| Question No. | From | Proforma section | Criteria | Question | Date question asked | Date response required | Date received | Follow up to Question # | Confidential (y/n) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | CO | N/A | Mulitple | Please provide a break-down showing the types of excavation utilised in the field, which could be performed by RRES and in each case, what the benefits would be for:<br>o Works footprint<br>o Time<br>o Excavation issues<br>o Cost (number of excavations per year by type and cost savings for each). State assumptions for the number of RRES units in the field with justification. | 29 August 2017 | 31 August 2017 | 31 August 2017 | | N |
| 2 | CO | 1.10 | d) Is innovative | Referencing the descriptions of Technology Readiness Levels (TRLs) in the Gas NIC governance document, how have you determined the current TRL as 4 for the RRES? | 29 August 2017 | 31 August 2017 | 31 August 2017 | | N |
| 3 | CO | Multiple | g) Robust methodology/ready to implement | It is unclear how large the team is, who's in it, where they are based, what their tasks will be and what they cost.<br>i) Please provide a table showing the task/role, person/resource, base location, time allocation and cost.<br>ii) For international working, what issues have been considered?<br>iii) What learning can you apply from other similar projects? | 29 August 2017 | 31 August 2017 | 31 August 2017 | | N |
| 4 | CO | Appendix F | a) Enviro+consumer bens | Please explain the assumptions behind your CBA. Please explain:<br>i) proposed utilisation rates (jobs per year/job types, etc)<br>ii) cost differences between RRES and conventional methods for different job types. | 29 August 2017 | 31 August 2017 | 31 August 2017 | | N |
| 5 | CO | Multiple | a) Enviro+consumer bens | Please explain to whom the different benefits of RRES will flow, eg tech provider, networks, customers etc. | 29 August 2017 | 31 August 2017 | 31 August 2017 | | N |
| 6 | CO | Multiple | a) Enviro+consumer bens | Please provide full life cycle impacts of RRES, not just impacts from 'use'. Please use clear summary tables/diagrams to help convey methods, assumptions and benefits. | 29 August 2017 | 31 August 2017 | 31 August 2017 | | N |
| 7 | CO | Appendix C | g) Robust methodology/ready to implement | The time plant and TRL maturation plan in Appendix C are illegible. Please provide a suitable high resolution copy. | 29 August 2017 | 31 August 2017 | 31 August 2017 | | N |
| 8 | CO | Multiple | g) Robust methodology/ready to implement | What literature study has been conducted? What learning can be applied from other applications/industries?<br>i) Will code be developed from scratch for RRES?<br>ii) Is there a plan to research other relevant applications (other industries) before specifying/purchasing/developing RRES hardware/software?<br>iii) Can scope be reduced through research? Finding alternative sources for the technologies, at a higher starting TRL? | 29 August 2017 | 31 August 2017 | 31 August 2017 | | N |
| 9 | CO | Appendix I | g) Robust methodology/ready to implement | In the Risk Register (Appendix I), several risks appear to be missing. Some are identified earlier in the submission but not logged/appraised in Appendix I. Please expand on the risks and mitigations proposed. Particularly:<br>i) Risk: The risk of poor RRES market uptake.<br>EG Mitigations: Customer questionnaires? Use of existing tooling/methods (but with automation)? Trialling of new tooling with users? Gaining consumer buy-in? Accessibility by other markets (how are details communicated?) Etc.<br>ii) Risk: Low RRES utilisation.<br>EG Mitigations: RRES is suitable for many excavation types (which?). What conservatisms are placed on the utilisation (e.g. jobs per year) planned for RRES in the cost benefits?<br>iii) Risk: Overrun on project Time and/or Costs.<br>EG Mitigations: alternative funding streams? Options for trimming scope if needed? Confidence in time/cost estimates from previous, similar projects (please provide specifics)?<br><br>The impact of these risks should be considered and presented in feedback. | 29 August 2017 | 31 August 2017 | 31 August 2017 | | N |
| 10 | CO | Multiple | c) Generates new knowledge | Please provide additional information on the openness and interconnectivity planned for RRES. In particular:<br>o It's unclear how technical specifics (hardware and software) will be communicated to the market (and other industries) enabling wider uptake and development of RRES.<br>o This is important to support its replication/development across GB.<br>o For example – will copies of code be shared? What features of the hardware design will be open? What features will ULC/SGN retain IP on? Will there be training sessions for the industry/users on RRES, to support their on-going use/development?<br>o Please present a plan for the dissemination of RRES specifications to the market, including any training that might be required for a 3rd party to adopt the (likely complex) development methods/tools/scripts. | 29 August 2017 | 31 August 2017 | 31 August 2017 | | N |
| 11 | CO | Multiple | N/A | Soft-Touch Tooling:<br>i) What was the scope/duration/cost of the soft-touch tooling project? How does this compare with the many components RRES will need developed? Does this show credibility to the current plan (which seems very ambitious in the timeplan/costings)?<br>ii) Please provide more information on preceding, similar project scope/costs/duration including the soft-touch tooling project (to give confidence the scope proposed here is feasible in the suggested time and cost).<br>iii) Provide some technical information for the soft-touch tool, demonstrating the claimed TRL and what was achieved in the time/cost allocation in previous work. | 29 August 2017 | 31 August 2017 | 31 August 2017 | | N |
| 12 | EP | Appendix D | N/A | Would the team working on this be the same as the project team who worked on the previous SGN and ULC Robotics project? | 05 September 2017 | 07 September 2017 | 07 September 2017 | | N |
| 13 | EP | 5.3 | c) Generates new knowledge | Please explain the IP arrangements in more detail? | 05 September 2017 | 07 September 2017 | 07 September 2017 | | N |
| 14 | EP | N/A | b) Value for money | How many times a year are the operations that the RRES would be used for required? | 05 September 2017 | 07 September 2017 | 07 September 2017 | | N |

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| 15 | EP | Multiple | b) Value for money | i) What would this project add to sensing technology above and beyond what is already available?<br>ii) What are the benefits of this project above having a digger mounted manually operated cutting and sensor enabled vacuum system? | 05 September 2017 | 07 September 2017 | 07 September 2017 | | N |
| 16 | EP | Multiple | Mulitple | What are the benefits of using robots rather than people? Has customer acceptance been considered? | 05 September 2017 | 07 September 2017 | 07 September 2017 | | N |
| 17 | NC | N/A | Mulitple | Please provide a justification for the scale of the funding contribution provided by ULC in relation to the benefits that they will accrue if the project is successful and they are able to seel the resulting product. | 05 September 2017 | 07 September 2017 | 07 September 2017 | | N |
| 18 | NC | 9 | g) Robust methodology/ready to implement | You appear to have allocated 10% to each of the project deliverables. Please provide a justification that the proposed percentage of funding associated with this deliverable is appropriate – some of the deliverables appear to relate to inputs and others relate to outputs from the project. Would it be appropriate for deliverables that relate to learning to have a higher level of funding associated with them than those that inform the development of the learning. | 14 September 2017 | 19 September 2017 | 19 September 2017 | | N |
| 19 | EP | Multiple | g) Robust methodology/ready to implement | Please provide more detail regarding the project plan, highlighting key junctures over the project's life, where there may be a risk of delay or where key go/no-go decisions might be taken based on evidence that becomes available. | 26 September 2017 | 10 October 2017 | 10/10/2017 and answered at Second Bilateral on 05/10/21 | | N |
| 20 | EP | Multiple | a) Enviro+consumer bens | Please provide a breakdown and more detail to justify the claimed time saving benefits expected of this technology compared to typical current practices. Currently, not all the time taken to do the work relates to the excavation process. | 26 September 2017 | 10 October 2017 | 10/10/2017 and answered at Second Bilateral on 05/10/21 | | N |
| 21 | EP | Multiple | f) Relevance and timing | Please give more information on the range of likely financial impacts and timings of the further introduction of lane rental charges. | 26 September 2017 | 10 October 2017 | 10/10/2017 and answered at Second Bilateral on 05/10/21 | | N |
| 22 | EP | Multiple | Multiple | Please provide more detail on the anticipated key benefits that the sensing and soft touch tooling technologies will provide. | 26 September 2017 | 10 October 2017 | 10/10/2017 and answered at Second Bilateral on 05/10/21 | | N |
| 23 | EP | Multiple | b) Value for money | Please provide more information as to why this project is value for money for consumers and that the consumer contribution (vs company contribution) is proportionate to the benefits that may be realised. | 26 September 2017 | 10 October 2017 | 10/10/2017 and answered at Second Bilateral on 05/10/21 | | N |
| 24 | EP | Multiple | g) Robust methodology/ready to implement | The NIA project identified a wide range of sensor and excavation technologies. However, it is unclear how these technologies would be selected, combined and developed into a single system, and what the limitations of that system would be. Experience from other domains (such as IED detection) has shown that this is very difficult. | 26 September 2017 | 10 October 2017 | 10/10/2017 and answered at Second Bilateral on 05/10/21 | | N |
| 25 | EP | Multiple | a) Enviro+consumer bens | Please provide more figures to explain the time saving benefits expected of this technology compared to typical current practices described in response to Q20 (Q2 of Big Questions). | 10 October 2017 | 12 October 2017 | | 20 | N |

