# Funding for Innovation: Connected Vehicle Data

# Annex A

## 1 Executive Summary

1.1 This proposal is designed to allow Derby City to assess the emerging technology of Artificial Intelligence, with respect to its use in Asset Management. The hypothesis to be tested is that automated recognition of assets on our network from video data collected from our own fleet, will introduce both efficiencies in our current operations and enable new thinking in terms of how we manage those assets. Existing technology only allows for occasional data to be produced, however within this project, we will investigate how we can utilise continuously updating information which is automatically categorising the condition of certain assets, with little or no manual intervention.

1.2 We will aim to answer questions on the specifications required for this technology to be usefully employed, assess whether we can utilise our own fleets by making them connected, and as such open the door to the use of future vehicles connectivity as these become more readily available. In essence, we will test the science in readiness for a more connected transport network by using what is available today in Derby City and in doing so, immediately maximise the effectiveness of our existing asset management resource.

1.3 Clear deliverables are expected from each of the work packages of the project. Each will lead to a step change in the way that Derby City is able to manage its assets. This project will also inform how this can be utilised by other similar authorities in the immediate future. We will ensure that our learnings are presented in a way that makes this potential service, and the processes developed to capitalise upon it, readily transportable, should the hypothesis above be successfully proven.

## 2 The Strategic Case

### 2.1 Project funding

2.1.1 This funding will allow us to assess an emerging technology to a level where the evidence is clear enough to inform future business decisions. Without the Department for Transport backing, it is unlikely that we would be able to accept the risk of such a full initiative on our own. Over the last few years, Derby City has demonstrated success in modernising its winter maintenance activities by employing latest best practice from around the world and now we are looking toward our asset management services to do the same.

However, this time the leap is much greater than in winter, where established best practice was available from our partners in this bid, Vaisala Ltd. In this case, the technology is new to both entities as Vaisala have only just added this capability to its portfolio through a business acquisition at the end of 2017. As such, 'best practice' does not yet actually exist as the application of this technology to asset management is so new.

## 2.2 Expected benefits from the video survey

2.2.1 Derby City's Asset Management Team includes six Highway Inspectors, three of whom manually inspect the network and allocate repairs. We also have three staff who also deal with public enquiries and complaints. Even at its lowest level, the updating video, that we intend to capture at the beginning of the project, will allow efficiencies to be realised in this process. For instance, the report of a damaged road sign can easily be checked by video, rather than an inspector having to verify it onsite.

2.2.2 During the project, we will investigate whether this evaluation can even be undertaken by front line staff, at the time of the call. This will give a much better level of response to the customer, as our staff may be able to confirm the position and of course the reality of the report being made during the conversation.

*Figure 1: Mobile phone and annotation tool for capturing video from moving vehicles*

## 2.3 Automatic Identification of road signs from video

2.3.1 However, it is the automatic identification of assets that is so appealing. The video capture will act as a base for the Computer Vision, so in work packages 1 and 3, outlined on page 9, we will set up the necessary cloud infrastructure and use standard mobile phones mounted in our patrol vehicles to capture video of the entire Derby City road network. Computer Vision will then be trained to automatically deliver a road sign inventory, which Derby City has not been able to collect on its own to date.

2.3.2 This part of the project is the lowest risk, as this element of the offering from Vaisala has already started to be developed. The Norwegian Public Road Administration tested the road sign recognition service in 2016/17 and concluded that accuracy of automatic identification was in the order of 98%. Work has also been conducted for the Finnish Transport Agency, who have also taken a keen interest in this emerging technology.

*Figure 2 Automatic annotation of images: Green boxes signify road signs in Finland*

2.3.3 However now we need to 'translate' this service to UK style road signs. Currently, the service appears to be working well in these Scandinavian countries. There are some obvious differences in terms of the actual road signs that are all unique designs country to country. In addition, even the fact that our signs are on a different side of the road may pose challenges that this project aims to uncover and then solve. We have included what we hope will be enough development time within our project proposal to ensure that the UK sign recognition capability is raised to a level where it becomes fit for purpose.

2.3.4 There are significant differences in the landscape between Norwegian roads and the tight and cluttered environment of the highways of Derby City. A significant effort will be made during this project to bring this road sign identification up to level where we feel it can be used operationally. However, clearly should the urban environment prove too difficult to capture road sign data effectively, then we will be able to report on this to the benefit of others.

