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The Potholes Challenge

Achieving a Sustainable Response to Potholes

Pilot of the Digital Intelligent Brokerage Hub



Department
for Transport

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Executive Summary

The Digital Intelligent Brokerage Hub

The Department for Transport (DfT) supported the rollout of a Digital Intelligent Brokerage Hub to accelerate the benefits of research and development in addressing the potholes challenge. This was based on a pilot in collaboration with Wiltshire Council, and has demonstrated the potential for Small and Medium Enterprises (SMEs), to bring innovation to the local highways sector.

The Key Benefits from the Digital Intelligent Brokerage Project

The DIB project has also successfully demonstrated the potential for broadening engagement with Small and Medium Enterprises (SMEs), academia and other innovative organisations (collectively referred to as SMEs throughout this report); and encouraging cross-sector learning and shared best practice, and their potential role in promoting market growth and supporting increased productivity for UK plc.

The new and innovative approach taken by DIB is designed to explore challenges through a formal process; in this instance framed through the Pothole Challenge, by framing the underlying challenges and promoting active engagement with the broader supply chain and improving the definition of outcomes.

The approach enables the identification of appropriate SME capacity and capability to achieve the required outcomes.

Finally, the DIB approach sought to encourage technological and product innovation from SMEs whilst simultaneously identifying opportunities to introduce these innovations into local authority supply chains.

Four key theme areas were defined in consultation with a broad cross section of representatives from Wiltshire's highways team:

- > Repair;
- > Customers and Communication;
- > Design and Prevention; and
- > Our Digital Challenge.

The challenge statements within each area were shared with other local authorities to test commonality and consistency with the Wiltshire Council view of the problem; therefore increasing confidence that the findings of the study would be relevant to many local authorities and offering scalability of any opportunities identified.

Through this verification with other local authorities; a set of assessment criteria were developed against which the potential benefits of any identified opportunities could be assessed, covering:

- > **Safety:** Potential to reduce risks and improve safety for road users and operatives;
- > **Customer:** Potential to improve the road users and residents experience;
- > **Communication:** Potential to improve communications between the public, operatives and other stakeholders;
- > **Repair efficiency:** Potential to save time identifying and repairing defects;
- > **Effectiveness:** Potential to improve quality and durability, and to reduce the costs of repairs; and
- > **Data capture and utilisation:** Potential to collect and understand relevant information.

Participating SMEs were invited to use the DIB process to submit ideas via an online portal. They also indicated how they would like to engage with the challenge and the support they would need. The DIB is designed to be highly efficient for the SMEs.

The resultant submissions were then screened using a system developed by Atkins before being reviewed in more detail by highways professionals within the Atkins' Transportation business.

DIB secured strong engagement across multiple sectors

During the DIB project, over 3,700 individuals visited the Potholes Challenge website, of which 113 registered interest, and 70 completed a detailed questionnaire indicating innovations which covered all the challenge areas.

Furthermore 64% of all applicants were from outside the transport sector, demonstrating the potential for innovation from other sectors to enable better outcomes in highways.

DIB generated 102 different approaches including technology and service solutions; with some of the respondents expressing interest or capability across multiple challenge areas.

The project has demonstrated the potential of the DIB approach to stimulate engagement with SMEs (1-250 employees); as these organisations are often involved in innovation and whilst being part of the supply chain, may provide services through third parties and lack direct access to highways authorities.

The project was also a success in encouraging SME engagement, with 90% of responses meeting the criteria, with over 86% classified as Micro Enterprises; i.e. having fewer than 20 employees.

Findings & next steps

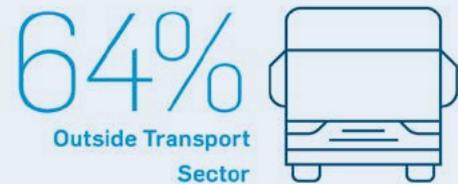
The DIB project has successfully demonstrated the potential of the approach to stimulate SME engagement and the ability to bring innovation into addressing the Pothole Challenge.

The project identified a shortlist of six potential innovation pilots for Wiltshire to consider, covering the themes of nanotechnology applied to materials, specialised plant for circular repairs, smart video for mobile devices, automated drones and analytics, digital twin systems and customer insight.

The shortlist, along with the rest of the findings from the DIB process have been reviewed by Atkins with Wiltshire in a workshop format, to validate and challenge proposals, and develop a plan for taking some of them forward to implementation.

The opportunities identified have the potential to support not only Wiltshire Council but also other local authorities across the UK in reducing the impact of potholes; helping deliver a better service to users of the network while potentially generating efficiencies.

The report has also outlined a draft roadmap to disseminate the findings to the wider sector including the need to engage with existing innovation and industry networks to further explore the potential benefits of the DIB approach.





Potholes have been a longstanding challenge in the Transport Sector

A brief context of potholes and why the Pothole Challenge is a 'Wicked Problem'

The road network in UK is the basis of socio-economic value in the UK and can also drive inclusiveness amongst our communities. However it has been recognised that the increased prevalence of potholes interferes with the value that the road network can deliver. This value is diminished in the short term, and left unchecked, potholes can have a significant adverse impact on economic value and inclusiveness in the longer term because of:

- > **Safety risks to road users** – whether in cars, buses or HGVs but also especially to motorcyclists, cyclists and pedestrians;
- > **Damage to vehicles** – resulting in increased wear and tear or direct damage, the true costs of which are difficult to assess;
- > **Delays to journeys** – impacting on the generation of economic value but also dissuading communities from connecting easily; and
- > **Environmental impact** – due to inefficient driving styles resulting in increased carbon emissions and the release of a disproportionate amount of particulates into the environment.

The causes of potholes are complex and may often be a result of the cumulative impact of many factors including but not limited to:

- > Local subsurface conditions;
- > Drainage;
- > Extreme weather;
- > Ageing infrastructure;
- > Changing patterns of use; and
- > The impact of excavations and poor reinstatements by the local authority or other organisations such as utilities.

Consequently, there is no simple set of measures that will maintain the integrity of, and value from, the road network. Indeed, in severe weather conditions there can be an accelerated deterioration of the road surfaces, which may result in restricted access to the potholes that prevents effective surveying and decision making. Even when a decision is made, effective repairs may not be possible due to the impact on repair materials in either cold or very wet conditions.

Since the publication in July 2013 of the *"Potholes Review – Prevention and a better cure (a follow up report)"* the pothole issue remains a focal point for highway maintenance concerns for both local and national politicians.

Due to the complexity of causes of potholes, the absence of a simple set of measures and the high-profile nature of engagement by stakeholders, it is easy to see why the Pothole Challenge is a 'Wicked Problem' in that traditional linear and analytical solutions are insufficient (defined in more detail below).

There are practicalities of engaging with partners and the supply chain to help respond to the Pothole Challenge

Whilst conventional solutions to the Pothole Challenge have been around for a while, they have for the most part been inadequate to deal with this Wicked Problem on a systematic basis. A broader engagement strategy across supply chains within the highways sector is needed, as well as importantly outside the highways sector.

Traditional local authority supply chains could share more

For example, there is a general assumption that the supply chain within a local authority includes many contractors with experience of leading practice, as well as in some instances, innovation. Often it is the case that solutions may have been deployed within a location or region but may not be more widely available cross local authority boundaries.

Road reinstatements often can be based on low cost, short term solutions

Within the highways sector but outside local authority interactions, other organisations maintain the roads or undertake excavations to provide utility services. The perception is that this is a low skill and low technical role, where decisions that impact sub-surface integrity are hidden by the surface finish.

The contractual relationship between the contractor and the employer (utilities company, local authority etc.) is invariably highly transactional and focused on lowest cost rather than the delivery of quality or resilience. As such these contracts are often very tightly priced with low margins and result in contractor teams being driven to complete works as soon as possible.

Fleet organisations have untapped information that could be a opportunity (and a threat)

Motoring organisations and fleet owners are well placed to understand the impact on vehicles which have allowed them to compile national estimates of damage caused by potholes. Additionally, they have developed technology which can geospatially locate which road surface failures have resulted in damage to vehicles. As vehicles become more sophisticated with increasing deployment of sensors, the evidence of damaging events caused by potholes and resulting liability may increase the knowledge of specific potholes. This could, in time, result in higher claims against highway authorities.



Enabling SMEs to access challenges such as the Potholes Challenge

Moving beyond conventional Transportation based organisations, we understand that SMEs often are not able to actively engage with solutions for highways nor understand the broader context of issues such as the Potholes Challenge. This Challenge is just not just about repair, but also other activities before the repair process as well as the management of road users – all the component parts that make the Pothole Challenge and Wicked Problem.

There is therefore a need to provide SMEs with a deeper appreciation as articulated in *“Potholes Review – Prevention and a better cure”*.

DIB shares and expands on the preventative aspects, underpinning communication and improving decision making. This leads to better outcomes (e.g. productivity from focused investment) because of a different and enhanced view of the Pothole Challenge.

Reframing this Wicked Problem to make it more accessible

Achieving a sustainable response to potholes sits in the realm of social planning problems that cannot be successfully treated with traditional linear, analytical approaches. This type of problem was defined as a 'Wicked Problem' a term originally proposed by H. W. J. Rittel and M. M. Webber, both urban planners at the University of California, Berkeley, USA in 1973.

Wicked Problems are difficult to clearly define and as they have many interdependencies, and they are often multi-causal. They may also be characterised as having internally conflicting goals or objectives within the broader challenge.

Defining a sustainable response to the Pothole Challenge is a Wicked Problem as it needs to engage with multi-dimensional and interdependent factors including:

- › **Environmental factors** – from extreme weather conditions to the sustainability of materials used; from climate change to impact of congestion which could result in reduced road condition;
- › **Design factors** – balancing the economic constraints of network wide investment versus local investment – both have different benefit profiles arising from the different levels from investment over different timescales, and
- › **Repair factors** – various repair solutions are available, all of which have differing impacts on different road users).

To solve Wicked Problems there needs to be an appreciation of the complexity and tensions between these various factors. This appreciation is developed through the reframing of the problem such that it becomes more accessible to potential solution providers.