*Gas Network Innovation Competition Full Submission*

# *Supplementary Answer Form*

# Project: Robotic Roadworks and Excavation System (RRES)

Tick if this answer has been provided verbally: ☐

| | | | |
|---|---|---|---|
| Project code | SGN_GN_04 | Question Number | Q1 |
| Question date | 29/08/17 | Answer date | 31/08/17 |
| Submission section question relates to | Multiple | | |
| Topic | Excavation | | |
| Question | Please provide a break-down showing the types of excavation utilised in the field, which could be performed by RRES and in each case, what the benefits would be for:<br><br>o Works footprint<br><br>o Time<br><br>o Excavation issues<br><br>o Cost (number of excavations per year by type and cost savings for each). State assumptions for the number of RRES units in the field with justification. | | |
| Notes on question | Excavation and reinstatement requirements vary significantly for each work activity and operation.<br><br>For example, two gas escape repairs are generally incomparable in terms of the excavation work required due to site specific issues, such as depth of the gas main, location of other utility apparatus, ground type and associated safe digging practices etc. Excavation and reinstatement costs pertaining to all our work activities are not split out in the way requested, they are bundled with the work activities.<br><br>Rather than list all work types, we have split into both Urban and Rural categories and applied an aspirational yet achievable reduction in excavation and reinstatement for each. The targeted reduction and associated benefits are derived from the reduction and/or elimination of asset identification through safe digging practices, the automation of excavation activity, i.e. a | | |

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| | machined excavation is more compact and quicker than a manually excavated one using hand tools or mechanical plant.<br><br>We are seeing reduced excavation and reinstatement costs now from our Core & Vac activity, however this is limited to the job types that can be facilitated through keyhole activity (an area where we are innovating now). The assumptions relating to this are in Appendix E.<br><br>By design the RRES seeks to reduce the excavation requirements and associated reinstatement for every operation in either urban or rural environments.<br><br>There are anticipated to be direct cost savings from this activity as well as social and environmental cost savings. |
| Answer | <u>Types of urban excavation considered are for:</u><br><br>(i) cast iron joint repair (emergency repair), already addressable by C&V<br><br>(ii) cast iron joint repair, not addressable by current C&V (location, asset congestion)<br><br>(iii) network intervention via Universal Access Fitting (covers fracture repair, water extraction, camera access, and flow stopping).<br><br>(iv) gas service/main renewal and connection<br><br><u>Types of rural excavation considered are for:</u><br><br>(v) excavation in 'hazard zone' near LTS pipelines.<br><br><u>Time</u><br><br>For (i) to (iii) current C&V application reduces project cycle time from 2-5 days to 0.5 days. Urban-RRES efficiency target is 0.4 days. Time reduction likely to be less for (iv) owing to more accessible location of services. For (v), rural-RRES is 16x quicker than hand excavation; overall project cycle time projected to fall from 10 days down to 1-2 days.<br><br><u>Excavation Issues</u><br><br>Only a portion of total work volumes are assumed addressable by RRES; issues arise in soil type (large rocks), vehicle access issues, over-congestion in underground assets beyond expected AI capability.<br><br><u>Excavation Costs</u><br><br>Traditional excavation (urban) £904/excavation<br><br>(i) RRES Cost £708 - £735<br><br>(ii) RRES with soft touch £708 - £800<br><br>(iii) and (iv), as per (i) or (ii)<br><br>Typical rural excavator hire costs £1,100 to £1,500/day<br><br>Rural RRES hire costs £1,600 to £3,200 / day. |

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| | <u>Numbers of Excavators in the field</u><br><br>Urban – RRES vehicle doing 576 excavations each per year; peak addressable work volumes rising to ~ 37,500 by 2026. Fleet size at peak ~ 65 vehicles.<br><br>Rural – RRES capacity 4m3/h; ~12,000 m3 of excavation required per annum (375 8-hour days). 2-4 field vehicles dependent on geographic need and service delivery model. |
| Attachments | |

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|---|---|---|---|
| Project code | SGN_GN_04 | Question Number | Q2 |
| Question date | 29/08/2017 | Answer date | 31/08/17 |
| Submission section question relates to | 1.10 | | |
| Topic | d) Is innovative | | |
| Question | Referencing the descriptions of Technology Readiness Levels (TRLs) in the Gas NIC governance document, how have you determined the current TRL as 4 for the RRES? | | |
| Notes on question | Further details of the TRL evolution for the different technologies incorporated in the RRES can be found in table on page 33 of the submission document. | | |
| Answer | The Gas NIC governance document makes a distinction between two TRL ranges: 2-3 and 4-6. A TRL of 2-3 is indicative of “applied research driven by a desire to broaden scientific and technical knowledge”, whereas a TRL of 4-6 is indicative of “development activities with a more commercial application including technology validation and or demonstration in a working environment”.<br><br>Realisation of the RRES’ proposed capabilities does not require the development of any fundamentally new technology that would substantively broaden scientific or technical knowledge; rather, existing technologies will be researched, selected, adapted and integrated to create an innovative system with direct commercial applications. While certain elements of the RRES (such as support equipment) currently have TRLs greater than 4, a TRL of 4 was selected for the system since it is the lowest TRL of any individual subsystems in our view, and it also best represents the maturity of the techniques that will be employed to integrate the RRES subsystems. The table located in Section 6.2 of the RRES proposal provides the estimated TRL for each of the subsystems comprising the robotic system as well as justifications for the specific TRLs assigned. | | |
| Attachments | | | |

