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CONNECTED VEHICLE DATA FOR ROAD SAFETY

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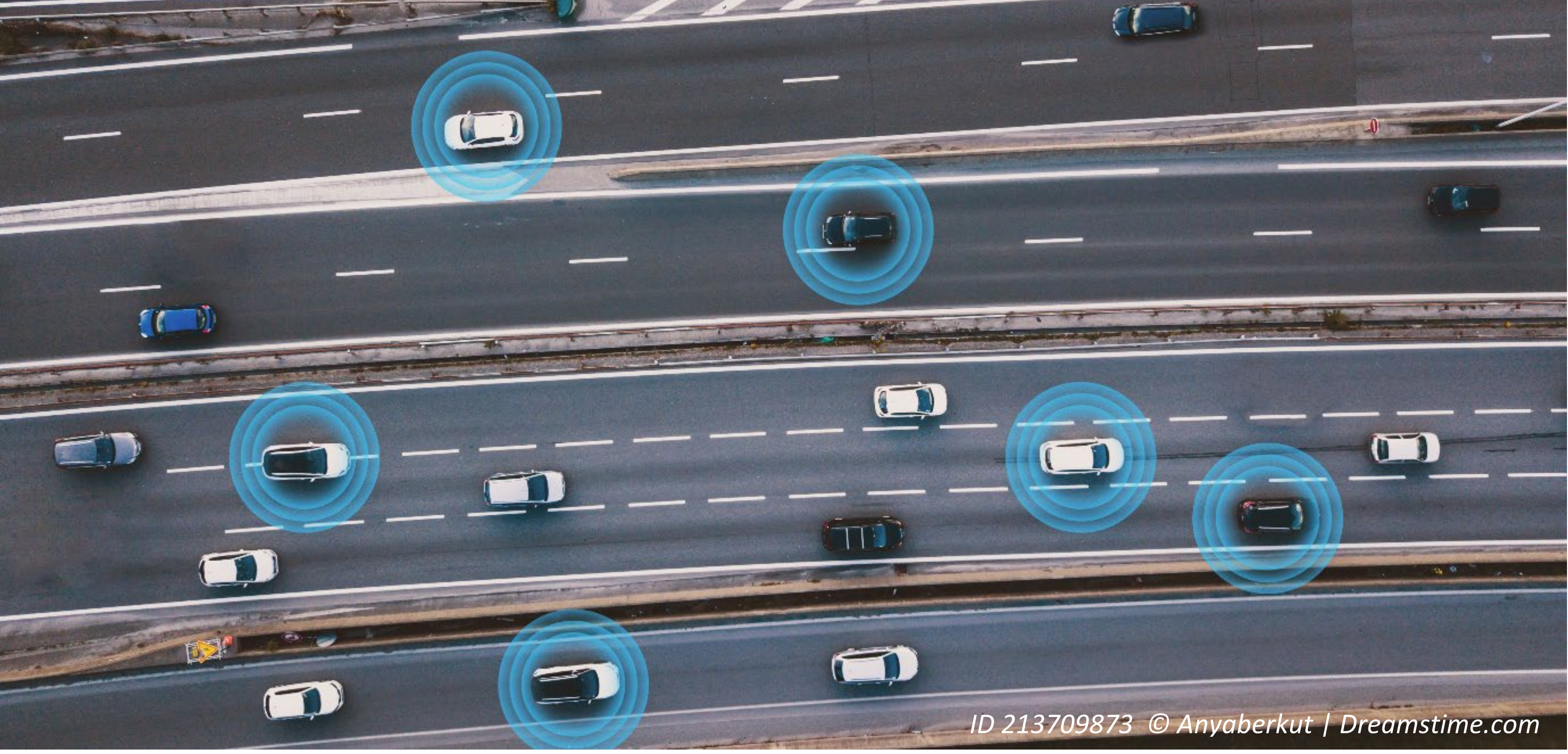
WHITEPAPERS

Agilysis' whitepapers seek to shine a light on important topics facing the highways sector. Drawing on the expertise of the authors, they embrace a variety of evidence sources, as well as thought leadership, to unpack complex challenges and their plausible solutions. They are not commissioned research and as such, do not attempt to provide a definitive view for a particular organisation, rather they offer an informed opinion with an invitation for discussion and deliberation. Our ambition is that these whitepapers serve to spark debate, inspire innovation and create coalitions and build momentum to move us forward together.



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INTRODUCTION

For us at Agilysis, we have always placed a high value on accurate and reliable data to inform our understanding of road safety. Information and data relating to roads has been the cornerstone of almost all innovation in our sector – how else are we to decide how to prioritise our work and understand the impact it has on road user behaviour?

In the past, if you wanted to understand something about the nature of the road network, the vehicles, or people that use it, you would need to undertake some form of primary data collection. This normally required people and equipment measuring traffic behaviour, or surveying road features. The need for high-quality data collected by experts in their field will always be there but we are now finding practical alternatives from 'big data' sources.

The term 'big data' has been around for since the early 1990's[i] and it has often been seen as the next paradigm shift in transport modelling[ii], which it may well be. The problem for many, and by this I mean those charged with delivering change on road networks, is that it is too abstract a concept without the resources and ability to demonstrate the direct benefit it brings at a local level. One of the problems is that the data in itself is not useful or usable without some form of processing. Quite often these data need 'digital twins'[iii] to bring them to life on the ground; context is only achieved with an understanding of place in our field of work.

