The State of the Connected Nation

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The State of the Connected Nation

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About the Forum

This document has been prepared by the Transport Technology Forum (TTF) to help meet the need for action to deliver the future of mobility by driving more effective and efficient management of existing and new road networks.

Road transport will remain a pillar of how people and goods move across the whole nation, not just on strategic roads. Improving road travel through technology is a core aim of the Forum. The TTF is sponsored by the Department for Transport and provides a neutral meeting place for those who are investing in technology for roads management and operation.

The TTF also promotes a collaborative culture to open up opportunity and address the caution which has historically impeded innovation in the local roads network.

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Foreword

The question that most often springs to my mind when someone is singing the praises of some clever new technology is 'so what?' In what way, precisely, is this new invention going to help make the world a better place? Followed in short order by 'are you sure it really works?' and 'could anyone actually afford it?'

Happily, this report sets out to answer all of those questions, documenting the learning from a selection of the many 'pathfinder' schemes that the Department for Transport has supported.

These are not the sort of multi-million-pound projects that tend to grab the headlines, rather they demonstrate that more modest budgets can deliver practical options for tackling real-world issues – including the ever-present challenge of cutting the cost of asset management.

But it's not just the technology that's new, putting it into practice begs questions about the specification and contracting approaches of highway administrations, procurement authorities and suppliers, which, again, this report seeks to explore. Part of the mission of the Transport Technology Forum is to foster and promote a better understanding of the scope new technologies offer to all involved in the construction, maintenance and operation of our roads, throughout the supply chain.

It is with that in mind that I commend this report to highway authorities, suppliers, and technology developers alike, in the hope that it will foster fresh thinking and fresh approaches that more than meet the challenge of my 'so what?' test.

Steve Gooding

Chair, Transport Technology Forum and Director, RAC Foundation

Executive Summary

The UK government sees connected and autonomous vehicles (CAVs) as an important strategic opportunity and so continues to invest heavily in their development and introduction. Perhaps less visible is government funded work to connect existing vehicles and the roads they use, largely led by local road authorities with support from UK industry. The UK is a leader in this area and is already demonstrating benefits of connectivity.

Delivering the future of mobility strongly supports the Government's aims for decarbonisation and will unlock reductions in road casualties and contribute to improvements in public health and social inclusion. The Department for Transport (DfT) and a wide range of local authorities have already invested over £8m in 43 projects across the UK looking at ways in which Co-operative Intelligent Transport Systems (C-ITS) can contribute to this. This co-operation is between vehicles and road infrastructure, and between road authorities, industry and users. This benefits all road users through smarter parking, by using new data to address problems including road maintenance, better ways to set traffic signals to reduce emissions and congestion and the provision of better information and intelligence. These projects are showing how C-ITS can boost productivity, increase safety, help revitalise high streets and reduce real-world costs for local authorities. The projects took place in large and small cities and on rural and urban networks. They made use of public and private data from new and old vehicles and new in-vehicle and existing cellular communications. A variety of road users have been involved, from bicycles to buses and refuse vehicles, to increase the breadth of evidence gathered.

Larger projects such as the A2/M2 Connected Corridor[1], UK CITE[2], Flourish Car Trials[3] and the Zenzic projects[4] in the wider CAV portfolio looked at vehicles on motorways and in large cities. Together with the local C-ITS projects, they provide a

[1] https://www.gov.uk/government/news/signs-of-the-future-new-technology-testbed-on-the-a2-and-m2-in-kent

[2] https://gtr.ukri.org/projects?ref=102581

[3] https://seis.bristol.ac.uk/~eerjp/v2xtrials/

[4] https://zenzic.io/

diverse portfolio of learning on the technical, business and institutional challenges involved in making vehicles and roads co-operate. Central to the programme has been measuring benefits to road users and authorities, and highlights include:

- reducing stops at traffic signals on the A45 by up to 14%, thereby reducing emissions not just from tailpipes but also brake dust, tyre wear and asphalt damage
- reducing delay significantly for all road users in Warrington and in York by up to 30% by improving traffic signal settings using new data sources, with immediate benefits of up to 35 times the cost of deployment
- ways for mitigating the future traffic impact of construction of the Hinkley Point 'C' nuclear power station and of urban regeneration in Croydon
- measuring road asset condition from vehicle data in the West Midlands, Buckinghamshire, North Yorkshire and Westminster to help reduce road maintenance costs by up to 5% across the UK (potentially worth up to £150m)
- improved parking for customers in Harrogate, Coventry, Cardiff, Oxford, Milton Keynes and many other towns and cities. By making it easier to find and pay for a parking space, these improvements can lead to reduced congestion and pollution and supporting the revitalisation of the high street
- Using the Transport Technology Forum and the resources developed through the C-ITS projects, a coherent national dataset has been built from local authority data sources to incredibly tight timescales as part of the Governments Covid-19 response measures.

All these projects reinforce the value of data from vehicles of all types. They have generated a mix of economic and monetary savings, such as using new data to enable more effective risk-based road maintenance.

The DfT has also invested £1m to promote the opening and sharing of local authority transport data and improvements in traffic management platforms. This includes supporting a new consensus-based standard developed by the Alliance for Parking Data Standards (APDS) which covers parking payment and availability.

The DfT has extended support to smaller towns and cities with practical projects that enhance and extend the life of current assets, including training in making the most of existing investment. The Department is working with the Cabinet Office and

Government Digital Service to deliver GovTech Catalyst Congestion Challenge projects. These will support the development of new products and solutions to help manage congestion. These initiatives have been recognised by external stakeholders such as the Institution of Engineering and Technology (IET), British Parking Association (BPA) and ITS(UK) as being vital to future developments.

But there are still barriers, such as siloes of data and a lack of resources and skills in local authorities faced with increasing pressures on the “day job”. We need seamless services between authorities across one nation and must capture more information on benefits to inform wider investment in future mobility. Next steps include moving from paper-based to digital traffic regulations, opening up data in many more towns and cities, and making the whole roads maintenance chain able to use data from vehicles.

Technology adoption is currently patchy, with some authorities making great progress and others still to engage. This can be due to skills and resource issues, inertia in working practices or simply not seeing technology deployment in their local area as a priority. DfT has supported training and business case development to increase the speed of adoption of technology and ensure that skills and resource limitations have less of a future impact.

C-ITS can deliver benefits in the short term to UK road users and pave the way for future driverless vehicles. There is often talk of the need to make the roads ready for CAVs, but for connected vehicles at least, this is already happening. This report shows that it is not the roads that need to be made ready, but the people – along with the data, processes, systems they use – who maintain and operate them.

The need to respond in the short term to the Covid-19 pandemic, and in the longer term to the changes in society that will result from this has shown new potential for C-ITS. Over thirty authorities and suppliers have contributed to new national datasets covering traffic, cycling, parking and freight movements, based on the flexible approaches to data that we have pioneered through the C-ITS Opening Data projects. The use of new technologies will be central to the challenges we will face in the future configuring transport infrastructure and services to the ‘new normal’.

1. Introduction

This report describes the state of the nation in helping vehicles and infrastructure to co-operate. It brings together information about projects run by UK local authorities and funded by DfT, to prepare for the challenges and opportunities new technologies will bring.

The UK sees the adoption of connected and autonomous vehicles as a way to increase productivity and improve mobility and so has invested heavily in autonomous vehicle pilots. In addition, a range of relatively inexpensive technologies loosely termed "Co-operative Intelligent Transport Services" (C-ITS) have been developed. These technologies will help deliver what is now being called Connected, Cooperative and Automated Mobility (CCAM). They have been deployed in months rather than years, to improve traffic flow, reduce road casualties, maximise capacity, reduce tailpipe emissions and cut maintenance costs. Many of the technologies have been tested in real-world pathfinder projects funded by the DfT, which as a complete programme is comparable to anything else being done around the world.

Connected, Co-Operative and Automated Mobility (CCAM)

This report pulls together the learning from these projects in a way that is useful to practitioners, both those supplying the technology and their prospective highway and traffic authority customers and highlights the potential value that C-ITS could generate.

The report also highlights the pressing issue that much of the technology we have deployed previously is no longer delivering the traffic benefits it could. This can be because of inadequate maintenance of, for example, sensors in traffic control systems or journey time capture equipment. The report therefore also looks at ideas for recapturing and safeguarding those benefits for the future by capitalising on ever greater vehicle connectivity and new data sources.

Co-operation does not just relate to communications technology solutions, but also the ways in which vehicles and infrastructure connect and how the various bodies involved relate to each other. This will ultimately involve automotive, communications, police and rescue and road authorities who each potentially benefit from improved ways of working due to better connectivity. This is a theme of the report, that many of the challenges it highlights are not technical but often institutional or skills based.

The report shows:

- the bigger picture of government initiatives and policy development (section **2**)
- the challenges to be addressed and the national business case (section **3**)
- wider government initiatives to address these (section **4**)
- the technology tools used and example pilot projects (section **5**)
- how co-operation between stakeholders has delivered benefits (section **6**)
- the insights from users of the technology (section **7**)
- lessons learnt from the pilot projects (section **8**)
- next steps and recommendations for actions (section **9**)

2. The Bigger Picture

This report fits into a growing landscape of initiatives and policy development being undertaken in Government to meet the challenges of new mobility. This is central to addressing the challenges of decarbonisation and making better use of data. Both are key elements in improving social inclusion, protecting the environment and promoting economic growth.

The **Local Transport Data Discovery** project set the scale of the challenge in ensuring local authorities make the most of data they already have to deliver better, more cost-effective services and has driven much of the Government's recent activity in this area. This report shows how, with DfT funding, many areas are meeting this challenge. The **Future of Mobility Urban Strategy** builds on the **Industrial Strategy** and the four **Grand Challenges** and sets out Government policy to ensure the UK can maximise the benefits that new opportunities present, and this report illustrates numerous real-world examples of this happening now. The **Regulation for the Fourth Industrial Revolution** White Paper presented to Parliament in June 2019 sets out the challenges for adapting to new ways of working. The **Transforming Cities Fund** and the **Future Transport Zones (FTZs)** it is supporting will offer an opportunity to deliver at scale many of the solutions discussed in this report. The projects described here will form the basis of many of the initiatives delivered in the FMZs and are invaluable in teasing out many of the technical and institutional challenges that will have to be overcome.

The new data standards including the **APDS parking standard** described in this report, and ongoing development of a **Digital Traffic Regulation Order (TRO) process,** are crucial to the orderly and safe inclusion of connected and autonomous vehicles on our roads. Many of the projects highlighted here have contributed to the work we are undertaking in this area and have illustrated the pressing need for data standards to be in place to allow at scale deployments.

The DfT is currently progressing work examining **Highways England and local authority data opportunities** and the development of a **Connected Vehicle Data Strategy**. This report demonstrates the need to establish national data strategies and standards to allow further and wider adoption of the highly effective and valuable initiatives we have seen to date.

Recently, much of Government's activity has been directed to the challenges presented by the Covid-19 pandemic and the measures needed to secure the National Health Service, protect the vulnerable and limit the effects of the pandemic. Going forward, the challenges of restarting the economy and getting the Country working again will come to prominence, as will ensuring some of the positive outcomes around better air quality and reduced traffic levels are perpetuated. The Government is accelerating many initiatives planned for the coming years to meet this challenge. In areas such as micro-mobility, traffic management and the use of data and apps, we are seeing pressure to move further and faster than previously envisaged. C-ITS has a huge role to play in this, as a catalyst for wider investment and growth and a primary means by which we will ensure transport meets the challenges of the post Covid-19 world.

3. The National Business Case

The Strategic Business Case

The Strategic Business Case[5] developed by the Transport Technology Forum in 2018 highlighted national scale benefits of increased technology adoption in the roads sector. The economic cost of roads, including congestion, accidents, emissions and asset management are now a £100bn per year problem for the UK.