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| Project code | SGN_GN_04 | Question Number | Q3 |
| Question date | 29/08/2017 | Answer date | 31/08/2017 |
| Submission section question relates to | Multiple | | |
| Topic | g) Robust methodology/ready to implement | | |
| Question | It is unclear how large the team is, who's in it, where they are based, what their tasks will be and what they cost.<br><br>i) Please provide a table showing the task/role, person/resource, base location, time allocation and cost.<br><br>ii) For international working, what issues have been considered?<br><br>iii) What learning can you apply from other similar projects? | | |
| Notes on question | | | |
| Answer | i) Please see table provided in attachment<br>ii) Potential issues that are inherrent with international working centre around communication barriers posed by time zone differences and digital conferencing. These barriers can make it harder for all stakeholders to agree on system specifications, perform technical reviews, and respond appropriately to technical and schedule risks that surface during the project. A communication plan will be developed to facilitate successful communication between SGN and ULC prior to the start of the project. Additionally, funds were allocated during project planning for ULC personnel to meet in person with SGN personnel once per quarter throughout the project. Regular, effective engagement is essential for projects. As a minimum we engage weekly for our major projects through a diarised meeting with the core team involved. We have a number of partnerships with international partners and employ a number of communication methods throughout the project, such as live streaming of testing activities, or videos of component testing.<br>iii) SGN and ULC have developed a highly effective working relationship over the course of a previous Robotics project made possible by NIC funding. Learnings from that project that can be applied to the RRES project include:<br>a. The optimal cadence for teleconferences and in-person meetings to review the project's status and address open items as needed – It has been found that this cadence should be increased or decreased as appropriate based on the | | |

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| | project's progress in relation to milestones and the degree of collaboration required at any given time.<br>b. Effective procedures for reviewing and providing prompt feedback on project progress reports, test plans, design documentation, and other information – A balance must be struck to provide both parties with the freedom necessary to perform productive work while enabling the detection and mitigation of potential conflicts.. |
| Attachments |  [redacted] |

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| Project code | SGN_GN_04 | Question Number | Q4 |
| Question date | 29/8/17 | Answer date | 31/8/17 |
| Submission section question relates to | Appendix F | | |
| Topic | a) Enviro+consumer bens | | |
| Question | Please explain the assumptions behind your CBA. Please explain:<br>i) proposed utilisation rates (jobs per year/job types, etc)<br>ii) cost differences between RRES and conventional methods for different job types. | | |
| Notes on question | Counterfactual base case is either (a) hand excavation where current core-and vac processes can't be deployed, or (b) performance metrics of current core-and-vac process. Work volumnes are for SGN only. | | |
| Answer | i) as a simple excavation/reinstatement machine (Method 1) RRES is assumed to have a 20% efficiency margin over current C&V methods. Current machine can perform 480 emergency escape excavations (primarily joint repair) and reinstatements per year; RRES will target 576 excavations per year (displacing 96 excavtions per machine per year that would require traditional hand excavation). Current fleet is 6 vehicles.<br><br>For joint repair, RRES excavation work volumes are forecast to grow from 3,456 in 2021 to 10,947 in 2026, and then fall to 3,066 by 2032 (enduring work thereafter on residual Tier 2/3 assets).<br><br>Fracture repair/asset intervention (Universal Access Fitting): 0 rising to 1300 in 2026 (around 30% of total fracture repair work load), then falling to 360 by 2032 as Tier 1 mains are decommissioned.<br><br>Mains/Servies excavations: 0 rising to 18,600 in 2026 (20% of total work volume), falling to 0 in 2032.<br><br>Soft-touch and AI capability (Method 2) allow a further extension of 25% in operations, adding 7,700 per annum in peak year.<br><br>LTS, 12,000 m3 of danger zone excavation per annum; RRES capacity 4 m3/h, hand dig 0.25 m3/h<br><br>ii) Costs:<br><br>a) urban<br><br>Traditional Excavation/Reinstatement Method, £904/excavation | | |

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| | Current Core-and-Vac Machine (ex-Capex), £514<br>Current Core-and-Vac (with Capex), £708<br>RRES Service Cost (basic excavation/reinstatement), £708 - £735<br>RRES Service Cost Soft Touch, £708 - £800<br>UAF Fitting (marginal service cost), £25 - £75 (ex fitting cost)<br>Service relay/transfer (marginal service cost) , £25 - £75 (ex fitting cost)<br>b) rural (LTS)<br>Current Hire Rates for dumb excavators £1,100 to £1,500 /day<br>RRES for LTS £1,600 to £3,200 /day<br>Hand dig team labour rate £400/day |
| Attachments | |

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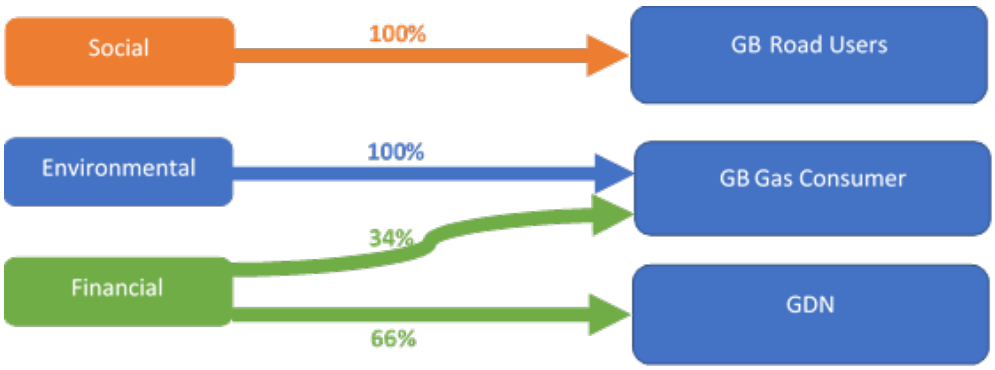
|---|---|---|---|
| Project code | SGN_GN_04 | Question Number | Q5 |
| Question date | 29/08/17 | Answer date | 31/08/17 |
| Submission section question relates to | Multiple | | |
| Topic | a) Enviro+consumer bens | | |
| Question | Please explain to whom the different benefits of RRES will flow, eg tech provider, networks, customers etc. | | |
| Notes on question | | | |
| Answer | The directly attributable benefits of the RRES fall to three groups; GB Road Users; GB Residents and the GDN's. These can be summarised as environmental, social and financial. The diagram below shows the flow and distribution of each.   | | |
| Attachments | | | |

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|---|---|---|---|
| Project code | SGN_GN_04 | Question Number | Q6 |
| Question date | 29/08/2017 | Answer date | 31/08/2017 |
| Submission section question relates to | Multiple | | |
| Topic | a) Enviro+consumer bens | | |
| Question | Please provide full life cycle impacts of RRES, not just impacts from 'use'. Please use clear summary tables/diagrams to help convey methods, assumptions and benefits. | | |
| Notes on question | Apologies but we're not sure what's being asked here. Could you expand a little please if not answering what you are looking for? | | |
| Answer | By 'full life cycle impacts' is that the impact on the network in terms of remediation or is this a question about the probable life cycle of a RRES unit in terms of it mechanics/build or something else completely?<br><br>Reinstatement using the RRES method will be subject to the same reinstatement life requirements specified by HAUC and RAUC.<br><br>Any work on our assets following the RRES will require to meet the same standards in terms of asset life, unless demonstrated otherwise.<br><br>Full life cycle costs of the RRES should be comparable with any other similar vehicle. | | |
| Attachments | | | |

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| Project code | SGN_GN_04 | Question Number | Q7 |
| Question date | 29/08/17 | Answer date | 31/08/17 |
| Submission section question relates to | Appendix C | | |
| Topic | g) Robust methodology/ready to implement | | |
| Question | The time plant and TRL maturation plan in Appendix C are illegible. Please provide a suitable high resolution copy. | | |
| Notes on question | | | |
| Answer | Apologies. Please find high resolution copies in the PDF attachment below. | | |
| Attachments |  [redacted] | | |