For example, the appreciation of the customer experience of reporting potholes may lead to solutions that facilitate feedback to improve customer satisfaction. Customer management techniques commonly used in other sectors could also be engaged by making the Wicked Problem more accessible.

Wicked Problems need diverse solutions accessing cross sector thinking

DIB provides access to experience from multiple sectors such as oil and gas, aerospace, water and rail. It is specifically designed to benefit from investment in innovation from other sectors. DIB has been used to meet the Potholes Challenge, with innovation expected to arise in many different areas, including:

- › Materials;
- › Sub-structure matrix analysis;
- › Surveying;
- › Detection and evaluation methods;
- › Quality control and quality assurance;
- › Predictive analysis;
- › Big data analytics;
- › Communication; and
- › Sensors.

Considerable investment in innovation has been made by UK government, universities, venture capitalist funding, commercial entities and independent investors, and DIB seeks to capitalise on this investment through the reuse and recycling of ideas.

The DIB approach to problem redefinition provides key benefits to the following types of organisations across the economic landscape:

- › **Local authorities and other organisations responsible for highways:** Develop a more detailed understanding of the challenge from multiple perspectives, providing insights into different solution options. In this study the collaboration has been with Wiltshire Council and the understanding gained has been verified through discussions with other local authorities.
- › **Supply chain and especially SMEs:** Understand the value of implementing their technology or services in the highways sector, potentially making the case for additional third-party funding, and navigating through supply chain constraints. It is critical that there is full engagement with respect to not just repair but the prevention, decision making and communication elements of the challenge.
- › **Universities and Research Institutes:** Provide the opportunity to tailor research themes to develop outputs with enhanced impact, and create a pipeline of knowledge and graduates with the interests and skills to more effectively engage with the problem. Prevention, including the richer understanding of the importance of the sub-structure of roads are areas where some universities may provide leading insight.

- › **Central Government:** The UK Government recognises the importance of UK productivity and the need to drive efficiency across all sectors. It is bringing innovation to bear by facilitating collaborations through Innovate UK and other sector initiatives.

We recognise that solutions to the Pothole Challenge at a national level may need to be flexed depending upon different local circumstances such as:

- › **The complexity of different local authorities** – rural versus suburban versus urban environments and also the existing size and interactions with other agencies including Sub-national Transport Bodies (STBs) for example;
- › **The local management of highway networks** – including the forms of contracts in place; and
- › **The extent of the financial challenge of affordability** and investment in the highway service.

The approach outlined below in this DIB project provides access to innovation from across many supply chains from many different sectors, and highlights how these innovations may be combined to provide solutions to local authorities and especially to Wiltshire Council.

The DIB process is structured with clear steps

The DIB process is designed to maximise the chance of engagement with potential service providers (including SMEs).

The DIB approach is designed to enhance innovative capability through improved supply chain engagement. Specifically, it seeks to engage with SMEs around the problem definition phase of complex challenges, ultimately to achieve the typical outcomes shown in the process diagram below.

- › Definition of the Pothole Challenge, recognising and capturing the complexity based on our themes above;
- › Creation of an online Pothole Opportunity Gateway to communicate the challenges to supply chain, both within and outside the Transportation sector, including a structured questionnaire and tool to screen responses to facilitate expert review;



Looking at the Pothole Challenge in a different way

Our Problem Definition Workshop redefines the pothole challenge

The findings from a problem definition workshop held with Wiltshire Council sought to disrupt the traditional way of viewing the Pothole Challenge. The workshop with Wiltshire Council was attended by a cross section of the highway service and customer service teams to give a broad range of insights into the problem definition.

An additional perspective on repairs, through better data management

Traditionally, repair prioritisation and approaches had been widely considered during the selection and commissioning of road works. However, the utilisation of data to improve design and prevent potholes has been exploited less.

Through discussion, it was thought that better use of data able to better support asset management, data collection and analysis needed to be considered. There was an expectation that whilst the concepts might be mature in other sectors, innovation application within the Pothole Challenge could realise benefits.

The impact of potholes on the customer experience

Our problem definition workshop also helped focus on the customer experience and how customers value the road as a service as critical components of the Pothole Challenge. This was an important development of the challenge as it was then used to explain to potential solution providers (including SMEs) how potholes impact different road user groups. Derived from this was a need to focus on customer experience and associated communications.

A thematic view of the Pothole Challenge

The workshop identified four diverse themes that would attract innovation from across different sectors from solution providers including SMEs. From the previous experience of deploying the DIB approach, the importance of developing relatable storyboards makes the engagement by organisations such as SMEs more likely as they can more effectively relate their experiences and see transferable value from their innovations.

The workshop developed the structured content for the website that became the *'The Potholes Opportunity Gateway'*.

Upfront structured analysis lowers the bar for involvement for potential solutions providers

A key objective of the problem definition workshop and subsequent work was to make it as easy as possible for potential solutions providers to respond. A wide range of diverse responses was required to help resolve this Wicked Problem.

Working with Wiltshire Council the workshop developed targeted questions that deliberately excluded the need for SMEs to reveal commercially sensitive information and avoided the need to disclose intellectual property.

Table 1: The Four Pothole Challenge Themes.

Theme 1 Repair	Theme 2 Customers & Communication
<ul style="list-style-type: none"> › Drive consistency and quality › Raise repair standards 	<ul style="list-style-type: none"> › Customers and Communication › Capture customer intelligence to inform our decisions › Improve customer communication › Work efficiently with others
Theme 3 Design & Prevention	Theme 4 The Digital Opportunity
<ul style="list-style-type: none"> › Design and Prevention › Deliver effective condition assessment › Prioritise our interventions › Improve predictive capabilities 	<ul style="list-style-type: none"> › Improve collaboration & communication › Optimise investment supporting the decisions that deliver customer value. › Use of data analytics within common data environments to drive success through better collaboration

The second factor is the use of an online presence which introduces the Pothole Challenge in an accessible way and requests input in a highly structured form. This enables potential solutions providers (including SMEs) to efficiently provide information. The structure of the online system also supports the assessment process to evaluate potential solutions provider responses.

The DIB approach specifically enables SMEs to provide input into the Pothole Challenge investing no more than an hour of their time. They can access the site whilst primarily working in any sector, from anywhere in the country and at any time. Consequently, SMEs can engage at low cost to themselves. This is a significant differentiator compared to many open innovation approaches where there is a need to attend events or complete extensive questionnaires.

Through our approach we sought to maximise the response rates from potential solutions providers.

A focused question set was developed for Wiltshire Council (and other local authorities)

Having developed the themes, there was a more detailed assessment of which aspects of the themes may be specifically addressed by the SME community. It was considered by Wiltshire Council that some of the more complex specialist aspects would need significant understanding of the existing operational systems and therefore they were deemed to be outside of the capability of the SME community, especially from across other sectors. These aspects were therefore excluded from being taken forward as part of our question set.

Due to the nature of the Pothole Challenge, and its applicability across a wider landscape of local authorities, the question sets for each theme were tested with selected other councils:

- › Coventry City Council
- › Gloucestershire County Council
- › Hampshire County Council
- › Solihull Council
- › Surrey County Council
- › Warwickshire County Council

This ensured that there was wider applicability of the themes so that as an when we received opportunities from potential solutions providers, they would have applicability beyond Wiltshire as well.

A set of assessment criteria for Wiltshire Council, to evaluate opportunities

Coming back to Wiltshire, assessment criteria were developed to support the later prioritisation of opportunities and to enable Wiltshire Council Members to recognise how the innovation would align with wider Council priorities. This assessment criteria is therefore at a more strategic level:

- › **Safety** – Potential to reduce risks and improve safety for road users and operatives;
- › **Customer** – Potential to improve the road users and residents experience;
- › **Communication** – Potential to improve communications between the public, operatives and other stakeholders;
- › **Repair efficiency** – Potential to save time identifying and repairing defects;
- › **Effectiveness** – Potential to improve quality and durability, and to reduce the costs of repairs; and
- › **Data capture and utilisation** – Potential to collect and understand relevant information.

Outputs from the workshop are presented in Appendix 1 and set out the text and questions that were used to develop the website '*The Potholes Opportunity Gateway*'.



The Pothole Journey provides the wider context needed

The Pothole Challenge can be defined in our Potholes Journey (with a wider appreciation of outcomes that are sought)

To assist in the communication of the complexity of the Pothole Challenge, an infographic depicting the 'Potholes Journey' was also created and is presented opposite. This infographic shown in Figure 2, breaks down the Pothole Challenge into accessible components. More importantly it provides an appreciation of how potholes are considered, and the interplay between aspects from different stakeholder points of view.

The infographic was included as part of the launch '*The Potholes Opportunity Gateway*'.

It was also used in discussions with other local authorities and to share the appreciation of the Pothole Challenge with the SME community.