It showed that road technology already reduces that cost by around £4 to 6bn across the UK, with a benefit to cost ratio of between 12 and 15 to 1, compared to a typical road scheme ratio of 3 to 1. This existing benefit must firstly be safeguarded as it is currently at risk from lack of funding, resource and skills pressures whilst it is also an important foundation for connected and later, automated vehicles.

Work by the TTF also showed that the benefits achieved initially from traffic infrastructure systems such as UTC and SCOOT that have been installed and operated for many years are now being lost. This is through lack of funding and resources, for example to repair faulty sensors in traffic control systems or maintain journey time capture equipment.

If all the systems currently installed were working optimally, work by the TTF showed that this could be worth at least £2bn nationally in journey time savings. MOVA on its own, for example, could deliver over least £400m of benefits with a payback time in weeks[6], while Transport for London's use of SCOOT delivers over £100k of benefit per junction[7]. If all systems are working only 50% optimally across the nation, there is a £1bn benefit not being captured. Work by the TTF showed for some cities this 50% optimal assessment is optimistic, although some are better than others. Recent work by Warrington detailed later in the report showed 30% journey time savings through their optimising existing systems using new data.

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[5] https://www.ttf.uk.net/publications/

[6] Traffic Advisory Leaflet 3/97 - https://www.gov.uk/government/publications/traffic-advisory-leaflets-1989-to-2009/traffic-advisory-leaflets-1989-to-2009 (1997 prices converted to 2020)

[7] http://www.itsinternational.com/sections/cost-benefit-analysis/features/tfl-expands-scoot-adaptive-traffic-management

Use of Co-operative ITS

A core theme of “make the most of what we have already” has emerged from this work. It follows that a principal area of research is connected technology to help reduce the costs of safeguarding these existing benefits, freeing-up resources for new innovations. However, once this is done, there is a further potential to rapidly save up to a further £4-5bn of economic and real-world costs in the UK, through the adoption of technology according to the Strategic Business Case.

Reducing journey time unpredictability and smoothing out traffic flows while reducing tailpipe emissions without large physical infrastructure spend will be a real benefit of adopting Signal Phase and Timing (SPAT) developments. This would help towns, cities and rural areas across the UK grow without hard infrastructure investment and will potentially add an extra £2.5bn per annum to GDP. This would mainly be achieved through reduction in congestion but would require technological implementation within authorities to be seen as a national rather than local investment. The local benefits that would arise would add up nationally to give major scheme level outcomes which the TTF estimated could reduce the cost of congestion by £400m per annum across all of the UK’s roads.

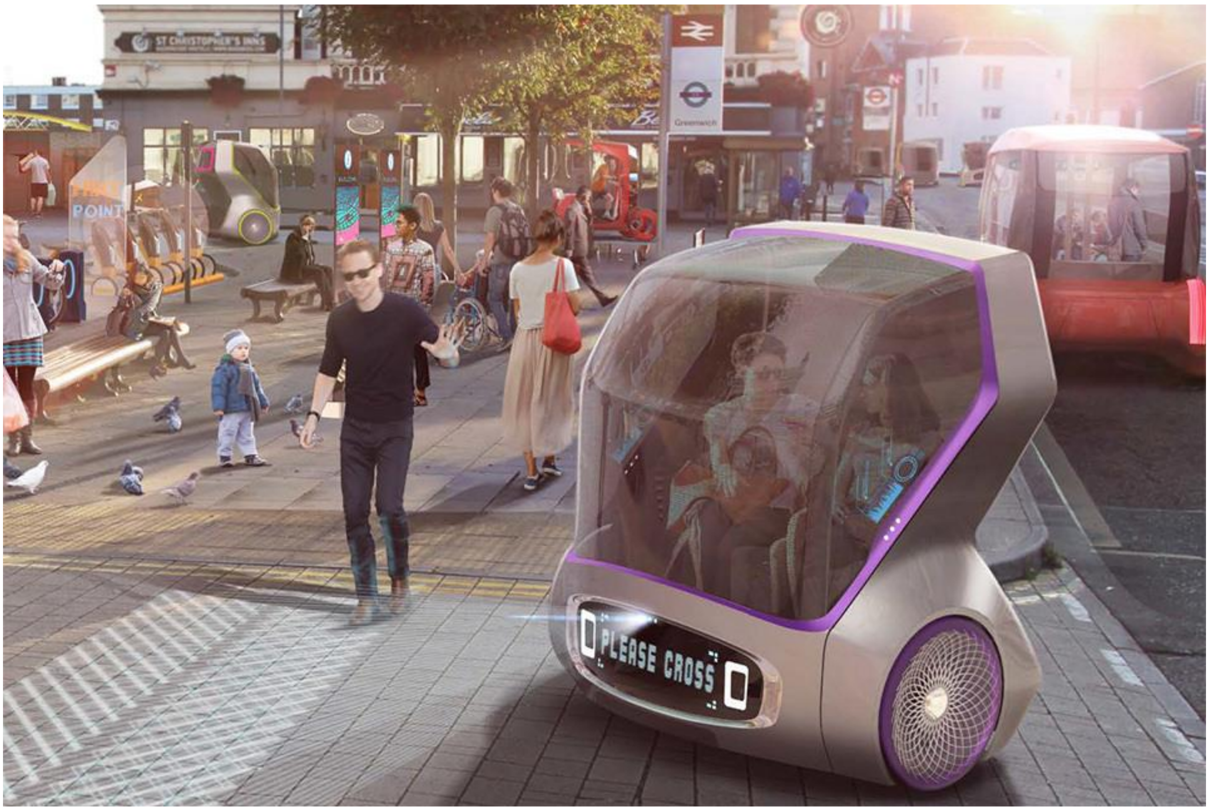
Maintenance and asset management costs could be reduced by exploiting new data sources to target and focus services. Real-world efficiencies in asset management and planning of up to £300m per annum could be delivered by data supporting risk-based maintenance programmes that help target where resources are needed most and reducing the costs of site surveys for example.

Improving road safety, including reducing the incidence of collisions, was estimated by the TTF to have a potential to reduce the cost to society of road casualties by £360m per annum.

These benefit areas are the focus for this report.

4. Wider Government Initiatives

The background for this work is the Government's Industrial Strategy. A key part of it is the movement of the people and goods industry needs to aid Gross Domestic Product and improve local productivity. For example, reducing the costs of delivery and regularity of supply to support just in time operations.



The Future of Mobility Grand Challenge

The Future of Mobility Grand Challenge was established in 2017 to make the UK a world leader in the way people, goods and services move now and in the future. For many years advances in transport services have been incremental and predictable with fixed infrastructure, a legacy regulatory framework and lack of access to data creating high barriers to entry for suppliers and a lack of services for authorities. Following on from that challenge, the Government published the Future of Mobility Urban Strategy which set the following principles:

"In facilitating innovation in urban mobility for freight, passengers and services, the Government's approach will be underpinned as far as possible by the following principles:

- New modes of transport and new mobility services must be safe and secure by design.
- The benefits of innovation in mobility must be available to all parts of the UK and all segments of society.
- Walking, cycling and active travel must remain the best options for short urban journeys.
- Mass transit must remain fundamental to an efficient transport system.
- New mobility services must lead the transition to zero emissions.
- Mobility innovation must help to reduce congestion through more efficient use of limited road space, for example through sharing rides, increasing occupancy or consolidating freight.
- The marketplace for mobility must be open to stimulate innovation and give the best deal to consumers.
- New mobility services must be designed to operate as part of an integrated transport system combining public, private and multiple modes for transport users.
- Data from new mobility services must be shared where appropriate to improve choice and the operation of the transport system."

Whilst we clearly must consider the future, we should also be mindful that local authorities face many day-to-day pressures. They have statutory legal obligations to fulfil, local policies to adhere to and local political expectations. Resources have been squeezed resulting in a shortage of resources and suitable people with the skills and experience to exploit the opportunities of new technology, although there is a backlog of maintenance and road defects to content with, and strong evidence of the losses incurred through poorly configured traffic signals, transport spending must compete with other often higher, priorities.

Hence finding a way to turn these strategic initiatives into deployment of new C-ITS on the ground is a challenge and a central theme of this report.

5. The C-ITS Pilot Projects

The Department for Transport has run several competitions in recent years to connect its strategic approach to the Future of Transport, with the need to establish and showcase real-world benefits at local level. These competitions have funded local authorities directly, who then engage with the roads and automotive suppliers, service providers, researchers and academia through local procurement processes.

In total, over £6m has been invested in 44 separate C-ITS Pilot Projects, in the following groups:

Signal Phase and Timing (SPAT)

Projects that aim to reduce congestion though the co-operation between vehicles, drivers and traffic signals though providing information about when signals will turn green. This has often been through Green Light Optimum Speed Advice (GLOSA) services into the vehicle, or by using data from the vehicles instead of fixed sensors to set signals. These projects were undertaken in Newcastle, Portsmouth, Somerset (at Hinkley Point), Birmingham on the A45 test site and City of York. The focus here is reduced fuel use and emissions from reduced stopping of vehicles.

Asset Management

Projects that focus on new data to help improve management of the road asset, including finding and measuring potholes and other road defects, detecting impacts of construction traffic, checking for missing road signs, measuring impacts on structures, etc. These projects were undertaken in Buckinghamshire, Croydon, Derby, Essex, North Yorkshire, Oxfordshire, Southampton, Swindon, the West Midlands, Westminster, West Sussex and City of York.

Connected Technologies and Data

Projects that aim to connect information, data and new technology for safety, other traffic management, policy or accessible transport aims and were undertaken in Derbyshire, Dorset, Peterborough, Reading, Southampton, Swindon, Warrington and Worcestershire.

Smarter Parking

Projects that aim to deliver smarter parking, with both a better customer experience and new policy tools to support mobility. This is for example, to help reinvigorate the high street and support Blue Badge enforcement. These were undertaken in Blackpool, Coventry, Hounslow, Luton, Milton Keynes, Oxfordshire and Westminster, with non-DfT funded projects in Sunderland, Cardiff, Portsmouth, Halifax and Harrogate amongst others adding additional knowledge.

Opening Local Authority Transport Data

The DfT announced 11 projects in Spring 2019 that focus on unlocking siloed data held by Local Authorities to improve transport outcomes in Bedfordshire, City of York, Essex, Hull City, Nottingham City, Transport for Greater Manchester and Transport for the West Midlands and use of new standards for open parking data in Manchester, Cambridgeshire and across South Essex.