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| Project code | SGN_GN_04 | Question Number | Q8 |
| Question date | 29/08/2017 | Answer date | 31/08/2017 |
| Submission section question relates to | Multiple | | |
| Topic | g) Robust methodology/ready to implement | | |
| Question | What literature study has been conducted? What learning can be applied from other applications/industries?<br><br>i) Will code be developed from scratch for RRES?<br><br>ii) Is there a plan to research other relevant applications (other industries) before specifying/purchasing/developing RRES hardware/software?<br><br>iii) Can scope be reduced through research? Finding alternative sources for the technologies, at a higher starting TRL? | | |
| Notes on question | | | |
| Answer | Following ULC's response to our call for innovation in confidence, we carried out a detailed industry search for existing/new products and felt that their proposal was unique.<br><br>Following this review, in partnership with ULC, we carried out a more detailed feasibility study to identifiywhich existing technologies utilised in a wide range of applications and industries could be suitable for integration to the RRES application. Literature published on company websites, in trade journals and in scientific journals were reviewed. The results of the feasibility study were documented in a report that is available for review (albeit a large document). ULC and SGN intend to adopt learning as far as possible from other applications/industries by leveraging technologies already commercialised in those industries.<br><br>i) Some code will be developed from scratch for RRES. Some source code will be used as well. It is difficult to predict how much of the code will be custom-developed prior to initiating the project. It will depend on the robotic arm, mobile platform, and cameras and sensors selected. Efforts will be made to use source code where possible and to emulate existing closed-loop feedback control algorithms as appropriate.<br>ii) Research performed during the feasibility study will be revisited and expanded prior to the selection of RRES hardware or the development of software.<br>iii) The TRLs provided in the proposal represent ULC and our best approximation of the project scope based on previous research on available technologies. If it is determined during the project that, | | |

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| | based on recent developments or innovations, alternative sources with higher TRLs are available, then the scope will be reduced accordingly. |
| Attachments | |

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| Project code | SGN_GN_04 | Question Number | Q9 |
| Question date | 29/08/2017 | Answer date | 31/08/2017 |
| Submission section question relates to | Appendix I | | |
| Topic | g) Robust methodology/ready to implement | | |
| Question | In the Risk Register (Appendix I), several risks appear to be missing. Some are identified earlier in the submission but not logged/appraised in Appendix I. Please expand on the risks and mitigations proposed. Particularly:<br><br>i) Risk: The risk of poor RRES market uptake.<br><br>EG Mitigations: Customer questionnaires? Use of existing tooling/methods (but with automation)? Trialling of new tooling with users? Gaining consumer buy-in? Accessibility by other markets (how are details communicated?) Etc.<br><br>ii) Risk: Low RRES utilisation.<br><br>EG Mitigations: RRES is suitable for many excavation types (which?). What conservatisms are placed on the utilisation (e.g. jobs per year) planned for RRES in the cost benefits?<br><br>iii) Risk: Overrun on project Time and/or Costs.<br><br>EG Mitigations: alternative funding streams? Options for trimming scope if needed? Confidence in time/cost estimates from previous, similar projects (please provide specifics)?<br><br>The impact of these risks should be considered and presented in feedback. | | |
| Notes on question | | | |

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| Answer | We have updated the risk register to include the three risks specifically highlighted and mitigation plans for each prior to the final RRES submission:<br><br>Risk: If the RRES market uptake is poor, the full value of the RRES as described in the cost-benefit analysis may not be realised.<br><br>Controls and Mitigation: A – Distribute customer and stakeholder questionnaires to ensure that customer needs are being addressed; B – Design robotic tooling, including soft-touch excavation tooling and Universal Access Fitting (UAF) installation tooling, so as to enable operation and commercialisation without the use of a robotic arm; C – Disseminate Interface Control Drawing (ICD) for open-source tooling; D – Continue to seek out project partners in the utilities and industrial sectors<br><br>Risk: If the RRES utilisation is low, the cost per excavation will continue to increase and the full value of the RRES outlined in the cost-benefit analysis may not be realised.<br><br>Controls and Mitigation: A – Design control algorithms for mobile platform and toolpath generation such that the size and shape of excavations that can be performed is maximised; B – Disseminate Interface Control Drawing (ICD) for open-source tooling so as to maximise the number repair and inspection operations which can be performed on excavated infrastructure;<br><br>Risk: There is a risk that the project scope cannot be delivered within the allocated budget and schedule<br><br>Controls and Mitigation: A – Use a phased approach to project planning with go/no-go milestones such that the project can be reevaluated upon completion of key milestones and terminated if needed; B – Maintain a prioritised list of potential scope reductions that can be exercised if needed (e.g. elimination of automated tool changing, UAF installation tooling, etc.); |
| Attachments |  <br>[redacted] |

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|---|---|---|---|
| Project code | SGN_GN_04 | Question Number | Q10 |
| Question date | 29/08/2017 | Answer date | 31/08/2017 |
| Submission section question relates to | Multiple | | |
| Topic | c) Generates new knowledge | | |
| Question | Please provide additional information on the openness and interconnectivity planned for RRES. In particular:<br><br>o It's unclear how technical specifics (hardware and software) will be communicated to the market (and other industries) enabling wider uptake and development of RRES.<br><br>o This is important to support its replication/development across GB.<br><br>o For example – will copies of code be shared? What features of the hardware design will be open? What features will ULC/SGN retain IP on? Will there be training sessions for the industry/users on RRES, to support their on-going use/development?<br><br>o Please present a plan for the dissemination of RRES specifications to the market, including any training that might be required for a 3rd party to adopt the (likely complex) development methods/tools/scripts. | | |
| Notes on question | | | |
| Answer | • An interface control drawing (ICD) will be developed for the robotic arm. This is a technical document which will provide the details required for companies in the market to develop tooling that would successfully integrate with the arm. Information on the geometry and structure of mounting or interlocking features, the supply power, and supplied air pressure will be provided. The communication protocol used to actuate and control tooling will be identified. It will be determined under the project whether or not an Application Programming Interface (API) will be developed to enable companies to write their own software. The operator console developed under the project could be designed to accommodate open-source tooling, with specific controls accessible for programming through the API. If an API is not utilised, ULC would provide services to develop custom software and/or operating consoles for companies designing additional tooling for the RRES.<br>• In general, the software developed for the RRES will not be made publicly available. The software is not needed for companies to develop custom tooling. Only the information required for companies to develop tooling that can interface with the RRES will be provided, as outlined above. SGN will retain all foreground IP on behalf of the | | |

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| | GB gas consumer, in proportion to the funding, on all aspects of the system and any tooling developed under the project. ULC and SGN would not have IP rights to tooling developed by other companies for use on the RRES.<br>• To aid in the dissemination of RRES specifications to the market, an online manual is proposed to be developed upon completion of the project containing the ICD as well along with a case study of tooling developed for the RRES. The case study would provide descriptions of how the tooling was designed to integrate with different RRES interfaces according to the ICD. 3D models of the example tooling would be disseminated with the manual. The goal of this manual would be to make the information needed to design custom tooling accessible to anyone with an engineering background. |
| Attachments | |