POTHOLES JOURNEY: OUTCOMES

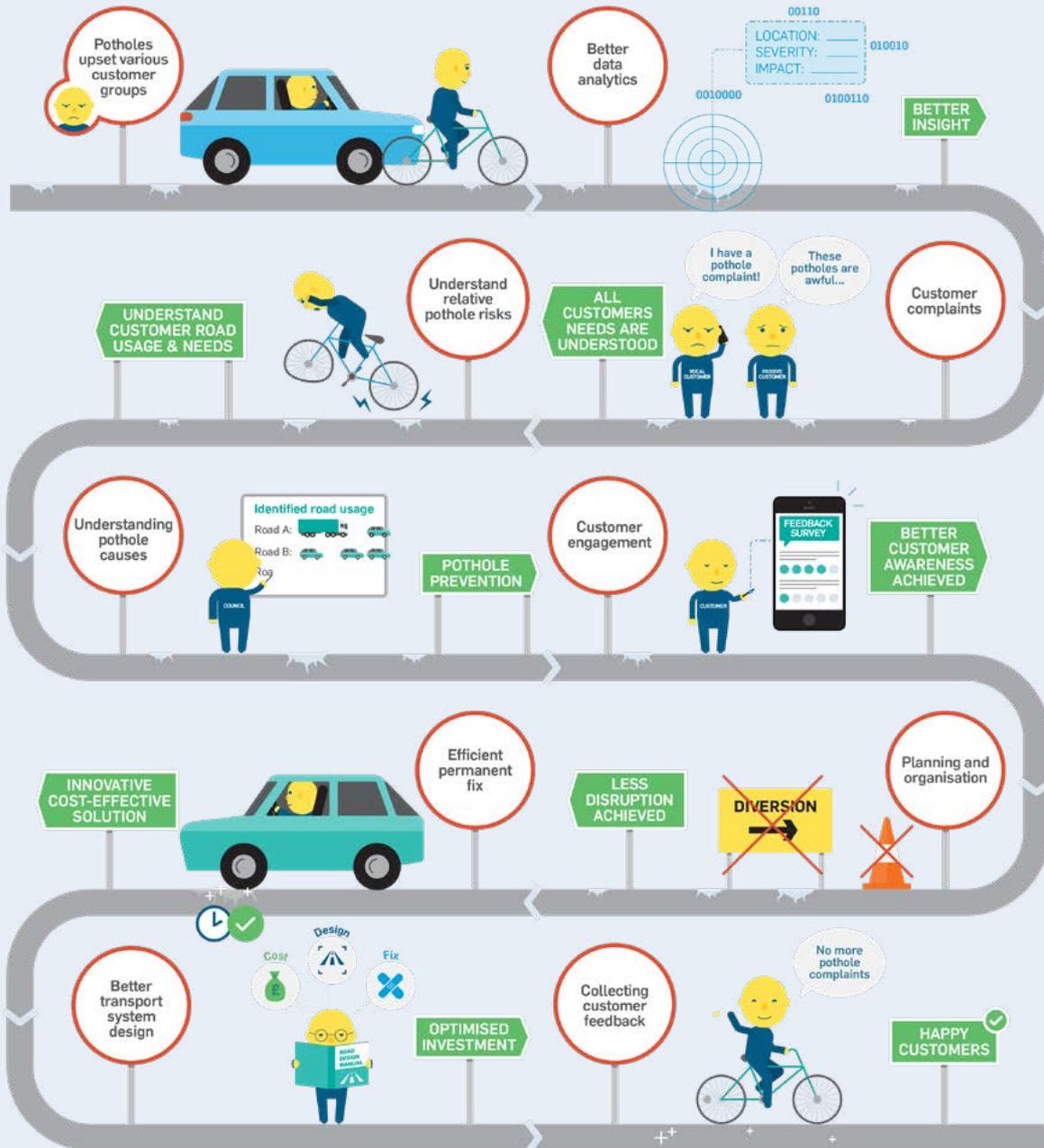


Figure 2: The Potholes Journey Infographic facilitated the widening of the discussion of this Wicked Problem.



Successful engagement with the potential solutions providers

Some impressive metrics through the 'The Potholes Opportunity Gateway'

The 'The Potholes Opportunity Gateway' was launched in early November 2019, acting as a hub for the Digital Intelligent Brokerage project to be communicated, challenge statements to be shared with SMEs and a route for organisations to engage with the process and contribute potential innovations. The site remained available open until the end of January 2020. It was publicised through trade media, social networks (e.g. Atkins LinkedIn), trade associations, links to Innovate UK and through non-transport orientated SME networks. The site was monitored to assess the relative impact of the different channels.

Over 3,700 distinct visits were recorded, and the page hits indicated interest across all the Pothole Challenge Themes.

From these, 113 organisations registered with contact details to follow progress in the potholes challenge and 70 completed detailed questionnaires, resulting in the identification of 102 potential opportunities.

Success in engaging micro organisations as well as wider SMEs

As mentioned above, the DIB process has been developed with the specific aim of engaging SMEs across many sectors.

Figure 3 indicates that smaller SMEs (<20 FTE) were very well represented in the returns, which contrasts with more common experiences of these organisations, where they may often feel excluded from the broader supply chain. It is important to engage these smaller organisations as whilst they may be resource limited they can be exceptional in being more innovative and agile than larger organisations.

Targeting investment towards the integration of these SMEs and increasing end user awareness of the opportunities may develop further market pull and encourage integration. For example, investment that facilitates SMEs working with local authorities or with contractors and consultants may be valuable in creating the depth of challenge appreciation and the trusted relationships required to bring innovation into the sector. This is discussed further later in this report.

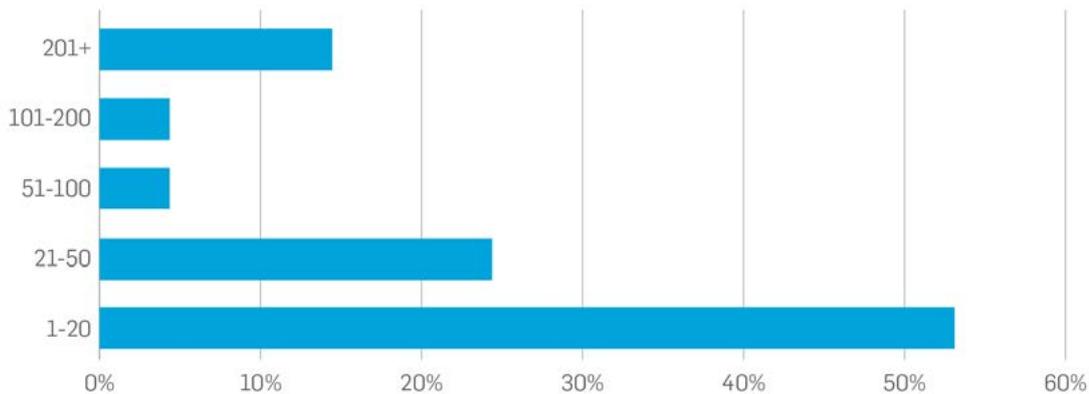


Figure 3: A majority of responses from small and micro organisations. (note: threshold of 200 selected to focus on smaller size SMEs)

Most engagement from outside the Transportation Sector

A significant barrier to overcome with respect to the Pothole Challenge was to demonstrate that it involves more than just the Repair Theme. Through the process of the initial client workshops, the complexity of the challenge and the wider cross sector opportunities were developed. The presentation of the challenge (as described earlier as the Pothole Journey) was designed to open up these opportunities, and the evidence from the responding organisations was that the DIB approach did encourage respondents from different sectors.

Respondents were asked to identify the sectors that they operated in. Whilst 36% identified with Transportation Sector, the majority identified themselves as mostly active in other sectors. The DIB process resulted in the Pothole Challenge being publicised across several social media outlets, which potentially increased the exposure across other sectors but does not necessarily guarantee an associated response.

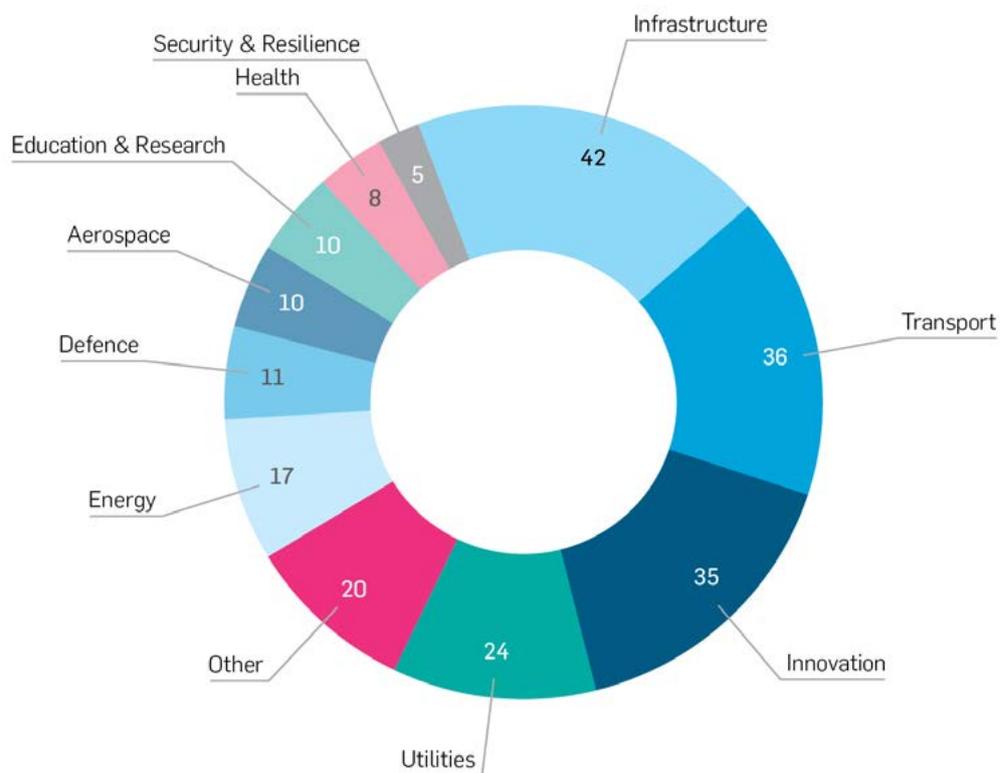


Figure 4: A majority of responses received from outside the Transportation sector.

The success of the high response rate from non-transport sectors was likely to be due to the structuring of the Pothole Challenge Themes. The workshop with Wiltshire Council was attended by a cross section of the highway service and customer service teams. It is likely that having the wider range of client inputs facilitated the richer definition of the Pothole Challenge and hence the accessibility and relatability that resulted in the respondent engagement.

Figure 4 illustrates the percentage of respondents that identified with each sector (the fact that the total is over 100% is because some potential solutions providers identified as being active in more than one sector). On average, potential solutions providers identified approximately three sectors each (218 sector interactions were identified for the 70 respondents).

The premise that DIB has the potential to reach across sectors and introduce the SMEs to new sectors is supported as the SMEs evidently do not consider themselves as serving a single sector and recognise cross-sector value of their work.

The open data sector has developed methodologies to bring stakeholders together to efficiently reach consensus on standards, with potential benefits for highways.

The cross-sector reach of SMEs is a critical observation as it demonstrates that the UK SME business community has flexibility and inherent responsiveness to complex challenges offered to them.

More specifically to the Potholes Challenge, local authorities should consider reaching out to SMEs from other sectors as the transition to the transport sector is likely to be less of a barrier for the SMEs than they may have expected.