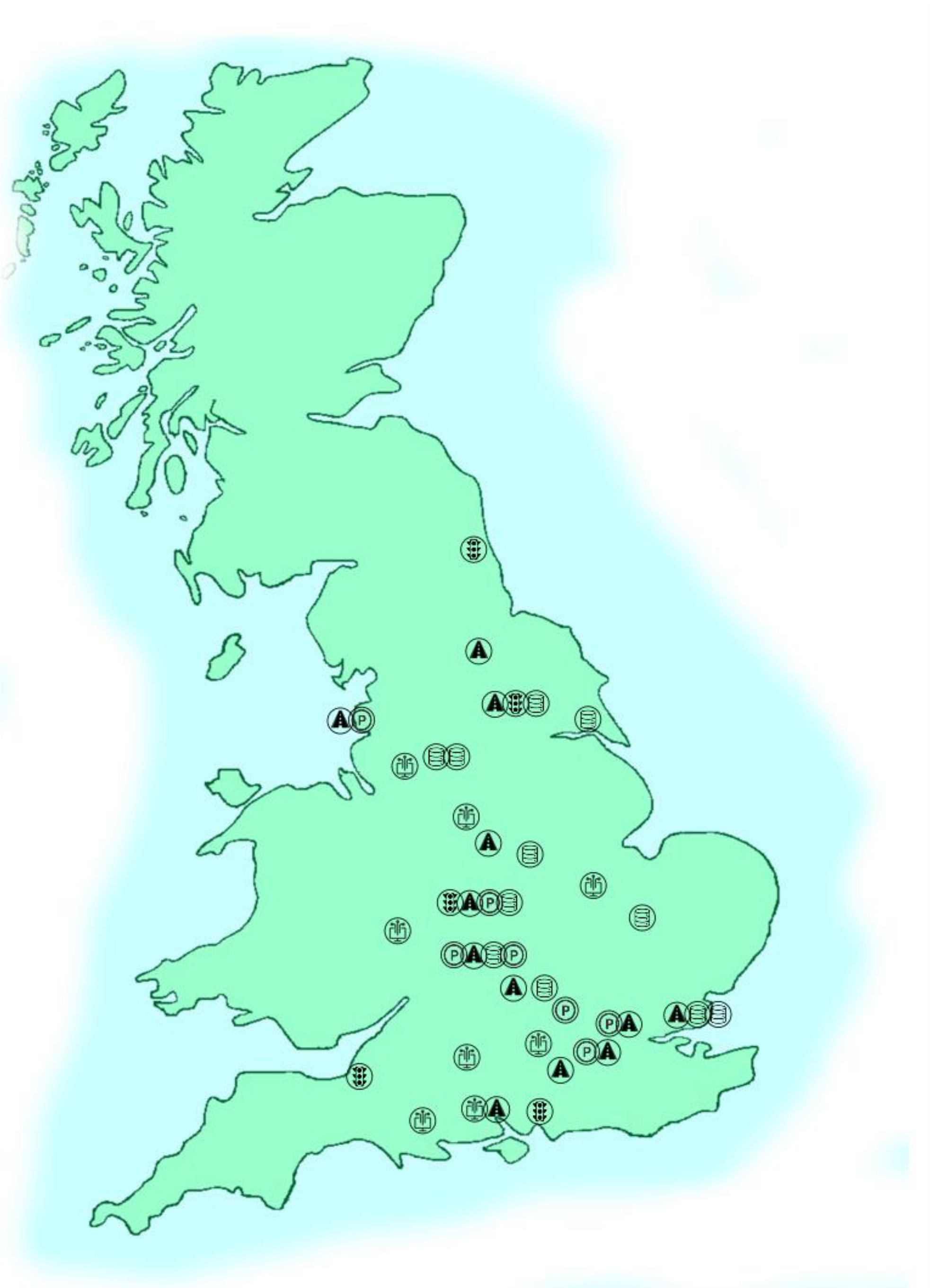
GovTech Catalyst Congestion Challenge Projects

This is a Small Business Research Initiative competition with funding provided jointly by the DfT and SBRI GovTech Catalyst. Many local authorities lack access to reliable, real-time information about vehicle traffic, cyclists and pedestrians. This competition is helping local authorities better understand and respond to traffic congestion by providing data that is less resource intensive and higher quality.

The projects the DfT has funded are listed in **Annex A**.

These pilot projects on their own are not enough to provide a connected nation, so DfT also funded the following related activities:

- co-ordinated evaluation of benefits of these schemes by Newcastle University
- support for development by the BPA of a standard model for the digitisation of Traffic Regulation Orders
- support for training and skills development through working with the European ITS body, ERTICO to deliver the EU-funded CAPITAL training and skills programme
- establishment of the TTF, bringing together all interested parties for example to develop this report and providing training for practitioners
- support to the Transport Data Initiative (TDI) to encourage sharing of data



SPAT (Signal Phase and Timing)

Asset Management

Smarter Parking

Connected Data and Technologies

Opening Local Authority Transport Data

C-ITS Projects in England

- working with the Government Data Service (GDS) in recent SBRI and GovTech projects on making better use of data by local authorities to reduce congestion. This includes in-vehicle data for signal performance monitoring
- In addition, the Department is involved with Kent County Council and TfL in delivering the EU-funded Intercor A2/M2 Corridor programme, bringing international connectivity testing and motorway in-vehicle services. The UK is also involved with larger scale pilots through Zenzic, CCAV and Innovate UK funding. The learning from these projects, for example UK CITE, Flourish and Autodrive, supports the findings of this report. Together with the DfT local authority C-ITS Pilot Projects, they provide a rich set of learning and testbeds for future research.

The details of C-ITS Pilot Projects are available on the TTF website[8]. It was a funding requirement of all projects that authorities should take part in a cross-cutting evaluation undertaken by Newcastle University. Each authority was also required to join the relevant user group set up by the DfT (see section **7**) that followed the above areas of funding and publish a final report on their website.

[8] https://www.ttf.uk.net/october-2018-conference-resources/

5a. Signal Phase and Timing (SPAT)

Typical Features

These projects typically involve, for GLOSA:

- data being collected from traffic signal systems to determine when they will turn green. Due to the adaptive nature of many UK traffic systems, this is a challenge compared to the fixed timings used in many other countries
- publishing a feed of these predictions to onboard units or apps that show when a signal will turn green, or the speed needed to follow a "green wave"

Other signals projects use data from the vehicles themselves. This is either as commercial floating vehicle data or from similar on-board units used for GLOSA. This is used to detect congestion and change traffic signal timings, in addition to or in place of physical road sensors such as loops.

Example Projects

A45 Corridor GLOSA (Birmingham City Council)

This £300k project provides an operational implementation of GLOSA on the A45 Coventry Road. It provides information about current and predicted traffic signal stage via a public web API available to all developers and OEMs, etc.

Eboracum (City of York Council)

City of York Council has led a £525k project focused on improving traffic signalling on the A59 while testing technology options for communications vehicles.

C-ITS Platform (Portsmouth City Council)

This wide-ranging £303k project aims to help Portsmouth deal with the challenges that most other UK small cities face around congestion, air quality and resource limitations.

Common Learning

The main common learnings from SPAT projects are:

- When delivered with care, GLOSA can be made to work sufficiently well with the SCOOT adaptive signalling technique used widely in the UK but the MOVA individual junction optimisation tool needs further research to understand the benefits that could achieve through reduction in vehicles stops

- The A45 project suggests that for GLOSA, existing 3g and 4g communications are suitable for this site and use case
- the “plumbing” of existing roadside equipment and new services can be a challenge, especially with limited local authority resources without specialist skills
- the use of an app in vehicle needs careful work to ensure it is safely deployed but this is already underway
- the user experience is crucial, as this is not a mandatory service it has to work well for users from the first time they experience it
- floating vehicle data is already sufficiently good to set traffic signals to reduce delays

Links to the Future

GLOSA and co-operative traffic signals could clearly provide a new rapidly available tool for reducing stops and congestion and potentially reducing the cost of maintaining and installing physical sensors. GLOSA is attractive to road users and authorities alike because the benefits of fewer stops and emission reductions from tyre wear, brake dust and road particles are the same for both groups. The adoption of GLOSA data by automotive companies is starting in Spain, Germany and the US, and sufficient local authorities deploying data would provide a business case for full integration with new vehicles as well as apps for older ones.

GLOSA data will be useful for autonomous vehicles approaching traffic signals to be able to avoid slowing down on the approach to a signal and to optimise EV range.

In the Netherlands, the Talking Traffic Partnership is a collaboration between the Dutch Ministry of Infrastructure and the Environment, sixty regional and local authorities and national and international private companies. These partners are working together to develop and deploy traffic signal data and convert this into real-time and made-to-measure data sets and information. This will provide information to a wide variety of road users though their smart phones, personal devices and in-car systems.

5b. Asset Management

Typical Features

These projects typically use data from vehicles to measure the condition of road assets including road pavement and roadside structures, traffic signs, obstructions, street lights, and hazards. This can be acquired from smartphones, in-vehicle dashcams, and pay as you go insurance and fleet management devices, often connected to standard OBD2 in-vehicle diagnostic connections[9].

Other data sources include LIDAR and smart sensors for culvert flooding. Other projects focused for example on the condition of rural roads. The focus here is on improving the roads themselves, as opposed to the operation of traffic on them.

Example Projects

CONVERT (Westminster City Council)

In this £115k project, Westminster City Council (WCC) extracted and re-purposed LIDAR survey data, already captured as part of the DfT funded Smarter Parking initiative within Westminster's road network.

Sign Inventory using Connected Vehicle Data (North Yorkshire County Council)

This £83k project catalogued traffic signs on the category 2, 3a, 3b highway network using smartphone video images collected from a vehicle refined with elaborate image recognition algorithms and signal processing methods.

Street lights in Buckinghamshire (Buckinghamshire County Council)

This £50k scheme proposed relating to the monitoring and maintenance of street lights involved testing ways to reduce cost and using deep learning techniques.

ECAMS (Transport for the West Midlands)

The £98k TfWM Enhanced Continuous Asset Monitoring Solution (ECAMS) project uses accelerometer data collected from OBD2 "dongles" retrofitted in 17 existing vehicles in the West Midlands (Birmingham and Coventry).

[9] http://www.obdii.com/

Common Learning

The common themes from the Asset Management projects are that there is clear potential to both reduce survey costs and improve maintenance planning and design, as well as increase asset life. Several opportunities emerge from data sources that are already in place. Data from smartphones, dashcams and 'pay as you go' insurance devices can be reused for other purposes, for example LIDAR data used for parking also shows road and pedestrian pavement condition.

There is clearly an opportunity to save as much as 5% of a UK authority's maintenance costs. But to exploit this, other parts of the maintenance chain need to be able to fully use this data. It is a fundamental finding of this report that the entire process of transport technology delivery must be reconfigured to make the most of data and this is considered to be a key challenge. New data must not sit in new siloes and there is an opportunity to exploit datasets and make more cash savings.

Of the themes explored in this report, improved asset management is the area with the clearest monetary savings for an authority and the one potentially requiring least changes in technology to deploy. It does need however to be fully integrated into the maintenance process and supply chain.

Links to the Future

There is a wide range of data already being collected from human-driven vehicles of value for future connected and then autonomous vehicles. Examples are traffic sign data and condition, which is a useful first step to potential deployment of Intelligent Speed Adaptation (ISA) and on road pavement and footpath quality, needed by all road users. The volume and scope of data collected by vehicles will only grow, for example as LIDAR is fitted to autonomous vehicles and as dashcam and insurance black box growth continues. Data from vehicles to improve roads therefore is perhaps a hidden benefit of connectivity, with real monetary savings rather than the economic ones often delivered by other themes.

5c. Connected Technologies and Data

Typical Features

These are projects that typically use existing infrastructure such as traffic signals and variable message signs. They use new forms of data for setting them, for example wi-fi data anonymously harvested from vehicles for journey time, Bluetooth data or commercial floating vehicle data. It also includes projects looking to ensure all road users benefit from connected data, for example in Peterborough looking at information for visually impaired road users.

Example Projects

Warrington Intelligent Transport System (Warrington Borough Council)

This project cost £330k and combined real-time journey information harvested anonymously from wi-fi and 'smart devices' and vehicles with wireless communications. It developed strategies to manage the network more efficiently using the Urban Traffic Management and Control (UTMC) system.

Pre-emptive Traffic Management (Derbyshire County Council)

Derbyshire developed a technology demonstrator for strategic-level traffic management on the County Council's road network. This £250k project used commercially available floating vehicle data to provide intelligence on the state of traffic flow and roadworks.

Hinkley Point GLOSA (Somerset County Council)

This ambitious £313k project was set up to mitigate the impacts of construction at Hinkley Point 'C' Nuclear Power Station, one of the largest construction projects in Europe.