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| Project code | SGN_GN_04 | Question Number | Q11 |
| Question date | 29/08/2017 | Answer date | 31/08/2017 |
| Submission section question relates to | Multiple | | |
| Topic | N/A | | |
| Question | Soft-Touch Tooling:<br><br>i) What was the scope/duration/cost of the soft-touch tooling project? How does this compare with the many components RRES will need developed? Does this show credibility to the current plan (which seems very ambitious in the timeplan/costings)?<br><br>ii) Please provide more information on preceding, similar project scope/costs/duration including the soft-touch tooling project (to give confidence the scope proposed here is feasible in the suggested time and cost).<br><br>iii) Provide some technical information for the soft-touch tool, demonstrating the claimed TRL and what was achieved in the time/cost allocation in previous work. | | |
| Notes on question | | | |
| Answer | i) The development process for the prototype soft-touch excavation tooling that was developed during the RRES R&D study included research on potential methods for soft-touch tooling, development of multiple conceptual designs, detailed development of the selected design concept, fabrication, proof-of-concept testing, design iterations to improve performance, and final testing. Multiple potential solutions were considered, and the selected solution was tested as quickly and as simply as possible. Existing equipment available in ULC's shop, such as a hand drill and vacuum pump, were used to facilitate rapid early testing of the device. This allowed the team to focus on validating and improving the most challenging aspect of the design – the agitation and removal of soil. After initial testing was completed, improvements were made to the tool's auger design and a camera was added to the tool to provide visuals during excavation. [redacted] | | |

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| | ii) The process described above is representative of ULC's rapid and flexible approach to product development. ULC's small size allows the company to operate in a fashion similar to technology startups, whereby close-knit project teams can generate ideas, build prototypes, and change direction if needed very quickly. This is enabled by minimal bureaucracy, a well-rounded and resourceful engineering staff, and in-house fabrication equipment such as mills, lathes and 3D printers. While no two R&D projects are the same, ULC has a proven track record of delivering on similar scope within the allocated costs and duration, both in partnership with SGN, but for other utilities and industry too. For instance, the Robotics project awarded through NIC in 2013 is comparable to the RRES project in terms of the magnitude of the scope, budget and schedule.<br><br>Please refer to pages 40 through 58 of the RRES feasibility study for technical information on the prototype soft-touch tooling including images of 3D models and the fabricated device, documentation on the development process, and details of the prototype's test performance. The claimed TRL of 4 is commensurate with the development and testing performed during the R&D study; the soil-lift technology has been validated, and the design will be improved and adapted towards commercial rollout under the project.<br><br>A copy of the preceeding NIA final report is available in either hard or soft copy by request (albeit a large document). |
| Attachments | |

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| Project code | SGN_GN_04 | Question Number | Q12 |
| Question date | 05/09/17 | Answer date | 05/09/17 |
| Submission section question relates to | Appendix D | | |
| Topic | N/A | | |
| Question | Would the team working on this be the same as the project team who worked on the previous SGN and ULC Robotics project? | | |
| Notes on question | | | |
| Answer | The principles and structure utilised for the establishment of the Robotics project will be used for the establishment of the SGN RRES team. The core team will be headed up by Ollie Machan who had significant involvement with the Robotics bid. It is likely that others within SGN who had involvement in the Robotics project, such as members of the Policy and Operational teams would be involved again, leveraging their knowledge.<br><br>Core ULC team members from the NIC Robotics project will work on the RRES project as either part time or full time contributors or as advisors. Their experience developing complex robotic systems, experience deploying technology in and around gas piping and for their ability to ideate, evaluate and enable new sensing and robotic technology for use in critical environments will de-risk the project and provide a more streamlined workflow. | | |
| Attachments | | | |

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| Project code | SGN_GN_04 | Question Number | Q13 |
| Question date | 05/09/17 | Answer date | 05/09/17 |
| Submission section question relates to | 5.3 | | |
| Topic | c) Generates new knowledge | | |
| Question | Please explain the IP arrangements in more detail? | | |
| Notes on question | | | |
| Answer | Upon project award, ULC and SGN will enter an agreement that will fully define and dictate project terms and conditions and delivery criteria. SGN and ULC have already agreed in principle that both parties are committed to the default IPR position from the Phase 1 and 2 RRES feasibility studies. The Phase 1 and 2 feasibility study agreements were designed to enable a smooth transition into a future NIC project.<br><br>Under the NIC RRES project agreement, SGN will ultimately own IPR for technology developed under the project. ULC will register all applicable IP to ensure that new developments are protected as early as possible. This will be assigned to SGN, along with any foreground IP developed by SGN or others involved in the project. Any registered IP will be licenced to ULC upon completion of the project. If rollout of RRES is successful, sales or services of the system, or derivative works requiring IP, will be subject to royalty payment. Any Royalty will be returned to Gas Customers in proportion to the funding via the royalty return mechanism.<br><br>Multiple royalty scenarios have been considered and have been expanded upon in Section 5.3 of the bid submission. Each of the scenarios provide a royalty to be paid to Ofgem as the technology is deployed as a service, sold as a product and as new tooling and functionality is developed by ULC or third party developers.<br><br>Network Licensees will have the right to use Relevant Foreground IPR within their network royalty free. They cannot sell or grant sub licenses to Relevant Foreground IPRs.<br><br>A license will be provided to qualified third party developers and purchasers of the technology to enable a royalty to be acquired and passed on to the GB gas consumer via Ofgem. | | |
| Attachments | | | |

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| Project code | SGN_GN_04 | Question Number | Q14 |
| Question date | 05/09/17 | Answer date | 07/09/17 |
| Submission section question relates to | N/A | | |
| Topic | b) Value for money | | |
| Question | How many times a year are the operations that the RRES would be used for required? | | |
| Notes on question | As touched on in Q1, by design the RRES seeks to reduce the excavation requirements and associated reinstatement for every operation in either urban or rural environments where there are different operational requirements. | | |
| Answer | In the urban setting, the RRES is anticipated to be utilised for around 576 excavations each per year with the peak addressable work volumes rising to around 37,500 excavations by 2026. This would equate to a peak fleet size of around 65 RRES's.<br><br>In the rural setting, which aligns more to volume of excavation rather than frequency of excavation, we're the RRES to have an capacity of around 4m3 an hour. We're expecting to excavate around 12,000m3 per annum which equates to 375 8-hour days and 2-4 RRES's dependent on geographic need and service delivery model. | | |
| Attachments | | | |

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| Project code | SGN_GN_04 | Question Number | Q15 |
| Question date | 05/09/17 | Answer date | 05/09/17 |
| Submission section question relates to | Multiple | | |
| Topic | b) Value for money | | |
| Question | i) What would this project add to sensing technology above and beyond what is already available?<br><br>ii) What are the benefits of this project above having a digger mounted manually operated cutting and sensor enabled vacuum system? | | |
| Notes on question | | | |
| Answer | i) It is anticipated that no new sensor or vision technologies will be developed as a part of the project. In that sense, the project would not "add" to sensing technology beyond what is currently available. However, the project will generate capabilities that are not commercially available by integrating multiple existing sensor and vision technologies in a system with closed-loop feedback control.<br>ii) While a manually operated soft-touch excavation tool mounted to a backhoe or similar equipment would offer benefits over existing methods, its functionality and conditions for use would be limited. Development of the full RRES proposed in our bid submission would afford GDNs and other utility companies several advantages.<br>a. While the manually-operated system could be programmed to abort soil agitation when an object is detected, the operator would still be free to lower the tool deeper into an excavation and potentially impact infrastructure, thereby incurring cost penalties and safety risks. Automated manipulation of the tool ensures that both the soil agitation and movement of the tool are aborted when an object is detected.<br>b. The manually-operated system would be limited to performing excavations. The automated RRES will perform excavation as well as coring, tamping, repair, and reinstatement operations. An automated tool changing system will allow the RRES to quickly and safely transition between different operations. Open-source tooling will facilitate continued expansion of the types of operations the system will be capable of performing. Automating these operations allows for reductions in the size of excavations, the personnel requirements, and the safety risks.<br>c. The proposed system features a robotic arm mounted to a mobile platform. The small size and mobility of the system will allow it to be deployed in remote areas in which GB's local transmission network often resides. The mobile platform will also enable larger | | |