Given that the ability and willingness to work across sectors is inherent within the supply chain, there is a clear opportunity to increase the exposure of SMEs to challenges and value propositions from across sectors. However, this needs to be done in a way that is efficient for the SME to engage in the next steps, which may include trials or pilots.

Encouraging results for all Pothole Challenge Themes

Responses for each of the Pothole Challenge themes were shared by potential solutions providers. In addition, some other responses were received as a consequence of the Pothole Journey.

Many of the opportunities presented addressing digital, customers and design were digital solutions such as innovative survey techniques or data interpretation. Outside of the Repairs Theme, the responses could be broadly considered as digital opportunities or collaboration opportunities.

Innovative digital responses demonstrated the value that mobile devices can add. Quality of delivery of work can be ensured through visual workflows that can incorporate Artificial Intelligence (AI) powered suggestions, promoting consistency and driving accountability.

Many of the opportunities presented addressing digital, customers and design were digital solutions such as innovative survey techniques or data interpretation. Outside of the Repairs Theme, the responses could be broadly considered as digital opportunities or collaboration opportunities.

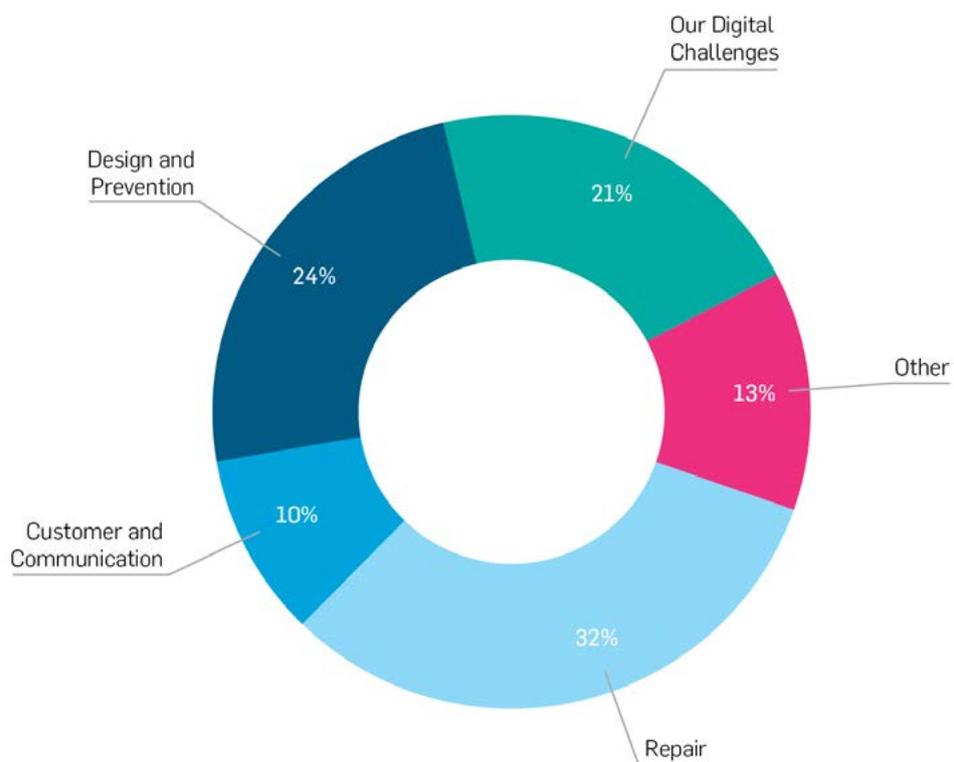


Figure 5: We received engagement across all four themes (and for other areas as well).

Cross-SME collaboration is already happening and can provide value from elsewhere, such as digital consultancy organisations partnering with commercial drone platforms for inspection and data collection operations in Europe.

Analysis of information within the submissions indicated that some respondents were not always able to explain the benefits of their approach or proposed solution. For example, the value of a quieter fix and hence reducing noise disturbance to the public or having greater resolution as to the position of the fixed pothole, were not seen as benefits but are valued by the local authorities.

SME offerings included technology that potentially offers quieter operation as well as reducing the debris from the surface excavation, both valuable outcomes for local authorities.

Repair technologies may have customer benefits, some of the survey technology solutions again did not recognise the value of reporting exact locations of potholes, an important feature when considering the warranty of a fix.

Although there were some cases where repair solutions were identified as offering customer benefits, such as reduced road closures, in most cases the respondents left the potential wider benefits open to interpretation.

Although the DIB approach focused on expanding the supply chain understanding of the challenge detail and developing an appreciation of the value that local authorities place on different aspects, the complexity of the challenge may well limit the SME appreciation of the value of innovations. There may be a benefit in making the description of the challenge more definitive in terms of both the value proposition and benefits.

In one example, the initial response was a simple statement regarding how software could be used to capture dimensions of potholes and thus understand condition.

However, as the respondent worked through the questionnaire the response begins to develop to outline potential applications and benefits such as prioritising works and managing risk.

This demonstrates that the respondent started with a simple offer of a solution, and then as they interacted with the challenge, they developed their understanding of either the challenge or their appreciation of their proposed service. Informing the supply chain and developing the appreciation by the SME of their proposed innovation was one of the core principles of the DIB.

Sub-theme responses were also received across the thematic areas, providing more insight

Several sub-themes were also developed in the client workshops. For example, the Repair Theme was broken down into the following sub-themes:

- > Consistency and Quality;
- > Standards of Repair; and
- > Collaboration and the opportunity to identify other concepts.

These sub-themes enabled a more refined understanding of the Pothole Challenge and resulted in more focused responses being received. It also stimulated potential solutions providers (including SMEs) to consider in more detail the types of benefits that their opportunity may deliver.

Figure 6 illustrates the number of respondents identifying within each sub-theme. A further sub-theme of ‘Other’ captured the concepts that were outside of the identified groupings.

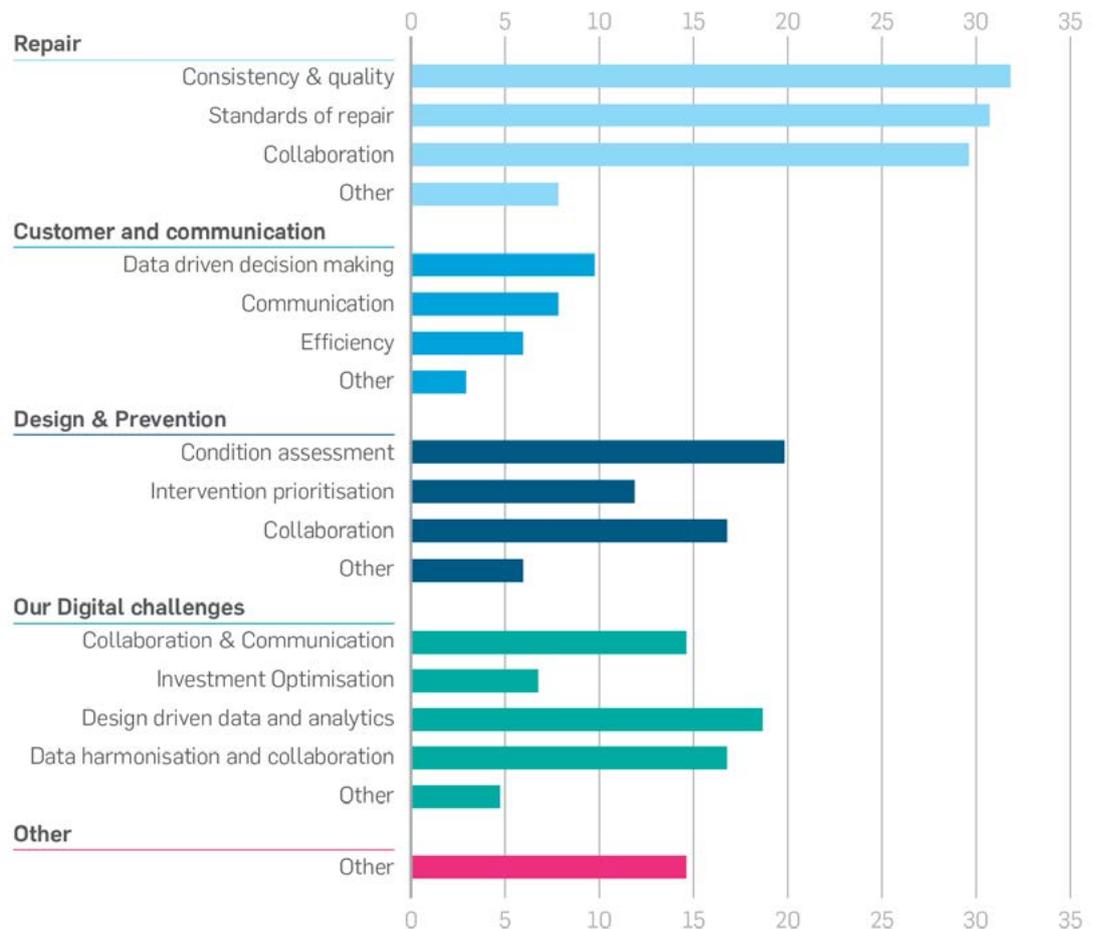


Figure 6: Responses received across all of the sub-themes.

Some respondents did not see themselves aligned to specific sub-themes included organisations which provided insight with respect to research activities. Some responses were supportive in principle but not focused, for example providing observation and critique of existing systems. Some of the wider principles of open-source, and especially concerning documentation were identified. In this case, the benefits could be considered as relevant to all of the sub-themes, as stakeholders can re-use, adapt and contribute to content for any subject matter so it can be improved based on lessons learned and easily adapted for different clients or projects.

We had a good response in terms of the Repair Theme

The largest number of responses were received in the Repair Theme. Standard of Repair opportunities offered included new integrated techniques such as circular repairs or new materials such as the use of carbon based products.

The use of graphite nanoparticles in asphalt was proposed for carriageways, based on evidence of the same additive creating improved performance within concrete, such as reduced microcrack generation and increased concrete compressibility.

