Cast Iron Risk Model, the Ductile Iron Risk Model and the Steel Risk Model. These models have been developed using data from the entire UK network.

The models were originally implemented by Transco in 2000 and have undergone several updates since then.

The MRPS enables distribution mains to be ranked in order of decreasing risk, thus the risk on each mains unit can be quantified and an optimal replacement strategy implemented.

Management of mains replacement prioritisation is based on incident rate (explosion incidents/km/year). Three events must occur in order to cause an explosion incident; gas escape, gas entering a property and a source of ignition causing an explosion incident. Thus the constituent parts of the risk models (cast, ductile and steel) are based on three main factors, mains fracture/corrosion, gas ingress and incident consequence.

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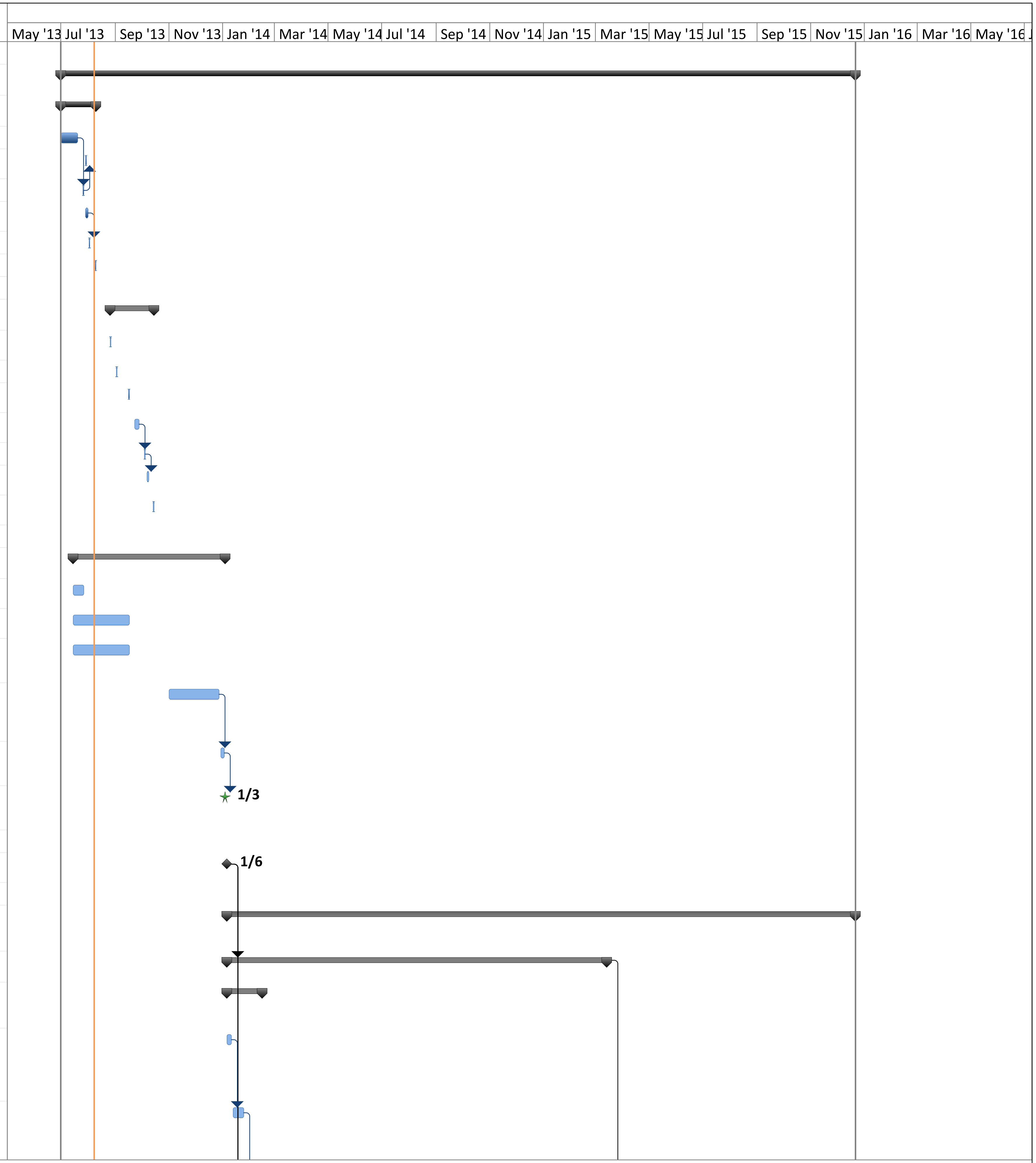
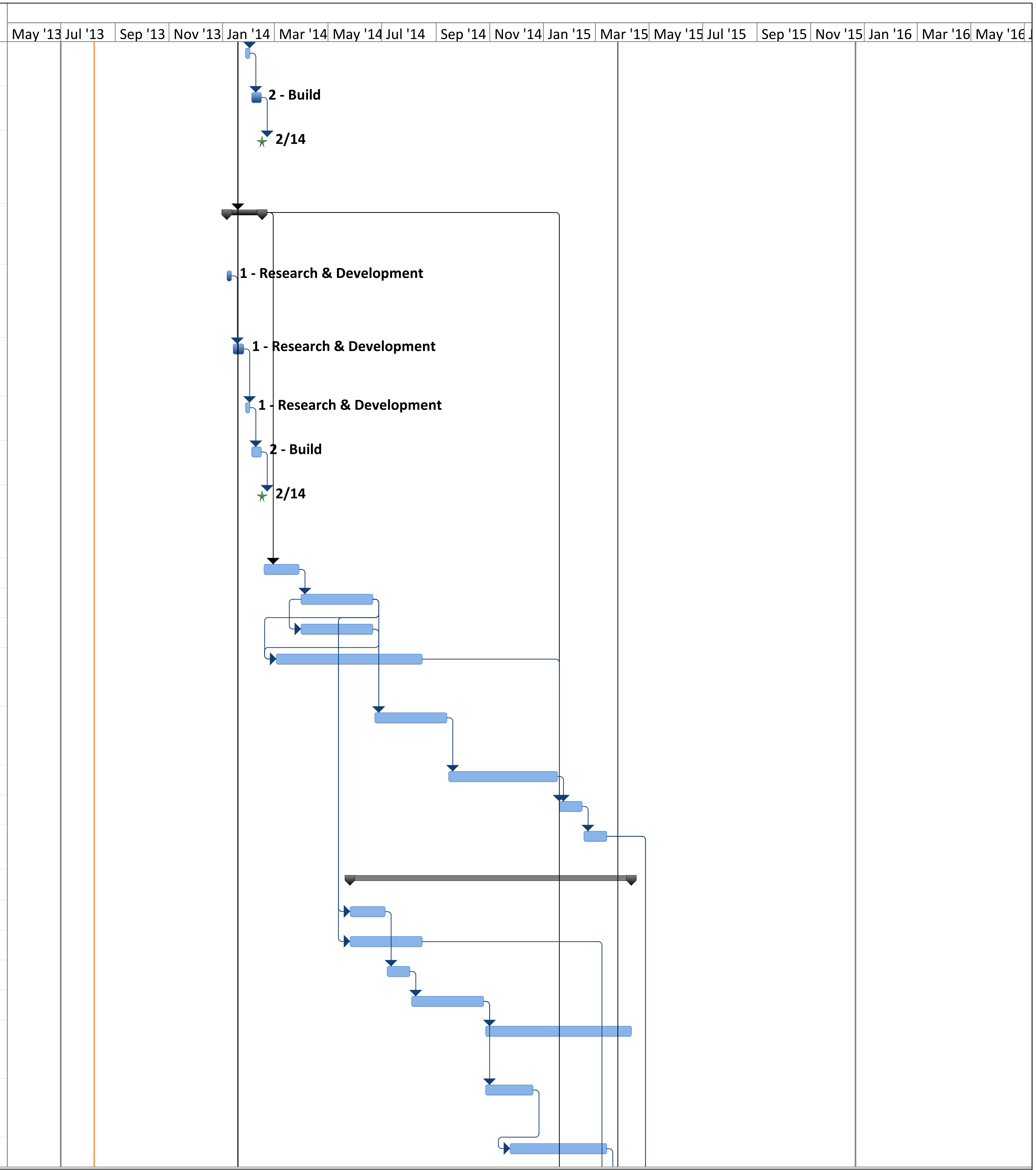
Appendix F – Project Plan

See next page.

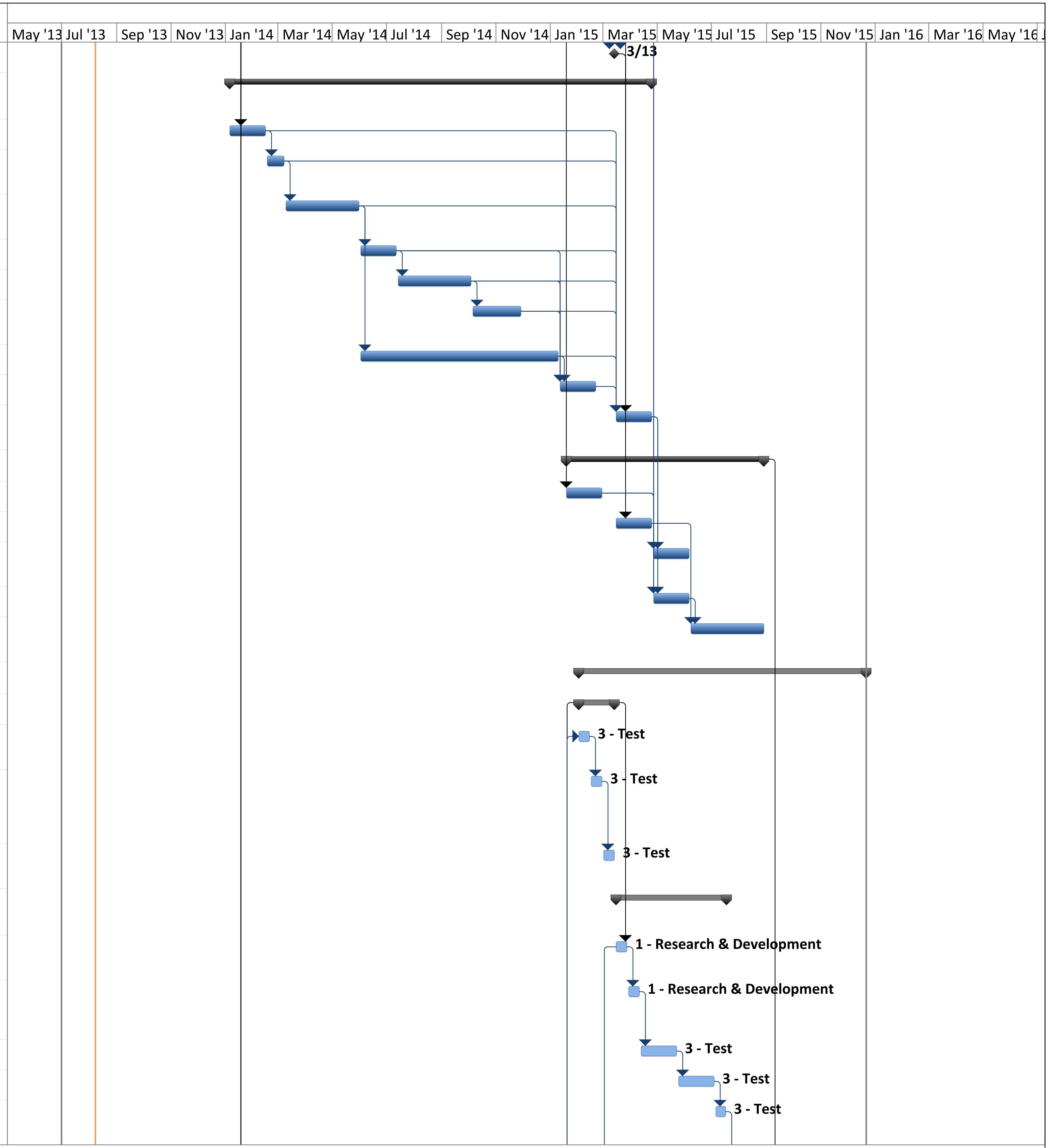
ID		Task Name	Duration	Start	Finish	Predecessors	Workstream	Owner
1								
2		**NIC SGN_GN_01 Proposal - SGN**	**646 days?**	**Mon 7/1/13**	**Mon 12/21/15**			
3		**Initial Bid Submission**	**30 days?**	**Mon 7/1/13**	**Fri 8/9/13**			**SGN**
4		Complete 1st Draft	15 days?	Mon 7/1/13	Fri 7/19/13			**SGN**
5		Executive Sign Off	1 day?	Mon 7/29/13	Mon 7/29/13	6		**SGN**
6		Review 1st Draft	1 day?	Fri 7/26/13	Fri 7/26/13	4		**SGN**
7		Revise 1st Draft	3 days?	Mon 7/29/13	Wed 7/31/13			SGN
8		Prepare Bid Folders	1 day?	Fri 8/2/13	Fri 8/2/13	7		SGN
9		Submit bid to OFGEM	1 day?	Fri 8/9/13	Fri 8/9/13			SGN
10								
11		**Bid Resubmission**	**36 days**	**Mon 8/26/13**	**Mon 10/14/13**			
12		Bilateral Meetings	1 day?	Mon 8/26/13	Mon 8/26/13			SGN
13		Consultants Meetings	1 day?	Mon 9/2/13	Mon 9/2/13			SGN
14		Further Billaterals	1 day?	Mon 9/16/13	Mon 9/16/13			SGN
15		Revise Bids	5 days?	Mon 9/23/13	Fri 9/27/13			SGN
16		Review Bid	1 day?	Fri 10/4/13	Fri 10/4/13	15		SGN
17		Prepare Bid Folders	2 days?	Mon 10/7/13	Tue 10/8/13	16		SGN
18		Resubmit to OFGEM	1 day?	Mon 10/14/13	Mon 10/14/13			SGN
19								
20		**Project Preparation**	**125 days**	**Mon 7/15/13**	**Fri 1/3/14**			
21		Generate Detailed Project Plan	10 days	Mon 7/15/13	Fri 7/26/13			ULC
22		Assess Staffing Needs and Hire Dedicated Project Staff	46 days	Mon 7/15/13	Mon 9/16/13			ULC
23		Procure Project Specific Equipment - Computers, Office Equipment	46 days	Mon 7/15/13	Mon 9/16/13			ULC
24		Establish Project Reporting Structure and Timetable between Project Team Partners	41 days	Fri 11/1/13	Fri 12/27/13			ULC
25		Create Project Reporting Structure & Timetable Documents	4 days	Mon 12/30/13	Thu 1/2/14	24		SGN & ULC
26		SDRC 9.1.a - Publish Project Reporting Structure Document	1 day	Fri 1/3/14	Fri 1/3/14	25		SGN
27								
28		**Project Start Date**	**0 days**	**Mon 1/6/14**	**Mon 1/6/14**			
29								
30		**Project Element 1 & 2 - Develop Modular Robotic Inspection & Repair Platform**	**511 days**	**Mon 1/6/14**	**Mon 12/21/15**			
31		**Task 1 - Develop Robotic Platform**	**310 days**	**Mon 1/6/14**	**Fri 3/13/15**	**28**		
32		**Electrical Specification Document Development**	**30 days**	**Mon 1/6/14**	**Fri 2/14/14**			
33		Establish detailed specifications of scenarios for use of systems on Gas Network	5 days	Mon 1/6/14	Fri 1/10/14			SGN
34		Match Network Specifications to Robotic high Level design requirements	10 days	Mon 1/13/14	Fri 1/24/14	33		SGN & ULC