The good news is that, after many years of discussions, there are now a growing number of examples of how big data, traditional data processing methods, AI technologies, and cloud-based data delivery and visualisation tools are creating the potential to revolutionise our sector – and save money. Real examples of new data being used by practitioners for practical purposes is key. Lots of innovative companies may suggest potential uses for untested and unverified data sources, but what brings greatest value to experienced professionals is the validation provided by peers.

This paper will focus on connected vehicle data, what data are available, how it can be used to support or replace existing data, and the potential for innovation in the future by adding something entirely new.

CONNECTED VEHICLES AS A DATA SOURCE

The term connected vehicle can mean a variety of different things and is often used together with the word autonomous in the phrase "Connected and Autonomous Vehicles (CAV)". This is not always helpful and it should be recognised that the act of connecting a vehicle to the internet in itself is something that has been happening for over 15 years already[iv], and does not require the vehicle to have autonomous driving features. A connected vehicle can simply be described as one that has two-way communications with the internet to exchange information.

Roadsafe produced an excellent positioning paper[v] in 2021 addressing connected vehicles and road safety. This paper, which we contributed to along with Bosch, Geotab, Highways England, Reed Mobility, the Road Safety Foundation, and TRL, had a focus on how the exchange of data between drivers, vehicles, and infrastructure enables new ways to support safe, efficient, and sustainable driving. It considered wider aspects of connected vehicle use but highlighted the value the data that comes from connected vehicles would have for those delivering safety on our roads.

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If we try to think about a very simple example of data from connected vehicles, the easiest one to describe is a connected SatNav system. In a non-connected vehicle, this system would use a static database of maps and addresses, together with a GPS[vi] sensor, to enable turn-by-turn navigation from a vehicle's current position to a destination. In a connected vehicle, the system will be able to access up-to-date maps as soon as they are available, receive traffic updates for the planned route, and also pass information back to OEMs[vii] or third parties supplying the technology for the vehicles. The two-way supply of data about vehicle positions and speeds is critical to warning users of unusual traffic conditions. This approach is also used by navigation apps in mobile phones where user data are effectively traded in exchange for free navigation apps. Even non-navigation apps collect GPS data from mobile phone users, which are then sold into the connected data market.

Other examples of connected vehicle data will be covered later in this paper, which discusses the potential use of other sensors. There will, of course, be limitations, principally that data are only collected for the roads and territories where the vehicles drive, but also local data privacy concerns and regulation. Information on vehicle braking, steering inputs, safety warnings, and many more may be of interest to those championing road safety. Accessing the data will always come at a cost, of course, and this will also be reviewed later in the document.

VEHICLE LOCATION AND SPEED DATA FROM TRADITIONAL SOURCES

Currently, and for a great many years, if you want to understand speed profiles at specific locations this has required sensors on roads such as Inductive Loops (IL) which sense disturbances to the electromagnetic field over a coil of wire built into the roadway. These devices are typically installed by being buried under, or cut into, the carriageway. In the UK, one of the best examples of this is the MIDAS[viii] system operated by National Highways which uses these sensors to monitor traffic volumes and automatically set signs and signals as the motorway becomes more congested. Historic data using this and other IL sources can be viewed on the National Highways WebTris system[ix]. ILs collect data on traffic flows and speeds and have the advantage of being able to classify vehicles using axle length. They also collect details on the vast majority of vehicles and can provide information on headway (the gap between two vehicles, measured in seconds). They are, however, prone to failure and are costly to maintain, which can be seen on the WebTris site where there are often large data gaps.

Inductive loops are an example of permanent infrastructure used to detect speeds and flow and there are other sensors that operate on the road or by the roadside. Automatic Traffic Counters (ATC), of which IL are one technology, can also take the form of temporary surveys, using tubes stretched across the carriageway, or roadside radar devices. These units typically record data internally which then needs to be downloaded, processed, and analysed. Some newer systems will themselves be connected, however. The data outputs are used by local authorities, police forces, planners, and others to understand the number of types of vehicles using the road as well as profiling speeds.

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One other technology that it used to detect traffic movement is ANPR[x]. On motorways and other major roads, ANPR cameras check the average speed of vehicles by taking timed images between two locations and from this, they can determine the speed of the car. The use case for this technology is principally for detecting traffic jams and providing feedback to drivers through in-vehicle systems or variable messaging signs. This technology is also in the successful ‘average speed cameras’ which are now a common sight on the roads.

We have established that here are lots of technologies and lots of use cases for speed and traffic data, but how can connected vehicle data add to this wealth of data? Is it a complete replacement and what are the advantages and drawbacks? The best way to consider this is to look at some ways in which the data are already being used.