Our Digital Challenge Theme provided insights to the maturity of the model

There was however much less engagement with “Investment Optimisation” in Our Digital Challenge Theme. This sub-theme requires a mature understanding of how a local authority delivers benefits to the community through its highway service. Therefore, it is much harder to comprehend by SMEs and other potential solutions providers that are not actively engaged in the highways service.

Predictive deterioration capabilities would provide local authorities with the ability to address road defects proactively and prioritise early interventions; creating savings and optimising investment.

To overcome this potential lack of appreciation, the concept of the ‘Pothole Journey’ could be enhanced to make the experiences of the customer and the requirement for efficient information management more evident.

A video or animation approach may be more immersive and could be deployed using the ‘The Potholes Opportunity Gateway’.

As well as understanding where SMEs' capabilities lie, the analysis also enabled the characterisation of approaches to be better understood. Specifically, it identified that 78% of all proposed opportunities were technologies. Whilst this is understandable given the technical context of the engagement, it may demonstrate a lack of diversity in the offerings of SMEs or a lack of appreciation of how technology capability may be developed as a service offering. Understanding how to enhance this diversity could benefit Wiltshire Council's innovation opportunities moving forward.

Whilst it was expected that the Pothole Challenge was going to have a Repair Themes bias the number of organisations that understood the complexity of the Our Digital Challenge Theme and associated sub-themes was very positive. This outcome would not have been expected by the attendees at the client workshop if the usual supply chain of highway engineers and service providers had been solely engaged with highway engineers and service providers.

A mixture of variable responses received in some instances

Finally, when reviewing the responses, it was evident that respondents did not necessarily recognise the benefits of their offered solution. In many cases the sub-themes were mentioned in the text by respondents but not necessarily identified in the questionnaire response. This may be a factor of greater awareness developed as respondents completed the questionnaire, they developed either a richer understanding of the challenge or appreciation of how their opportunity would offer wider benefits.

The DIB approach was designed to convey the complexity of the Pothole Challenge without forcing the respondents towards specific solutions. The growing appreciation by the respondents of the more complex benefits may be evidence that this problem familiarisation has been achieved.



Opportunities for improvement span technology, services and other areas for all four Themes

The DIB process has analysed the opportunities using different views to understand the nature of the potential SME community. It was expected that due to the nature of potholes being considered as physical failures in the road surface, that most of the proposed solutions would be technologies to better repair potholes, technologies to perform physical functions such as logging location, or the introduction of new materials. These solutions would be very transactional, i.e. the authorities or their engineering services companies would buy the technology to make repairs.

However, the responses included service providers and blended offers whereby the technology was available or offered within a wider service wrapping.

Access to displays and data generated by SMEs can be provided to other parties with the permission of the Council. This will allow other parties such as utility companies to coordinate with the Council to minimise customer impact by combining the digging up of roads with the repair of road defects.

This is important because different local authorities provide highway services via different technology or service perspectives. Depending upon the model that use will define how innovative offerings might be procured.

Across all themes, the majority of respondents have identified technology as the basis of their opportunities.

The bias to technology offerings demonstrates that the potential service providers and SMEs may benefit from support in the integration of their technology capability into a business model offering that can then be scaled up for local authorities.

As noted above this support may be through the local authority such as Wiltshire Council, or may involve a service agent. The value of partnering will be critical for many of the organisations to access the market.

Later in this report we discuss how the Council could help develop some of these partnering models with SMEs.

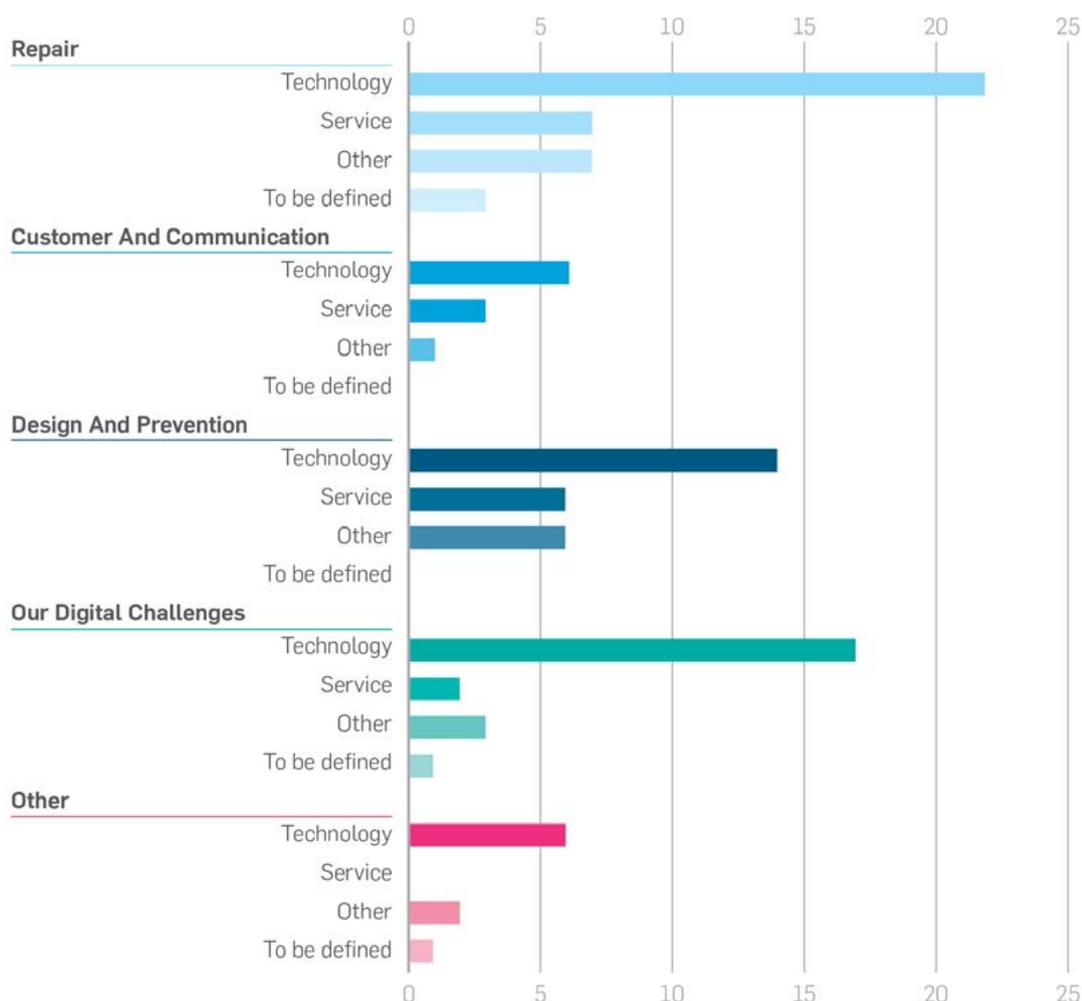


Figure 7: The nature of the opportunities identified across all four Themes.

The technology readiness of solutions spanned all levels of maturity

There are significant issues around the maturity and ability of the potential solutions providers to work together. These factors are considered later in the Report.

This was not unexpected as the workshop with Wiltshire Council did raise the importance of identifying deployable solutions, as the sector needs to address the pothole challenge as soon as possible, but without stifling the identification of more innovative approaches. So the question set implicitly encouraged proven solutions alongside innovative opportunities.

Notwithstanding this, it was noted that 52% of the opportunities were Commercially Proven. Whereas 11% of the opportunities were at Early Concept Phase.

Bio-bitumen is produced by placing plastic and organic waste in a reactor and heating it to around 500°C in the absence of oxygen. The process is called pyrolysis. It causes the chemical decomposition of organic, carbon-based materials to create a substance with similar qualities to bitumen.

This was not unexpected as the workshop with Wiltshire Council did raise the importance of identifying deployable solutions, as the sector needs to address the pothole challenge as soon as possible, but without stifling the identification of

more innovative approaches. So the question set implicitly encouraged proven solutions alongside innovative opportunities.

UK academia offers a range of innovations that may help address the pothole challenge.

This includes a pre-heating strategy and associated finite element simulation for consistent and enhanced interface bonding of asphalt patch repair.

Also, research has been undertaken on novel surveying systems and integrating robotics to reduce risks when delivering repairs.

Further research has been carried out into the collection of data using camera images, processing these for the evaluation of pavement condition to understand the influence of moisture content, freeze-thaw effects and traffic loads on pavement distress.

This results in the development of mechanistic-empirical deterioration models for predicting long-term performance of bituminous pavements.

The DIB process also gained technology responses from established providers and university start-ups, based on our targeting approach. Once again a diverse set of opportunities were being sought from a varied set of potential services providers.

The Potholes Challenge is conceptually easiest to understand at the physical, fixing of Potholes. However, the supply chain, including SMEs, appreciate the need to think about the Challenge in the context of the Potholes Journey. This would indicate that investment in the integration across the supply chain of potential solutions providers would be beneficial.

Different business models affect the solutions being provided

We note that in some cases the Pothole Journey has led to the appreciation of how a technology may offer a service solution.

Road inspections can be augmented with machine learning models to automatically identify assets and detect defects using video footage. Digital inspection models can be developed and trained using a fully integrated automated workflow module.

Benefits identified included addressing safety and compliance, clear audit trails, improved stakeholder management, and continuous and objective understanding of the asset.

There are multiple different business models for such equipment, including but not limited to:

- › Manufacturing and selling equipment;
- › Hiring the equipment out, using the equipment and selling the results;
- › Using the equipment selling the interpretation of the results; and
- › Producing a franchised business model with the equipment, the analytics and the support around marketing.

Each model requires different levels of appreciation, different skill sets and also different risk profiles. The latter ones require a broader appreciation of the benefits and value to the customer.

It should be noted that it is a challenge for SMEs to appreciate the wider opportunities in the Pothole Journey if they are considering selling through a Tier One contractor. Selling via an intermediary may reduce the opportunities to understand the detail of the value proposition and secure payback for delivering this opportunity.

Whilst an intermediary may provide access to a market, it may also block the opportunities. The role of different organisations within supply chains of potential solution providers and the impact on the opportunity realisation are developed later in this report.





Perfect Partners Alignments

This section looks to identify communities of potential solution providers who demonstrate the potential to work together.