Common Learning

Common learning has emerged on the need to help stakeholders understand new concepts and understand how these may fit into existing procedures, the need to understand how to procure and integrate new technology alongside proven infrastructure and the value of shared data.

Links to the future

These projects show how data from vehicles can be used with existing systems to generate information for all roads users. The interface between connected and driverless vehicles with existing traffic control systems will be important. This work has informed many developments about links to future systems. It also shows how local authorities can transition from sensor-based to vehicle-based data sources.

5d. Smarter Parking

Typical features

Smarter parking projects typically involve:

- identifying the availability using automatic number plate recognition (ANPR), other cameras or sensors either installed in the parking bay or on lamp posts
- communicating this availability and the related prices to the road user, typically via integration of space data into navigation apps and then having payment once the vehicle is parked safely
- links to the “back office” of the authority, to ensure for example that someone paying via an app does not then receive a penalty charge notice from a civil enforcement officer
- using open source data standards such the APDS and TRO Discovery Data Model to streamline data processing and management, ensuring compatibility with current and future user requirements

Example Projects

Coventry City Council, Harrogate Borough Council and Calderdale Council, (Halifax)

These schemes are aimed at helping to reduce driver stress, congestion and emissions generated while looking for parking spaces by navigating drivers directly to available bays.

CASPAR (Oxfordshire County Council)

The £268k CASPAR Project monitors 299 spaces by sensors and cameras, focusing on disabled parking bays and integration with UTMC systems.

Common Learning

The main learnings from the smarter parking projects are:

- road users and local politicians find smarter parking initiatives attractive and they enable new policies for parking, for example pay by the minute, emissions-based parking and escalating tariffs for those exceeding the authority’s desired duration of stay

- digital versions of traffic regulation orders are needed to make the most of smarter parking and to ensure that compliance can be checked. This is being supported by DfT as it is a major challenge to some authorities who still have paper-based or non-machine-readable systems
- integration with existing parking back office systems can be challenging
- managing roadside installations can be a challenge, especially where building wayleaves and street lighting are involved, on cobbled streets and where on street furniture is involved

Smarter parking is a success story, where the UK leads not just in technology but also in customer experience, integration with legislation and use for all road users. However, to move from various pilots and city deployments to a UK-wide interoperable service needs opening-up of data held in local authorities. It also needs standard ways for using tariff, traffic regulation and availability data. This is being supported in Manchester, Oxfordshire, Cambridgeshire and South Essex Councils with further DfT funding and in the City of London, Cardiff and other cities.

Links to the Future

Smarter parking is clearly an area where increased data itself from vehicles themselves will, over time, augment or even replace physical sensors. Historical vehicle-based parking data may already be enough for less congested parking areas, but sensors provide the real-time confidence that spaces are available. Parking of automated vehicles, be they Mobility as a Service, (MaaS) shuttles in periods of low demand or early adopter personal vehicles will all need this link to parking availability, tariff and payment systems. The wider link to CAV parking is being explored in Innovate UK projects such as ParkAV and in the Zenzic testbed project Park-IT. The standards that will enable CAV parking are being developed by the APDS in collaboration with the automobile industry.

5e. Opening Local Authority Transport Data

Typical Features

The opening local authority data projects focus on the use of datasets currently held by local authorities or other public bodies in new and innovative ways. Significant opportunities could be realised from better use of the datasets that local authorities currently hold or could easily create from their activities. The potential for data sharing, cross border working and cooperation between public bodies is not happening as widely as it could.

Studies undertaken by government including the Local Transport Data Discovery[10] have highlighted the potential benefits in better provision of current services and new service opportunities that could come from opening up data. The projects that make up this group have a strong emphasis on sharing data across boundaries. This is to promote service delivery, the use of open standards and building new intelligence on existing underutilised data sources. The eleven projects that make up the Opening Local Authority Transport Data theme are currently underway and working towards their conclusion and will report in 2020.

Example Projects

Parking Data and Payments through Smartcard (Transport for the West Midlands)

This project, valued at £100k, will prepare for the development of the Swift smartcard app to enable mobile parking payments in Dudley and Sandwell. The app will initially provide customer registration, parking payments including reminder messaging and a live data link to parking enforcement teams. It will provide a reporting tool to highlight usage and payment patterns. In the future, this functionality will be merged into an enhanced Swift app that will bring together payment and dynamic information for all modes of transport, as part of the wider work to develop an integrated MaaS solution and reduce congestion.

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[10] https://www.gov.uk/government/publications/local-transport-data-discovery-findings-and-recommendations

The Hull City Canonical API Project (Hull City Council)

This £55k project aims to build on the Council's development of a Smart Digital City Strategy to "Share and open up the use of non-personal data to support new digital initiatives and businesses to develop". It is developing a template for sharing information based upon the approach pursued by Transport for London. Information will be brought together into a single API and shared through an innovation platform.

The project will inform improved transport network efficiency, air quality and reduced emissions, increased access to multimodal transport services, improved citizen experience and provide better information to plan journeys more easily. These will be achieved through five primary API data sets: road network data, cycle & pedestrian data, bus & coach data, parking data and pollution data.

The UTMC Data Warehouse Bedford Project (Bedford Borough Council)

The data warehouse delivered as part of this £92k project is part of the 'Transporting Bedford 2020' initiative and works towards developing an intelligent highway network. Initially, the data warehouse will amalgamate traffic count data, signal data and offline models into a single platform accessed in a standardised open format. The interface from the common database to the data warehouse will be based on XML, and tools will provide scheduled or one-off data export of selected data objects to the data warehouse.

5f. GovTech Catalyst Congestion Challenge Projects

Typical Features

This is a Small Business Research Initiative competition with funding provided jointly by the DfT and SBRI GovTech Catalyst. It is to support a challenge from DfT and (for Phase one), the Royal Borough of Greenwich. Many local authorities lack access to reliable, real-time information about vehicle traffic, cyclists and pedestrians. This competition is helping local authorities better understand and respond to traffic congestion by providing data that is less resource intensive and higher quality.

Traditional attempts to both address congestion and assess the effectiveness of interventions are underpinned by data gathering, often carried out manually. The first phase of this competition focused on feasibility studies and it has now entered Phase 2. This focuses on prototype development and testing of the technology proposals of three consortia.

For phase 2, three of the five projects that received seed funding in phase one are being taken forward to develop their proposals into market ready digital products. These must be capable of meeting current government digital design guidelines and meeting acknowledged user needs. The three projects are outlined below and each will receive £500k drawn from a combined £1.5m fund (made up of a £1m contribution from SBRI and £0.5m from DfT). The projects are being managed by the DfT and run from January 2020 to January 2021.

Example Projects

Data Analytics and Simulation for Traffic Operations (IM23)

Lead partners IM23 working with Immense Simulations and Oxfordshire County Council will create a decision support tool for congestion management. This will maximise the use of existing data supplemented by real-time data from an established data provider. This will ensure the platform will be affordable for ongoing use. The solution will include a user interface, connected to Immense's IMSim platform, where multiple mitigation scenarios can be evaluated for planned and unplanned events to minimise impact. This will provide operators with a means of testing alternative traffic management strategies in an operational environment, without detailed knowledge or experience of simulation.

PROACT – Predictive & Real-time Operational Alerts for Congestion Transformation (Vivacity Labs)

The PROACT system will monitor the traffic network on behalf of the control room operator, acting as a watchdog to flag incidents and provide next-generation real-time forecasts to enable decisive proactive decision-making. This capability will be delivered by a partnership between lead partner Vivacity Labs, FlowX, Siemens and Bournemouth, Christchurch & Poole (BCP) Council. They will be combining data from Vivacity's current video analytics software, Siemens' UTC system and other traffic data sources (e.g. existing Bluetooth Journey Time sensors). They will use machine learning on these merged data feeds to detect incidents, and help implement strategies to alleviate congestion.

PATH – Performance Analysis Trajectory Help (INRIX Traffic Ltd)

Work by the TTF showed many UK traffic signals do not now work optimally, despite technologies like SCOOT and MOVA being used. Lead partner Inrix experimented with individual GPS tracks to map 'paths' through signals. These show a long "hockey stick" characteristic shape when signals are not working well and when vehicles queue at other types of junctions. Inrix are working to explore a much nearer to market tool set, improved by capturing user needs and agile prototyping. By developing quantitative measures of congestion, they plan to test the developing toolkit with the City of York Council and 10 other authorities as a web-based service.

6. Outcomes from Co-operation

Policy outcomes

The projects outlined in Section 5 have all aimed at benefits aligning with local authorities' own policies and national aims:

- journey time savings and reduced congestion, and / or reduced emissions
- reduced asset maintenance costs, both for better management of traditional road maintenance activities and using cheaper, more reliable technology.
- improved road safety for all users
- increased accessibility to transport and parking and improved customer experience
- Dealing with the immediate impacts of the Covid-19 pandemic and the challenges of restart and society's 'new normal'.

Technology learning

These research projects also act as pathfinders by exploring issues in the real world of UK towns, cities and rural areas. In addition, deploying equipment in the real world has exposed "softer" learning too, in areas including the General Data Protection Regulation (GDPR), and how it applies to harvesting data for connected vehicles and ways to be compliant with it, and on how to access data from in-vehicle systems in a local authority environment.

Many of the projects encountered challenges around procurement of new technology and the interoperability of equipment between roadside and vehicles. There are often restricted local authority resources to support the project delivery. Sometimes the stated performance of new co-operative technology has not been fulfilled in the real world.

Nevertheless, all the projects have contributed to learning that has been shared, as this is often of most value. The user groups discussed next are vital to establishing co-operation not just between vehicles and the roadside but between local authorities also. This sharing of experience across the nation is likely to be of increasing value as more and more connected services emerge.

7. User Groups

DfT set up four user groups to bring disparate projects together to share experiences and learning, to lead to wider support and guidance. These now form the core of the TTF Technical Working Groups, with a clear focus on expanding participation. The groups are now working towards producing implementation guidance for local authorities and suppliers considering adopting C-ITS.

The first meeting of the Asset Management Focus Group

Signal Phase and Timing (SPAT)

This group focuses on GLOSA, but includes projects using data to improve signals. It includes road users and the automotive industry through the Automotive Electronic System Innovation Network (AESIN), and the RAC Foundation. The group met with automotive-led projects and established a strong knowledge sharing partnership. The issues of roadside-to-vehicle communication compatibility, human-machine interface and automotive industry standards were shared, as was the need to engage with customers and policy makers.

The group has also shared GLOSA technical documents and Birmingham City Council shared its open source code which enables other projects to access its data.

Asset Management

This group focuses on projects using new sensors, notably but not exclusively in vehicles, to improve information about road assets. It has been looking at the potential for a standard “image bank” of data for image processing-based projects to reduce time taken for machine learning and standardise reporting on traffic signs.

There are strong links between this group and the Highways Maintenance Strategy within the Local Infrastructure directorate of the DfT. This group has notable success in identifying potholes through different approaches and is working with the Local Council Roads Innovation Group (LCRIG) to ensure the benefits of linking developments in technology with those in asset management are maximised.

Smarter Parking

This group draws together a wide range of government and privately funded initiatives to share findings, opportunities and lessons learned. It is particularly connected to the DfT-funded work by the British Parking Association (BPA) on parking standards, digital TROs and other smarter parking projects not funded by DfT, for example in Cardiff and Harrogate.

The group covers a mix of projects including the adoption of bay sensors, cameras, variable message signs. It includes work to pilot open data standards through adoption of the Alliance of Parking Data Standards (APDS) and a digital TRO Discovery data model, developed through DfT support for BPA initiatives. The Smarter Parking group will also focus on drawing together the lessons learned in procurement, evaluation and cyber security from each project.