2.3.5 On the other hand, should these obstacles be overcome successfully the addition of a road sign inventory will significantly improve Derby City's asset database, our asset valuation and allow us to manage it in the future more effectively. Through this stage, we will also be able to plan our immediate repair regime much more effectively as we will be able to view what is in effect a snapshot of the state of all our road signs in one go. Other benefits may be forthcoming in perhaps understanding which signs are most prevalent within the city, leading to a more informed procurement policy.


*Figure 3: Screenshot from the Vaisala Computer Vision User interface (RoadAI).*

- *Column 1 shows the actual image lifted automatically from the video*
- *Column 2 Shows the Computer Visions automated categorisation*
- *Column 3 shows its best alternatives*
- *Column 4 is the input for an inspector to correct or confirm an image*

## 2.4 Dealing with personal data security

2.4.1 It is clear that as we collect the valuable video information from our road network, we will inevitably also record personal data from those using our highways. Data such as number plates and faces will be matched with GPS location and timestamps that if left unedited, could lead to the unwanted ability to track personal movement.

2.4.2 As a result, a significant element in our proposal is to develop the anonymisation of these images to a level where tracking of individuals cannot be undertaken by anyone viewing these images after the event. It is our intention that as the images are loaded into the cloud, we will have a pre-storage phase that removes anything that could lead to the identification of an individual and their location at a particular time. We feel this solution is the most robust that can be offered and we will ensure that it is enabled early on in the project.

*Figure 4: early work on automatically anonymising vehicles captured in the video*

## 2.5 Connecting the fleet

2.5.1 In the second main phase of the project, we aim to investigate whether the video images collected by our refuse collection fleet, for health and safety reasons, could be reused by the Computer Vision process set up in phase 1. If applicable, this means we will enable a continually updating view of our entire network. This opens the door to completely new ways of working and suggests a tactical rather than

strategic asset management approach. The project will report on these findings as a primary outcome for other local authorities to consider.

2.5.2 It is our sincere hope that the cameras in which we have already invested can be utilised for this purpose, as it will mean our return on investment for their deployment will be significantly improved. Each refuse truck has four cameras located on each corner, primarily to improve safety of the operatives, but also to be able to study claims made for minor accidents or incidents that occasionally occur.

2.5.3 This part of the project will look at the quality of those images with respect to Computer Vision techniques and if applicable, we will look to fully connect some, or all, of these four cameras to the cloud based storage offered by Vaisala. The providers of these systems, ISS, are also part of this project, as they have installed similar systems to over 75 other local authorities in England. As a result, should this element be successful, the expansion to other authorities will be clearly defined.

2.5.4 During this phase, we will start by upgrading a small number of vehicles and connecting them in such a way that the current manual downloading of information can be made automatically. We will consider whether direct streaming of images is desirable or whether this can wait until the vehicles return to our local depot based Wi-Fi. Depending on this phase, we will enable as many vehicles as the budget allows.


*Figure 5: Current camera system installed on the Derby City refuse collection fleet*

## 2.6 Realising the benefits of a connected fleet

2.6.1 Once this regularly updating information is flowing, the project will investigate how this new source of video data can be best utilised by the Computer Vision capability. We will investigate the possibility of automatically identifying road signs that have fallen into disrepair, perhaps due to road traffic collisions, vandalism or general deterioration. We aim to have an alert system developed that will be a call to action for our repair crews, which may significantly improve our response times and as a result, provide a much better service to our road users.

2.6.2 This phase of the project will attempt to fully connect our own fleet and then re-use the hardware already installed. We will then learn how this data can be used operationally. For instance, we will examine how it could affect our Dynamic Inspection frequencies. All risk assessments should be reviewed following an incident or annually, whichever comes first. We hope the system may help us to quickly identify roads that have consistently high numbers of defects, in which case we could increase inspection frequencies. Conversely, inspection frequencies could be reduced on roads that do not generate high numbers of defects. This project offers the potential to use our connected fleet to be able to create this intelligence and as such, speed the whole process and target our resources more effectively, whilst ensuring that all risk assessment reviews are consistently backed up by sound data in an evidenced based way.