To support the identification of these communities, the analysis characterised each organisation into a specific role typology. The seven roles used for the characterisation are visible in Figure 8. To minimise the risk of collaborative failure, Figure 8 also illustrates the preferred distribution of SMEs, indicated in green.

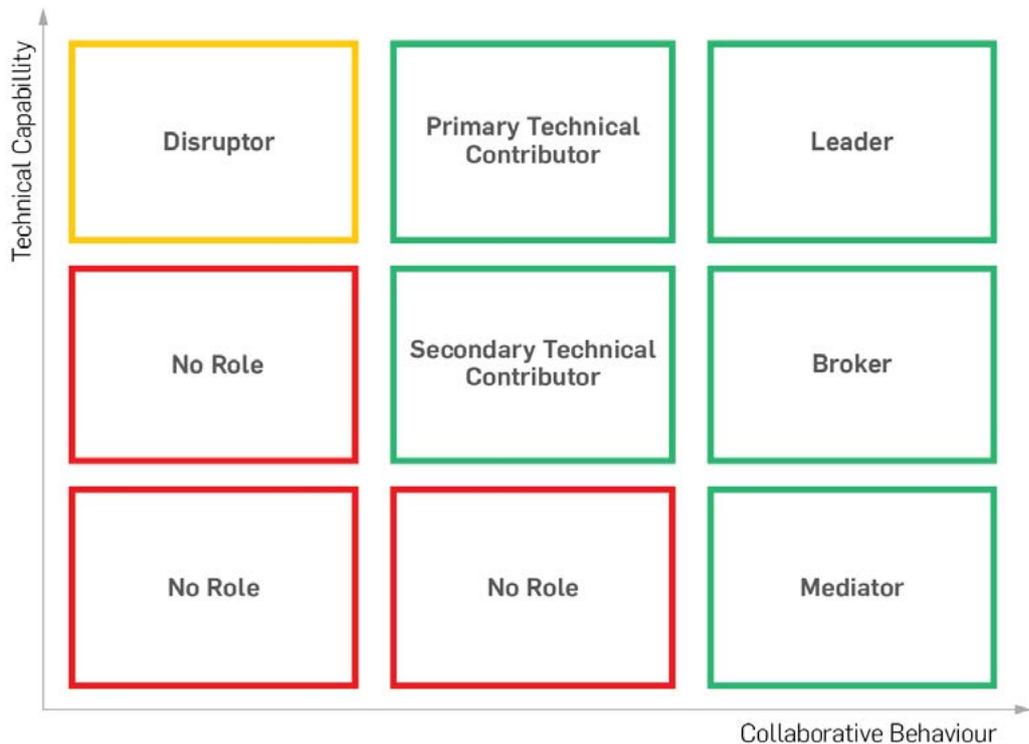


Figure 8: Aligning opportunities based on characteristics of the organisations.

Figure 9 shows that of the selected top opportunities, the organisations were mainly in the secondary technical contributor role. These organisations are likely to need a delivery partner such as a highway service engineering organisation or partnering with the local authority’s highway service team.

SME response indicated that vehicles have been developed that can address potholes, however they may not have the capacity or commercial capability to provide the full pothole surveying and fixing service.

From this work, the analysis of respondents has identified two initial collaborative opportunities. These are presented below.

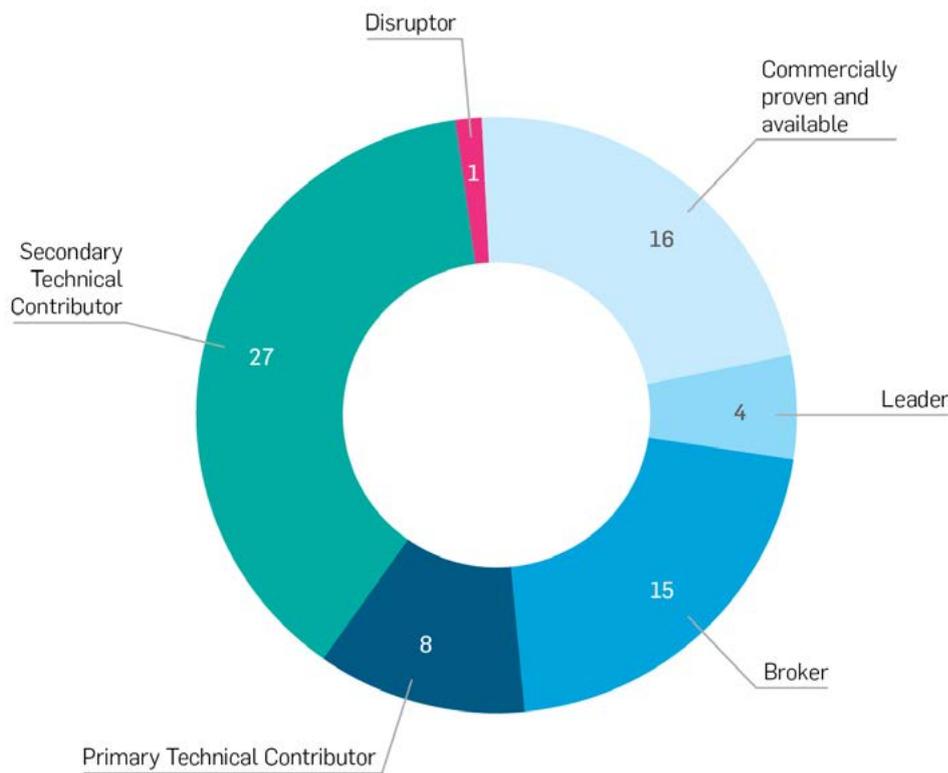


Figure 9: A range of organisations with different characteristics provides different options for Perfect Partners.

Brokers and delivering enhanced fixes

Pre-existing local research and innovation networks may provide an opportunity to develop some of the technology provider offers within a combined proof of principle environment. Collaboration with such networks may reduce implementation costs for all parties.

From the other respondents, a testing facility is an obvious partner with respect to assessing some of the road preparations, materials and fixes. This may include working with SMEs to introduce new carbon materials-based products to the pothole challenge, and the opportunity to consider how the performance of new materials may be tested and if they facilitate new standards of repair increasing road surface durability.

A related opportunity may also include the developing standards of fixes and there may be value in considering the relationship with Open Data organisations that can support the development of standards and procedures. This approach has been used in developing BIM and digital engineering approaches for the highways sector for both regional and strategic roads programmes.

Data capture and interpretation elements across one or more sub-theme

If the approach of continuous improvement in data capture and interpretation was to be pursued, then there may be synergies between the following:

- › Data from busses etc with API and presentation;
- › Digital solution and GIS location and interpretation using machine learning;
- › Software prioritising through 3D investigations and prioritisation of interventions; and
- › Providing automated quality assurance systems in real-time, with particular focus on better compaction of asphalt.

These organisations may be able to form a collaboration around data capture, analysis optimisation and fix quality assurance. The skillsets look to be complimentary although the economics and boundaries between the organisations will need investigation.

Potential new entrants within the leader space in the UK include SMEs with an international track record of offering asset management support, with potential impact in the data and design performance space.

Several SMEs have already self-identified as potential partners. The opportunity of using drones that are on a mission (i.e. autonomous) however, is an approach being developed by other organisations known to the Digital Intelligent Brokerage team. The technology exists and the data interpretation is progressing rapidly, therefore this is worthy of maintaining as a watching brief.



Conclusions: Evidence of the project meeting its objectives

Achieving a sustainable response to potholes

- › The DIB process has successfully engaged with over 3,700 visitors to the website and has, with minimal cost to the SMEs or responding organisations, identified a range of opportunities that have cross-sector alignments.
- › The complexity of the challenge was presented in accessible terms, and SMEs responded with cross-sector and cross-discipline opportunities with benefits including economic savings, reduced customer impact, waste minimisation and customer engagement.
- › Responses covered all aspects of the challenge such as design, identification, assessment, repair, use of innovative materials and future monitoring.

Presenting a deep understanding of the complexity of the underlying issues and implications of potholes in the UK

- › SMEs demonstrated that they were able to understand the challenge statements, and through the process, improved their appreciation of the technologies and service benefits that could be offered.
- › Evidence showed that SMEs recognised the complexity of the challenge, and although many had not worked in the transport sector previously, were able to understand the benefits that their opportunities could deliver.

Working together with stakeholders and across the supply chain to efficiently access innovation:

- › Core to the design of the DIB process, whilst the pothole challenge was a transport-centred challenge, many of the respondents have their core business interests in other sectors.
- › Respondents included another council which itself was part of a research group, universities and SMEs that have worked across different sectors.

Be inclusive of SMEs creating an open innovation platform:

- › Over 50% of respondents were from SMEs with 1-20 employees, which are organisations that often have the least resource and are not traditionally easy to communicate with as they sit within the supply chains of others.
- › The evidence demonstrated that the DIB approach has meaningfully engaged with these organisations and has brought some of their innovations to Wiltshire Council.

Driving cross-sector innovation and shared best practice, promoting market growth and supporting increased productivity for UK plc:

- › On average each SME represented connections with three other sectors.
- › Whilst only 36% identified as connected with the transport sector. Demonstrating the strong cross-sector representation.

Aligning with UK universities to stimulate targeted research and creating the links with industry supply chain to deliver research impact:

- › The DIB approach has engaged with the university sector as an innovation partner, collaborating with Exeter University in developing the brokerage approach and especially the characterisation of the roles within business relationships.
- › Universities have responded to the challenge themselves with innovation and research concepts, e.g. innovation related to robotics.





Recommendations: Next Steps

The outputs from the DIB analysis have been refined using a specific understanding of Wiltshire's issues and aspirations, and combined where synergies exist between different suppliers. This has produced the following shortlist of potential proposals to be considered by the client.

1. Materials

Nanotechnology is one of the most exciting and rapidly developing fields in science, building on the discovery of graphene in the UK in 2004. An SME response to the DIB hub proposed the use of graphite nanoparticles in asphalt for carriageways, based on evidence of the same additive creating improved performance within concrete, such as reduced microcrack generation and increased concrete compressibility.

If these characteristics could be replicated within asphalt materials, then the durability of pothole repairs could potentially be increased, and further research would be worthwhile to investigate the addition of these nanoparticles within other highway maintenance or highway construction materials and the benefits they may offer such as prevention of potholes forming in the first place.