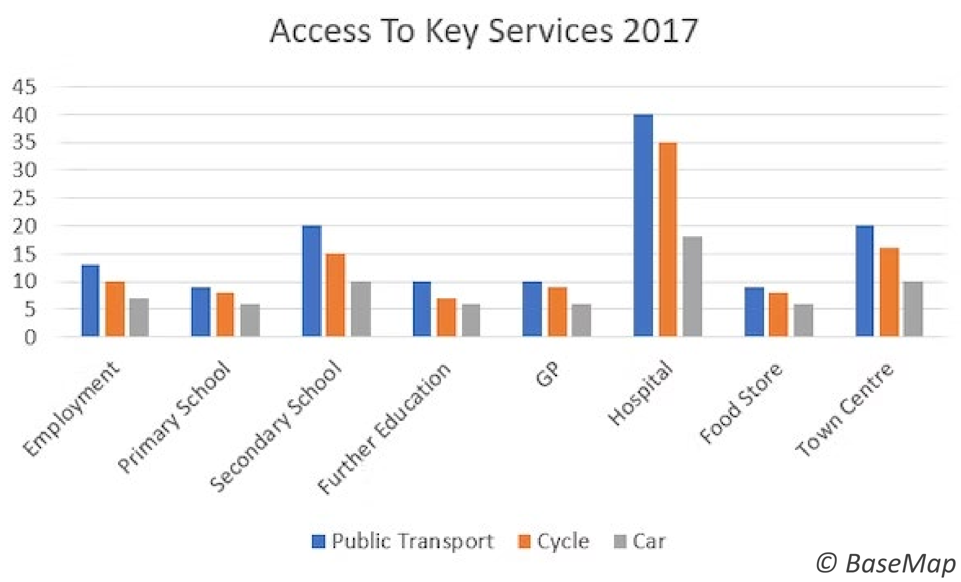
HOW CAN CONNECTED VEHICLE DATA REPLACE TRADITIONAL DATA SOURCES AND USE-CASES?

Before we turn to novel uses for connected vehicle data, we should explore the use cases that already exist and are most in-demand. The first clear and obvious use-case comes from leveraging vehicle GPS systems. Using historic, or live vehicle data, matched to a road network containing GPS locations plus speeds and headings, can potentially be used to replace or support existing methodologies.

JOURNEY TIME STATISTICS

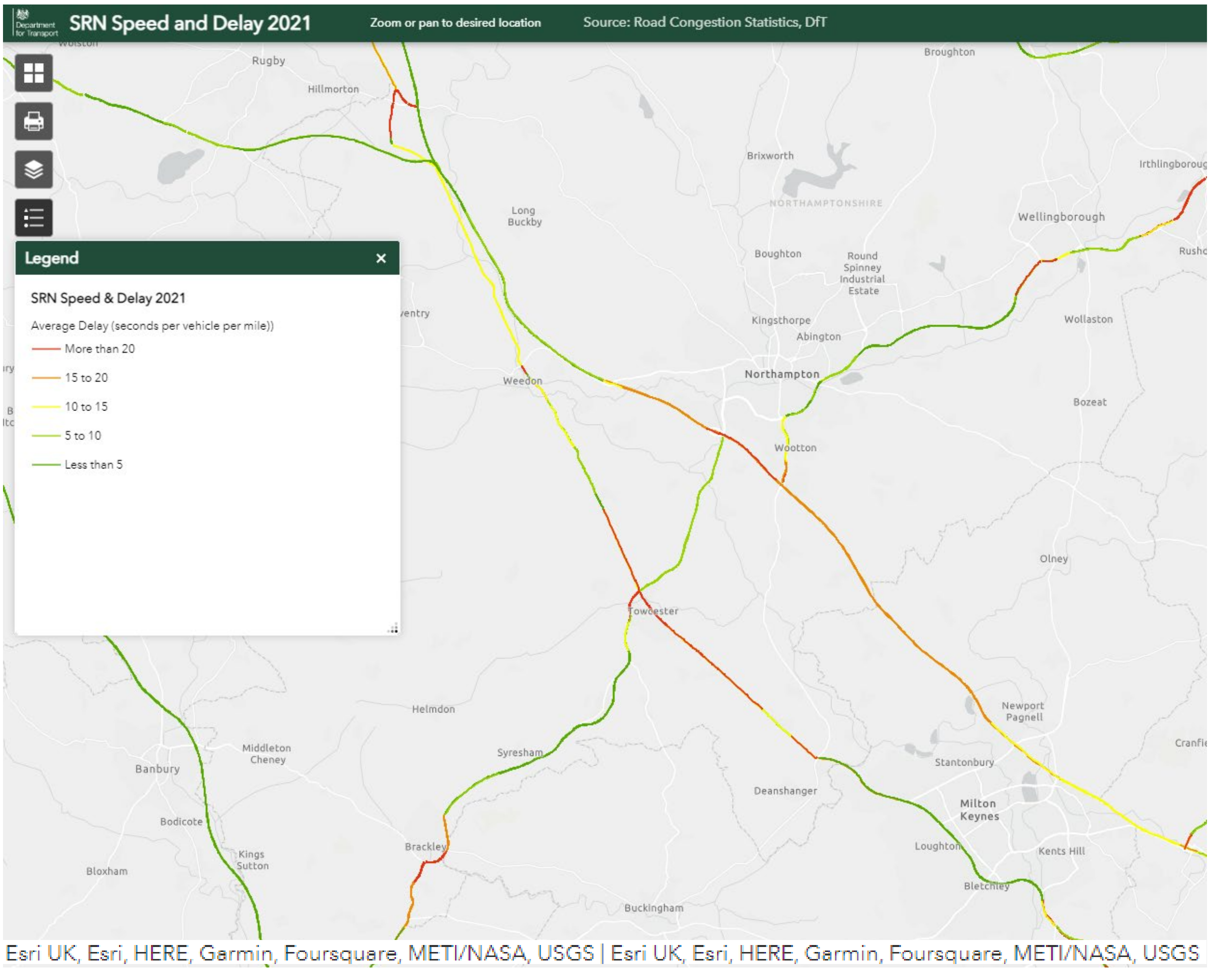
The Department for Transport has been using data from connected vehicles since around 2005. According to a report from *Basemap*[xi],

> *"These present travel times from where people live to eight key local services including schools, hospitals, supermarkets and employment centres broken down by small geographical areas in England. They cover journeys travelled by walking, cycling, driving and public transport and these journey times are supplemented with connectivity reports to see how easy it is for some to access an airport or railway station."*



© BaseMap

This data has been provided by two suppliers, by *Teltrac Navman* until 2019, and now *Inrix* and *Ctrack*. Both use GPS data from connected vehicles. The data are also used to provide journey time delays and, crucially, average vehicle speeds for many classified roads in England[xii]. This information has been published for a number of years and would in theory give authorities information about average speeds and journey times for long stretches of road. It was noted, however, that in the switch between the two data sources there was a drop in recorded average speeds[xiii]. There appear to be significant differences in recorded speeds which would reduce the ability to compare values between time periods and brings into question comparability with traditional sources.