## 2.7 Risk mitigation

2.7.1 One of the key risks in the project concerns the use of the existing cameras in the refuse vehicle fleet. We do not know at this stage whether we will be able to enable a continuous feed of video imagery into the cloud. We also do not know whether the imagery will be suitable for the Computer Vision team to utilise. Questions around the angle of the camera, the height and position on the vehicle are to be answered in the project, as they vary from the mobile phone deployment upon which the capability has thus far been built. Learning from this will help when future vehicles begin to start sharing their own images more widely, but for this project we have to consider this element as a risk.

2.7.2 However, we have decided that a strong fall-back position is available in the further deployment of mobile phones to be used in the first set up and inventory phase. Should the refuse vehicles cameras prove unsuitable, we will deploy further mobile phones to then be able to realise and assess the stated potential benefits above.

## 2.8 Post project

2.8.1 Critically this connected fleet data has the potential for multiple uses as the Computer Vision capability continues to expand. We see this project as a springboard to then use our connected fleet data as an integral part of our asset management, where we will look to employ some of the future services that

Computer Vision may be capable to deliver. For instance, the video imagery collected could be used to identify other asset deteriorations such as pothole occurrence. Our experience with this project will help to inform us on how we may approach this, particularly in terms of changing our internal processes, to capitalise on what would be automatically identified deterioration. If the project budget allows due to lower cost than expected, we could start to investigate this pothole occurrence potential as well.

## 2.9 Conclusion

2.9.1 This project is designed to specifically test whether new advances in Computer Vision, a branch of Artificial Intelligence can be used in pursuit of cost effective asset management. Specifically we will use video imagery taken from moving vehicles, pass that into the Cloud from where Artificial Intelligence will be used to automatically detect assets and their condition.

2.9.2 We are not only testing Computer Vision's effectiveness in automatically identifying assets but also looking to assess whether our own fleets can be connected in such a way as to provide continuously updating information. The goal is to ascertain whether we can utilise this information to create a new risk based approach to what we might term 'tactical asset management'. This project offers a first step in what will be a paradigm shift in the way that asset management is approached, especially for smaller authorities like our own.

2.9.3 We have ensured that the risks have been minimised as far as possible and that at each phase, a significant and useful deliverable will be forthcoming. One key risk surrounding data privacy will be mitigated by developing an anonymising layer to remove any information from the images that could be used to determine the identity or movement of individuals.

2.9.4 Key project outcomes include an inventory of road signs on the Derby City network with imagery collected by mobile phones installed in vehicles. We will then assess whether a pre-existing installation of cameras on our refuse collection vehicles can be used for this purpose and enable this capability.

2.9.5 By the end of the project, we aim to have a new way of dealing with our road sign assets both in terms of a formal inventory, but crucially in terms of how we deal with maintaining this in a real time fashion. We aim to move from an entirely manual process to one that is smarter and almost totally automated, one that significantly reduces the load on our existing inspector resource, whilst both improving our efficiency and the standard of our assets at the same time. In addition, we will have increased the utility of already installed equipment and given ourselves a base for moving forward with further investigations on how Computer Vision can further improve our asset management operations within the City of Derby.

# Annex B – Work Programme

**Stage 1: Infrastructure set up and testing of Computer Vision capability on an urban network, to automatically detect road sign type and location.**

1. **Work Package 1 – Cloud infrastructure set up**
   1.1. Vaisala to send Derby City mobile phone – Galaxy S7
   1.2. Derby to install in suitable inspectors vehicle
   1.3. Vaisala to create cloud based account and check connectivity
   1.4. Vaisala to supply Derby with login account details and Viominer application access
   1.5. Derby to conduct test drives to ensure end to end solution is active
   1.6. Vaisala to confirm that system is operational

   **Deliverable 1: Operational cloud based system**

2. **Work Package 2 – Anonymisation**
   2.1. Vaisala to anonymize data collected before cloud storage
   2.2. Derby to confirm that no personal identification is possible from video imagery displayed within Road AI

   **Deliverable 2: Anonimised data sets**

3. **Work Package 3 – Data collection**
   3.1. Derby to plan full inspector routes for data collection purposes
   3.2. Derby to run routes as planned
   3.3. Vaisala to confirm that data has successfully been captured in the cloud based storage facility