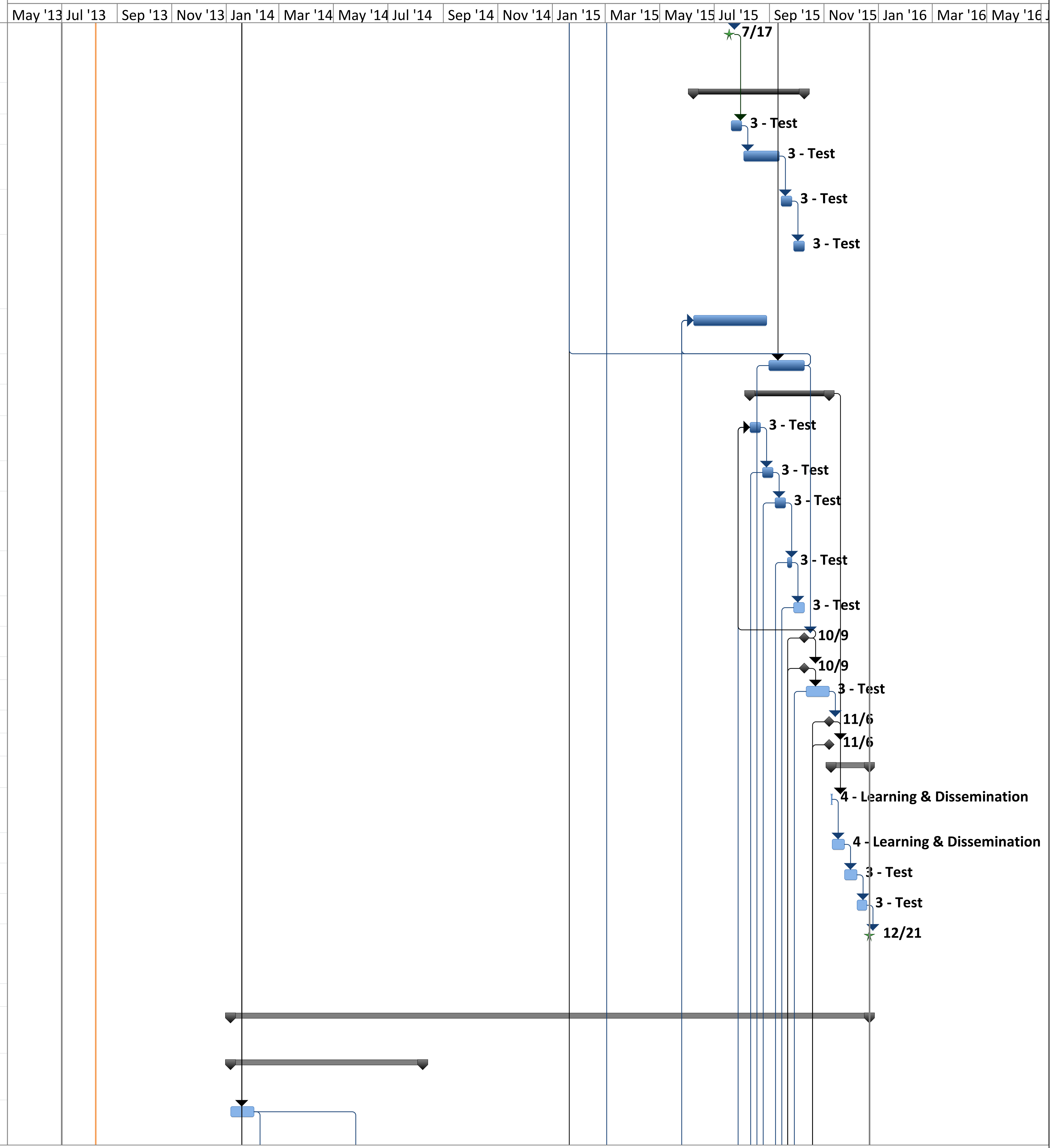
ID		Task Name	Duration	Start	Finish	Predecess	Workstream	Owner
35		SGN confirm with ULCR specification match	5 days	Mon 1/27/14	Fri 1/31/14	34		SGN
36		Obtain Stage 1 approval for scenario specifications	9 days	Mon 2/3/14	Thu 2/13/14	35	2 - Build	SGN & ULC
37		SDRC 9.2.a - Publish Element 1 & 2 Electrical Stage 1 Scenario Specification Approval Certificate	1 day	Fri 2/14/14	Fri 2/14/14	36		SGN
38		**Mechanical Specification Document Development**	**30 days**	**Mon 1/6/14**	**Fri 2/14/14**	**28**		
39		Establish detailed specifications of scenarios for use of systems on Gas Network	5 days	Mon 1/6/14	Fri 1/10/14		1 - Research & Development	SGN
40		Match Network Specifications to Robotic high Level design requirements	10 days	Mon 1/13/14	Fri 1/24/14	39	1 - Research & Development	SGN & ULC
41		SGN confirm with ULCR specification match	5 days	Mon 1/27/14	Fri 1/31/14	40	1 - Research & Development	SGN
42		Obtain Stage 1 approval for scenario specifications	9 days	Mon 2/3/14	Thu 2/13/14	41	2 - Build	SGN & ULC
43		SDRC 9.2.b - Publish Element 1 & 2 Mechanical Stage 1 Scenario Specification Approval Certificate	1 day	Fri 2/14/14	Fri 2/14/14	42		SGN
44		Development of Conceptual Designs	30 days	Mon 2/17/14	Fri 3/28/14	38		ULC
45		3D Design of Transport Platform	60 days	Mon 3/31/14	Fri 6/20/14	44		ULC
46		3D Design of Repair Module	60 days	Mon 3/31/14	Fri 6/20/14	45SS		ULC
47		Selection and Procurement of Motors, Gears, & Bearings for Propulsion System	120 days	Mon 3/3/14	Fri 8/15/14	45FS-80 days,46FS- days		ULC
48		Creation of Detailed Fabrication and Manufacturing Documentation	60 days	Mon 6/23/14	Fri 9/12/14	45,46		ULC
49		Parts Fabrication	90 days	Mon 9/15/14	Fri 1/16/15	48		ULC
50		Robotic Platform and Joint Repair Module Assembly	20 days	Mon 1/19/15	Fri 2/13/15	49,47		ULC
51		Robotic Platform and Joint Repair Module Preliminary Functional Test	20 days	Mon 2/16/15	Fri 3/13/15	50		ULC
52		**Task 2 - Launch System Development**	**230 days**	**Mon 5/26/14**	**Fri 4/10/15**			
53		Mechanical Specification Document Development	30 days	Mon 5/26/14	Fri 7/4/14	45FS-20 days		ULC
54		Electrical Design, Fabrication and Assembly	60 days	Mon 5/26/14	Fri 8/15/14	45FS-20 days		ULC
55		Development of Conceptual Designs	20 days	Mon 7/7/14	Fri 8/1/14	53		ULC
56		3D Design of Mechanical Components	60 days	Mon 8/4/14	Fri 10/24/14	55		ULC
57		Selection and Procurement of Motors, Gears, & Bearings for Launch System	120 days	Mon 10/27/14	Fri 4/10/15	56		ULC
58		Creation of Detailed Fabrication and Manufacturing Documentation	40 days	Mon 10/27/14	Fri 12/19/14	56		ULC
59		Parts Fabrication and Assembly	80 days	Mon 11/24/14	Fri 3/13/15	58FS-20 days		ULC