Increased familiarity with the material within the wider highways supply chain may also result in further trials of the existing concrete technology, providing further benefits within concrete sections of road, structures and tunnels. British SME capability exists and pioneering this type of nanotechnology within the highways sector may not only provide benefits within the UK sector but also provide value to UK plc in terms of exporting the approach to a global audience.

Development of trials within a local authority environment are likely to involve the SME working with the client along with their consultant and contractor. All parties would have strong incentives to collaborate, as successful trials of the material would lead to improved asset performance and a safer, more resilient network for the highway authority, competitive advantage for Tier 1 suppliers, and increased profile for all involved.

Any testing could be planned using lessons learnt from similar trials of other new materials or maintenance approaches, a thorough review of the existing research into concrete additives, identification of test sites on the network, and agreement on funding mechanisms and IPR issues.

Potential opportunities to collaborate with other DIB respondents include using testing facilities for off-network trials (if initial tests are considered too risky for the main network), and trialling monitoring equipment to ensure the quality of repairs.

2. Process

Improvements to the process of pothole repair are a fundamental area of interest for all highway authorities and align with the “Right First Time” approach championed in the Potholes Review. An SME response to the DIB hub proposed an innovative process of using specialist plant equipment to deliver circular pothole repairs, thus creating an even distribution of density within the repair and avoiding traditional weak points in the corners of square fixes. The SME has a degree of experience within the highways sector, but outside of Wiltshire, covering both local and strategic roads. Collaborative behaviours are demonstrated through this previous work which includes highway authorities, contractors, logistics operators and ports.

The submission outlined potential benefits including improved durability of repairs (claims of over 7 years’ service life), fast and efficient delivery of repairs, environmental improvement through the capture of debris and noise, and health and safety gains through the elimination of Hand Arm Vibration Syndrome (HAVS for highway operatives, a significant risk for them when using traditional techniques.

This SME also has further designs in place for additional equipment to address further challenges for the highways sector. Again, there may be potential gains for UK plc through international sales of the solution, if validated through further testing, as demonstrated by the high levels of global interest in UK specialist plant at the 2019 World Road Congress.

Testing of the equipment within a local authority context would likely be embedded into current working arrangements with a contractor. This may require amendments to existing contractual terms between client and contractor and/or sub-contracts with current plant providers.

Resourcing would also need to be considered, to ensure that competent operatives are able to implement the equipment safely and effectively. Use of this innovation would involve a very visible “fix” for the public, and thus provide good customer engagement opportunities.

Potential opportunities to collaborate with other DIB respondents are similar to those for the materials proposal, i.e. use of testing facilities for off-network trials (if initial tests are considered too risky for the main network), and trials of monitoring equipment to ensure the quality of repairs.

3. Smart Video

The use of mobile technology is already well embedded within highway services and related operational processes. However, advances in “smart video” offer a potential step change in the value that mobile devices can add. An SME response to the DIB hub identified an app to ensure quality of delivery of work through visual workflows that can incorporate Artificial Intelligence (AI) powered suggestions, promoting consistency and driving accountability.

In a highway environment, the app could be used for undertaking safety inspections, identifying potholes (or other asset defects), and also monitoring and supporting the delivery of maintenance activities.

Benefits include more streamlined planning and delivery of works, avoidance of repeat defect problems and a reduction in claims against the highway department. Ultimately it has been designed to be connected and integrated into decision-making systems and processes, using open APIs, rather than simply act as a point solution. The SME has experience with working with international partners including a number of blue-chip clients, and has applied the technology with sectors including utilities, telecoms, services and manufacturing over the course of the last 6 years.

Trials within a local authority would be expected to take place with operative staff, either within an authority workforce or within a contractor’s organisation. For the latter, there may be possible issues to address around contractual changes required to implement the technology, which may have a cost impact. For either situation, there would be expected license costs and risks around change management, with the biggest challenge not perhaps around the technical capability of the app but in the human response from staff who may be resistant to changing from “tried and trusted” ways of working. As well as adoption within the highway inspection / maintenance workforce, the app may support collaboration and alignment with other stakeholders such as utilities, if adopted by them too. The SME technology may be trialled as a standalone piece of work, or alternatively linked into the Digital Twin proposed theme to provide a two-way flow of data.

4. Automated Drones

Drones (unmanned aerial vehicles) are becoming increasingly widespread in the UK delivering a broad range of services across almost every sector. Within the highways sector, a number of trials have been undertaken already, however the DIB opportunity gateway identified a cutting-edge approach of using autonomous drones to carry out highway inspections. This opportunity was submitted by an international “mini-consortium” of SMEs, each already demonstrating collaborative behaviours through this joined-up approach.

The proposal is intended to function in both urban and rural locations, to assess conditions on the road for defects such as potholes. Key features include the autonomous mission management software used to control the drones without the need for a competent pilot (addressing challenges around safety and skills constraints), and the use of predictive analytics and statistical analysis capabilities. This provides a joined-up process of data collection and processing.

The SME group have existing experience in this field delivering related work for the Ministry of Defence (MoD) and carrying out urban inspections of roads outside of the UK. As the technology becomes more proven in this country, there is potential to extend this beyond potholes / carriageways, to all asset types of highway infrastructure.

It is likely that an initial pilot within a local authority would involve comparing the system’s performance and reliability in assessing pothole defects with traditional machine or human based techniques.

Considerations would need to be given to the risks of using automated equipment on or above a live highway network, so off-network trials may need to be considered. Similarly, compliance with Civil Air Authority regulations need to be factored in, but lessons learnt from the MoD work should be transferrable here.

The automated drone technology may be trialled as a standalone piece of work, or alternatively linked into the Digital Twin proposed theme to provide a two-way flow of data. Also, the drone offering includes an element of analysis, but there may be value in combining with another DIB respondent who can take the processed data and feed this into their advanced decision support tool that not only supports lifecycle planning from a financial and asset performance perspective, but also provides an understanding of social performance impacts. This includes availability and disturbance (travel time and vehicle operating costs), road safety (fatal and severe accidents related to asset condition), environment (noise, air pollution and natural resources), and socio-economic (asset value and wider social effects).

The SME has a strong track record in the international highways market, but currently have a limited footprint in the UK. Potential for collaboration with other partners is demonstrated by the flexibility and interoperability of their solution, and they have already been developing an approach for their platform to be used with drones.

5. Digital Twin

A National Digital Twin programme was set up in 2018 to respond to recommendations from the National Infrastructure Commission and supports the UK Government's existing commitment to promoting the use of BIM within engineering. On a more local level, an SME respondent outlined their capabilities in collecting, managing and visualising data related to infrastructure. This included traditional image capture techniques, more innovative approaches such as drones and cutting-edge use of satellite data.

Systems are available to incorporate data from multiple sources, followed by the analysis and compilation of data, including the combination of spatial and non-spatial data. Data can be further processed through the use of deep learning and evolutionary, and the resulting Digital Twin model can be used to model simulations and scenarios.

The SME respondent was based in the south west of England, so geographically close to Wiltshire Council. Implementation of their offering as a pilot within the authority would require ownership from the client's digital and asset management teams as a minimum. Other stakeholders may need to be included as and when appropriate, especially as there are a multitude of potential opportunities to combine providers with this proposal.

Firstly, there is scope to link the system into existing data owned by Wiltshire, either within the existing asset management system and/or visual asset data collected by the authority's providers. Secondly, there are options to introduce SMEs from the DIB process. This section has also outlined options, and further support may be provided in the form of security and systems integration support. Extensive SME experience of working in the defence sector and with a range of international clients and partners, resulting in award-winning recognition may support this.

6. Customer Experience

As covered earlier in the report, the Problem Definition workshop resulted in customer experience being identified as a critical theme when addressing the Pothole Challenge – ultimately, the whole purpose of the highway network is to connect people, goods and services. Whilst the previous innovation themes are likely, if taken forward, to be tested and validated along technical lines, the impact on customer experience may be less well-understood by local authorities and their partners.

To address this, SME response included the provision of thinking and approaches to resolve this, using lessons learnt from their work in delivering customer insight services for Highways England in the strategic road sector. It is also able to draw upon extensive market research experience from across a wide range of industries; thus bringing in best practice and innovation in this skillset to the UK local authority market.

It is not envisaged that this would involve a standalone piece of work, but instead should be aligned with other proposals (such as those outlined above) to provide a baseline of customer experience prior to any trials being undertaken, and then to assess and evaluate the impact post-implementation. This is likely to require coordination from the client side, either by appropriately experienced resource within the client's strategic team and/or comms team, or consultancy support with highways domain knowledge.

Next Steps for Wiltshire

The shortlist above was compiled using an informed, but still external, view of Wiltshire's priorities and appetite for innovation.

The next step in the process has involved the Atkins project team meeting with representatives from Wiltshire to validate and challenge the proposals, and co-create plans for the development and implementation of innovation pilots. This will be developed outside of this specific project, but any outcomes of interest to the broader sector will be considered for sharing in due course.

Roadmap for beyond Wiltshire

The above innovation proposals have been compiled using the context of Wiltshire Council's highway service, meaning some of these may be more or less attractive to other highway authorities. However, this report and the information supplied within it are to be made freely available to all within the sector, so that others can review the innovations identified and consider developing business cases to trial some of these in their own authorities.

Similar to the approach used in the SME engagement phase, it is intended that the findings will be disseminated via industry platforms such as Transportation Professional magazine, Transport Network and social media.

As with all innovation, there is no absolute guarantee of success, but authorities should consider risks as well as costs and benefits to engaging with suppliers arranging potential pilots. Throughout this DIB process, a number of supporting networks have been identified and engaged with, and will play a key role in sharing the learning from this work and the potential value to highway authorities. These include the **Local Council Roads Innovation Group (LCRIG) and the Road Surface Treatments Association (RSTA)** who responded to the opportunity gateway and are recognised and trusted industry bodies who may wish to promote the findings of this process and support adoption by authorities.