   **Deliverable 3: Video capture and storage of all Derby City's road network**

4. **Work Package 4 – Training Computer Vision to identify road signs**
   4.1. Vaisala to train system to recognise UK road signs in the urban environment
   4.2. Vaisala to analyse and demonstrate road sign inventory within the web user interface
   4.3. Derby to confirm that the demonstrated inventory is fit for purpose

   **Deliverable 4: Automatically created Urban Network road sign inventory**

5. **Work Package 5 – Data ingestion into existing asset management software**
   5.1. Derby to supply Vaisala with requirements for data ingest into Pitney Bowes Confirm software
   5.2. Vaisala to create suitable conversion to data held within Road AI
   5.3. Vaisala to create a full data file for all road signs identified by the Computer Vision system created in stage 1.
   5.4. Derby to import data file into asset management software and confirm that the transfer has been successful

   **Deliverable 5: Stored road sign inventory within existing asset management software.**

**Stage 2: Connecting the fleet to provide continuously updating video footage of the Derby City road network without manual intervention.**

**6. Work package 6 – Installation of test system to one refuse truck**

6.1. ISS to provide 1 camera with full HD capability to refuse truck or modify an existing installation with reference to operational usage requirements
6.2. ISS to modify existing data capture system to allow manual WiFi download at the end of each run into the Vaisala cloud
6.3. ISS to automate data download when WiFi network is reached in the depot following a video capture run
6.4. Vaisala to confirm that the captured video data is of suitable quality
6.5. If necessary Vaisala/ISS/Derby to detail lessons learnt from fleet deployment

**Deliverable 6: Proof of concept of using existing fleet in a connected way to capture video of the Derby City road network**

**7. Work Package 7 – multiple vehicle deployment**

7.1. Derby to consider wider deployment of new system to more than one truck
7.2. ISS to deploy any further systems
7.3. Vaisala to confirm that all data is being received automatically

**Deliverable 7: Automatic, multiple vehicle video capture system**

**8. Work Package 8 – Missing road sign alert service development**

8.1. Vaisala to analyse how multiple data can be utilised within the Computer Vision system
8.2. Vaisala to enable Computer Vision system with multiple data sources
8.3. Vaisala to create warning system to alert of missing signs
8.4. Derby to introduce procedure for missing sign repairs as detected through the computer Vision system
8.5. Derby to assess suitability of the service for tactical asset management purposes.

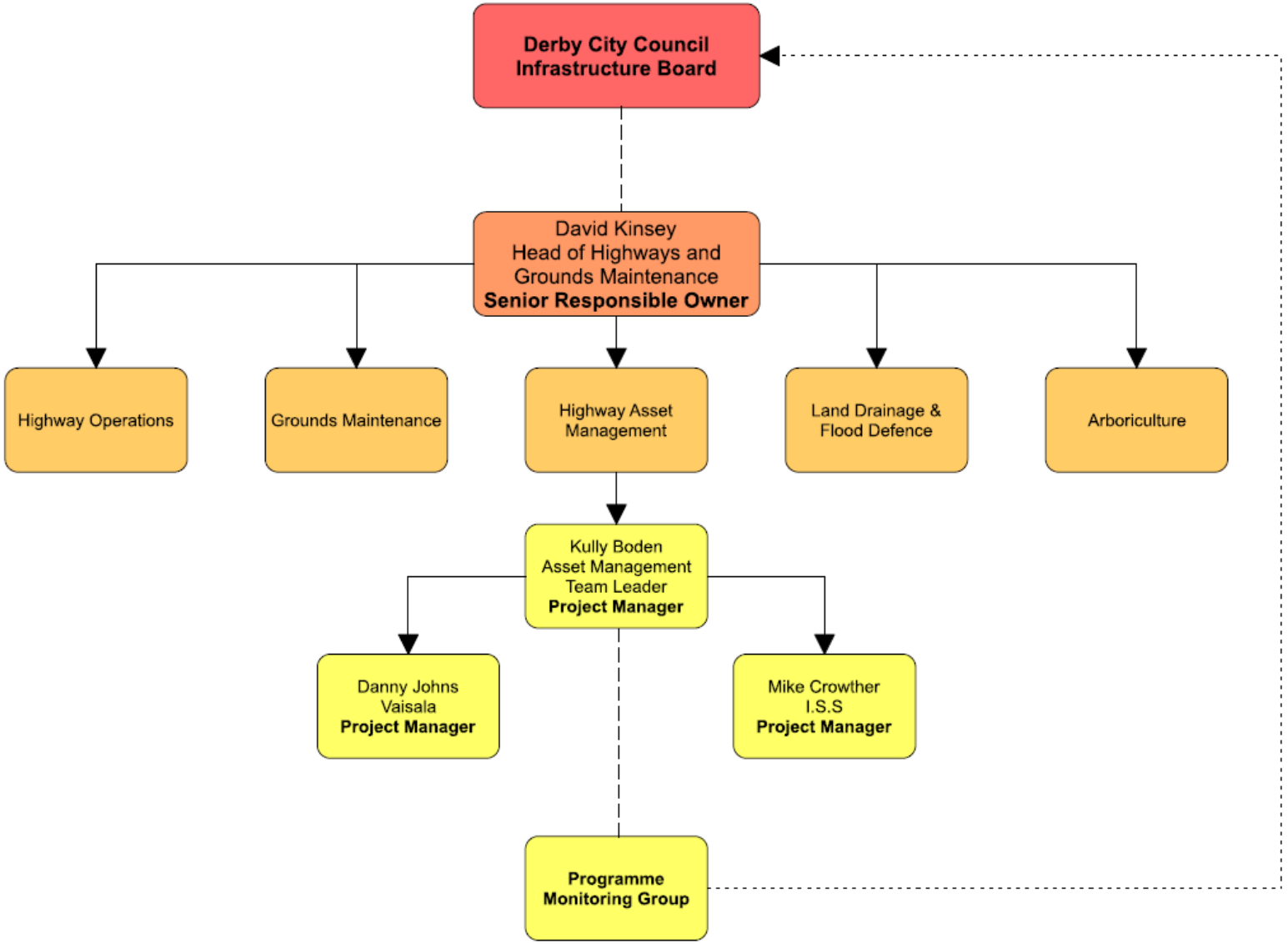
**Deliverable 8: Missing road sign alert service and operational procedure**