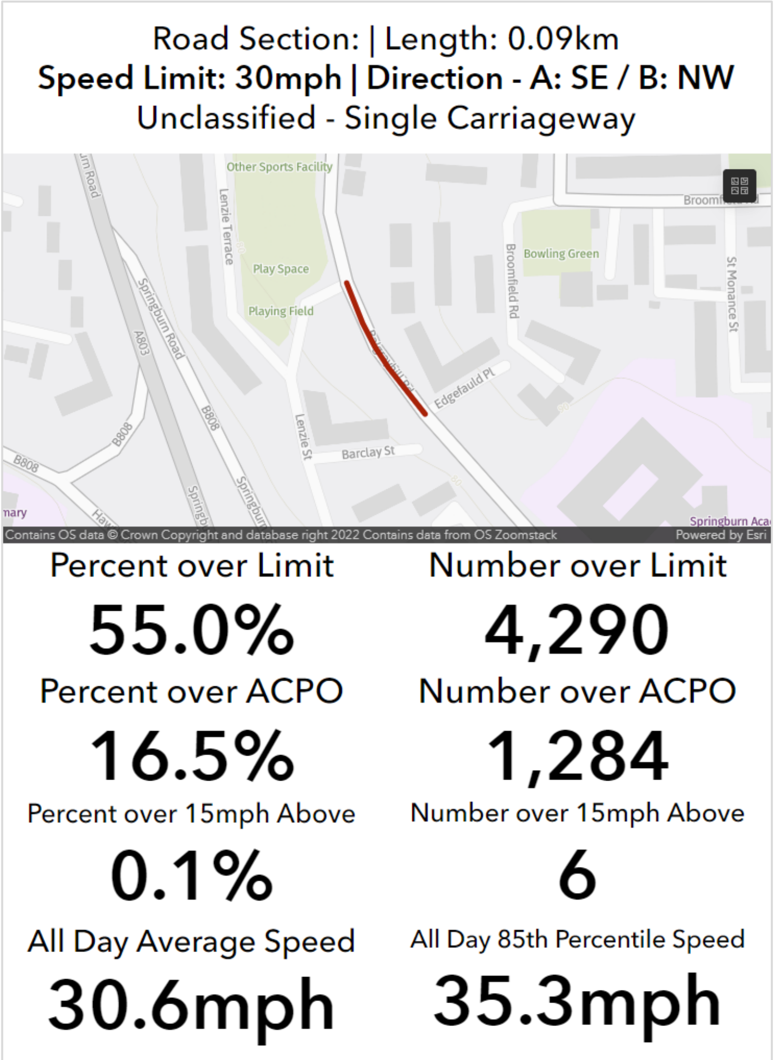
Source: https://dft.maps.arcgis.com/apps/webappviewer/index.html

SPOT SPEED DATA

The publication of speed data for longer routes indicates that there is a source available that could assist with evidence collection at a more local level. The nature of the GPS data means that results are presented for a specific section of road rather than a single point. For example, a device may collect one reading every second (1hz) which would potentially give a high degree of accuracy, but others may work over much lower frequencies. . The ability to investigate very small sections e.g. junctions would be diminished for this longer-frequency data. The approach taken by data companies is that they will summarise data based on a road network geometry, usually via a Geographical Information System (GIS) file. In Great Britain, the most commonly used network geometry is provided by Ordnance Survey[xiv] and this has had speed and speed limit data matched to their MasterMap Highways network since 2018. This detailed network joins ways and nodes on the network according to where features change, typically at junctions but also sometimes at other features such as traffic islands.