Other organisations who supported the SME engagement phase, such as the Association of Directors of Environment, Economy, Planning & Transport (ADEPT), the Chartered Institution of Highways & Transportation (CIHT) and the Institute of Highway Engineers (IHE) may play a role in raising awareness and also championing innovation within the sector. The Department for Transport is also looking to facilitate engagement between the DIB team and the UK Roads Liaison Group, which represents all highway authorities in the UK and may help to share the project's potential value with a wider audience.

Atkins consulted with a number of local authority clients throughout the DIB process, to test the challenge statements for applicability across the sector and also to give early sight of the themes to be addressed. The project team gratefully acknowledge the participation of representatives from Coventry, Gloucestershire, Hampshire, Solihull, Surrey and Warwickshire councils, and look forward to exploring opportunities to implement innovation within their networks.

Finally, as covered in the previous section, the project has proven the concept of Digital Intelligent Brokerage as an approach to bring together innovation from across sectors and involve SMEs who may not have traditional routes to local highway authority clients. The Hub approach provides not only a means of addressing the immediate Potholes Challenge, but also a robust mechanism of addressing further sector challenges in an efficient and effective way. This would support the Government's commitment to not only promote innovation and support to UK SMEs, but also provide potential value to the sector through scalability of successful solutions.

Appendix – Themes & Sub-Themes

Theme 1: Repair

A successful repair converts a pothole to a surface that is, by use, practically indistinguishable from the rest of the road surface: It will last at least as long as the surrounding road surface, and if it fails presents an equal or lower environmental impact to the wider road surface. The management of the repair is dependent upon: the road, condition and location.

In this challenge theme we are looking to work with partners that deliver repair services, that may be using innovative technology or have developed working practices that deliver better and more sustainable services.

Consistency & Quality

- > **Fast to fix:** How does innovation in fixing techniques reduce the number and duration of road closures or reduce the space taken on carriageway- Aligning repair processes to traffic management outcomes?
- > **Cheaper and Customer friendly:** Innovative repair technologies driving efficiencies including potential automation opportunities?
- > **Customer friendly / health & Safety:** Can we create a better operational environment- Minimise sound disturbance, dust, debris and vibration?
- > **Customer friendly:** Is there the potential for night working if silent excavation (repair preparation)?
- > **Cheaper and customer friendly:** How can clustering repairs delivering minimum disruption and efficient outcomes and reduce the equipment on the road?

- > **Customer friendly:** How do we provide minimum disruption through the optimal repair vehicle access?

Raising the standards

- > **Right first time:** How can we collect and process evidence that the repair has been delivered as it should (e.g. more thorough prep, drying of repair area, quieter and safer)?
- > **Pride in our work:** Is there the opportunity to capture the repair, as a video, and potentially share with customers?
- > **Location, location, location:** How can we locate the repair accurately, within a meter, for warranty purposes?
- > **Location, location, location:** How do we create a collaborative standard of evidence with contractors, utilities and share this with our customers?
- > **Customer / data:** How do we generate the evidence that we returned the road to use as soon as is practicable?

Working better with others

- > **Efficient Delivery:** Can we collaborate with utilities to define a standard data set for every repaired or reinstatement that includes the quality of sub-surface and other local defects including other utility assets?
- > **Sustainability & Environment:** Are we able to use sustainable materials: From recycled tyres to graphene the materials used bring opportunities but also emerging risks?

Theme 2: Customers & Communication

Our customers value the service that our roads provide so to improve this service the challenge is to share information in an effective timely manner. Also, we can improve communication and collaboration with other organisations that work on our roads.

We are seeking partners that communicate with customers, who are likely to be operating in other sectors where capturing customer feedback and reports is business critical. We want to capture what is critical and valued by our customers, so that we can enhance our service and present a fantastic communication experience.

Capturing and processing information to better inform our decisions

- › **Customer Focus:** How do we support the accurate reporting of potholes; location size and linked to potholes already reported enabling us to optimise the inspection, solutions selected and delivery? We also need to capture and understand which reports are duplicated, to know where customers are most concerned.
- › **Customer Focus:** How can we increase our appreciation of the relative importance of a pothole placed upon it by different customers (cyclist, pedestrian, driver, horse rider)? In the UK driver experience and vehicle user safety is the definition, is that what our customers want?
- › **Customer Focus:** Can we interpret pictures submitted by customers / contractors using tools such as Artificial Intelligence and machine learning and expert systems? If so we simplify the reporting and provide an efficient use of the time we invest in the road service.
- › **Customer Focus:** From this understanding can we define appropriate metrics for our service that are including speed of response or recovery of service after events such as a diesel spill, shows the long-term

improvements for customers?

- › **Customer Focus:** Can we respond faster if there is an alignment of statutory and customer inspections creating a single optimised process?

Improving Customer Communication

- › **Customer Communication:** Can we better understand the cost to customers of actual closures including; economic impact, journey times, public transport disruption, cycling and pedestrian inconvenience that our customers suffer?
- › **Customer Communication:** Can we then demonstrate the value of the innovative plans to carry out work that keeps the traffic flowing and minimises the customer impacts?
- › **Customer Communication:** How can we efficiently get back to our customers, letting them know progress and recognising the positive impacts that our improved planning delivered?
- › **Customer Communication:** How do we provide tracking of the repair online to improve customer feedback and set reasonable expectations?
- › **Customer Communication:** How do we provide more assurance and support to demonstrate the management of risk of non-critical defects?
- › **Customer Communication:** What are the tools and techniques that our customers would prefer us to communicate with them, ensuring social inclusion, especially for our most vulnerable customers? (On-line/ Apps, telephone bots)?

Working more efficiently with others

- › **Efficient Collaboration:** How can we work with utilities to optimise the digging up of our roads to minimise customer impact?

Theme 3: Design & Prevention

Beyond the more obvious harsh winters there are many aspects of the environment that impact our roads and we are aiming to improve our predictive capabilities. It is a challenge due to the nature of rural roads they are variability in construction and usage changes over time. However, planning interventions drives significant customer value and has the potential to save money.

Improving condition assessment to become more proactive

- › **Improving the Roads:** We want to know what are the opportunities are to improve our assessment of road condition, surface and sub-surface, based on emerging technologies: scanning and vibration monitoring to align photos and shock to vehicles, photos, lidar, drone surveys and physical cores?
- › **Improving the Roads:** We want to learn the best techniques for interpreting the large data sets that we could achieve by using cameras on refuse trucks to photograph the road surface?
- › **Predicting Pothole Risk:** We have a variety of data sets including core samples, access to soil and sub-strata, maintenance reports, accident site reports, skid reference tests and the opportunity to access contractor data including historical repairs. How can we use analytical techniques to predict or explain the pothole hotspots that we encounter?

Prioritising Interventions

- › **Efficient Resource Utilisation:** How can we develop models that are predictive based on rate of change in road condition and hence prioritise early interventions? This will support our assessment of the effectiveness of interventions and hence improve both predictive and design processes.
- › **Efficient Resource Utilisation:** Conversely, how do we identify critical points on our network, and potential external factors, that will affect deterioration and learn where NOT to intervene?
- › Improving collaboration to improve predictive capabilities
- › **Collaboration and Predicting Pothole Risk:** We also collaborate with utilities including water, telecommunication and gas with access to, location of assets, drainage, soils and subsurface, water leaks etc. How can we use analytical techniques to predict or explain the pothole hotspots that we encounter?

Theme 4: Digital Challenge

This challenge theme is cross-cutting theme and we recognise that data underpins our customer service. In this Data Challenge theme, we highlight how SMEs from any sector may have valuable capabilities that will support us in converting diverse data sources into actionable insights.

We anticipate working with partners that may manage; site data, real time data, photo and video analytics and interpretation. We are looking to enhance how we visualise and share our understanding of these data to improve collaborations and improve customer experience.

We have identified our challenge areas of Repair, Collaboration and Communication, Design and Prevention. These all rely on how we integrate data interpretation and visualisation into our processes to better supporting our decision making and improve customer engagement.

Improving Collaboration & Communication

- › **Capturing data from our customers, contractors or other utilities:** Photos, pothole location and size, through Apps, websites or telephone calls.
- › **Interpreting pictures:** Using tools such as Artificial Intelligence and machine learning and expert systems.
- › **Analise and prioritise:** Visualise risks based on location, characterisation or customer activities- cyclist, pedestrian, driver or horse rider.
- › **Communication to customers:** Including progress, disruption and service improvements the tools and techniques social media, apps or SMS?

Optimising investment whilst making the decisions that deliver customer value

- › **Traffic management tools:** What tools do we need to reduce road closure aligning with the repair technique selection? How does these provide evidence of the efficiencies made returning the road to use as soon as is practicable?
 - **Predictive tools:** How do we develop predictive tools, based on rate of change in road condition, and prioritize early interventions?
 - **Predictive tools:** How do we identify critical points on our network, and potential external factors, that will affect deterioration and learn where NOT to intervene?
- › **Customer impact assessment tools:** How can we measure and visualise for our customers how our decisions add value adds value using data including; road closures including; economic impact, journey times, public transport disruption, cycling and pedestrian inconvenience?
- › **Optimise Solutions:** How can we capture our cost data from repairs and optimise investment by aligning solutions with customer value and outcomes?

Using data and improved Analytics to optimise Design and Prevention

- > **Improved data capture:** How can we capture data through emerging technologies including, scanning and vibration monitoring to align photos and shock to vehicles, photos, CCTV interpretation, lidar, drone surveys and physical cores?
- > **Improved data interpretation:** How do we develop tools and techniques to interpret a variety of data sets including core samples, access to soil and sub-strata, maintenance reports, accident site reports, skid reference tests?
- > **Improved data interpretation:** What is the opportunity to access contractor data including historical repairs and the data from cameras on refuse trucks/ busses / other to photograph the road surface?

Creating a common data environment

- > **Common data environments:** Collaborate with utilities including water, telecommunication and gas with access to, location of assets, drainage, soils and subsurface, water leaks etc. Predictive: How can we use analytical techniques to predict or explain the pothole hotspots that we encounter?
- > **Collaboration tools:** How do we improve working with utilities to optimise the digging up of our roads to minimise customer impact?
- > **Communicating Success:** Visualisation of metrics as dashboard in collaboration with contractors demonstrating successful repairs and value to the customer?