## Annex B continued


Deliverable 1: Operational cloud based system
Deliverable 2: Anonymised data sets.
Deliverable 3: Video capture and storage of all Derby City's road network
Deliverable 4: Automatically created Urban Network road sign inventory

Deliverable 5: Stored Road Sign inventory within existing asset management software.
Deliverable 6: Proof of concept of using existing fleet in a connected way to capture video of the Derby City road network
Deliverable 7: Automatic, multiple vehicle video capture system
Deliverable 8: Missing road sign alert service and operational procedure

## Annex C - Governance



## Annex D – Risk Register

| Ref | Risk Description | Consequence | Likelihood | Impact | Mitigation | Risk Management |
|---|---|---|---|---|---|---|
| 1 | Waiver not agreed to so unable to spend the funding | Unable to commence the project | Medium | High | Engaged with Finance and Procurement leads early on in bidding process to make them aware of this opportunity and working in line with current DfT / Asset Management agenda | Both supportive and will assist bid through procurement |
| 2 | Failure by one of the suppliers to deliver | Project termination without benefits being realised. | Low | High | Use of normal ordering channels to allow for contract law to be enforced in the unlikely event of non-delivery | Have ensured clear benefits are likely to be realised by partners, hence ensuring buy-in and commitment |
| 3 | Anticipated results not delivered | Imagery from refuse vehicle fleet not suitable for Computer Vision or unable to provide a continuous feed of imagery into the Cloud | Medium | Medium | Should the refuse truck cameras not be suitable we will revert to the current methodology of mobile phone deployment. As a result we will still be able to analyse the potential for a more dynamic approach to asset management | Risk Identified in project plan with alternative approach documented. |
| 4 | Loss of data | Data collected is lost due to technical issues | Low | High | Data storage facilities are cloud based with standard security and failover processes already in place.<br>Local storage and data dissemination from the refuse trucks has more risk. | Computer Vision system is operational and as such has mitigation strategies already deployed<br>Mitigation is as risk 3 for refuse truck camera images |
| 5 | Project over runs | Unanticipated problems with project delivery | Medium | Medium | A programme has been provided. If required work will stop after stage 1 | Project plan has been defined over a short enough period to allow some small overruns should that be necessary.<br>Computer Vision learning is a continuous process hence we will be able to call a halt to this phase whilst still delivering useable results. |

## Annex E – Benefits Realisation Logic Map