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| | areas to be excavated seamlessly by commanding the robotic arm to new locations as an excavation is proceeding. |
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| Project code | SGN_GN_04 | Question Number | Q16 |
| Question date | 05/09/17 | Answer date | 05/09/17 |
| Submission section question relates to | Multiple | | |
| Topic | Multiple | | |
| Question | What are the benefits of using robots rather than people? Has customer acceptance been considered? | | |
| Notes on question | | | |
| Answer | There are several benefits linked to using robots rather than people:<br>• The risk of human injury or loss of life is eliminated<br>• The number of people required to perform operations can be reduced<br>• The time it takes to perform operations can be reduced<br>• The size of excavations can be reduced<br>• The risk of damage to buried infrastructure can be greatly reduced<br><br>Customer acceptance has indeed been considered and SGN in committed to engaging our customers. Section 8 of the bid submission goes into much further details on our plan for listening to customers and incorporating that feedback. | | |
| Attachments | | | |

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| Project code | SGN_GN_04 | Question Number | Q17 |
| Question date | 05/09/17 | Answer date | 05/09/17 |
| Submission section question relates to | N/A | | |
| Topic | Multiple | | |
| Question | Please provide a justification for the scale of the funding contribution provided by ULC in relation to the benefits that they will accrue if the project is successful and they are able to seel the resulting product. | | |
| Notes on question | | | |
| Answer | This project has an ambitious scope and will provide substantial benefits if successful. There are inherent technical risks associated with an R&D project of this magnitude and complexity; SGN and ULC will largely bear the burden of managing these risks and overcoming technical challenges that surface over the course of the project. Although an SME, due to the importance of this project, ULC has provided co-funding to support the development of this system. The offer of co-funding at this early stage of development demonstrates ULC's commitment to developing and commercialising this technology on behalf of the GB gas consumer. We believe the scales of the co-funding is appropriate for an SME at this early stage of the development project.<br><br>At the conclusion of the project, a greater direct investment in the commercialisation will be required to support the commercial rollout should the project be awarded and if it is successful.<br><br>In addition to the co-funding contribution, ULC also offers the following in-kind contributions and potential future benefits:<br><br>• To aid in the dissemination of RRES specifications to the market, ULC will provide a free demonstration to the GB GDNs, other utility networks and construction companies at the completion of the project. Additionally, ULC will invite high potential manufacturers and third-party developers to the technology demonstration. This in-person demonstration will provide an ideal forum for preliminary information sharing on the technology and will open the door for other companies to develop expansion capabilities for the RRES.<br>• As a follow-on to the demonstration and to broaden the information sharing, ULC will market to and engage other high potential manufacturers and third-party developers, not available to attend the demonstration, to present the new technology.<br>• As alternative developers are identified, ULC will support training and technical consultations and will modify RRES design documentation to | | |

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| | streamline the development time/resources needed to maximise the benefit of the RRES.<br>• Beyond the completion of the project, ULC will become the lead marketer and technology commercialiser and will continue the developing the technology to enable a transition into business as usual at the UK GDNs and to expand opportunities for the system outside of GB. The IP arrangements for the RRES project, along with the NIC funding, will enable ULC to provide a path to commercialisation for the RRES technology.<br><br>Based on these factors, we believe ULC's funding contribution is commensurate with the risks and value if the project is successful. |
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| Project code | SGN_GN_04 | Question Number | Q18 |
| Question date | 14/09/17 | Answer date | 19/09/17 |
| Submission section question relates to | 9 | | |
| Topic | g) Robust methodology/ready to implement | | |
| Question | You appear to have allocated 10% to each of the project deliverables. Please provide a justification that the proposed percentage of funding associated with this deliverable is appropriate – some of the deliverables appear to relate to inputs and others relate to outputs from the project. Would it be appropriate for deliverables that relate to learning to have a higher level of funding associated with them than those that inform the development of the learning. | | |
| Notes on question | | | |
| Answer | Deliverables for the project were selected because they are key stage gates that will have a substantial impact on the learning acquired, the technology developed and the outputs of the project as a whole. Upon review, the NIC funding percentages in the table within the bid document were incorrect or misleading, rather it was intended that this table evidence the % of work completed by each Go/no go stage gate or deliverable.<br><br>Following the challenge from the expert panel regarding clarity of effort associated with each aspect, we have sought to clarify the work and the payment terms for our primary partner ULC relative to the deliverables, and provide an associated short summary of outputs and ongoing work. This is detailed in the table attached. This does not affect the project plan or payment structure, rather it now better reflects the cumulative effort and its value. | | |
| Attachments |  <br>SGN_RRES_150917_<br>Q18_DeliverablesTab | | |

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| Project code | SGN_GN_04 | Question Number | BQ1 (Q19) |
| Question date | 26/9/17 | Answer date | 10/10/17 |
| Submission section question relates to | | | |
| Topic | | | |
| Question | Please provide more detail regarding the project plan, highlighting key junctures over the project's life, where there may be a risk of delay or where key go/no-go decisions might be taken based on evidence that becomes available. | | |
| Notes on question | | | |
| Answer | The development of the RRES is divided into four elements:<br><br>• Element 1: Development of major subsystems<br>• Element 2: Integration of Element 1 subsystems and initial testing<br>• Element 3: Mobile operations, fittings, tooling and support vehicle<br>• Element 4: Complete integration and live field test<br><br>Project deliverables are distributed throughout the plan to mitigate risks and to provide practical Go/No-Go points over the course of the project. As shown in the project plan (Appendix C of the bid submission) and in Section 9 of the bid submission, a total of ten project deliverables with associated Go/No-Go Stage Gates have been proposed. These are situated at critical dates in the project and allow SGN to put the project on hold and revise its status or terminate the project should SGN believe that it will fail to deliver the objectives. Note: in response to the Expert Panel's inquiry (#18), an updated table outlining deliverables, their weighting along with details of tasks which will be performed in parallel has been provided.<br><br>Multiple development and procurement workstreams will be executed in parallel to minimise the project duration and so that subsystems can be specified, designed or procured, and tested in concert with one another. Parallel development increases the likelihood that the integrated system will function as intended. As an example, consider the development of the RRES below-ground sensing capability. Generally, sensor performance is significantly influenced by the method and process of deployment. Evaluating the performance of sensors mounted on the robotic arm will enable the most efficient, accurate and reliable outputs to be achieved during testing.<br><br>Note that at multiple stages during this parallel development process, learnings from the development and testing of one subsystem will inform the selection, procurement activities and development related to others. For instance, as specifications for excavation tooling, such as the subsystem's weight and size, are being developed, they will inform the selection of an | | |