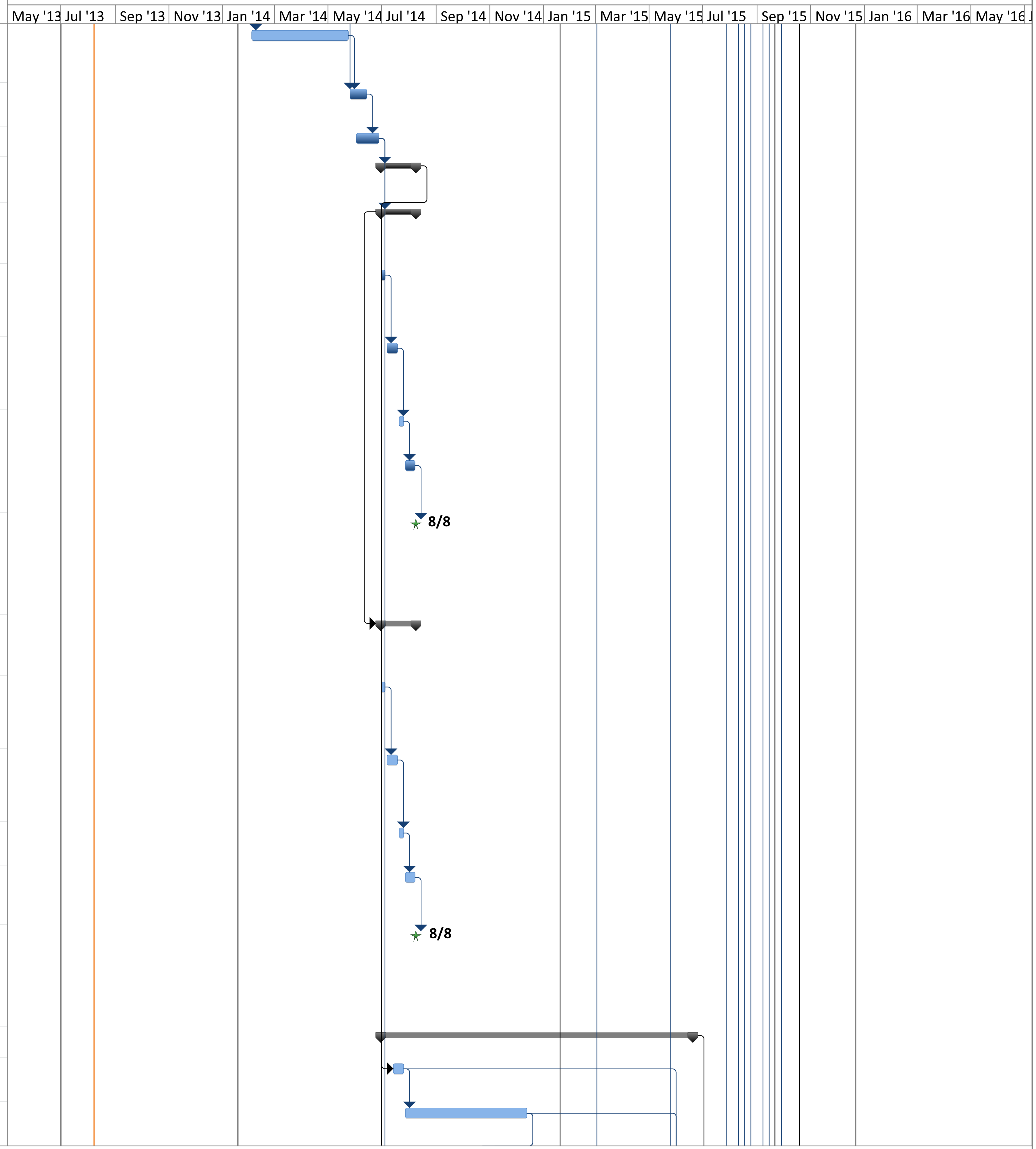
ID		Task Name	Duration	Start	Finish	Predecess	Workstream	Owner
60		Launch System Prototype Complete	0 days	Fri 3/13/15	Fri 3/13/15	59,54		ULC
61		**Task 3 - Support & Control System Development**	**340 days**	**Mon 1/6/14**	**Fri 4/24/15**			
62		Electrical Specification Document Development	30 days	Mon 1/6/14	Fri 2/14/14	28		ULC
63		Electrical and Software System Block Diagram Development	15 days	Mon 2/17/14	Fri 3/7/14	62		ULC
64		Electrical Schematic Design and Parts Selection	60 days	Mon 3/10/14	Fri 5/30/14	63		ULC
65		Circuit Card Layout and Fabrication	30 days	Mon 6/2/14	Fri 7/11/14	64		ULC
66		Microprocessor Firmware Programming	60 days	Mon 7/14/14	Fri 10/3/14	65		ULC
67		User Interface and Control System Design and Programming	40 days	Mon 10/6/14	Fri 11/28/14	66		ULC
68		Tether Design and Procurement	160 days	Mon 6/2/14	Fri 1/9/15	64		ULC
69		Bench Testing of Electrical System	30 days	Mon 1/12/15	Fri 2/20/15	65,66,67,6		ULC
70		Integration Of Electrical System into Mechanical Prototype	30 days	Mon 3/16/15	Fri 4/24/15	62,63,64,6		ULC
71		**Task 4 - Off Site Testing and Modifications**	**160 days**	**Mon 1/19/15**	**Fri 8/28/15**			
72		Fabricate Mock Test Environment at ULC Shop	30 days	Mon 1/19/15	Fri 2/27/15	38FS+240 days		ULC
73		Launch System Testing	30 days	Mon 3/16/15	Fri 4/24/15	60		ULC
74		Robotic Platform Launch, Retrieval and Travel Testing	30 days	Mon 4/27/15	Fri 6/5/15	51,70,72		ULC
75		Seal Repair Tool Testing	30 days	Mon 4/27/15	Fri 6/5/15	51,70,72		ULC
76		Incorporate Improvements Discovered During Testing	60 days	Mon 6/8/15	Fri 8/28/15	73,75		ULC
77		**Task 5 - Field Testing**	**231 days?**	**Mon 2/2/15**	**Mon 12/21/15**			
78		**Site Selection and Planning**	**30 days**	**Mon 2/2/15**	**Fri 3/13/15**		**3 - Test**	**SGN**
79		Identify Potential live mains suitable for trial on SGN network	10 days	Mon 2/2/15	Fri 2/13/15	95FS-180 days	3 - Test	SGN
80		Network Analysis/Mains Replacement Design/Contingency Planning	10 days	Mon 2/16/15	Fri 2/27/15	79	3 - Test	SGN
81		Highways Authority liaison and road opening notices	10 days	Mon 3/2/15	Fri 3/13/15	80	3 - Test	SGN
82		**Complete Technical Assurance Statement and Risk Assessment**	**90 days**	**Mon 3/16/15**	**Fri 7/17/15**			
83		Establish and approve G/23 Field Trial requirements	10 days	Mon 3/16/15	Fri 3/27/15	78	1 - Research & Development	SGN
84		Hazard and Risk Analysis of Network mains by Asset Management	10 days	Mon 3/30/15	Fri 4/10/15	83	1 - Research & Development	SGN
85		Electrical safety and Compliance	30 days	Mon 4/13/15	Fri 5/22/15	84	3 - Test	SGN
86		Site Management and CDM Requirements	30 days	Mon 5/25/15	Fri 7/3/15	85	3 - Test	SGN
87		Obtain Stage 2 approval for Technical Assurance	9 days	Mon 7/6/15	Thu 7/16/15	86	3 - Test	SGN



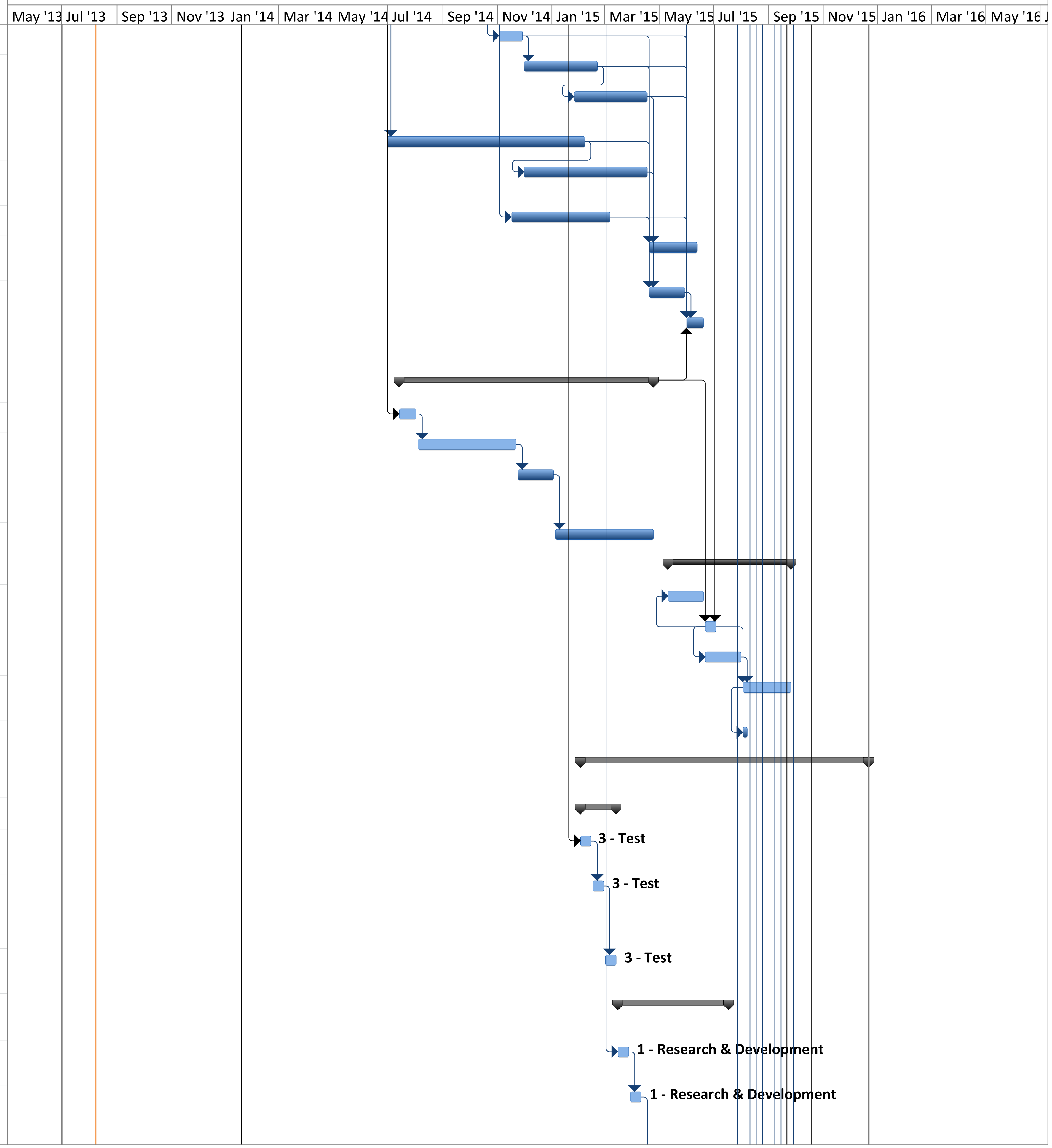
ID		Task Name	Duration	Start	Finish	Predecessors	Workstream	Owner
88		SDRC 9.3.a - Publish Element 1 & 2 Stage 2 Technical Assurance Approval Certificate	1 day	Fri 7/17/15	Fri 7/17/15	87		SGN
89		**Pre Site Preparation**	**90 days**	**Mon 6/8/15**	**Fri 10/9/15**			
90		Site specific risk assessment	10 days	Mon 7/20/15	Fri 7/31/15	88	3 - Test	SGN
91		Drilling and Assessment of Network Impact	30 days	Mon 8/3/15	Fri 9/11/15	90	3 - Test	SGN
92		Design Anchorage for launch tube / site specific civils	10 days	Mon 9/14/15	Fri 9/25/15	91	3 - Test	SGN
93		Prepare excavations in accordance with SGN's SMF/traffic management procedures	10 days	Mon 9/28/15	Fri 10/9/15	92	3 - Test	SGN
94		Procure Spares and Materials for Field Testing	60 days	Mon 6/8/15	Fri 8/28/15	95FS-90 days		ULC
95		Pack and Ship System to the UK	30 days	Mon 8/31/15	Fri 10/9/15	71		ULC
96		**Perform 20 days Field Testing**	**65 days**	**Mon 8/10/15**	**Fri 11/6/15**			
97		Prepare and authorise NRO's and PTW's under SCO	10 days	Mon 8/10/15	Fri 8/21/15	102FS-45 days	3 - Test	SGN
98		CDM Site Management	10 days	Mon 8/24/15	Fri 9/4/15	97	3 - Test	SGN
99		Prepare drillings for pre-deployment inspection / specialist contractor	10 days	Mon 9/7/15	Fri 9/18/15	98	3 - Test	SGN
100		Carry out pre-deployment inspection using CCTV	5 days	Mon 9/21/15	Fri 9/25/15	99	3 - Test	SGN
101		Prepare drillings / specialist contractors	10 days	Mon 9/28/15	Fri 10/9/15	100	3 - Test	SGN
102		Mount Launch Tube on Valve at Site	0 days	Fri 10/9/15	Fri 10/9/15	95	3 - Test	ULC
103		Launch Robot	0 days	Fri 10/9/15	Fri 10/9/15	102	3 - Test	ULC
104		Support deployment of robotic solution	20 days	Mon 10/12/15	Fri 11/6/15	103	3 - Test	ULC
105		Retrieve Robot	0 days	Fri 11/6/15	Fri 11/6/15	104	3 - Test	ULC
106		Reinstate	0 days	Fri 11/6/15	Fri 11/6/15	105	3 - Test	SGN
107		**Generate Final Report**	**31 days?**	**Mon 11/9/15**	**Mon 12/21/15**			
108		Report on Field Trial against Success Criteria	1 day?	Mon 11/9/15	Mon 11/9/15	96	4 - Learning & Dissemination	SGN
109		ULCR generate final report	10 days	Tue 11/10/15	Mon 11/23/15	108	4 - Learning & Dissemination	ULC
110		Update Technical Assurance Report	10 days	Tue 11/24/15	Mon 12/7/15	109	3 - Test	SGN
111		Obtain Stage 3 Internal Approval	9 days	Tue 12/8/15	Fri 12/18/15	110	3 - Test	SGN
112		SDRC 9.4.a - Publish Element 1 & 2 Stage 3 Committee Approval Document	1 day	Mon 12/21/15	Mon 12/21/15	111	4 - Learning & Dissemination	SGN
113								
114		**Project Element 3 - Robotic Visual & Non-Visual Inspection**	**511 days?**	**Mon 1/6/14**	**Mon 12/21/15**			
115		**Task 1 - Research Sensor Requirements & Capabilities**	**155 days**	**Mon 1/6/14**	**Fri 8/8/14**			
116		Develop Sensor Specifications and Data Requirements	20 days	Mon 1/6/14	Fri 1/31/14	28		ULC