Connected Technologies and Data

This group focuses on use of data and connections to provide new and improved services to users often using existing channels such as variable message signs, UTMC and existing local authority data sources. The key is that they look horizontally across previous siloes to make the most of existing investment.

The group initially consisted of projects looking at a wide range of technologies to bring data sources together for the benefit of road users. To this, the Opening Local Authority Transport Data competition winners have been added, bring a new focus on the opportunities that data integration and amalgamation will bring across local authority service delivery.

8. Lessons Learnt

A first lesson is that more emphasis is needed on measuring benefits and outcomes to help build a UK-wide and local business case. Many projects work at a technical level but do not yet engage with the road user to change their behaviour. We need to move to measuring customer facing outcomes.

Too much time is still spent integrating between siloes of data in old systems and exploring what data lies hidden in them. The DfT's most recent competition, Opening Local Authority Transport Data, will enable 11 authorities, including many such as Hull City Council new to the C-ITS world, to engage more fully and tap into locked-in data.

There is clearly a lack of resources and skills in local authorities faced with increasing pressures on their day-to-day work. Equally, authorities often lack the data science skills needed for integration of the necessary pieces of the jigsaw, especially in areas such as connecting infrastructure to vehicles, wireless hardware, big data and network connections to local authority systems.

Procuring new technology is still a challenge for many authorities, especially with new suppliers, some new to the UK and its way of working. Terms and conditions may need attention, for example when buying data as a service rather than assets. The prime aim of safety must always be respected also, and some new suppliers may need to consider areas as liability and insurance further. Authorities need to be able to buy innovation and creativity whilst continuing to seek best value, properly managed risk and maximum public benefit. As local authorities increasingly look to use frameworks to buy products and services, initiatives developed by the Crown Commercial Services (CCS), such as SPARK[11], will help address this barrier.

In many areas, the innovation will come from non-traditional vendors and SMEs and it is important that such companies are able to engage with local authorities, qualify for tendering exercises and offer innovative and novel solutions to problems. It is also important that such companies are visible to local authorities and ways are found to undertake "match-making" between appropriate vendors and purchasers.

[11] https://www.crowncommercial.gov.uk/agreements/RM6094

Local Authorities want to avoid wasted investment, so equipment that will be upgradeable and backwards compatible is needed. Wider knowledge of the evolving standards landscape needs to be shared with UK Local Authorities.

Many of the services have been deployed using existing 3g and 4g communications, whilst some have used ITS-G5. This has provided valuable evidence on the coverage and capability of both technologies, as well as cost and benefit comparisons for cities.

GDPR is an issue but often it is the perception of it being a barrier (not a safeguard) that is the problem. Shared best practice between authorities and model privacy assessments would help here.

We need seamless services. Drivers do not know or care whose roads they are on. There is already an issue with cashless parking having many apps for different areas but, as yet, not a single interoperable service. This requires both standards and a business model and we must avoid the same situation developing for GLOSA for example. This is a major threat to customer satisfaction and risk of being locked into single suppliers. The Highways England and Local Authority networks need to interoperate seamlessly too.

All these projects reinforce the value of data for connected – rather than autonomous vehicles. The use of commercial floating vehicle data in York for signal setting, insurance black box data in Birmingham for road condition monitoring and smartphones for sign assets and smarter parking reminds us that drivers of vehicles already on the road today can benefit too.

DfT has also invested in help for those deploying services, including training in new traffic signal technologies, making the most of prior investment in world leading systems and sharing advice in how best to procure new technology. Middlesex and Newcastle Universities are now offering Master's degrees to bring on the next generation of experts.

The scope of the UK portfolio for C-ITS is now large. The 32 projects in the first tranche added with 11 further open data projects means probably more projects than any other nation in Europe. So, when combined with projects not funded by DfT (Kirklees, TfGM, Harrogate, for example), and the A2/M2 project, and other CAV projects plus the Zenzic portfolio this means the UK covers all levels of connectivity and many different use cases.

The DfT C-ITS activities have been recognised as being fundamental to future developments by external stakeholders such as the IET, BPA and ITS(UK).

There are still barriers. The next steps include moving from paper-based to digital TROs, opening up data more towns and cities and making the whole roads maintenance chain able to use data from vehicles.

The C-ITS projects, and the wider adoption of new technology has played a vital role in the response to Covid-19. It is also clear that whatever form transport takes in the future, it will for some considerable time be different to what we previously envisaged. Likely changes in work patterns, modal-split and the commercial economics of transport operation, together with a greater acceptance of the need for and use of data all suggest an increaing role for C-ITS and technology.

Finally, there is a need to manage expectations and avoid being tainted with the hype surrounding many autonomous vehicle concepts. These pathfinder projects may make small incremental changes to the way traffic operates in towns and cities, may reduce emissions and may save a small proportion of the asset management costs faced by councils. They are not an immediate cure for all congestion. But because of the national scale of the problem, deploying these ideas across the nation would give similar benefits to national schemes but at far less cost.

9. Lighting the Way Ahead

Where do we go from here?

This report has shown a wide range of deployments across the nation and equally importantly the beginning of data sharing, education, training and evaluation needed to deploy connected vehicles effectively. There are some strong success stories highlighted with clear outcomes especially in asset management, often a “Cinderella” subject but one where there is potential for significant cashable savings for local authorities.

Together with the autonomous vehicle pilots, we are starting to build a connected nation for all road users. But before we consider a national solution, there is clearly scope while new developments mature to make the most of investments already made in areas such as SCOOT and UTMC. New data sources, new sensors and new techniques can clearly help here, as will training and support for local authorities. The theme of “let’s make the most of what we have already” is very common when talking to local authorities about C-ITS investment, as there is evidence that benefits from previous investments is now being lost.

The work of these projects forms part of a much larger picture. Government is investing heavily in developing UK roads’ services and capabilities through national initiatives. Under the Industrial Strategy Future Mobility Grand Challenge described earlier in this report, the Future of Mobility Urban Strategy sets out the aims and challenges around new transport technologies. Future Transport Zones funding is part of the wider £1.7bn Transforming Cities Fund and will provide significant support to large urban areas to facilitate transformational change in urban transport.

Government is also funding development of new standards and frameworks needed to support new technologies. These are the Local Authority Mobility Platform (LAMP), a framework for designing and delivering cross-modal services, and the National Access Point (NAP), a catalogue and standards for vehicle to infrastructure data flows across the whole of Europe.

In terms of C-ITS, there are still barriers to overcome to make the most of this progress. There are still many siloes of data in old systems. The next steps also include further investment moving from paper based to digital parking regulations, better support for procuring technology and services, updating guidance for local authorities.

It is important to not overstate benefits, for example users who are told that their vehicles will report potholes will expect to see an improvement in “their” reported potholes, and techniques such as GLOSA clearly cannot deliver benefits in highly congested conditions. Nevertheless, small gains made from deploying a variety of local interventions nationally could still provide significant economic and cashable benefits before the uptake of autonomy.

There is often talk of making the roads ready for CAVs. This report shows that, for connected vehicles at least, there is already some success. It also shows that it is not the roads that need to be made ready, but the data, systems and people that use, maintain and operate them

Annex A: C-ITS Pilot Projects

The Department for Transport ran five competitions from 2016 to 2019 for its strategic approach to the Future of Mobility and the need to establish and showcase real-world benefits at local level. These competitions have funded local authorities directly, who then engage with the roads and automotive industries, service providers, researchers and academia through their local procurement processes.

This annex focuses on a selection of the projects where the overall learning has been most valuable. Rreports on the other projects are available on the TTF website[12]. Over £6m has been invested in 44 separate C-ITS Pilot Projects which resulted from DfT competitions and a further £1.5m has been invested, in partnership with the Cabinet Office SBRI Govtech Challenge in projects that use technology to address congestion. From this, we have formed the following groups:

- Signal Phase and Timing (SPAT)
- Asset Management
- Smarter Parking
- Connected Technologies and Data
- Opening Local Authority Transport Data
- GovTech Catalyst Congestion Challenge

Signal Phase and Timing (SPAT)		
Newcastle	The Great North Road – C-ITS Smart Corridor	£98,200
Portsmouth	Portsmouth CITS (Co-operative Intelligent Transport Systems) Platform	£285,000
Somerset	A38 Cooperative Intelligent Transport Systems demonstrator	£298,090
West Midlands	TfWM GLOSA Trial, A45 Coventry Road	£285,000
City of York Council	Eboracum	£295,200

[12] https://www.ttf.uk.net/publications/

Asset Management		
Blackpool	Digital Inspector	£100,000
Buckinghamshire	Developing deep learning techniques for semi-automatic detection of road assets in Buckinghamshire	£50,300
Croydon	UCAMP (Urban Construction Asset Management Pilot)	£80,000
Derby	Derby City Funding for Innovation	£40,000
Essex	Vehicle Informed Asset Management	£61,560
North Yorkshire	Road Traffic Sign Inventory using Connected Vehicle Data	£55,000
Oxfordshire	CAVL4R (CAV LIDAR for Roads)	£88,200
Southampton	Smarter Asset Management for Southampton	£90,500
Swindon	Highway Asset Smartphone Data Application	£48,000
West Midlands	ECAMS (Enhanced Continuous Asset Management System	£92,800
West Sussex	ReTRAC (Local Road Condition Analysis)	£44,000
Westminster	CONVERT (Connected Network Vehicles in Real Time for Network and Asset Management Operations)	£100,000
City of York Council	Pergamentum	£72,000

Smarter Parking		
Blackpool	Blackpool Tourism Traffic Flow and Enhanced Car Park Guidance System	£234,000
Coventry	Real-time Bay Sensor System	£150,000
Hounslow	Electric Vehicle Smarter Parking	£204,000
Luton	Luton Town Centre Connected Parking Guidance: I2V & VMS	£73,500
Milton Keynes	Milton Keynes Transport Information System	£175,000
Oxfordshire	CASPAR (Collaborative Smarter Parking)	£239,000
Westminster	Westminster Connected Parking Initiatives	

Connected Technologies and Data		
Derbyshire	Derbyshire Pre-emptive Traffic Management	£237,500
Dorset	A31 Smart Collaboration	£182,100
Peterborough	Connecting Peterborough	£50,000
Reading	C-ITS for UTMC Network management	£250,000
Southampton	Better Journeys in Southampton	£90,000
Swindon	Connecting Swindon	£235,000
Warrington	WITS (Warrington Intelligent Transport System)	£300,000
Worcestershire	WITS (Worcestershire Intelligent Transit Systems)	£300,000

Opening Local Authority Transport Data		
Bedford	UTMC Data Warehouse	£92,000
Cambridgeshire County Council	DfT open transport data for Cambridgeshire	£94,000
Essex County Council	Real-time information for connected vehicles	£79,500
Hull City Council	Hull City Canonical API	£55,000
Manchester City Council	APDS Pilot: Off Street Car Park and Kerbside Availability	£100,000
Nottingham City Council	Nottingham Live Transport Data	£50,000
Oxfordshire County Council	HeartPark	£91,860
Southend-on-Sea Borough Council	ASELA Open Transport Data Initiative	£98,000
Transport for Greater Manchester	GMDataHive	£95,000
Transport for West Midlands	Transport Data Unification (traffic data)	£100,000
City of York Council	Opening Local Authority Transport Data	£100,000

GovTech Catalyst Congestion Challenge Projects		
IM23	Data Analytics & Simulation for Traffic Operations	£500,000
Vivacity Labs	PROACT - Predictive & Real-time Operational Alerts for Congestion Transformation	£500,000
INRIX Traffic Ltd	PATH - Performance Analysis Trajectory Help	£500,000

Annex B1: Signal Phase and Timing (SPAT) – Example Pilot Projects

A45 Corridor GLOSA (Birmingham City Council)

This £300k project provides an operational implementation of GLOSA on the A45 Coventry Road. It provides information about current and predicted traffic signal stage (red, amber, green, etc) via a public web API available to all developers, OEMs, etc. The project also developed an open source mobile phone application. Traffic signal data will be useful for autonomous vehicles to indicate whether to prepare to stop or slow down, especially in mixed traffic environments.