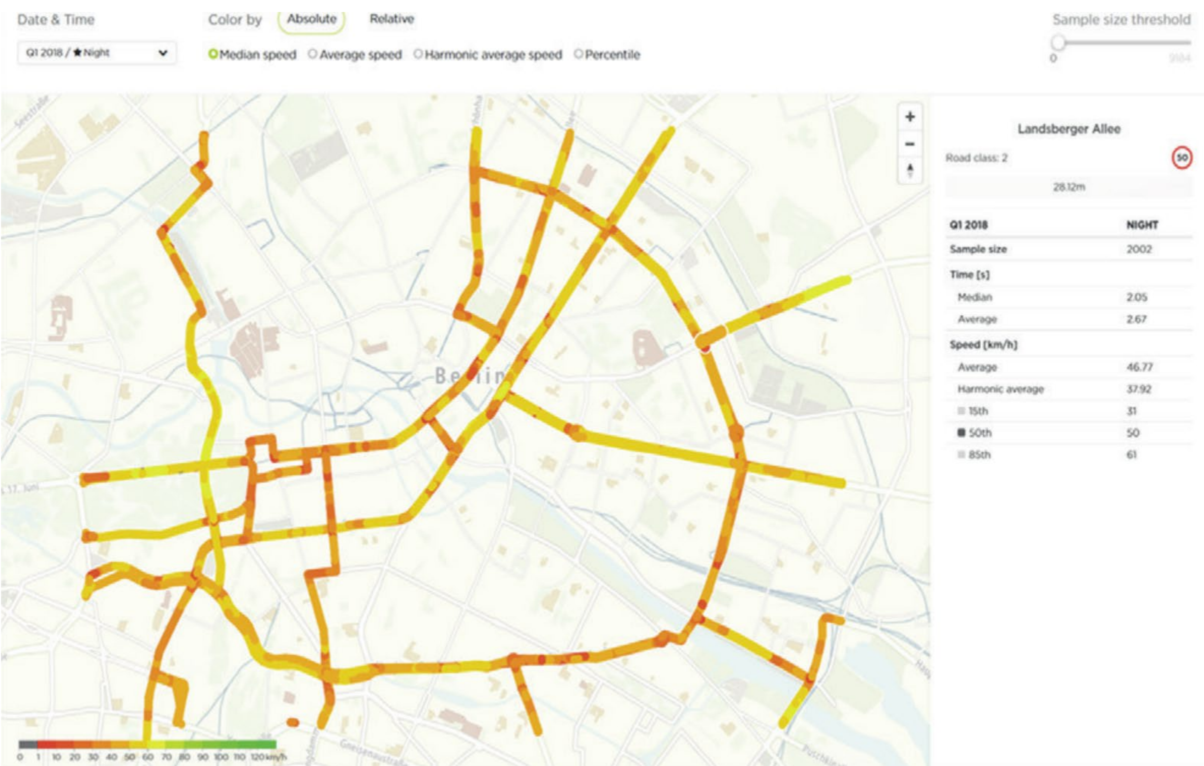
The GPS data is then matched annually from the raw data to these individual ways. It is estimated that in 2020, this resulted in 14 billion individual vehicle tracks contributing to the total speed profile dataset. Some ways are short, and some ways are long, which means that granularity is dependent on the donor network. This does mean that the results are not the same as you would expect for a 'spot speed survey' which measures speeds at a very specific location, often placed where free-flow traffic would be expected. The GPS speed data are effectively an average speed measurement from point A at the start of the way to point B at the end. If traffic is proceeding normally from the adjoining way and continuing at a free-flow speed then the results are expected to be broadly similar to a spot speed survey, but if there is significant queuing, or turning then the speeds would be supressed.

There are other considerations with the use of this data as a direct replacement for a traditional ATC survey. Firstly, of course not all vehicles are monitored. It is unlikely that any individual source would cover more than a few percent of vehicles on the road, but if this data are built up over an entire year, the sample size would still be more than acceptable. Secondly there tends to only be coverage for passenger vehicles and goods vehicles; motorbikes and bicycles are not included in the data. Thirdly, in the case of the Ordnance Survey data, the time period analysis is limited to pre-defined bands e.g., 7am-9am and it does not include an all-day average. Fourthly, there are not always speed profiles in this data through the production of percentiles e.g., 85th percentile.



© Agilysis - Speed Compliance Tool

These disadvantages will be present or absent in different systems, although lack of diversity in the traffic mix is common to all. The TomTom Traffic Stats portal[xv] offers fewer disadvantages as it allows users to define their own analysis periods and include percentiles. The disadvantages are, of course, somewhat outweighed by the ubiquitous nature of the data – you can see traffic speeds for all roads without requiring a survey. This does lend itself to network analysis and compliance detection at a more general level, rather than a detailed summary of traffic movements at a specific location.



© TomTom Traffic Stats - https://www.tomtom.com/products/traffic-stats/

PRE- AND POST-IMPLEMENTATION STUDIES

Understanding how speeds and traffic conditions have changed at a specific location, along a route, or across an area following some sort of intervention or change to the environment is a common piece of analysis. Changing junction layouts, installing new infrastructure, implementing new speed limits or other interventions are often put in place to reduce speeds and traffic conflicts. Using a traditional methodology such at tubes or radar requires forethought and planning prior to any change on the road, and also suitable measurements across the area monitored.

Using historic vehicle speed data, however, means access to a wider selection of roads in a treatment location as well as the ability to go back and analyse schemes that didn't have pre-installation data, or information for comparators in control areas. This approach is also useful for looking at the impact of un-planned events such as emergencies, or even comparing data after a road collision to see if traffic patterns were unusual on the day of an incident.

TRAFFIC MODELLING AND NETWORK USE

For road authorities, understanding which roads are used most often is critical in making decisions on investment including infrastructure, maintenance, and winter gritting. Average Annual Daily Traffic (AADT) is obtained through traditional surveys and is costly if all roads are to be covered each year. Agilysis have pioneered a new approach with exclusive access to raw vehicle counts from connected vehicle data to create a national map of AADT for all roads. This modelled AADT is used in different tools created by Agilysis which also make use of vehicle speed data.

One solution is the Active Streets Assessment Tool[xvi] which allows planners, engineers, and public health experts to review dozens of datasets in their area and check requirements against the latest government standards as set out in cycle infrastructure design (LTN 1/20)[xvii]. The combination of traffic flow and vehicle speeds is essential in identifying the potential for on-road, or segregated cycle infrastructure, and also indicates which residential areas are safe for active travel. Pre-designed filters easily highlight roads according to the safe use category or infrastructure requirement. It also includes information on pedestrian movements, community profiles, and school locations.