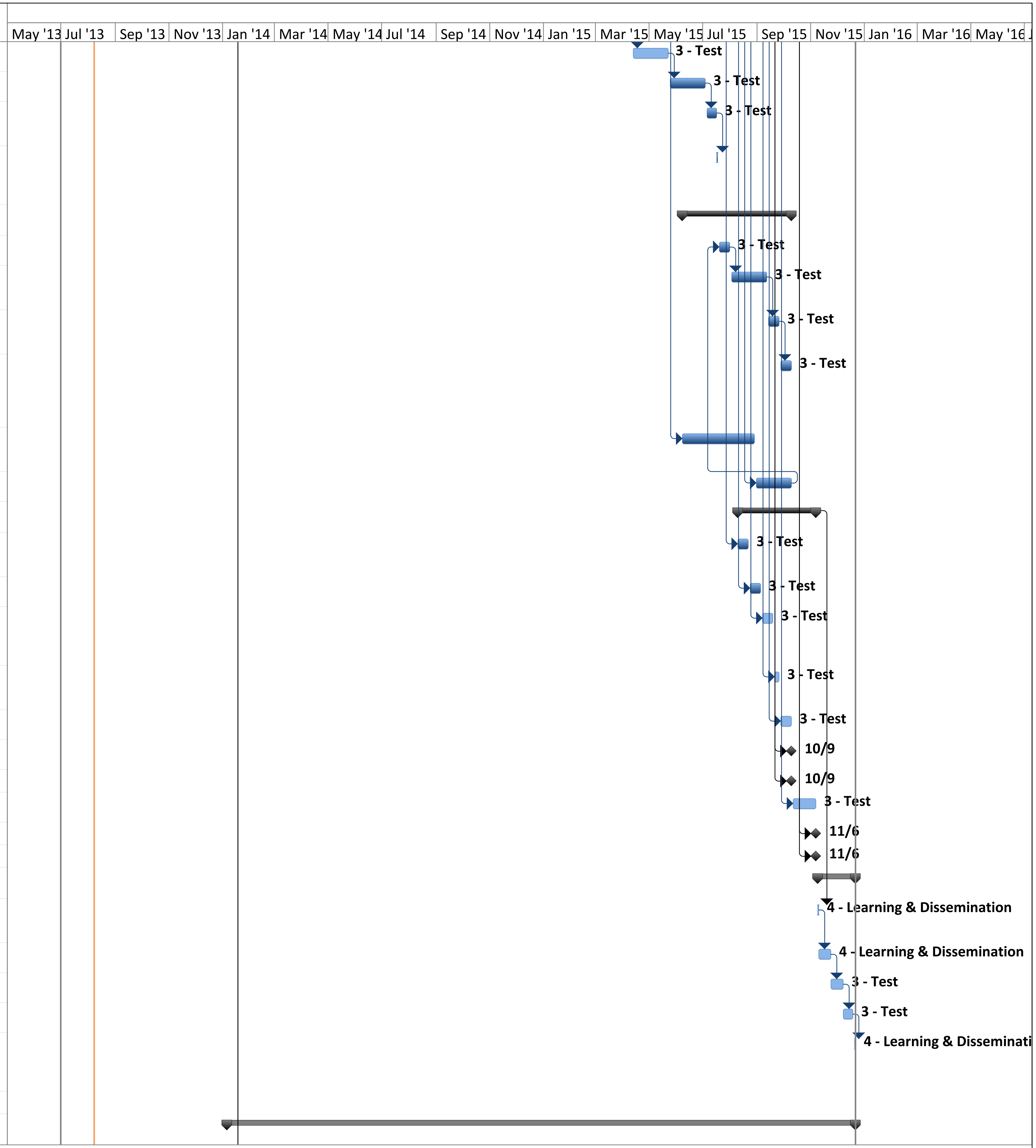
ID		Task Name	Duration	Start	Finish	Predecess	Workstream	Owner
117		Research Existing Technology and Generate Report (we/Sensor Recommendations)	80 days	Mon 2/3/14	Fri 5/23/14	116		ULC
118		Approval from SGN to Proceed With Sensor Selected	15 days	Mon 5/26/14	Fri 6/13/14	117,116		ULC
119		Source Vendor for Sensor	20 days	Mon 6/2/14	Fri 6/27/14	118FS-10 days		ULC
120		Sensor Module Specification Document Development	30 days	Mon 6/30/14	Fri 8/8/14	**119**		
121		**Electrical Specification Document Development**	**30 days**	**Mon 6/30/14**	**Fri 8/8/14**	**119**		
122		Establish detailed specifications of scenarios for use of systems on Gas Network	5 days	Mon 6/30/14	Fri 7/4/14			SGN
123		Match Network Specifications to Robotic high Level design requirements	10 days	Mon 7/7/14	Fri 7/18/14	122		SGN
124		SGN confirm with ULCR specification match	5 days	Mon 7/21/14	Fri 7/25/14	123		SGN
125		Obtain Stage 1 approval for scenario specifications	9 days	Mon 7/28/14	Thu 8/7/14	124		SGN
126		SDRC 9.2.c - Publish Element 3 Electrical Stage 1 Scenario Specification Approval Certificate	1 day	Fri 8/8/14	Fri 8/8/14	125		SGN
127		**Mechanical Specification Document Development**	**30 days**	**Mon 6/30/14**	**Fri 8/8/14**	**121SS**		
128		Establish detailed specifications of scenarios for use of systems on Gas Network	5 days	Mon 6/30/14	Fri 7/4/14			SGN
129		Match Network Specifications to Robotic high Level design requirements	10 days	Mon 7/7/14	Fri 7/18/14	128		SGN
130		SGN confirm with ULCR specification match	5 days	Mon 7/21/14	Fri 7/25/14	129		SGN
131		Obtain Stage 1 approval for scenario specifications	9 days	Mon 7/28/14	Thu 8/7/14	130		SGN
132		SDRC 9.2.d - Publish Element 3 Mechanical Stage 1 Scenario Specification Approval Certificate	1 day	Fri 8/8/14	Fri 8/8/14	131		SGN
133		**Task 2 - Design Sensor Module Electronics**	**255 days**	**Mon 6/30/14**	**Fri 6/19/15**			
134		Electrical and Software System Block Diagram Development	10 days	Mon 7/14/14	Fri 7/25/14	120FS-20 days		ULC
135		Electrical Schematic Design and Parts Selection	100 days	Mon 7/28/14	Fri 12/12/14	134		ULC



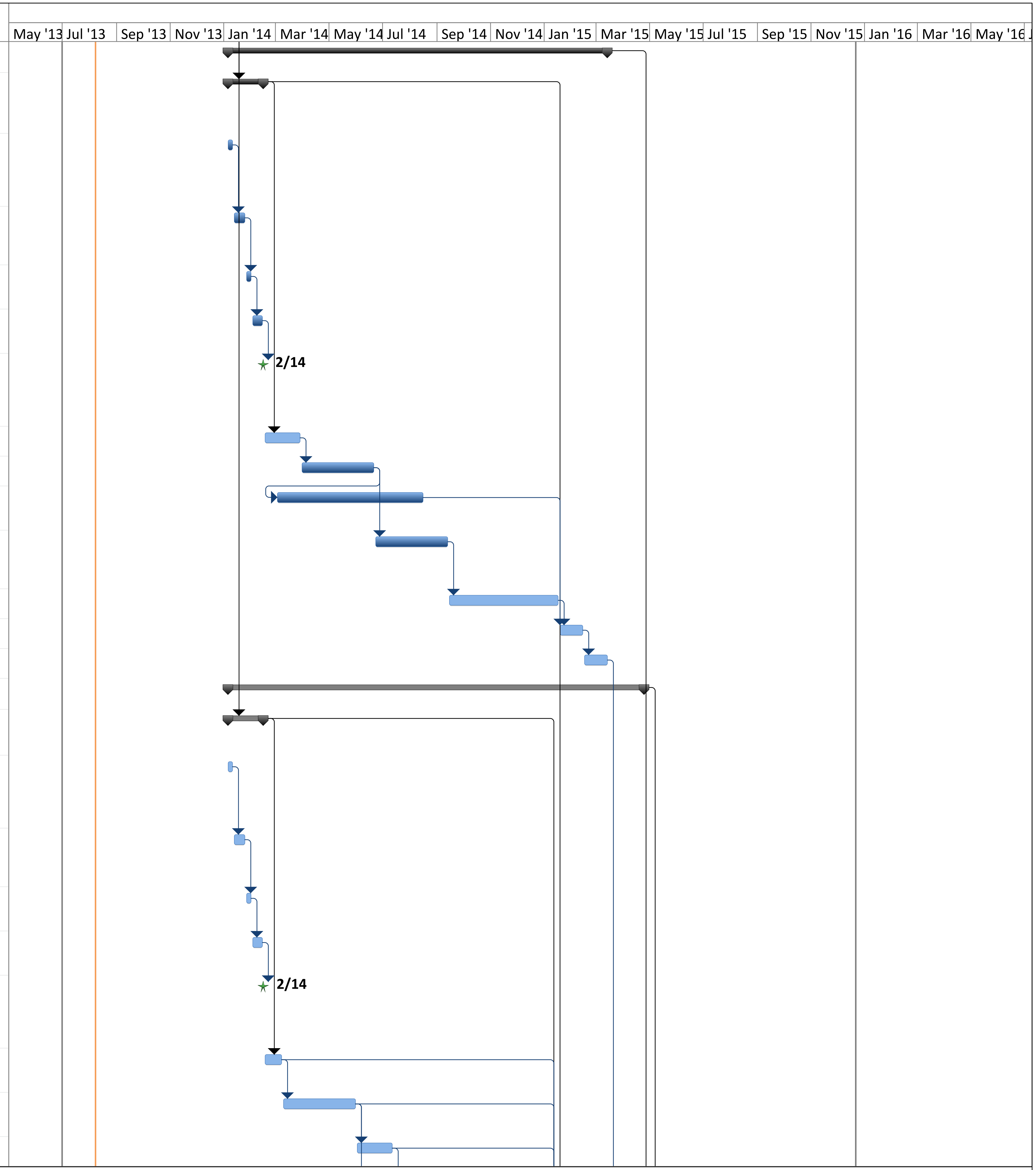
ID		Task Name	Duration	Start	Finish	Predecess	Workstream	Owner
136		Circuit Card Layout and Fabrication	20 days	Mon 11/3/14	Fri 11/28/14	135FS-30 days		ULC
137		Microprocessor Firmware Programming	60 days	Mon 12/1/14	Fri 2/20/15	136		ULC
138		User Interface and Control System Design and Programming	60 days	Mon 1/26/15	Fri 4/17/15	137FS-20 days		ULC
139		Procurement & Testing of Sensor Package	160 days	Mon 6/30/14	Fri 2/6/15	119		ULC
140		Develop, Procure, and Test Data Acquisition System	100 days	Mon 12/1/14	Fri 4/17/15	139FS-50 days		ULC
141		Design and Procure Tether	80 days	Mon 11/17/14	Fri 3/6/15	135FS-20 days		ULC
142		Integrate and Test Tether With Sensor/Data Acquisition System	40 days	Mon 4/20/15	Fri 6/12/15	140,141		ULC
143		Bench Testing of Electrical System	30 days	Mon 4/20/15	Fri 5/29/15	136,137,13		ULC
144		Integration Of Electrical System & Sensor into Modular Package for Deployment	15 days	Mon 6/1/15	Fri 6/19/15	143,141,13		ULC
145		**Task 3 - Design Sensor Module Hardware**	**205 days**	**Mon 7/14/14**	**Fri 4/24/15**			
146		Development of Conceptual Designs	15 days	Mon 7/14/14	Fri 8/1/14	120FS-20 days		ULC
147		3D Design of Mechanical Components	80 days	Mon 8/4/14	Fri 11/21/14	146		ULC
148		Creation of Detailed Fabrication and Manufacturing Documentation	30 days	Mon 11/24/14	Fri 1/2/15	147		ULC
149		Parts Fabrication and Assembly	80 days	Mon 1/5/15	Fri 4/24/15	148		ULC
150		**Task 4 - Off Site Testing & Modifications**	**100 days**	**Mon 5/11/15**	**Fri 9/25/15**			
151		Fabricate Mock Test Environment at ULC Shop	30 days	Mon 5/11/15	Fri 6/19/15	152SS-30 days		ULC
152		Configuration Testing with Robotic Platform	10 days	Mon 6/22/15	Fri 7/3/15	133,145		ULC
153		Sensor Data Validation	30 days	Mon 6/22/15	Fri 7/31/15	152SS		ULC
154		Incorporate Improvements Discovered During Testing	40 days	Mon 8/3/15	Fri 9/25/15	152,153		ULC
155		Develop Test Plan for the Field	5 days	Mon 8/3/15	Fri 8/7/15	154SS		ULC
156		**Task 5 - Field Testing - (Concurrent with Element 1&2 Field Test)**	**231 days?**	**Mon 2/2/15**	**Mon 12/21/15**			
157		**Site Selection and Planning**	**30 days**	**Mon 2/2/15**	**Fri 3/13/15**		**3 - Test**	**SGN**
158		Identify Potential live mains suitable for trial on SGN network	10 days	Mon 2/2/15	Fri 2/13/15	**78SS**	3 - Test	SGN
159		Network Analysis/Mains Replacement Design/Contingency Planning	10 days	Mon 2/16/15	Fri 2/27/15	158	3 - Test	SGN
160		Highways Authority liaison and road opening notices	10 days	Mon 3/2/15	Fri 3/13/15	159	3 - Test	SGN
161		**Complete Technical Assurance Statement and Risk Assessment**	**90 days**	**Mon 3/16/15**	**Fri 7/17/15**			
162		Establish and approve G/23 Field Trial requirements	10 days	Mon 3/16/15	Fri 3/27/15	83SS	1 - Research & Development	SGN
163		Hazard and Risk Analysis of Network mains by Asset Management	10 days	Mon 3/30/15	Fri 4/10/15	162	1 - Research & Development	SGN