The project is built upon systems which many UK local authorities will already have i.e. the SCOOT / MOVA traffic signal systems. It does not require significant investment in infrastructure as it uses existing web technologies, cellular and wi-fi communications, and uses connected vehicle standards (CEN/TC 278[13]) – SPAT and MAP – to pass the relevant data between the traffic signals and the vehicle. Tests with adaptive SCOOT timings were successful, but results with MOVA were mixed due to its unpredictable nature.

GLOSA Trial Junction N24211 - Live Data

For Tue Nov 07 2017

Local SPATS Time: 30420 (16:50:42)

SPAT Timing Summary

Phase end times shown. Last update: Received at 16:50:37

SPAT Clock Countdown

Phase	Red	RA	Green	Amber
A	30990	31010	31100	31130
B	30990	31010	31100	31130
C	30290	30310	30750	30780
D	31190	31210	30750	30780
E	31190	31210	36002	36002
F	30830	30850	36002	36002
G	30830	30850	31100	31130
H	30290	30310	30900	30930

Open data available on the A45 website

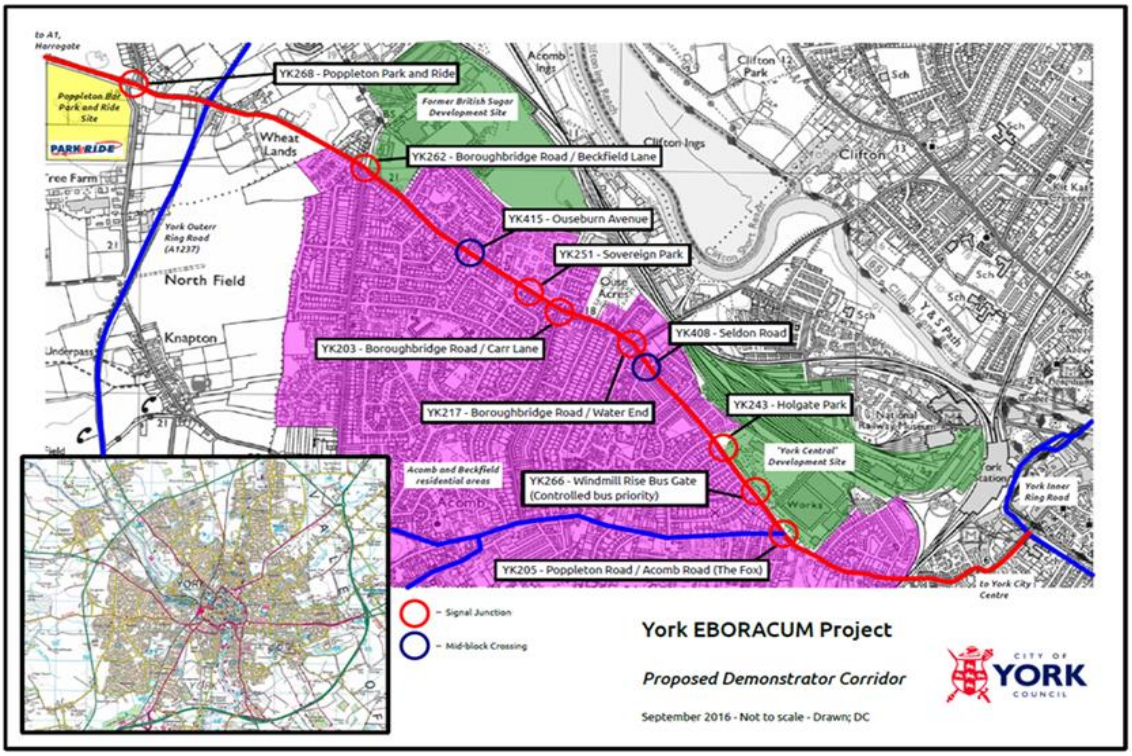
The project shows a 10-14% reduction in stops and starts over the 6km testing route with 10 junctions and a consequent reduction of 5-7% in journey times for the test

[13] https://www.itsstandards.eu/tc278

vehicles, although it should be noted this is from a small fleet. Drivers also report significant levels of satisfaction with the speed advice provided. This was all delivered using 3g and 4g technology – there was no business case for ITS-G5 deployment. A central technical outcome is the website which is able to show live timing data in an open and exportable way that has already been used by other DfT-funded projects. This shows the value of publishing open data in a research project, as other uses not foreseen may emerge and lever value from the data.

Eboracum (City of York Council)

City of York Council has led a £525k project focused on improving traffic signalling on the A59 while testing various technology options for vehicle communications.



The York Eboracum Corridor

The project has achieved:

- the first UK signal control using commercial Floating Vehicle Data (FVD) with existing UTC systems;
- comparing three different ways to collect data from vehicles – ITS-G5, standard Wi-Fi and cellular – looking at the softer aspects of a local authority use of each
- connecting data directly from vehicles to their existing network, to demonstrate potential new policy tools for emissions

- use of open data tools to build a “scale model” for future systems to ease integration
- rural ITS-G5 communicating with a bus, to inform the business case for ITS-G5 for York
- unlocking siloed traffic counter data, camera and UTC data
- a comparison of fixed time UTC, Scoot and UTC plans changed using FVD, showing up to 20% delay savings worth around £60k per annum per junction. Hence the same range of benefits from installing SCOOT has been obtained without physical infrastructure.

Much has also been learned about the “soft” implications of C-ITS in a smaller UK local authority. This includes overcoming the challenges of the perceived impact of GDPR, roadside installation, shortcomings in new ITS-G5 hardware, and a need for dedicated resources with new skills. main lessons from the project are:

- FVD via cellular data is already good enough for journey time monitoring instead of or alongside roadside equipment and can be used for simple signal control
- Using cloud storage is a manageable challenge, as data can flow from roadside via the local authority external network, but external to internal data connections (for example for signal control) need to work within the constraints of a local authority’s security policies
- perception of issues arising from GDPR needs active and clear non-technical explanation right from the start of the project
- installing new unproven technology requires additional skills and resources beyond “the day job” and this has clear implications for the roll out of C-ITS in local authorities
- the whole life cost of roadside installation of sensors and their ongoing maintenance in the real world needs to be compared with the perceived higher costs of “data as a service” and simplicity of data supply
- a common single network map for physical and virtual sensors, traffic system assets and road elements is essential.

City of York Council, working with Middlesex University, has undertaken a study to show that around 40 ITS-G5 beacons would be needed to provide coverage of just the main ‘A’ road arterials, with even more for the ring roads and other feeders. This would require substantial capital investment. This could be a benchmark for evaluating costs of cellular based services.

C-ITS Platform (Portsmouth City Council, cost £303k)

Portsmouth faces the same challenges as most other UK small cities (congestion, air quality, limited resources) but then has further constraints because of its location.

The majority of Portsmouth is located on Portsea island, with a motorway and other A road entrance from "the mainland" right into the city core and also a strategic road crossing through the city's north area. Allied to a busy port, with large freight and tourism traffic, thriving historic and waterfront areas and HM's Dockyard servicing two new aircraft carriers means Portsmouth is a good site for testing new ideas.

Portsmouth has in the past invested in new technology – notably a wireless Mesh network, VMS, SCOOT and MOVA. They are now exploring smarter parking in a similar style to Harrogate and rolling out sensors with integrated payment.

But instead of "diving in" to showcase technology in a pilot of immature technology, Portsmouth have taken a more long-term view to C-ITS. They are focusing on such areas as procurement of new technology and its interoperability with existing equipment and future tech in a long-term sustainable way. They prefer to test equipment and services "in the lab" before small-scale pilot and eventual roll-out to look at such areas as upgradeability, backwards compatibility and whole life costs. This vital work is essential to inform UK local authorities on what will be required to deliver the "day job" for their future, and to avoid abortive costs on short term pilots.

Portsmouth are being ambitious in rolling out services – they have plans for GLOSA, bus priority and improving network performance through driver behaviour and in vehicle information. Equally they are making sure they do not invest in technology that will have a limited shelf life or does not work interoperably. Portsmouth may be a geographical island but is inherently connected in terms of delivering end-user services with Highways England roads, other cities and visitors arriving from abroad.

Portsmouth now have 2 GLOSA-enabled junctions on the eastern corridor of the city and demonstrated traffic signal state being presented into the vehicle in real time via ITS-G5.

Annex B2: Asset Management – Example Pilot Projects

CONVERT (Westminster City Council)

The £115k Project CONVERT had 2 main objectives:

- to assess the benefits of transforming data from in-vehicle laser and cameras into actionable intelligence, and
- provide insights into future asset and network management requirements.

Westminster City Council (WCC) extracted and re-purposed LIDAR survey data, already captured as part of the DfT Smarter Parking initiative within Westminster's road network, to amongst other purposes:

- Audit in-situ signs and road markings to compare the quality of LIDAR data to on-street assets, locations and to data stored in WCC platform
- Assess the potential to reduce annual manual surveys of network condition and design surveys
- Understand potential impact upon people, processes and platforms from using connected data

WCC showed that LIDAR gave great accuracy including height information, road camber, pothole depth, etc. Generally, the inventory held by Westminster was correct but LIDAR corroborated, and, in some cases, improved the information held within the WCC platform.

The savings in annual condition surveys would be initially offset by the cost of an annual LIDAR survey, but, dependent upon the approach to reliance on real-time data from connected vehicle, WCC would realise a minimum £70k per annum cashable benefit by adopting connected vehicle information. The benefits from the reduction in surveys for maintenance scheme development and across disciplines including highways, street lighting, drainage and public realm is now estimated to be around 3-5% per scheme value, conservatively. The wider maintenance budget in Westminster is approximately £10-14m per annum so a monetary saving of £300-

700k could result. Extrapolated to the UK as a whole, this alone would be a saving of up to £60-150m per annum across all local authorities' roads.

What CONVERT revealed, perhaps surprisingly, was that the technology involved in the pilot (LIDAR) was to a degree secondary. The real impact came from the benefits of the collection of real-time data. This is because the process of introducing LIDAR drove the whole maintenance service to become 'digitised' and able to receive digital data from any source of information or sensor; something which officers believe will be true of most local highways authorities.