© Agilysis Active Streets Assessment Tool – https://activestreets.uk/

There are potentially hundreds of uses for accurate traffic count data for road networks. These include: transport plans, development planning, micro-simulations, feasibility studies, junction analysis, accessibility planning, and of course, road safety studies.

ENFORCEMENT PRIORITISATION AND PERFORMANCE MANAGEMENT

Using data from digital speed limit maps together with vehicle speed data are the central element of the Agilysis Speed Compliance Tool[xviii] which provides rapid, network-wide analysis of speed profiles. Again, data for an entire authority, or police force area is supplied on an Ordnance Survey network, this time with added data on all-day average speed and all-day 85th percentile speeds. This is then used to create speed profiles highlighting levels of non-compliance in different time periods for individual road sections.

The data can be used to review speed profiles across entire networks, helping to pick out potential new locations for speed enforcement, or it can be used to inform strategy planning for mobile camera units. Of course, the tool also shows details for individual roads too which is helpful when answering enquiries from members of the public who are concerned about speed and safety in their neighbourhoods.

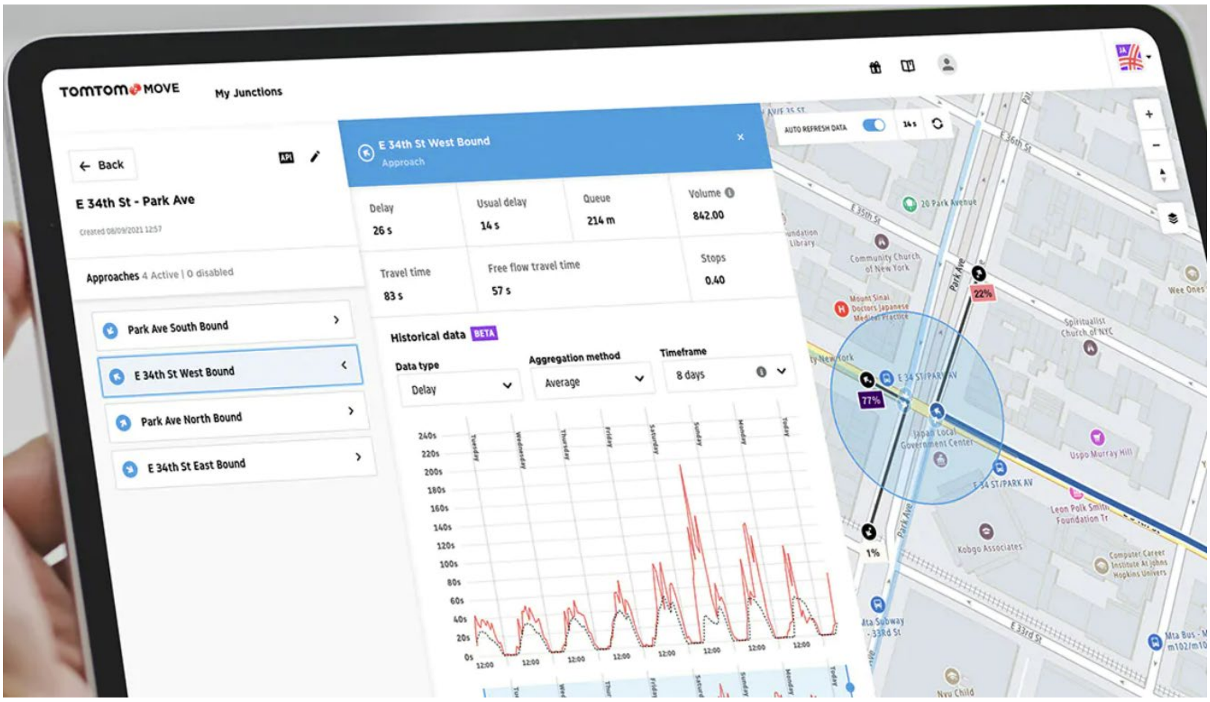
Crucially, the inclusion of AADT and the raw count data means that compliance can be measured across different road sections expressed as a percentage of journeys by road link within the speed limit. This metric is very helpful in creating safety performance indicators, which are used to assess levels of non-compliance across a whole network over a period of time.

JUNCTION MONITORING

Outside of the specific road safety sector, there has long been a requirement to measure and analyse traffic movements at junctions. Over the last two decades, there has been a movement towards the use of Urban Traffic Control (UTC) which uses permanent sensors in dense urban environments to continuously monitor traffic and ease congestion as much as possible. These complex systems integrate and coordinate traffic signal controls over a specific area and, when used with traffic management software, can deliver effective traffic management. This does come at a cost, however, and excludes any junction that doesn't have the pre-installed loops. Companies such as Vivacity are trialling new systems that use video analytics rather than loops, but this still requires planning and installation of equipment at specific locations. As well as noting turn frequency, systems can produce statistics for delays and queue lengths across a network covered by the sensors.

Ad-hoc surveys are still required for other purposes including planning applications, monitoring of scheme impacts, and safety schemes. Typically, these surveys are undertaken manually with either an observer in place at the junction, or through video surveys. Historically, video surveys have then been manually reviewed and coded by a trainer technician, although AI technologies are offering the potential to improve processing times.

Data from connected vehicles could offer significant advantages to those wishing to understand traffic patterns around junctions. Although the data would only cover those vehicles in the sample, with enough sources over a long enough period of time, the results would be good enough to replace manual surveys. TomTom provide a *Junction Analytics* solution that uses the same data source as their *Traffic Stats* package but offers a very different way of looking at the data. Instead of the user ordering a historic snapshot the tool, it gives live monitoring of a specific junction within minutes of the order being placed. Viewers can see a variety of outputs including turn frequency, delays, and queue lengths. This can be used to produce simple reports or users can connect to the API and ingest data to their own systems.