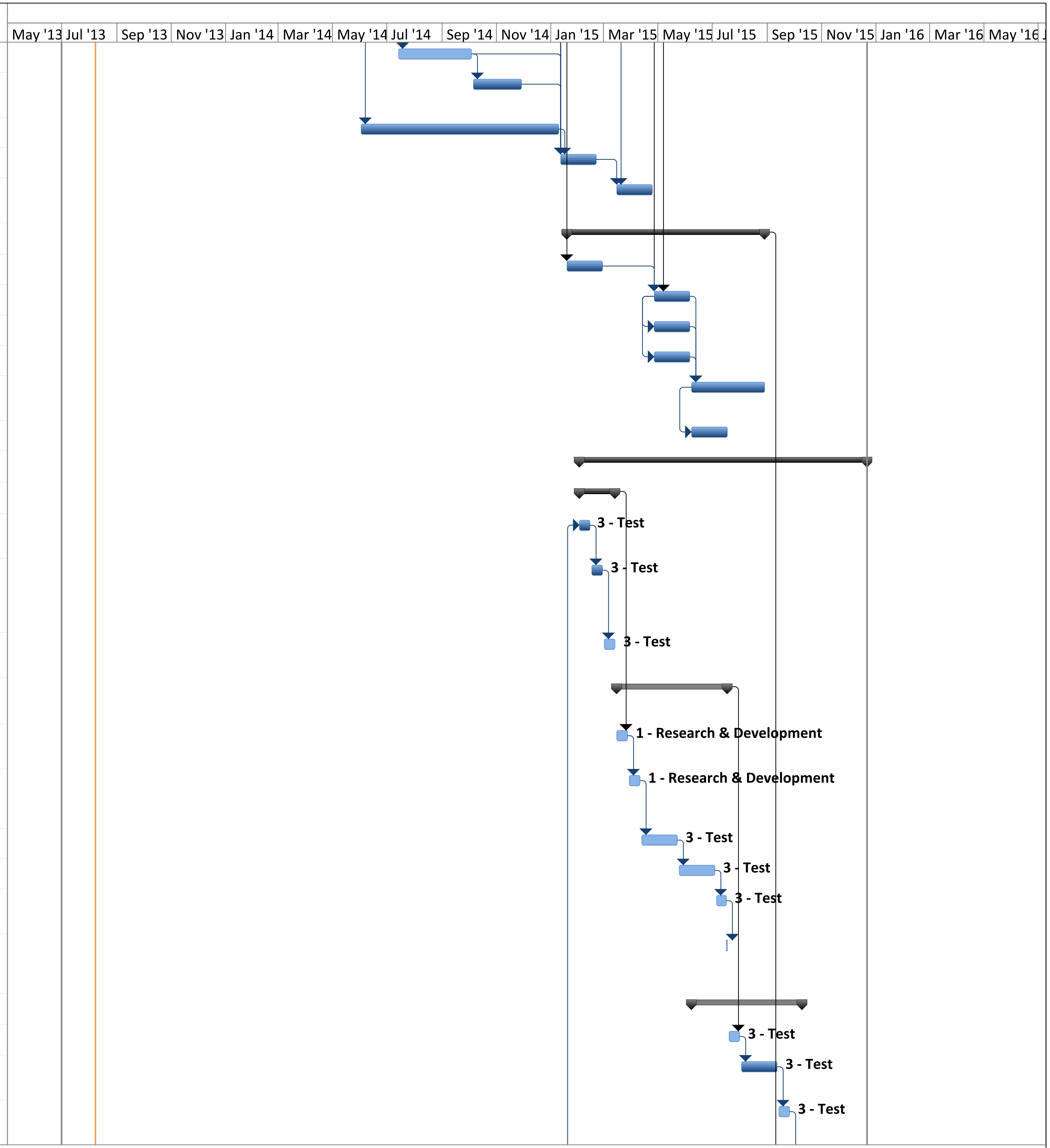
ID		Task Name	Duration	Start	Finish	Predecess	Workstream	Owner
164		Electrical safety and Compliance	30 days	Mon 4/13/15	Fri 5/22/15	163	3 - Test	SGN
165		Site Management and CDM Requirements	30 days	Mon 5/25/15	Fri 7/3/15	164	3 - Test	SGN
166		Obtain Stage 2 approval for Technical Assurance	9 days	Mon 7/6/15	Thu 7/16/15	165	3 - Test	SGN
167		SDRC 9.3.b - Publish Element 3 Stage 2 Technical Assurance Approval Certificate	1 day	Fri 7/17/15	Fri 7/17/15	166		SGN
168		**Pre Site Preparation**	**90 days**	**Mon 6/8/15**	**Fri 10/9/15**			
169		Site specific risk assessment	10 days	Mon 7/20/15	Fri 7/31/15	174FS-60 days	3 - Test	SGN
170		Drilling and Assessment of Network Impact	30 days	Mon 8/3/15	Fri 9/11/15	169	3 - Test	SGN
171		Design Anchorage for launch tube / site specific civils	10 days	Mon 9/14/15	Fri 9/25/15	170	3 - Test	SGN
172		Prepare excavations in accordance with SGN's SMF/traffic management procedures	10 days	Mon 9/28/15	Fri 10/9/15	171	3 - Test	SGN
173		Procure Spares and Materials for Field Testing	60 days	Mon 6/8/15	Fri 8/28/15	94SS		ULC
174		Pack and Ship System to the UK	30 days	Mon 8/31/15	Fri 10/9/15	95SS		ULC
175		**Perform 20 days Field Testing**	**65 days**	**Mon 8/10/15**	**Fri 11/6/15**			
176		Prepare and authorise NRO's and PTW's under SCO	10 days	Mon 8/10/15	Fri 8/21/15	97SS	3 - Test	SGN
177		CDM Site Management	10 days	Mon 8/24/15	Fri 9/4/15	98SS	3 - Test	SGN
178		Prepare drillings for pre-deployment inspection / specialist contractor	10 days	Mon 9/7/15	Fri 9/18/15	99SS	3 - Test	SGN
179		Carry out pre-deployment inspection using CCTV	5 days	Mon 9/21/15	Fri 9/25/15	100SS	3 - Test	SGN
180		Prepare drillings / specialist contractors	10 days	Mon 9/28/15	Fri 10/9/15	101SS	3 - Test	SGN
181		Mount Launch Tube on Valve at Site	0 days	Fri 10/9/15	Fri 10/9/15	102SS	3 - Test	ULC
182		Launch Robot	0 days	Fri 10/9/15	Fri 10/9/15	103SS	3 - Test	ULC
183		Support deployment of robotic solution	20 days	Mon 10/12/15	Fri 11/6/15	104SS	3 - Test	ULC
184		Retrieve Robot	0 days	Fri 11/6/15	Fri 11/6/15	105SS	3 - Test	ULC
185		Reinstate	0 days	Fri 11/6/15	Fri 11/6/15	106SS	3 - Test	SGN
186		**Generate Final Report**	**31 days**	**Mon 11/9/15**	**Mon 12/21/15**			
187		Report on Field Trial against Success Criteria	1 day?	Mon 11/9/15	Mon 11/9/15	175	4 - Learning & Dissemination	SGN
188		ULCR generate final report	10 days	Tue 11/10/15	Mon 11/23/15	187	4 - Learning & Dissemination	ULC
189		Update Technical Assurance Report	10 days	Tue 11/24/15	Mon 12/7/15	188	3 - Test	SGN
190		Obtain Stage 3 Internal Approval	9 days	Tue 12/8/15	Fri 12/18/15	189	3 - Test	SGN
191		SDRC 9.4.b - Publish Element 3 Stage 3 Committee Approval Document	1 day	Mon 12/21/15	Mon 12/21/15	190	4 - Learning & Dissemination	SGN
192								
193		**Project Element 4 - Live Asset Replacement**	**511 days?**	**Mon 1/6/14**	**Mon 12/21/15**			