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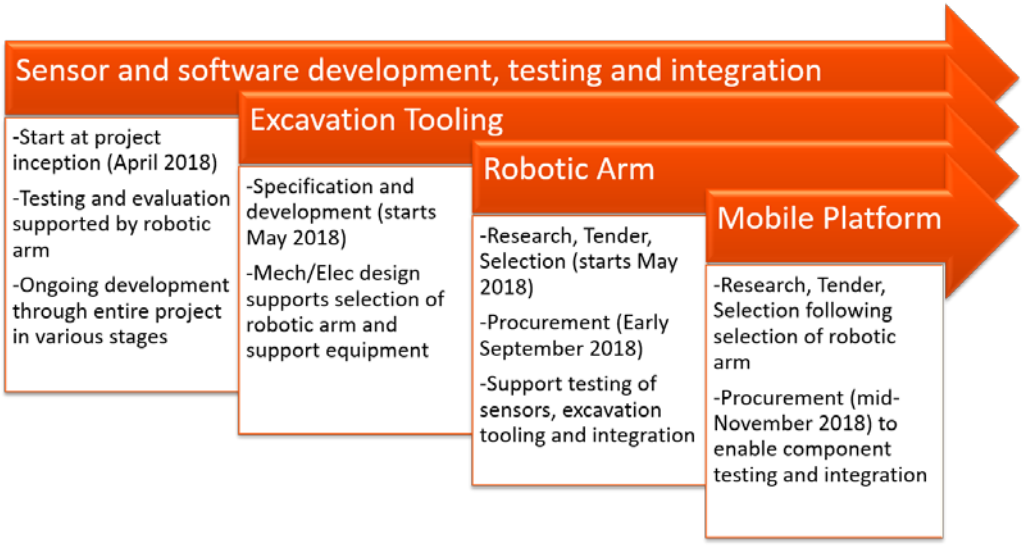
| | appropriate robotic arm (deployment method) based on parameters such as load capability and range of motion.<br><br>Schedule risks by Element will be monitored during the course of the project. Below is a summary of potential risks of delay:<br><br>• Final selection and lead time for robotic arm and sensors extends beyond planned durations<br>• Challenges which may arise due to integration of individual components into a complete system (selection/lead time)<br>• Software programming which exceeds planned durations and resource requirements<br>• Challenges associated with sourcing support equipment (selection/lead time)<br>• Unplanned iterations of design related to Universal Access Fitting (UAF) prior to field testing<br>• Unplanned requirements or challenges associated with site selection, permitting or approval to proceed with field testing |
| Attachments |  |

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| Project code | SGN_GN_04 | Question Number | BQ2 (Q20) |
| Question date | 26/9/17 | Answer date | 10/10/17 |
| Submission section question relates to | | | |
| Topic | | | |
| Question | Please provide a breakdown and more detail to justify the claimed time saving benefits expected of this technology compared to typical current practices. Currently, not all the time taken to do the work relates to the excavation process. | | |
| Notes on question | | | |
| Answer | At a high level, the RRES offers time savings over conventional and core-and-vac excavation methods in three key areas:<br>• Logistics: Because the RRES and associated support equipment requires a much smaller footprint than existing excavation methods, less site preparation (e.g., road closures, redirecting traffic) is required in advance of excavation work. Additionally, downtime between tasks is minimised since much of the labour is automated.<br>• Automated soft-touch excavation: By reducing the risk of cable strikes, third party damage and site planning, soft-touch tooling technology enables excavations to be carried out more rapidly than conventional or core-and-vac methods. For roadworks, the excavation footprint is substantially reduced compared to other methods since the RRES will require less space to perform operations than would be required for an operative to enter the excavated area. It also eliminates the need for time-intensive hand digging in the danger zone around transmission pipeline.<br>• Active sensing: The identification of buried assets enables the safe and efficient completion of excavation. Obstacles in the path of the RRES can be identified before they are reached and the excavation methodology can be adjusted accordingly; creating a more agile approach to operations.<br>Detailed breakdowns of the time savings benefits expected for the RRES in comparison to existing roadworks and transmission works are provided in the attachment. In both cases, time savings for all work related to the excavation process (not just the excavation itself) are addressed.<br>The term HAVS is the collective name for a range of injuries caused by hand transmitted vibration. HAVS is caused by regular and prolonged exposure to high levels of vibration resulting in damage to the tissues of the hands and arms.<br>Symptoms can include: | | |

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| | • Circulatory disorders - blanching of the fingers<br>• Numbness and tingling in the fingers<br>• Reduced sense of touch and temperature<br>• Reduced grip and dexterity<br>• Joint pain and stiffness in the hand and arm<br><br>The Control of Vibration at Work Regulations 2005 requires employers to protect employees from vibration at work.<br><br>We seek to achieve this by eliminating or controlling the exposure of workers to vibration. Our aim is to prevent any new cases or deterioration of existing cases and currently this is controlled by managed Exposure Action Values and Exposure Limit Values for operatives. If successful, the RRES system would not only eliminate exposure to HAVS for our operatives, but it will also remove significant downtime due to operative switchover for vibration exposure.<br><br>Exposure Action Value (EAV) 100 points:<br><br>This is the level of daily exposure to vibration for an employee above which we are required to take specific action<br><br>Exposure Limit Value (ELV) 400 points:<br><br>The ELV must not be exceeded by any employee during any given day.<br><br><br><br>Example 'White Finger'. |
| Attachments | RRES Time Savin |

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| Project code | SGN_GN_04 | Question Number | BQ3 (Q21) |
| Question date | 26/9/17 | Answer date | 10/10/17 |
| Submission section question relates to | | | |
| Topic | | | |
| Question | Please give more information on the range of likely financial impacts and timings of the further introduction of lane rental charges. | | |
| Notes on question | | | |
| Answer | The Government recently published a consultation paper entitled “Road works: The future of lane rental”. It offers four options based on the findings of trial lane rental charges in relation to permitting in parts of TFL and Kent:<br>• Baseline Option: Allow the trial to lapse (March 2019). This would mean the current schemes would end in March 2019 and no new schemes would be permitted. Permit schemes would be the main way that all road works were managed on all roads.<br>• Option 1: Retain lane rental in London and Kent. This would require a minor amendment to secondary legislation to remove the sunset clause.<br>• Option 2: New schemes permitted but on condition that certain criteria are met, for example, a permit scheme was in operation. This could be on a limited basis or it could be deployed more widely. It would be for authorities to ask for approval from the Government for schemes.<br>• Option 3: Amend permit schemes and add a new ‘super permit’ for works on the most congested roads. This would use permitting, which applies to all works on all local roads, to implement the key policy aims of lane rental and would allow those 60% of permitting LHAs that operate permit schemes to vary their schemes and include this new level of permit without the need for any approval from the Government.<br>The embedded graphic below illustrates the potential impact of Option 2. This very basically takes the current trial spend and then uplifts it to reflex the proportional difference between the incomes for the Option 1 (retention of the trial) and Option 2 (full roll out) as per the consultation paper analysis appendices (Lane Rental only, not incorporating permitary changes). | | |

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| | We're actively analyzing what the impact of this is and further and more detailed analysis will be undertaken and incorporated into the resubmission of the bid which will supersede this. |
| Attachments | Continuing to operate using traditional methods would generate a significant pass-through costs to consumers<br>• The table below shows the potential impact of Option 2:<br><br>**Scenario** / **£m p/a** / **GD2 Impact £m**<br>Current Trial Area / 0.74 / -<br>All Areas (Traditional) / 1.92 / 15.36<br>All Areas (RRES)* / 1.44 / 11.50<br><br>*Does not include additional savings relating to hourly lane rental introduction. |