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HOW CAN CONNECTED VEHICLE DATA OFFER SOMETHING NEW TO IMPROVE ROAD SAFETY INTELLIGENCE?

In the examples discussed so far, we have mainly been considering the position and speed of vehicles and how this can be used to answer existing questions relating to road safety and traffic management. GPS sensors are not the only ones fitted to connected vehicles, however, and there's a multitude of other sensors that could potentially offer something useful. Perhaps surprisingly, there is already legislation in place that requires the release of certain data from vehicles that can help road safety.

The *Commission Delegated Regulation (EU) No 886/2013* identifies procedures for the provision, where possible, of a road safety-related minimum universal traffic information dataset. This should be free of charge to users and provides a definition of eight categories for which any supporting data should be provided.

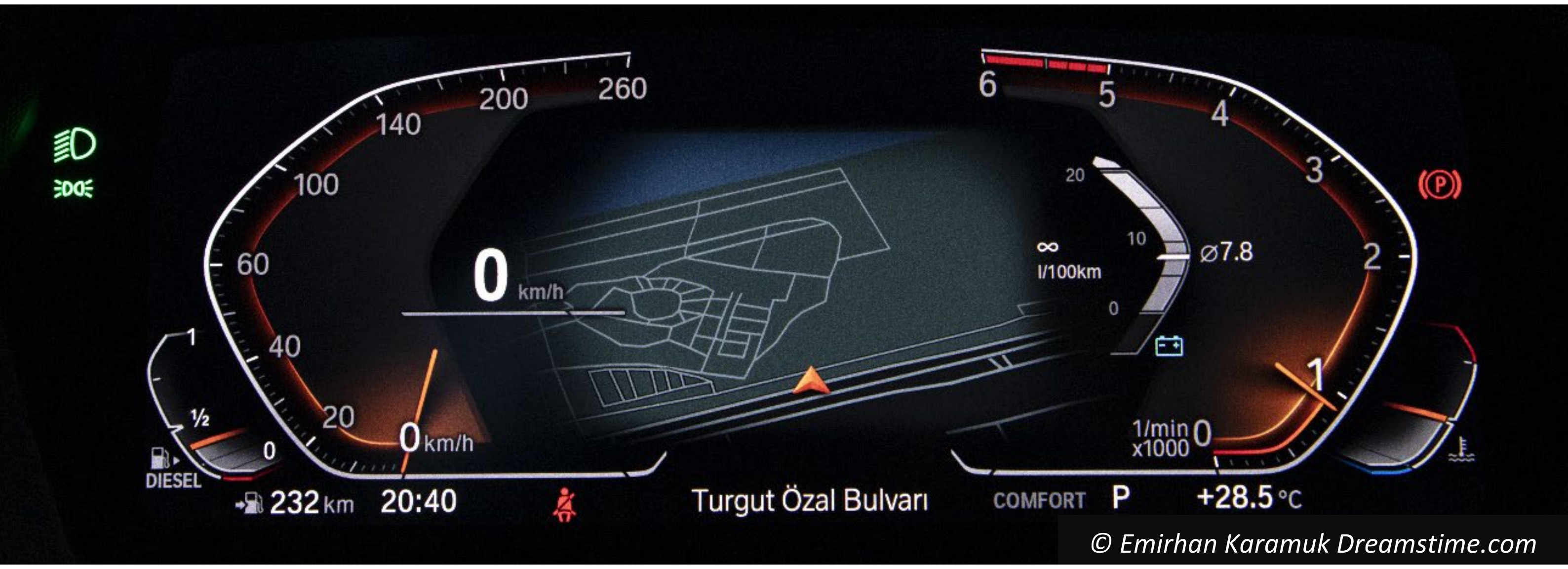
Finding examples of this data being published is hard enough, let alone its implementation. The NAPCORE website[xix] offers little information but does include links to national portals. Getting ahead of the game, however, are BMW who make relevant data from their vehicles available free of charge via the Here Marketplace[xx]. Their Safety Related Traffic Information (SRTI) is generated out of the respective vehicle signals (e.g. wiper speed, driving dynamics sensors) in a completely anonymised way and provides positional information along with a timestamp. Their outputs are as follows:

1. Broken down vehicle
2. Accident
3. Heavy rain
4. Slippery road
5. Fog
6. Dangerous slow down (harsh braking)

Data categories defined within Commission Delegated Regulation (EU) No 886/2013

a) temporary slippery road;
b) animal, people, obstacles, debris on the road;
c) unprotected accident area;
d) short-term road works;
e) reduced visibility;
f) wrong-way driver;
g) unmanaged blockage of a road;
h) exceptional weather conditions.

It is not clear in the documentation which specific sensors provide this information, although wiper speed appears to be used to identify heavy rain which is a neat touch. Despite the legislation being in place for some time, it is disappointing to see that few manufacturers and countries are using it to gather safety-critical information. This could be an evolving area, however, and it is worth keeping an eye on as both historical and real-time data on the six categories above would be helpful to highway authorities, if made available in a useable format. It could be used to trigger warning signs or potentially inform deployment of emergency and recovery vehicles. The caveat here is that these data should be validated against external reference data from real-world observations or other sensors. Small changes in weather events such as precipitation or fog may have a significant influence on safety but may not be detected within the vehicle data.