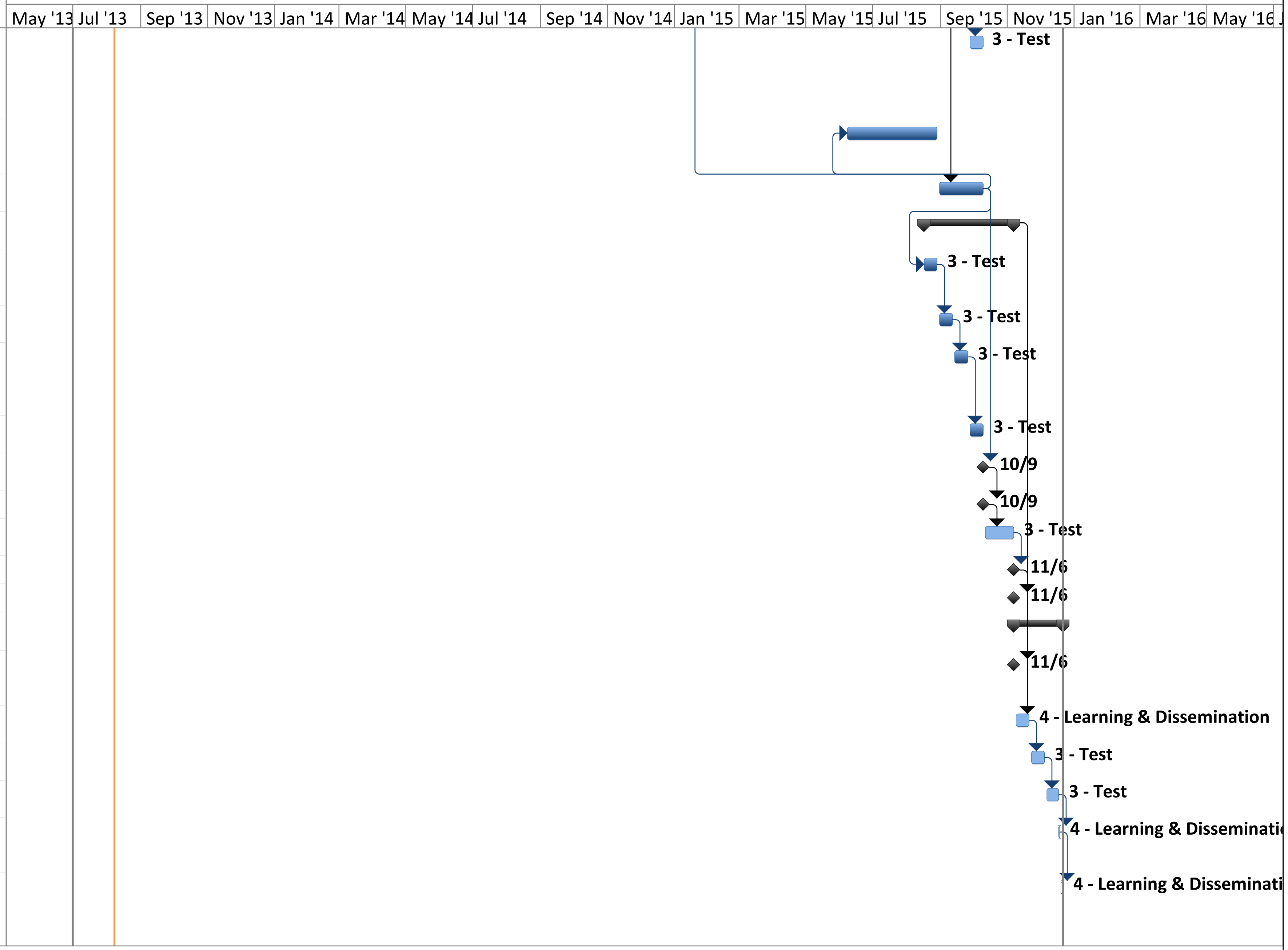
ID		Task Name	Duration	Start	Finish	Predecess	Workstream	Owner
194		**Task 1 - Robot Body Development**	**310 days**	**Mon 1/6/14**	**Fri 3/13/15**			
195		**Mechanical Specification Document Development**	**30 days**	**Mon 1/6/14**	**Fri 2/14/14**	**28**		
196		Establish detailed specifications of scenarios for use of systems on Gas Network	5 days	Mon 1/6/14	Fri 1/10/14			SGN
197		Match Network Specifications to Robotic high Level design requirements	10 days	Mon 1/13/14	Fri 1/24/14	196		SGN
198		SGN confirm with ULCR specification match	5 days	Mon 1/27/14	Fri 1/31/14	197		SGN
199		Obtain Stage 1 approval for scenario specifications	9 days	Mon 2/3/14	Thu 2/13/14	198		SGN
200		SDRC 9.2.e - Publish Element 4 Mechanical Stage 1 Scenario Specification Approval Certificate	1 day	Fri 2/14/14	Fri 2/14/14	199		SGN
201		Development of Conceptual Designs	30 days	Mon 2/17/14	Fri 3/28/14	195		ULC
202		3D Design of Mechanical Components	60 days	Mon 3/31/14	Fri 6/20/14	201		ULC
203		Selection and Procurement of Motors, Gears and Bearings	120 days	Mon 3/3/14	Fri 8/15/14	202FS-80 days		ULC
204		Creation of Detailed Fabrication and Manufacturing Documentation	60 days	Mon 6/23/14	Fri 9/12/14	202		ULC
205		Parts Fabrication	90 days	Mon 9/15/14	Fri 1/16/15	204		ULC
206		Robot Assembly	20 days	Mon 1/19/15	Fri 2/13/15	203,205		ULC
207		Robot Preliminary Functional Test	20 days	Mon 2/16/15	Fri 3/13/15	206		ULC
208		**Task 2 - Develop Support & Control System**	**340 days**	**Mon 1/6/14**	**Fri 4/24/15**			
209		**Electrical Specification Document Development**	**30 days**	**Mon 1/6/14**	**Fri 2/14/14**	**28**		
210		Establish detailed specifications of scenarios for use of systems on Gas Network	5 days	Mon 1/6/14	Fri 1/10/14			SGN
211		Match Network Specifications to Robotic high Level design requirements	10 days	Mon 1/13/14	Fri 1/24/14	210		SGN
212		SGN confirm with ULCR specification match	5 days	Mon 1/27/14	Fri 1/31/14	211		SGN
213		Obtain Stage 1 approval for scenario specifications	9 days	Mon 2/3/14	Thu 2/13/14	212		SGN
214		SDRC 9.2.f - Publish Element 4 Mechanical Stage 1 Scenario Specification Approval Certificate	1 day	Fri 2/14/14	Fri 2/14/14	213		SGN
215		Electrical and Software System Block Diagram Development	15 days	Mon 2/17/14	Fri 3/7/14	209		ULC
216		Electrical Schematic Design and Parts Selection	60 days	Mon 3/10/14	Fri 5/30/14	215		ULC
217		Circuit Card Layout and Fabrication	30 days	Mon 6/2/14	Fri 7/11/14	216		ULC



ID		Task Name	Duration	Start	Finish	Predecess	Workstream	Owner
218		Microprocessor Firmware Programming	60 days	Mon 7/14/14	Fri 10/3/14	217		ULC
219		User Interface and Control System Design and Programming	40 days	Mon 10/6/14	Fri 11/28/14	218		ULC
220		Tether Design and Procurement	160 days	Mon 6/2/14	Fri 1/9/15	216		ULC
221		Bench Testing of Electrical System	30 days	Mon 1/12/15	Fri 2/20/15	220,219,21		ULC
222		Integration Of Electrical System into Mechanical Prototype	30 days	Mon 3/16/15	Fri 4/24/15	221,207		ULC
223		**Task 3 - Off Site Testing**	**160 days**	**Mon 1/19/15**	**Fri 8/28/15**			
224		Fabricate Mock Test Environment at ULC Shop	30 days	Mon 1/19/15	Fri 2/27/15	195FS+24(days		ULC
225		Pipeline Travel Testing	30 days	Mon 4/27/15	Fri 6/5/15	194,208,22		ULC
226		Tapping & Fitting Tool Validation	30 days	Mon 4/27/15	Fri 6/5/15	225SS		ULC
227		Service Installation Validation	30 days	Mon 4/27/15	Fri 6/5/15	225SS		ULC
228		Incorporate Improvements Discovered During Testing	60 days	Mon 6/8/15	Fri 8/28/15	227,226,22		ULC
229		Develop Test Plan for the Field	30 days	Mon 6/8/15	Fri 7/17/15	228SS		ULC
230		**Task 4 - Field Testing**	**231 days?**	**Mon 2/2/15**	**Mon 12/21/15**			
231		**Site Selection and Planning**	**30 days**	**Mon 2/2/15**	**Fri 3/13/15**		**3 - Test**	**SGN**
232		Identify Potential live mains suitable for trial on SGN network	10 days	Mon 2/2/15	Fri 2/13/15	248FS-180 days	3 - Test	SGN
233		Network Analysis/Mains Replacement Design/Contingency Planning	10 days	Mon 2/16/15	Fri 2/27/15	232	3 - Test	SGN
234		Highways Authority liaison and road opening notices	10 days	Mon 3/2/15	Fri 3/13/15	233	3 - Test	SGN
235		**Complete Technical Assurance Statement and Risk Assessment**	**90 days**	**Mon 3/16/15**	**Fri 7/17/15**			
236		Establish and approve G/23 Field Trial requirements	10 days	Mon 3/16/15	Fri 3/27/15	231	1 - Research & Development	SGN
237		Hazard and Risk Analysis of Network mains by Asset Management	10 days	Mon 3/30/15	Fri 4/10/15	236	1 - Research & Development	SGN
238		Electrical safety and Compliance	30 days	Mon 4/13/15	Fri 5/22/15	237	3 - Test	SGN
239		Site Management and CDM Requirements	30 days	Mon 5/25/15	Fri 7/3/15	238	3 - Test	SGN
240		Obtain Stage 2 approval for Technical Assurance	9 days	Mon 7/6/15	Thu 7/16/15	239	3 - Test	SGN
241		SDRC 9.3.C - Publish Element 4 Stage 2 Technical Assurance Approval Certificate	1 day	Fri 7/17/15	Fri 7/17/15	240		SGN
242		**Pre Site Preparation**	**90 days**	**Mon 6/8/15**	**Fri 10/9/15**			
243		Site specific risk assessment	10 days	Mon 7/20/15	Fri 7/31/15	235	3 - Test	SGN
244		Drilling and Assessment of Network Impact	30 days	Mon 8/3/15	Fri 9/11/15	243	3 - Test	SGN
245		Design Anchorage for launch tube / site specific civils	10 days	Mon 9/14/15	Fri 9/25/15	244	3 - Test	SGN



ID		Task Name	Duration	Start	Finish	Predecessors	Workstream	Owner
246		Prepare excavations in accordance with SGN's SMF/traffic management procedures	10 days	Mon 9/28/15	Fri 10/9/15	245	3 - Test	SGN
247		Procure Spares and Materials for Field Testing	60 days	Mon 6/8/15	Fri 8/28/15	248FS-90 days		ULC
248		Pack and Ship System to the UK	30 days	Mon 8/31/15	Fri 10/9/15	223		ULC
249		**Perform 20 Days of Field Testing**	**60 days**	**Mon 8/17/15**	**Fri 11/6/15**			
250		Prepare and authorise NRO's and PTW's under SCO	10 days	Mon 8/17/15	Fri 8/28/15	248FS-40 days	3 - Test	SGN
251		CDM Site Management	10 days	Mon 8/31/15	Fri 9/11/15	250	3 - Test	SGN
252		Prepare drillings for pre-deployment inspection / specialist contractor	10 days	Mon 9/14/15	Fri 9/25/15	251	3 - Test	SGN
253		Prepare drillings / specialist contractors	10 days	Mon 9/28/15	Fri 10/9/15	252	3 - Test	SGN
254		Mount Launch Tube on Valve at Site	0 days	Fri 10/9/15	Fri 10/9/15	248	3 - Test	ULC
255		Launch Robot	0 days	Fri 10/9/15	Fri 10/9/15	254	3 - Test	ULC
256		Support deployment of robotic solution	20 days	Mon 10/12/15	Fri 11/6/15	255	3 - Test	ULC
257		Retrieve Robot	0 days	Fri 11/6/15	Fri 11/6/15	256	3 - Test	ULC
258		Reinstate	0 days	Fri 11/6/15	Fri 11/6/15	257	3 - Test	SGN
259		**Generate Final Report**	**31 days**	**Fri 11/6/15**	**Mon 12/21/15**			
260		Report on Field Trial against Success Criteria	0 days	Fri 11/6/15	Fri 11/6/15	249	4 - Learning & Dissemination	SGN
261		ULCR generate final report	10 days	Mon 11/9/15	Fri 11/20/15	249	4 - Learning & Dissemination	ULC
262		Update Technical Assurance Report	10 days	Mon 11/23/15	Fri 12/4/15	261	3 - Test	SGN
263		Obtain Stage 3 Internal Approval	9 days	Mon 12/7/15	Thu 12/17/15	262	3 - Test	SGN
264		SDRC 9.1.b - Publish Project Reporting Timetable Document	1 day	Fri 12/18/15	Fri 12/18/15	263	4 - Learning & Dissemination	SGN
265		SDRC 9.4.c - Publish Element 4 Stage 3 Committee Approval Document	1 day?	Mon 12/21/15	Mon 12/21/15	264	4 - Learning & Dissemination	SGN



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Appendix G – Knowledge Dissemination Plan

External Dissemination

Who	What	How	When
Ofgem	- Project data - Test results - Project progress	- Progress reports - Publish information on Ofgem portal - Update meetings - NIC Conference - SGN Website	- Progress report every 6 months - Comprehensive learning report after project completion - Regular updates Ofgem portal - NIC Conference dates tbc
Gas Transporters	- Network Performance data - Implications local distribution networks	- NIC Conference - SGN Website - Technical visits x 3 - free 300m demo	- Regular updates on SGN website - NIC Conference dates tbc - technical visits TBC - to be agreed with GDN's upon project completion
IGEM	- Interested in all aspects of project learning	- NIC Conference - SGN Website - Journal Paper - Paper evening presentation - IGEM Magazine article - Technical site visits	- Presentation at IGEM conference in 2014 - Results of Project to be published in IGEM magazine at end of project - Technical visit to be offered in 2014 to Young persons network
Pipeline Industries Guild	- Implications for gas production - Learning relating to transmission and distribution	- NIC Conference - SGN Website	- Regular updates on SGN website - NIC Conference dates tbc
Local Customers	- Project progress - Outcome of Project	- Twitter - Facebook - Youtube - Pamphlets	- Progress updates to be uploaded to twitter & facebook at regular intervals - Youtube video to be uploaded prior to start of Project - Information pamphlets will be used before and after Project to share knowledge with customers
Local and National Press	- project success (if successful)	- Press relese	- Upon any successful outcomes - You tube video for SGN website