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| Project code | SGN_GN_04 | Question Number | BQ4 (Q22) |
| Question date | 26/9/17 | Answer date | 10/10/17 |
| Submission section question relates to | | | |
| Topic | | | |
| Question | Please provide more detail on the anticipated key benefits that the sensing and soft touch tooling technologies will provide. | | |
| Notes on question | | | |
| Answer | RRES sensors enable active avoidance of infrastructure throughout the excavation process:<br><br>• Pre-excavation surface scanning detects underground pipelines, cables and obstacles prior to breaking ground<br>• Layer-by-layer scanning during excavation ensures that the soil to be removed is clear; the RRES system will alert the operator if an unknown object is identified<br>• Cameras and sensors will allow the RRES to recognise pipelines, cables and objects as layers of soil are removed and avoid contact<br>• Allows more coring operations to be performed along with eliminating aborted coring operation due to late asset detection<br><br>Soft-touch tooling adds a redundant safety feature that further protects buried assets during the excavation process:<br><br>• Auger agitation and soil lift rapidly removes soil<br>• A protective shroud surrounds the auger to prevent the rotating auger from impacting buried infrastructure<br>• Integration with sensors will provide the first “smart” excavating tool<br><br>The benefits of active sensing and soft-touch tooling include:<br>• Reduction in site preparation resources and costs<br>• Higher efficiency and repeatability through sensing/soft touch tooling<br>• Substantial social cost benefits through reduced:<br>  • Site footprint, time in street<br>  • Carbon emissions through lower usage of heavy construction machinery and vehicles<br>  • Excavated material to landfill through reinstatement using the original road surface<br>• Increased confidence while digging – RRES effectively de-risks excavation activity by removing human operatives<br>• Indirect cost savings due to avoided damages and interruption of energy supply | | |

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| Project code | SGN_GN_04 | Question Number | BQ5 (Q23) |
| Question date | 26/9/17 | Answer date | 10/10/17 |
| Submission section question relates to | | | |
| Topic | | | |
| Question | Please provide more information as to why this project is value for money for consumers and that the consumer contribution (vs company contribution) is proportionate to the benefits that may be realised. | | |
| Notes on question | | | |
| Answer | The RRES project will yield significant value for consumers if successful. This project can be the catalyst for future developments and advancements in roadworks. Given the ambitious scope of the project, investment is needed to complete the work scope.<br><br>The projected costs were tabulated by estimating the labour and materials (subsystems, hardware and raw materials) required to complete the project. ULC's labour costs were benchmarked against other industry leaders with similar technical expertise and were found to be competitive. Estimates for the cost of major subsystems (such as the robotic arm) were formulated based on two focused bodies of early stage development and research conducted under NIA funding. During the project, procurement of all major subsystems will undergo a competitive bid to ensure cost competitiveness and to eliminate supply chain challenges. ULC is providing £200k of the project funding to support project mobilisation (at its own risk), thereby reducing the cost to consumers.<br><br>GB gas consumers will attain several key benefits:<br><br>• Avoided disruption, street-works, social costs and potentially lane rental will provide long term ROI and benefits to the consumer.<br>• Substantial royalty-bearing IP may be generated on behalf of GB gas consumers.<br>• Future form factors and development will provide future growth of applications and benefits for consumers, as will transferability of the developed technology to other utility and infrastructure sectors such as Construction, Electricity and Water.<br>• ULC will offer free technology demonstrations to UK GDNs, other utility companies, construction companies, high-potential manufacturers and third-party developers to open the door for expansion of capabilities.<br>• ULC will also provide support, training and technical consultations to further expand application of the technology.<br><br>These benefits are further detailed in Section 3 of the bid submission | | |

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| Project code | SGN_GN_04 | Question Number | BQ6 (Q24) |
| Question date | 26/9/17 | Answer date | 10/10/17 |
| Submission section question relates to | | | |
| Topic | | | |
| Question | The NIA project identified a wide range of sensor and excavation technologies. However, it is unclear how these technologies would be selected, combined and developed into a single system, and what the limitations of that system would be. Experience from other domains (such as IED detection) has shown that this is very difficult. | | |
| Notes on question | | | |
| Answer | Sensor technologies will be evaluated and selected based on the following primary selection criteria:<br><br>• Capability: what objects, structures, and materials can the device sense?<br>• Efficacy: how reliably/quickly can the sensor detect targets of different sizes, compositions, and shapes through different mediums at different ranges?<br>• Physical: size and weight must conform to application (i.e. end of arm, platform mounted).<br>• Cost: must fit into project budgetary requirements.<br>• Maturity: how long has this method of sensing been utilised? How long has this particular sensor been commercially available?<br><br>Secondary focus areas for sensor selection include:<br><br>• Operational: power/data requirements, deployment considerations and consumables.<br>• Compatibility: is this sensor affected by other potential sensors or prevalent environmental conditions (i.e. wind, rain, sunlight, humidity, dust…etc.)?<br>• Stability: realignment or calibration requirements.<br>• Durability: can the sensor survive the physical demands required by the application?<br>• Lifetime: how long is the device expected to survive while utilized at a specified duty cycle in its intended environment?<br><br>Crucial to the selection of sensors is the determination of the types of utilities that will be initially detected by the RRES and the environments in which they will reside. For instance, the system will be developed to detect PE pipe in soil, so ULC will concentrate its efforts on technologies which can detect a void in the soil (formed by the PE pipe). The attached document, | | |

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| | "Common Buried Utility Types", provides a breakdown of potential pipe/wire materials and soil types that may be encountered and will provide the initial focus for sensor development. Under the NIA project, this comprehensive list was used as a guide for the evaluation of sensor technologies. Please refer to Appendix D, "Sensor Selection based on Buried Infrastructure" of the RRES feasibility study for specific details on the materials detected by different sensors and the soil types in which they perform best.<br><br>The attached "Technology Development Process" illustrates the tasks that will be executed to combine the selected technologies into a single system. ULC engineers have extensive experience integrating sensors and closed-loop feedback networks to implement control.<br><br>Note: The challenge of infrastructure detection is simpler than that of IED detection and certain other applications since the range of pipe materials and sizes are consistent and well understood, and the sensing is limited to a short rather than wide range (the region to be excavated) due to the fact that the target asset location is generally known prior to excavation.<br><br>One limitation of the RRES sensing technology is that the initial development will be focused on excavation of vertical columns in urban environments and transmission main danger zone excavation in rural environments. The physical size of the initial design and associated support equipment will limit its use to the selected applications (urban keyhole and rural transmission main excavation). However, future development could yield alternate form factors with a wider range of applications. Additionally, elements of the initial system may be manually controlled, but the system's capabilities will can be further automated over time. |
| Attachments |  <br>Common Burie<br>  <br>Technology |

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| Project code | SGN_GN_04 | Question Number | Q25 |
| Question date | 10/10/2017 | Answer date | 12/10/17 |
| Submission section question relates to | | | |
| Topic | | | |
| Question | Please provide more figures to explain the time saving benefits expected of this technology compared to typical current practices described in response to Q20 (Q2 of Big Questions). | | |
| Notes on question | Please see the attached figures providing ranges of time estimates for excavation and associated operations. These estimates are provided for both distribution works and transmission works. Note that for distribution works, the RRES process is compared with the core and vac process. | | |
| Answer | Time ranges are provided for each operation to be performed by the RRES based on research performed with NIA funding on the RRES system architecture. These ranges represent the durations we expect to achieve upon commercial deployment of the RRES. The time ranges will vary from excavation to excavation, and an attempt was made to characterise the typical variability of the environments that will be encountered; for example, mains that are located deeper in the road surface will require more time-intensive excavations than those which are closer to the surface.<br><br>One of the key advantages offered by the RRES is that operational procedidure is not subject to down time. The time savings benefits for urban distribution works presented also capitalise on lost time by recognising there are situations where core and vac cannot be used when the RRES can be. For rural transmission works, it is expected that significant time savings will be achived for excavation within the hazard zones. The time it takes the RRES to perform different operations will be evaluated during field trials; the results will be compared to existing methods for excavation and associated operations. | | |
| Attachments |  | | |