Having data available is one thing, knowing what it means and how you should use it is another matter. Away from the specific EU SRTI measures, BMW and other OEMs are promoting the availability of vehicle data to the commercial market[xxi]. A quick glance at the types of data collected by just one manufacturer opens a world of possibilities. Almost every system in any given car is measured, from the remaining fuel in the tank to the status of the electric sunroof. Of more interest to us as road safety professionals are the safety systems such as deployment of ABS, triggering of eCall, or one of the many ADAS systems, such as AEB. Let's consider these systems in the context of both collisions and near-misses:

CONNECTED VEHICLE COLLISIONS

In Great Britain, we are lucky that we have access to high-quality reported collision data collected via police forces and reported at record-level by the Department for Transport[xxii]. We do know this data has limitations, however, and we know it is not a record of all collisions where someone was injured as not all are reported to the police. It's pretty certain that all road fatalities are recorded but under-reporting rates get worse for lower severity collisions as well as those involving certain road user groups, such as cyclists. Crash locations are recorded with a reasonable level of accuracy and as the data is published openly, it's easy for websites such as CrashMap[xxiii] to make this information available to interested parties. There are other potential sources of information about collisions such as health records as well as records from the emergency services. Highways authorities may also have records of damage-only incidents where road infrastructure is involved.

Using connected vehicle information on collisions could offer a fantastic way of filling in many of the gaps seen through traditional data sources, and also providing much more damage-only data. The eCall system[xxiv], which has been a mandatory fitment for all new cars sold since 2018, would potentially allow for locations of events to be monitored if the data are recorded and held centrally. eCall can be triggered manually, however, as well as in crashes where the forces are sufficient to trigger airbags, and these events could simply be breakdowns or medical emergencies (as well as accidental triggers). Nevertheless, the use of this data, if subject to a rigorous evaluation, could be of assistance.

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NEAR-MISSES AND SAFETY EQUIPMENT ACTIVATION

The other category of safety data is potentially very broad and largely untested. This relates to specific safety systems being triggered within a vehicle. We know that manufacturers collect mundane data such as the status of individual doors, and it would therefore be reasonable to assume that information from other sensors would also be recorded. For example, knowing if there were specific locations where ABS is triggered may provide valuable information on low-friction surfaces around road hazards. Understanding hotspots for Pedestrian AEB warnings or triggers could also indicate locations where measures can be introduced to improve safety for vulnerable road users. An example of this type of analysis is provided by Mercedes who, in partnership with Transport for London, launched their developmental dashboard for road safety in 2021[xxv]. This dashboard looked at certain events and processed them as follows:

> If an acoustic and visual warning or an autonomous emergency braking is issued, the information is sent to the Mercedes-Benz Cloud and anonymized. Two algorithms process the data in the backend: firstly, the GPS positions with accumulations of occurred interventions are identified. Secondly, these potential collision blackspots are thoroughly analysed, and a risk score is calculated. This information is integrated and portrayed within the Road Safety Dashboard as a digital map.

Right now, there are few other examples of this kind of data being made available and used by professionals or researchers in our field. Harsh-braking outputs, defined by rapid deceleration sensors, are, however, coming to the fore. A collaboration[xxvi] between Aisin and Gaist has resulted in the data from tens of thousands of events being clustered and analysed alongside high-resolution imagery. When analysed together, these outputs present a new view to highway authorities on the driving patterns on their road network and can be used alongside traditional data sources to inform road safety engineering plans.

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As we strive to reduce and eventually eliminate the number of people killed and seriously injured on the road, some of this near-miss data will become more valuable to professionals who would normally rely on clusters of many collisions to identify priorities. Layering data and creating digital twins will surely be part of the future and connected vehicles offer a compelling source of information to the sector.

WHAT NEXT?

We have considered how data from connected vehicles is already being used to inform road safety interventions, replace existing sources of data, and offer new insight. There are also potentially other use-cases that don't require a human input at all, such as Vehicle to Infrastructure (V2I) and Vehicle to Vehicle (V2V). It's pretty easy to imagine how vehicles can warn each other about hazards ahead (harsh braking, slippery road surface) and the same can be said for infrastructure, such as warning signs. Drivers being informed of approaching traffic at a junction with poor visibility would be helpful, of course, and perhaps more connected vehicles would offer a solution in the future.

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Right now, though, we need to consider what happens in the near future. What will the years to 2025 bring in terms of access to connected vehicle data? It seems clear that traffic data, including speeds and vehicle movements, will become more open and available at affordable prices for those working to improve safety on the roads. Accessing newer datasets from individual manufacturers may be more challenging and some form of coordination will be required. It may be that the market leads this innovation, as seen by Gaist, and, of course, Agilysis. There will surely be pressures on spending by local authorities and this often drives changes in activity. Reducing traffic survey spending by relying on connected vehicle data instead would allow potentially greater coverage, even if some detail is lost on vehicle classes. Having access to more real-time data on speeds following changes to road networks could accelerate evaluation and inform future decision making. The gap in data around active modes also needs addressing. A better understanding of pedestrian movements and where people cycle would be of enormous benefit if available network wide. Will this be available via connected vehicles or will we have to rely on other data suppliers for this?

It's amazing what we can achieve when we start thinking a little differently but in order to do this you need the right environment and the opportunity to learn what others are doing. In our digital and connected world, there are a whole host of data sources out there being collected and used for different purposes. We need to find out what they are and discover how they can be used to help us save lives on the roads.

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