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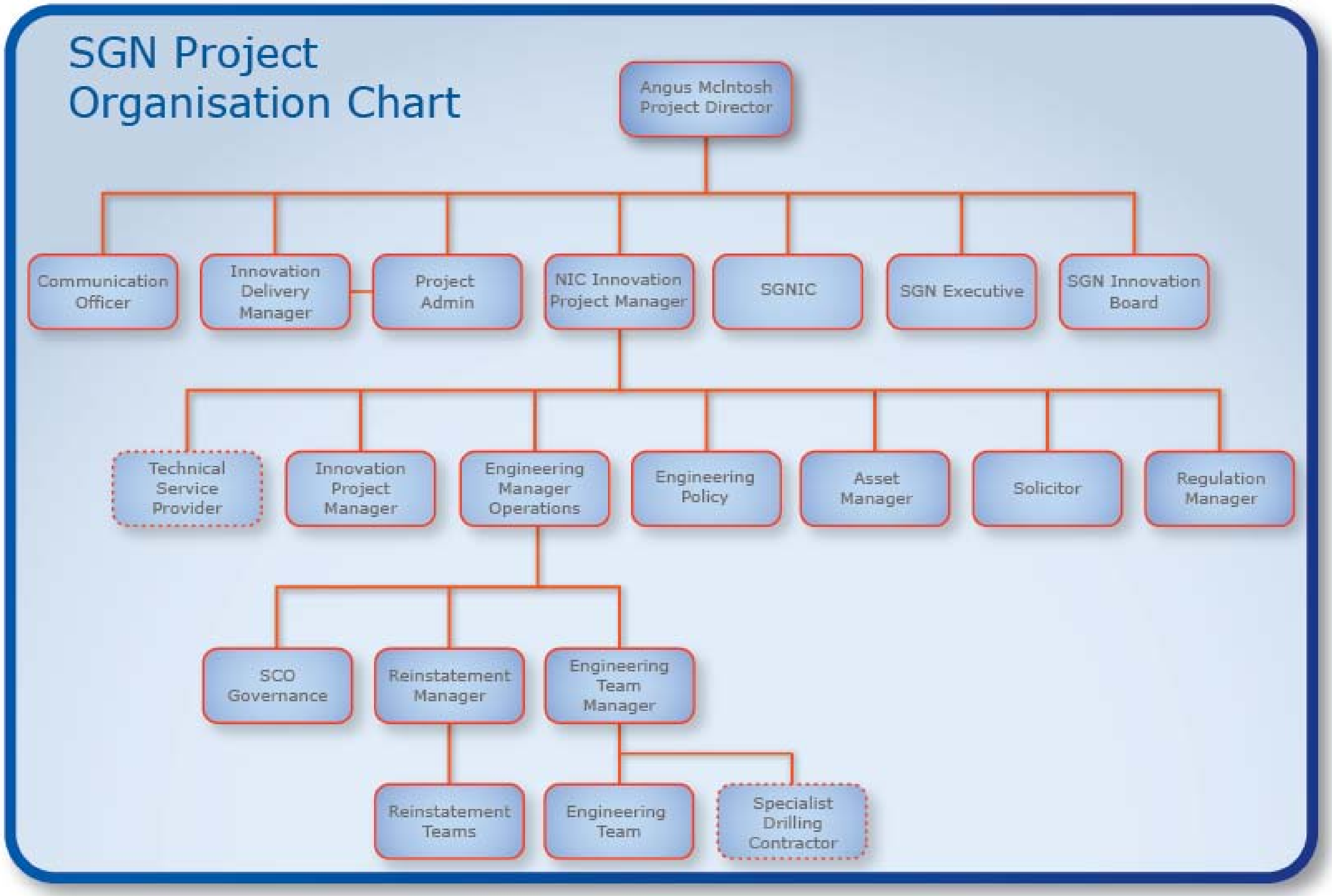
Internal Dissemination

Who	What	How	When
SGN Board of Directors	- Project outline - Project results	- Presentations to the Board - SGN Annual Report	- Presentations at the start and completion of the Project - Project outline to be submitted in 2014 Annual Report
SGN Executive	- Project outline - Project progress - Project results	- Presentation to the Executive Committee - SGN Annual Report - Progress reports - Site visits	- Presentation at the start and completion of the Project - Project outline to be submitted in 2014 Annual Report - Progress updates to be given monthly by Project Director - Site visits to be offered throughout Project
SGN Investment Committee	- Project proposal financial tracking and reporting	- Agenda item	- monthly update
SGN Innovation Board	- Project results - Change to operating procedures	- Bi monthly project progress - Briefing notes - Presentations	- Briefing notes to be issued before start of the testing programme - Presentations throughout the Project
SGN Operational Managers	- Project results - Change to operating procedures	- Briefing notes - Presentation at Operations Committees	- Briefing notes to be issued before start of the testing programme - Presentations at the start and completion of the Project
SGN Employees	- Project results - Change to operating procedures	- Team talks - Briefing notes - Engineering Bulletins	- Team talks at key stages of the Project - Briefing notes / engineering bulletins to be issued whenever deemed necessary
All other SGN Employees	- Project outline - Project results	- SGN Mail (internal magazine) - SGNnet (intranet site)	- At the start, regular updates to the intranet and completion of the Project

Appendix H – Project Team Organograms



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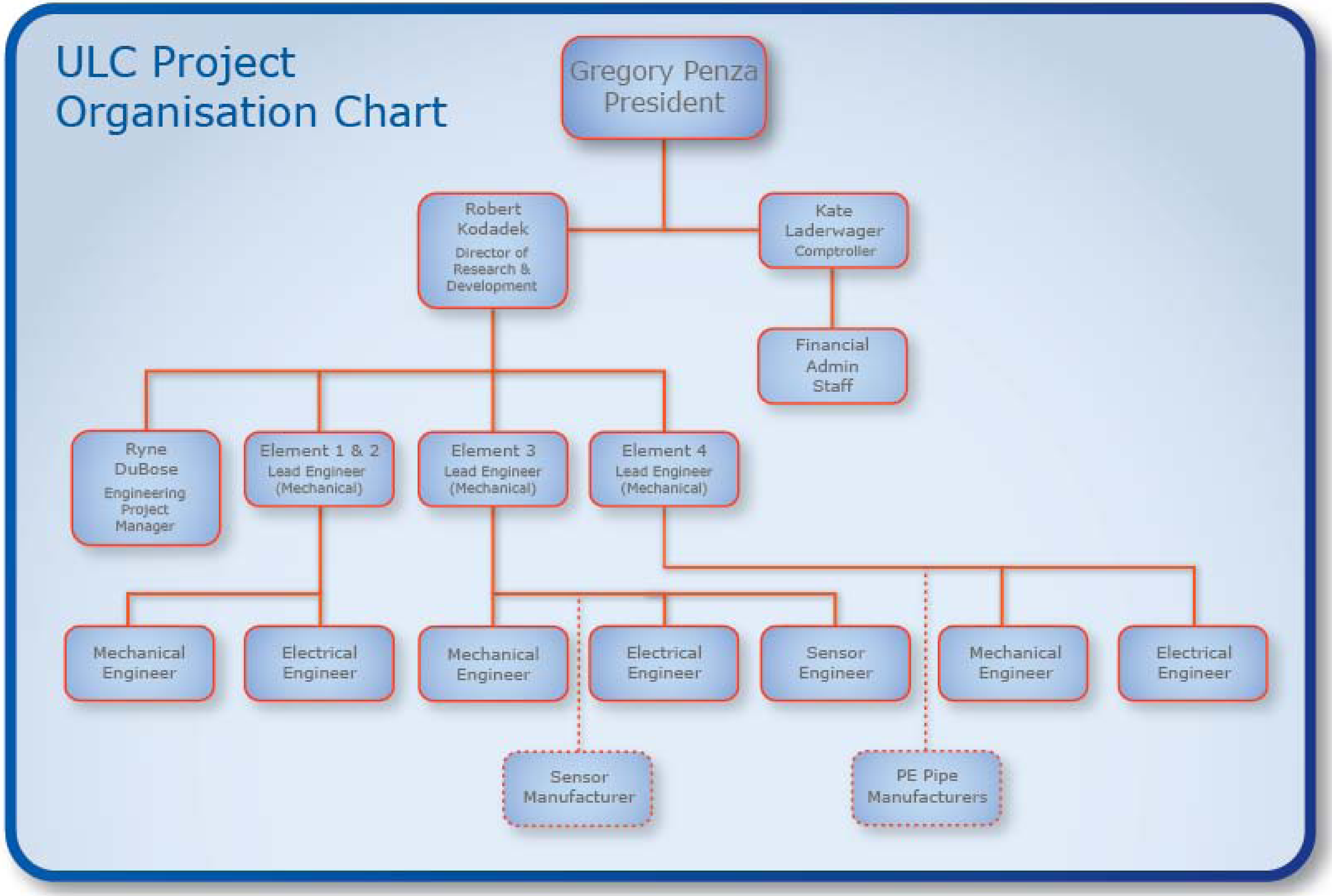

RIIO NIC NETWORK INNOVATION COMPETITION

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Appendix I – Risk Register and Mitigation

Project Risk Register

	Project Title	Robotics		Date: Established		30/07/2013					Scoring Key		
	Project Manager	Angus McIntosh		Review Date		06/08/2013						14	8
											16-25	10-15	1-9
Ref No	Risk	Business Risk	Inherent Risk			Controls & Mitigation	Current Issues	Owner	By When	Residual Risk			Status
			Likelihood	Impact	Score					Likelihood	Impact	Score	
1	Inadequate resource preparation by ULC Robotics for project start date	Financial	2	4	8	ULC Robotics to contract additional staff to project				1	4	4	
2	Project will exceed planned project schedule	Financial	3	4	12	Creation of project plan to track milestone dates. Dedicated staff and Lead Engineer. Project tracked on daily basis with weekly progress meetings.				1	4	4	
3	SGN unable to obtain notices from Local Authority to allow work on the highway.	Financial	1	4	4	Once sites and operation schedules have been agreed, SGN to liaise with local authorities as early as possible to expedite the process.				1	4	4	
4	SGN unable to resource personnel for on-site management and management of SCO procedures.	Financial	1	4	4	SGN to identify dedicated resources to undertake site management and management of SCO procedures				1	4	4	
5	Development of the robot platform could be delayed due to technical issues	Financial	4	4	16	Additional ULC Robotics staff to be diverted from other projects.		A - ULCR		1	4	4	
6	Development of the sensor module could be delayed due to technical issues	Financial	4	4	16	Additional ULC Robotics staff to be diverted from other projects.		A - ULCR	See Detail	1	4	4	
7	Delays from the sensor manufacturer could affect the overall schedule	Financial	3	4	12	Early identification of sensor manufacturer so that the vendor is not on the critical path				1	4	4	
8	Customs and shipping difficulties could delay deployment of system to the UK	Financial	2	4	8	Buffer time included in project. Equipment shipped early where possible.		A - ULCR	See Detail	1	4	4	
9	Technical issues with service replacement could affect the robotic system	Financial	4	4	16	Test robot in mock up of main with service connections.		A - ULCR	See Detail	2	4	8	
10	Development of service replacement robot delayed due to technical issues	Financial	4	4	16	Additional ULC Robotics staff to be diverted from other projects.			See Detail	2	4	8	
11	Unforeseen issues with service replacement tools could affect the overall schedule	Financial	4	4	16	Additional ULC Robotics staff to be diverted from other projects.		A - ULCR	See Detail	2	4	8	
12	Main not suitable for Robot operation	Financial	3	3	9	Pre inspection of main using camera				1	3	3	
13	Unable to launch Robot into main.	Financial	1	2	2	Ensure entry tee compatible with launch tube and manufacturers requirements.				1	2	2	
14	Gas ignition during Robot launch/recovery	Safety	2	4	8	Operation to be controlled under SCO documentation with approved purging method statement.				1	4	4	
15	Robot loses power during operation	Financial	2	2	4	Robot to be recoverable manually using umbilical cable. Umbilical cord to be designed to reduce the possibility of damage during operation.				1	2	2	
16	Robot becomes stuck in main	Financial	2	4	8	Pre inspection of main using camera. Network Analysis of impact of reduced flow characteristics of main. Preparation of contingency plan for mains isolation.		A - ULCR		1	4	4	
17	Robot drills through main wall	Safety	3	2	6	Trial hole to identify orientation of joint		A - ULCR	See Detail	1	2	2	

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Appendix J – Typical Stakeholder Communication Examples

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Appendix K – Extract from Licence condition regarding modifications to the leakage model (LRMM)

SPECIAL CONDITIONS APPLICABLE TO THE LICENSEES (DN's): PART E – Scotland & Southern Gas Networks Limited

Part E: Modification of The Shrinkage and Leakage Model

1F.17 The Licensee must review annually The Shrinkage and Leakage Model in order to assess how it can better achieve the objective set out in paragraph 1F.13 of this condition ("the SLM Review").
1F.18 The Licensee must consult with other DN Operators, gas shippers and other interested parties on the outcome of the SLM Review and send a copy of this consultation to the Authority by 31 December in each Formula Year.