Road Traffic Sign Inventory using Connected Vehicle Data (North Yorkshire County Council)

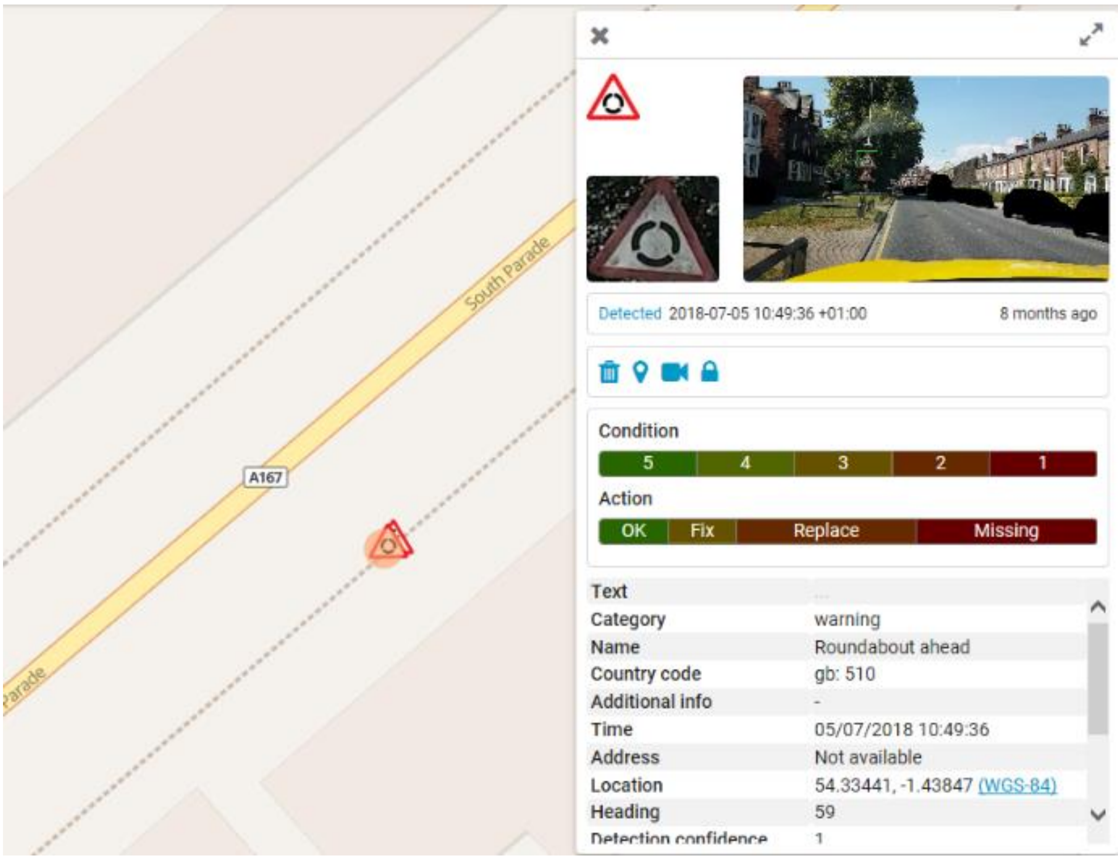
This £83k project was to collect traffic signs on the secondary highway network using smartphone video images collected from a vehicle refined with elaborate image recognition algorithms and signal processing methods. These were used for intelligent infrastructure management providing up-to-date visual data for documenting, automated inventories of road traffic signs.

The system is also being developed to identify pavement surface condition and is a lower cost way to collect survey data, done continuously using non-specialist tools and personnel, while still providing data that is consistent, accurate, and auditable. Using this enables:

- Early intervention with lower cost treatments based on asset condition to deliver 10-15% increase to the life of the asset
- Asset managers can target detailed surveying and maintenance works where they are needed
- Low resource impact data collection process enables asset condition surveying to be conducted at 4-5 times the frequency of existing methods
- Process time from data collection to availability of data of less than 48 hours
- Reduction in programme-time from identification to treatment of defects reducing asset deterioration and reducing the number of safety critical defects

More timely and efficient programming of maintenance works will potentially:

- Reduce the number of third-party claims against the Authority
- Reduce the cost of carrying out routine inspections by more than 50%



Camera-based traffic sign detection

The Council has decided to invest its own funds to continue the project in lieu of any other support funding streams from DfT due to the potential to save the UK significant expenditure.

Similar use of technology has been undertaken by Derby City Council with the same product. Other camera-based projects include Pergamentum in the City of York, using commercial dashcam equipment to identify missing road signs using refuse collection vehicles and streaming the information in real time, and the UCAMP project in Croydon that used smartphones to identify as well as potholes issues from construction vehicles such as mud on the road using motorbike and cycle cameras, and street lighting surveys in Buckinghamshire have been undertaken with smartphones.

Street lights in Buckinghamshire (Buckinghamshire County Council)

There are 27,000 street lights on the Buckinghamshire road network, with 6 full-time equivalent staff to routinely collect data and one for data collation and reporting. Inspectors drive the network at night and visually inspect street lights and this is a high exposure and risk to inspectors when they have to leave vehicles on highways and in poor or low light conditions. Such monitoring of street lights costs £248k per annum, not including the cost to repair and maintain street lights, so this £50k DfT-funded scheme proposed to test ways to reduce cost and risk to Buckinghamshire County Council using Deep Learning techniques

Off-the-shelf GPS-encoded dash cameras were mounted to inspection vehicles and Inspections at night-time were recorded and the video data was uploaded. A bespoke deep-learning offline server was enabled and all data transferred to it for 15+ hours of night-time driving over 327 km for Buckingham and Aylesbury.

The early results were that 100% of working lights could be identified, and 82% of other objects identified are classed as not-working – the main problem here was determining if the 'other' object was a light or just some other post. This project is in early stages but shows the potential to reduce risk and use existing sources of data.

It is another example of where one source of data could be used for multiple uses (e.g. signs, street lights, potholes, mud on road, etc).

ECAMS (Transport for the West Midlands)

The £98k TfWM Enhanced Continuous Asset Monitoring Solution (ECAMS) project uses accelerometer data collected from OBD2 "dongles" retrofitted in 17 existing vehicles in the West Midlands (Birmingham and Coventry). These dongles are similar to pay as you go insurance devices. The collected data was correlated against high fidelity SCANNER survey data to predict potholes, validated using existing asset management software.

The method can predict road roughness with an error of 7% and pothole density with an error of 0.13% compared to existing data approaches. A much larger dataset, from more vehicles equipped today and future connected vehicles, would help achieve cost savings by integrating the data into existing highway management approaches.

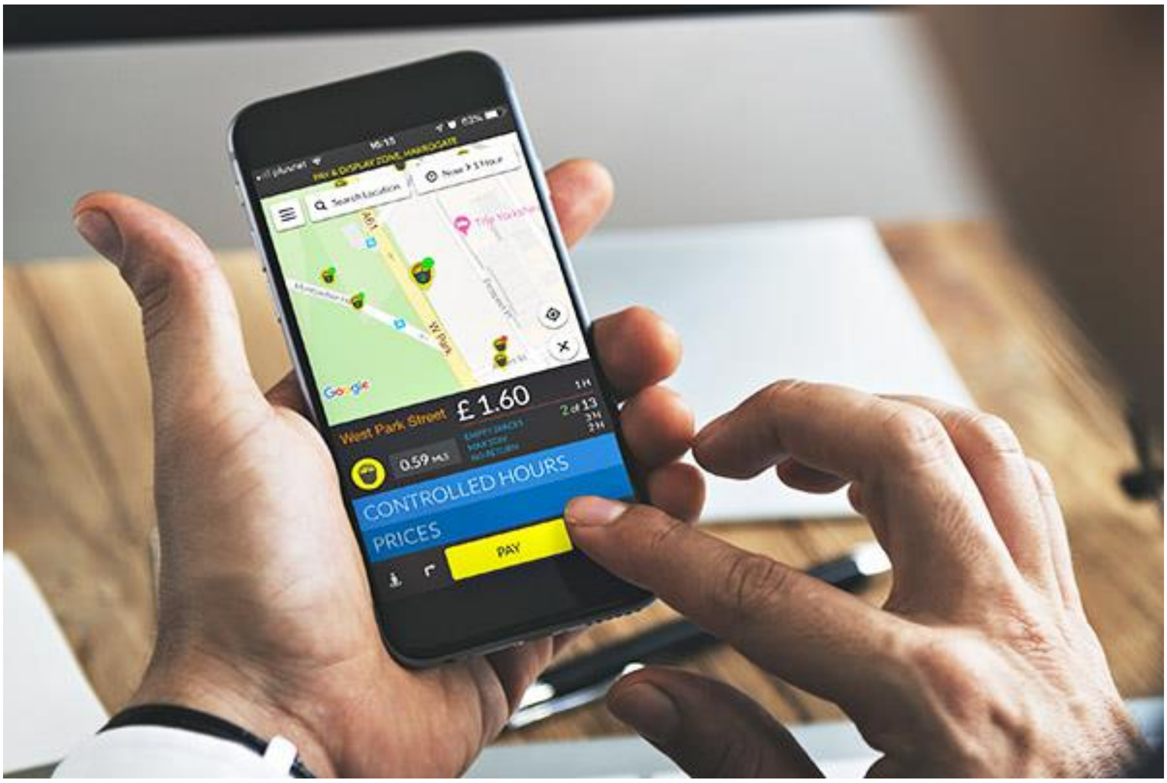
Whilst there is much more to do before vehicle data alone can replace existing surveys, having a new low-cost mass dataset clearly could improve the quality and timeliness of surveys.

Although this project was only a feasibility study, it has produced indications that cost saving can be achieved by integrating this solution in the existing highway management process. Crucially, a full SCANNER survey cost is higher than total cost of this project. With further work, there is great potential for developing this into a commercial solution that can deliver significant financial benefits for local authorities.

Annex B3: Smarter Parking – Example Pilot Projects

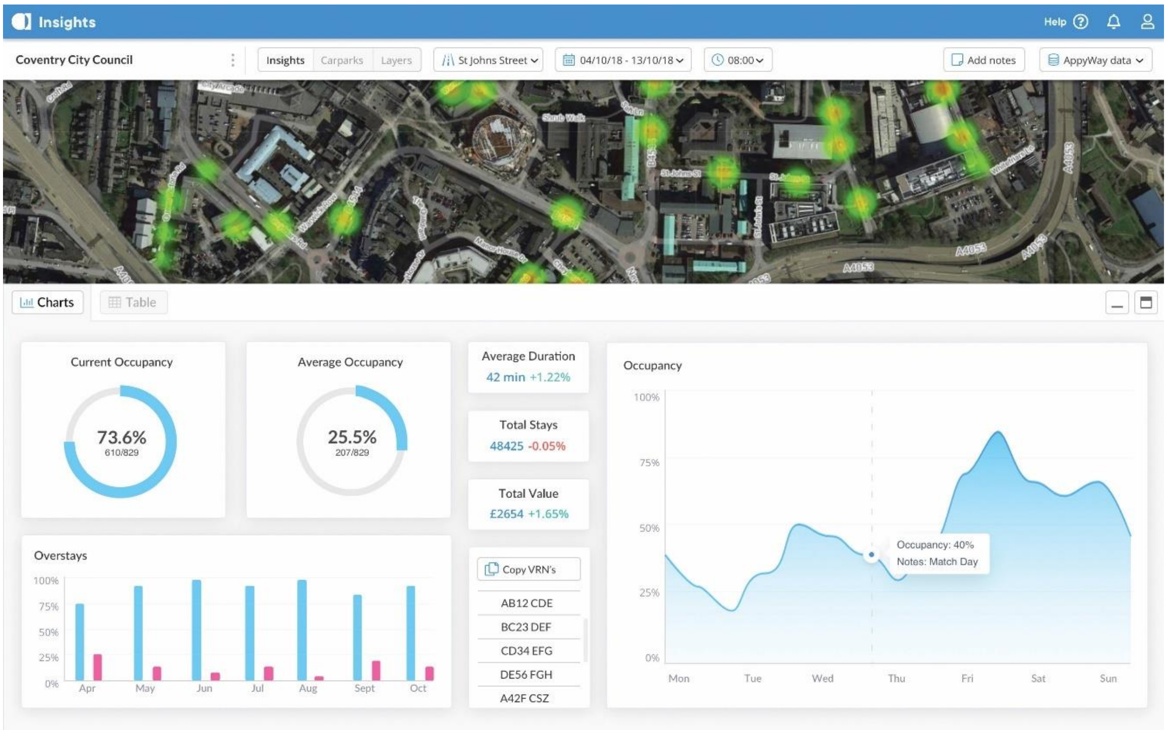
Coventry City Council, Harrogate Borough Council and Calderdale Council, (Halifax)

Smarter parking schemes have been deployed across several towns and cities, helping to reduce driver stress, congestion and emissions generated while looking for parking spaces by navigating drivers directly to available bays. Several UK authorities, including Harrogate Borough Council and Coventry City Council, have installed sensors in Pay and Display parking bays. This means users who download an app can see real-time availability of spaces and eventually EV charge points across the cities.