1F.19 Any modification that the Licensee proposes to The Shrinkage and Leakage Model pursuant to the SLM Review must, where appropriate, specify such revised allowed Shrinkage and allowed Leakage volumes for each Distribution Network, as would maintain the incentive properties of the Shrinkage Allowance Revenue Adjustment and of the Environmental Emissions Incentive, at the same levels as those applicable before the proposed modification.

1F.20 Where, following the SLM Review, the Licensee proposes any modifications to The Shrinkage and Leakage Model, the Licensee must:

(a) consult other DN Operators, gas shippers and other interested parties for their views on whether the allowed Shrinkage and allowed Leakage volumes should be revised as proposed, allowing them a period of not less than 28 days in which to make representations; and

(b) within 28 days after the close of that consultation make publicly available and submit to the Authority a report ("SLM Modification Report") in accordance with the provisions set out in paragraph 1F.21 of this condition.

1F.21 The SLM Modification Report must set out:

(a) the modifications originally proposed;

(b) the revised allowed Shrinkage and allowed Leakage volumes proposed pursuant to paragraph 1F.19 of this condition;

(c) the representations (if any) that were made to the Licensee by other DN Operators, gas shippers or other interested parties and not withdrawn;

(d) any changes to the modifications and to the allowed Shrinkage and allowed Leakage volumes that are proposed as a result of such representations;

(e) a copy of the independent expert"s report referred to in 1F.24 of this condition;

(f) an explanation of how the proposed modifications would better achieve the objective set out in paragraph 1F.13 of this condition; and

(g) a timetable, developed in accordance with paragraph 1F.25 of this condition, for implementing the modifications originally proposed or any alternative modifications developed in the light of any representations made by other DN Operators, gas shippers or other interested parties, including the date with effect from which such modifications (if made) would take effect.

1F.22 When proposing any modification to The Shrinkage and Leakage Model, the Licensee must, in conjunction with other DN Operators, appoint an independent expert, who will review The Shrinkage and Leakage Model and the proposed allowed Shrinkage and allowed Leakage volumes for the Licensee and all other DN Operators and provide a report of that review.

1F.23 If requested by other DN Operators, the Licensee must provide all the information reasonably required to enable DN Operators to comply with paragraph 1F.22 of this condition, including the proposed allowed Shrinkage and allowed Leakage volumes for the Licensee which would result from the proposed modification, even if the Licensee does not agree that the modification better meets the objective set out in paragraph 1F.13 condition.

1F.24 The SLM Modification Report submitted by the Licensee under 1F.20 of this condition must include an independent expert‟s opinion on the extent to which the proposed modifications to The Shrinkage and Leakage Model would better achieve the objective set out in paragraph 1F.13 and, where applicable, their opinion on the extent to which any proposed changes to the allowed Shrinkage and allowed Leakage volumes would maintain the incentive properties of the Shrinkage Allowance Revenue Adjustment and the Environmental Emissions Incentive at the same levels as those applicable before such changes.

1F.25 The Licensee must determine an appropriate timetable for any modification to The Shrinkage and Leakage Model, which ensures that such modification is able to take effect as soon as practicable after the Authority has directed it to be made and which allows for that timetable to be extended with the consent of, or as required by, the Authority.

1F.26 Where the Authority considers that modification set out in the SLM Modification Report submitted by the Licensee or SLM Modification Report submitted by another DN Operator under equivalent provisions in its licence would, as compared with the existing provisions of The Shrinkage and Leakage Model and any alternative modifications set out in the relevant report, better achieve the objective set out in paragraph 1F.13 of this condition, the Authority may issue directions requiring the Licensee, in conjunction with all other DN Operators:

(a) to revise The Shrinkage and Leakage Model in such manner as is specified in the directions;

(b) to revise the allowed Shrinkage and allowed Leakage volumes set out in Appendices 2 and 3 to this condition, to those set out in the report if these have been agreed by the independent expert appointed under paragraph 1F.22 of this condition; and

(c) to revise the allowance for Shrinkage costs set out in Appendix 1 to account for any revisions made to Shrinkage volumes under sub-paragraph (b) above.

1F.27 The Authority may, at any time, direct that either or both of paragraphs 1F.20 and 1F.21 of this condition do not apply, whether in whole or in part, and in that event, the Licensee must comply with such other reasonable requirements which are in line with the revised Shrinkage baselines included in the modification report submitted under Part E, as may be specified in that direction

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Appendix L – Guaranteed Standards of Service

Guaranteed Standards of Service

We follow Guaranteed Standards (GS) introduced by our regulator OFGEM to ensure a certain level of service. We promise to work hard to reach and exceed these service levels for our customers.

The Guaranteed Standards are shown in the table below and you are eligible for a compensation payment if we do not meet these. Compensation payments will be made through your gas supplier or by cheque.

GS1	Restoring customers' supplies after an unplanned interruption	Restore customers' supplies within 24 hours following unplanned interruptions on our networks. On failure to achieve this, a fixed compensation payment will be paid to the customer affected. The same amount of compensation will be paid for each additional period of 24 hours until the customer's supply is restored. EXEMPTIONS FROM PAYMENT If the event was caused by an act or default of the customer. Where more than 30,000 customers are interrupted. If the event was caused by severe weather or other exceptional circumstances beyond the control of Southern Gas Networks and all reasonable steps had been taken to prevent the circumstances from occurring and from causing the interruption.	£30 (domestic) £50 (small non-domestic) Cap per customer of £1,000
GS2	Reinstatement of customers' premises	On completion of Southern Gas Networks initiated work to re-lay service pipes on a customer's premises, the premises will be reinstated within five working days. If Southern Gas Networks fails to achieve this, a fixed compensation payment will be made. The same amount of compensation will be paid for each additional period of five working days until the premises are reinstated. EXEMPTIONS FROM PAYMENT If this work is initiated by the customer. If the customer's own actions (or a person under the customer's control) led to the work being required.	£50 (domestic) £100 (non-domestic)

Guaranteed Standards of Service

GS3	Provision of alternative heating and cooking facilities to priority domestic customers.	If a priority customer's gas supply is discontinued because of a planned interruption, Southern Gas Networks shall provide alternative heating and cooking facilities within four hours. If the supply to a priority customer's premises or gas fittings at those premises is discontinued because of any other event (e.g. a gas emergency or unplanned interruption) where fewer than 250 customers are affected, Southern Gas Networks shall provide alternative heating and cooking facilities within four hours of it becoming aware that the customer has been affected. Where 250 or more customers are affected, Southern Gas Networks shall provide alternative heating and cooking facilities within eight hours of it becoming aware that the customer has been affected. The period from 8.00pm to 8.00am shall be ignored when calculating the period the supply of gas is discontinued for purposes of paying compensation. In the event Southern Gas Networks fail to satisfy this requirement compensation will be paid. EXEMPTIONS FROM PAYMENT If the customer has alternative heating & cooking facilities or has declined the offer of alternative heating and cooking facilities.	£24 if claimed by the customer within three months
GS4	Provision of standard connection quotations	SGN Connections shall provide a standard quotation for providing a new or altering an existing connection up to an including 275kWh per hour within six working days. Where SGN Connections fails to achieve this, a fixed payment shall be made in respect of the initial failure and each additional day during which the failure continues. Where a quotation is later found to be inaccurate it shall be treated as if it wasn't provided on time.	£10 Cap per customer is the lesser of £250 or the quotation sum

Guaranteed Standards of Service

GS5	Provision of non-standard connection quotations < 275 kWh per hour	SGN Connections shall provide a non-standard quotation for providing a new or altering an existing connection up to an including 275 kWh per hour within 11 working days. Where SGN Connections fails to achieve this, a fixed payment shall be made in respect of the initial failure and each additional day during which the failure continues. Where a quotation is later found to be inaccurate it shall be treated as if it wasn't provided on time.	£10 Cap per customer is the lesser of £250 or the quotation sum
GS6	Provision of non-standard connection quotations >275kWh per hour	SGN Connections shall provide a non-standard quotation for providing a new or altering an existing connection greater than 275 kWh per hour within 21 working days. If SGN Connections fails to achieve this, a fixed payment shall be made in respect of the initial failure and each additional day during which the failure continues. Where a quotation is later found to be inaccurate it shall be treated as if it wasn't provided on time.	£20 Cap per customer is the lesser of £500 or the quotation sum
GS7	Accuracy of quotations	Where a customer challenges a quotation under SGN Connections' published accuracy scheme and the quotation is found to be inaccurate SGN Connections shall refund any overcharge that has been made.	N/A
GS8	Response to land enquiries	SGN Connections shall respond to a land enquiry in respect of a new connection or alteration of an existing connection within five working days. Where SGN Connections fails to achieve this, a fixed payment will be made in respect of the initial failure and each additional day during which the failure continues.	£40 Cap per customer is £250 for a new connection or altering an existing connection < 275 kWh per hour and £500 for > 275 kWh per hour

Guaranteed Standards of Service

GS9	Offering a date for commencement and substantial completion of connection work <275 kWh per hour	Where a customer has accepted a quotation, SGN Connections shall offer a date for commencement of the work and substantial completion within 20 working days. Where SGN Connections fails to achieve this, a fixed payment will be made in respect of the initial failure and each additional day during which the failure continues.	£20 Cap per customer is the lesser of £250 or the contract sum
GS10	Offering a date for commencement and substantial completion of connection work >275 kWh per hour	Where a customer has accepted a quotation, SGN Connections shall offer a date for commencement of the work and substantial completion within 20 working days. Where SGN Connections fails to achieve this, a fixed payment will be made in respect of the initial failure and each additional day during which the failure continues.	£40 Cap per customer is the lesser of £500 or the contract sum
GS11	Completion of the work on the agreed date	Where SGN Connections fails to substantially complete a connection on the date agreed with the customer, a payment will be made in respect of the initial failure and each additional day during which the failure continues.	Connections up to and including £1k - £20 (capped at the lesser of £200 or the contract sum) >£1k but not exceeding £4k – lesser of £100 or 2.5% of the contract sum (cap at 25% of contract sum) >£4k not exceeding £20k - £100 (cap at 25% of contract sum) >£20k but not exceeding £50k - £100 (cap at £5,000) >£50k but not exceeding £100k - £150 (cap at £9,000)
GS12	Notifying customers and making payments owed under the standards	Southern Gas Networks shall write to the relevant customer (or shipper) and make payment within 20 working days. Where Southern Gas Networks fails to achieve this level of service, a fixed compensation payment will be made.	£20

Guaranteed Standards of Service

GS13	Notifying customers at least five working days in advance of a planned interruption.	Southern Gas Networks shall notify customers at least five working days in advance of a planned interruption to their gas supply. Where Southern Gas Networks fails to achieve this level of service, a fixed compensation payment will be made.	£20 (Domestic) £50 (Non Domestic) If claimed by the customer within three months.
GS14	Responding substantially to a complaint.	Southern Gas Networks shall substantially respond to a complaint within 10 working days or 20 working days where a site visit or third party enquiries are required. However, if a substantive response is unable to be provided because a site visit is required, we will provide an initial response indicating this within 10 working days. Where Southern Gas Networks fails to achieve this level of service, a fixed payment will be made in respect of the initial failure and each succeeding 5 working days during which the failure continues.	£20 (capped at £100)