Paying for parking by smart phone.

In Harrogate, users no longer need to carry change for a pay and display machine or predict when they will get back to their car. They can start a parking session with a single click, and using 2,156 sensors, their session ends automatically when they drive away. Users pay a small convenience fee for using the service in addition to a per minute fee after the minimum charge has been reached. They are notified if they are coming to the end of the maximum stay. In Harrogate, around 10% of all parking sessions are completed via the app.



Live parking data

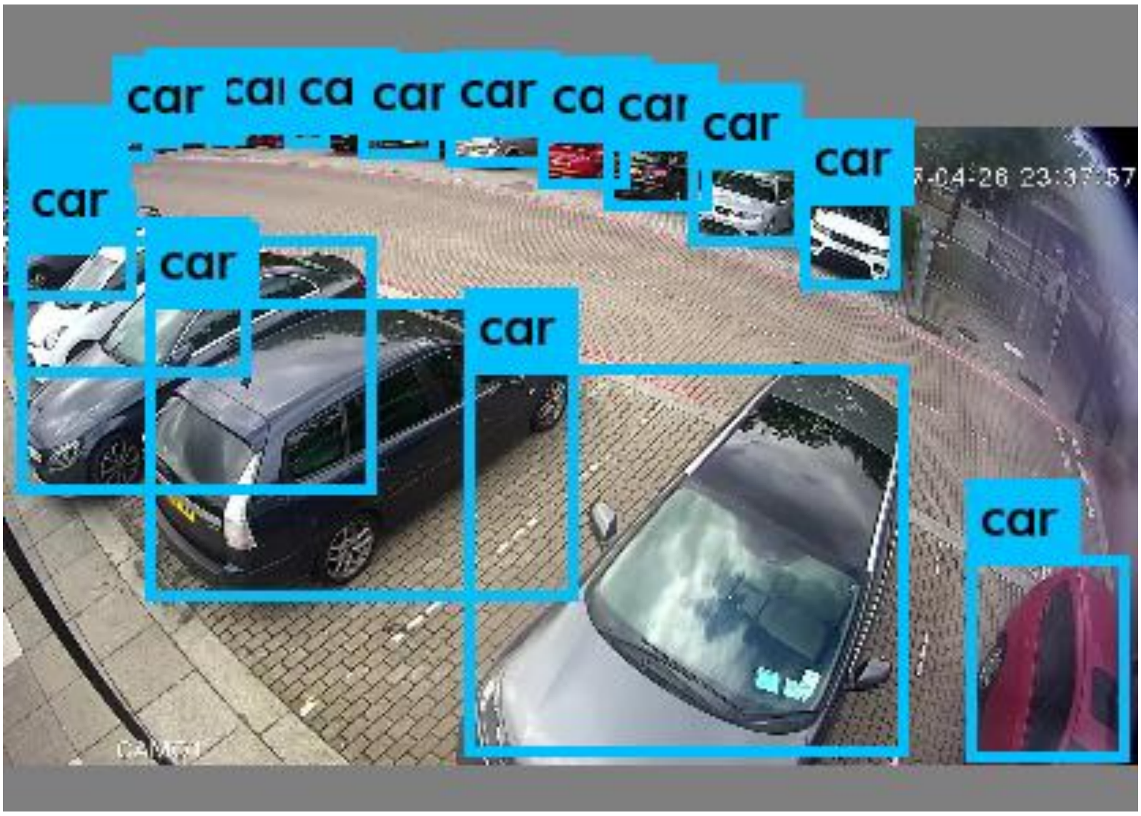
There have been over 50,000 new app users across the UK since January 2019. Uplift in length of average parking sessions when compared to Pay & Display is helping increase parking revenues and increased stay durations by around 6 minutes on-street and 23 minutes off-street. This is likely to have a positive impact on high street and town centre vitality, both in the ease with which people can park and the reduction in perceived risk of a penalty inherent in pay-by-the-minute systems. This is likely to be a significant contribution in encouraging people to use town centres rather than out of town shopping. Additionally, the availability of occupancy data from sensor networks supports parking use and policy reviews.

88% of people stated that the app is more convenient than a pay and display, with 68% stating that the app alleviated stress in parking. Users in particular value the ability to pay just for the time spent parking rather than paying in advance. 21% of users believed they saved time finding a parking space as a result of in-app real-time availability and 40% say they stay longer in town as they do not worry about their ticket expiring.

In Coventry, the sensors were used to provide a dashboard of parking, showing data from sensors, payments, penalties, overstays, etc. This can be used to see parking patterns among each district and each street.

CASPAR (Oxfordshire County Council)

The £268k CASPAR Project in Oxfordshire monitors 299 spaces by sensors and cameras, focusing on disabled parking bays and integration with UTMC systems. The physical makeup of Oxford is challenging, with heritage infrastructure such as small lighting columns that require a mix of various sensor types and approaches. The project has now been successfully completed with an aim to roll out the service to all bays.



Camera-based image processing - parking bay detection

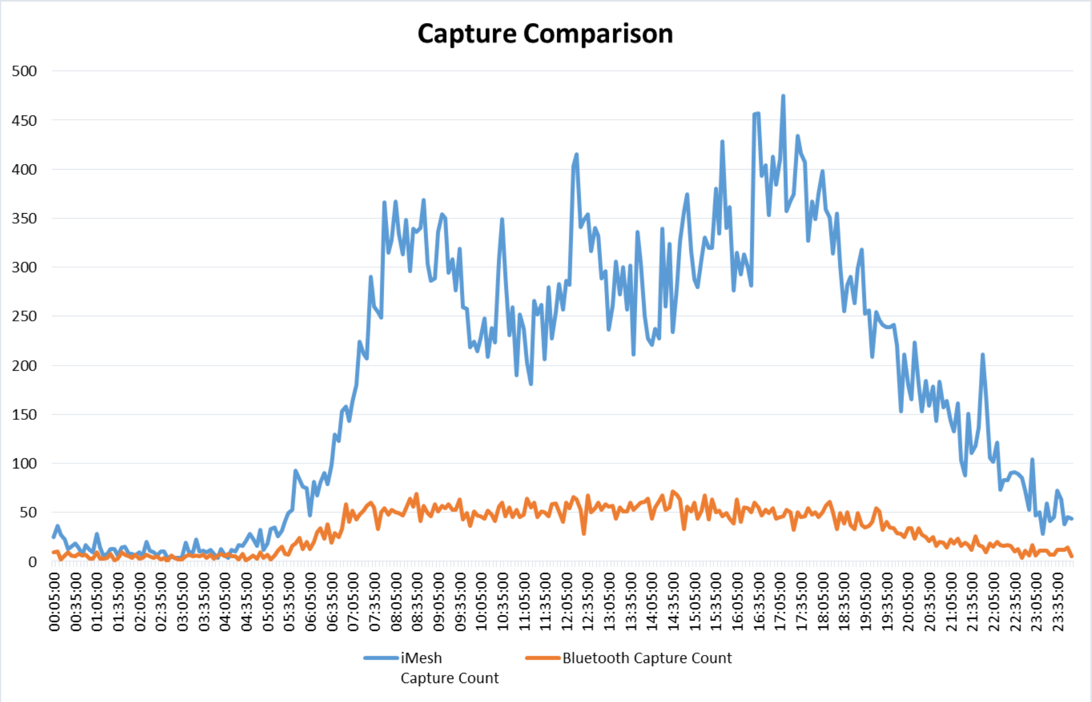
Sensor-based parking services are also used successfully in Cardiff (where they are used in particular to manage events at the various stadiums), the City of London (where they monitor Blue Badge space availability) and Milton Keynes (using camera-based image processing as shown above), and Hounslow where electric vehicle parking space monitoring was included.

Annex B4: Connected Technologies and Data – Example Pilot Projects

Warrington Intelligent Transport System (Warrington Borough Council)

The £330k Warrington Intelligent Transport System project combined real-time journey information harvested anonymously from wi-fi and 'smart devices' and vehicles with wireless communications to develop strategies to manage the network more efficiently using the UTMC system. The system provides real-time information to the public and businesses via on-street information displays, interactive web pages, social media and an innovative app freely available on the internet or via iOS or Android mobile-friendly operating systems.

Data from Wi-Fi and Bluetooth was collected for the same sites and compared. This showed a higher sample rate from Wi-Fi.



Comparison of capture rates between iMesh and Bluetooth

Strategies were developed both for daily operation, incident management and information outputs such as VMS. The results suggest there has been an average journey time saving of 30% during the pm peak on the A49 northbound route out of Warrington using these new data sources to build new strategies for traffic control.

Warrington intends to publish information to VMS, webpage and social media via the common database. All the information published is collected by WBC and processed in the UTMC common database.

This is a relatively simple project but shows the potential for harvesting new wi-fi data from vehicles and using it in the data chain for new control methods. It also highlights how to integrate new data services with in an existing UTMC architecture.

Pre-emptive Traffic Management (Derbyshire County Council)

In a similar way to Warrington, Derbyshire developed a technology demonstrator for strategic-level traffic management on the County Council's road network. This £250k project used commercially available floating vehicle data to provide intelligence on the state of traffic flow and roadworks. Derbyshire then developed a central control system for processing network intelligence and generating traffic management interventions.

In-vehicle live travel advice

The central control system comprised flexible data-feed adaptors to ingest the TomTom data, enabling ready integration of new data services and an operator interface. They also developed a rules engine, to enable Derbyshire to capture operational experience and develop rules around the network model and the appropriate response to events. This included a data publisher for delivering driver information to motorists both in-vehicle and on mobile VMS, as well as a demonstrator in-vehicle mobile app for in vehicle signing.

This was to display driver information directly in vehicle without the need for roadside infrastructure and with messages on the mobile VMS, fixed VMS and in vehicle being consistent. A trial was successfully carried out on Derbyshire's roads in 2018. Strategic and tactical driver information was automatically delivered to both the mobile app in the test vehicle and to mobile variable message signs.

Hinkley Point GLOSA (Somerset County Council)

This ambitious £313k project was set up to mitigate the impacts of construction at Hinkley Point C Nuclear Power Station, one of the largest construction projects in Europe with up to 750 HGV movements are expected every day. For each shift up to 5,600 construction workers will be transported from park and ride facilities. Traffic is routed via one of the two designated routes so route repeatability and journey frequency presented a unique opportunity to evaluate traffic Signal Phase and Timing technology. This scheme aims to reduce the impact of these movements through more efficient control of vehicle start/stop cycles, by enhancing existing traffic signals and deploying technology in HGVs and PSVs**.**

The Hinkley Point C development

The project initially intended to deploy both GLOSA and signal priority techniques but the vehicle priority was deployed first as integrating both GLOSA and priority in one vehicle was a concern for the vehicle operators. There were also technical challenges in synchronising roadside and on-board units. Nevertheless, significant learning has been gained about how to deploy bus priority using in vehicle systems and the benefits of this are currently being assessed. A primary learning outcome has been about the soft issues of working with bus operators on new technology.

Additional learning came from projects in Blackpool, which guided tourists to the best car parks using Bluetooth journey time measurement, and Dorset to share traffic control at an important Highways England junction. The Newcastle Smart Corridor has also deployed equipment to make vulnerable road users safer and reduce the environmental impacts of congestion and idling at traffic lights.

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This report describes the state of the nation in helping vehicles and infrastructure to co-operate. It brings together information about projects run by UK local authorities and funded by DfT, to prepare for the challenges and opportunities new technologies will bring.