

The Appeal to Novelty Fallacy: Transportation Data and Technology in an Urban Context

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Abstract

Transportation has the greatest potential for the often-cited benefits of Smart Cities to be realised, however in practice this has not come to fruition. The current reality of smart cities is that there are not any, instead you have cities that have become incrementally smarter through the introduction of technology, data, and techniques which address specific urban challenges. This paper presents an overview of the development of traffic control technologies through to the present day, outlines the roadmap needed over the next decade to put the UK back at the forefront of innovation in the sector through enabling connected mobility and finally provides an overview of the work being undertaken by TRL Software in closing the gap.

Keywords: Connected Autonomous Vehicles, Intelligent Transport Systems, Open Data, Smart(er) Cities.

1. Introduction

Transportation has the greatest potential for the often-cited benefits of Smart Cities to be realised, however in practice this has not come to fruition. The current reality of smart cities is that there are not any, instead you have cities that have become incrementally smarter through the introduction of technology, data, and techniques which address specific urban challenges. On the flip side you have numerous failed, abandoned, or closed projects which have not delivered the innovation or promise on which their implementation was based or those which present unsustainable models, otherwise put as “I cannot buy a promise.” [1]

1.2 The Same Problem – Only Worse

In 2020 UK drivers travelled more than 280.5 billion vehicle miles [2] on the UK highway network, noting the impacts of the COVID pandemic, this was down *c.21%* from the 356.5 billion vehicle miles [3] travelled in 2019. Based on pre COVID conditions, the Department for Transport (DfT) is forecasting up to a 55% increase in traffic by 2040 and up to an 85% increase in congestion levels compared with 2018 levels.

Since 1994, cars have accounted for approximately 78% of all motor vehicle traffic and continue to be the main contributor to changes in overall vehicle traffic. Continued growth in traffic places more demand on already busy roads, more traffic will invariably result in more congestion, delays, emissions and lost time. With increasing traffic volumes in urban areas, addressing network delay and

capacity optimisation is set to become even more challenging.

2. The Past, in brief

From the earliest manually operated “traffic control devices” to electromechanical timing circuits through to the widespread use of embedded computing and control algorithms that we see today, the evolution of traffic control has been significant in most, but not all quarters.

The evolution of traffic control has been shaped but two principal aspects, the technologies available at the time and Government policy. When looking to Transport policy in the UK during the 1990’s it was underpinned by a number of core policy outcomes:

- A safe and efficient transport system.
- A better, more integrated public transport system.
- A more environmentally sustainable transport system; and
- Better and more strategic integration of transport and land use planning.

The core theme of integration was the single most significant enabler and so came UTMC. Built around the heart of a UTC, UTMC enabled the expansion of functionality to include the ability to inform, warn and guide drivers. Conceptually a modular approach, which today can be viewed more as a heavy monolithic system.

3. The Present

Today, when looking at the nine principles of the Future of Mobility Urban Strategy [4]:

1. New modes of transport and new mobility services must be safe and secure by design.
2. The benefits of innovation in mobility must be available to all parts of the UK and all segments of society.
3. Walking, cycling and active travel must remain the best options for short urban journeys.
4. Mass transit must remain fundamental to an efficient transport system.
5. New mobility services must lead the transition to zero emissions.
6. 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.
7. The marketplace for mobility must be open to stimulate innovation and give the best deal to consumers.
8. New mobility services must be designed to operate as part of an integrated transport system combining public, private and multiple modes for transport users.
9. Data from new mobility services must be shared where appropriate to improve choice and the operation of the transport system.

the Transportation Decarbonisation Plan and continued trend of digitalisation, transportation is now in one of the single most transformative periods since Henry Ford and the internal combustion engine. For all the opportunity to be better, cleaner, safer, more efficient, affordable and sustainable there is a high risk of further fragmentation of the data available today and that which is expected in the short, mid and long term. Conversely, we are in a period of incredible opportunity in **addressing historical** decisions by opening of datasets in meaningful ways, to drive efficiencies, develop actionable insight and progress smarter cities. Such opportunity will be, needs to be data driven. Data, not devices.

Since before the 2010 comprehensive spend review at the exit from the last recession in the UK, Local Authorities have been seeking to drive cost efficiencies which has resulted in reduced investment in infrastructure and services along with the erosion of core knowledge, experience and

technical competencies in traffic control and network operation.

Moving from monolithic to modern, in seeking to do more, with less, innovation is key, along with the need for a competitive marketplace.

It is hard to imagine a rationale for making use of connected vehicle data for urban management in the absence of having a developed an understanding of the existing data available, this is crucial in:

- Leading the way to a connected future and the transition between today and tomorrow, because there isn't a clear roadmap
- Developing an understanding of value, application and data driven outcomes which can be achieved in a reproducible way, because of the high level of commonality across the user needs, data products, there is a high level of potential for reuse between authorities. Build once, share, iterate.
- Defining what is needed. Because there is a national use case

In defining a problem, when the question of *what is needed to solve this?* is asked before *how we can use this to address the problem?* you avoid the issue of a solution looking for a problem.

3.1 GLOSA

The concept of GLOSA is not particularly new, nor exciting. Data, not devices. At face value, it's a relatively simple concept. A limited two-way exchange of information; car and traffic signals, vehicle position, the signal timing and a calculation of the optimal cruise speed to arrive as the lights change to green, avoiding the need to either stop or restart.

In reality, GLOSA has proven somewhat elusive with only limited deployments as proof of concept and technology evaluators within the UK. There are a number of reasons to which this can be attributed:

- Vendor compatibility – what vendors hardware is in use, its capabilities and interoperability.
- “Technology all the things” – one of the main tenets of the “smart city” is that it involves extensive instrumentation across the urban environment.
- Data access – being able to access the right data, at the right time and getting it to the right place and finally
- Speed – how quickly data is moved and shared.

Where the expected benefits of GLOSA are marginal in terms of reduced emissions, delays and smoother journeys, the Benefit to Cost ratio (BCR) does not support the at scale deployment of more roadside technology. However, when considered as a data problem, very much like the Dutch Talking Traffic program of works which has been ongoing since 2014, marginal benefits during off peak and low flow periods at a national scale have the potential to become significant.

The TRL Software GLOSA implementation is a software and data solution which provides the right data, at the right time to be consumed by a mobile app in vehicle. Data, not devices.

Looking to the Dutch Talking Traffic works, where a national effort enables at scale availability of traffic signal data, innovation follows.

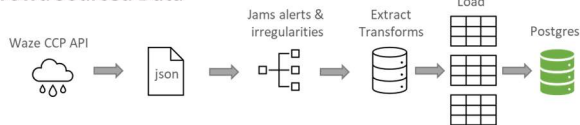
3.2 Waze - Crowd Sensed Data

The Waze Connected Citizens Program (CCP), now called Waze for Cities is a data exchange between local authorities and Waze. A local authority provides information around planned closures, incidents and events which impact the normal network in return for information gathered from Waze users on the local authority network area. With the Waze ethos of “*the best mobility solutions come from working together, so our partner programs are all free*”, there has been significant growth in the number of active users and partners now working with Waze.

Waze shares data about traffic jams and irregularities detected from data collected from drivers via the mobile app, additionally users of the app can actively feedback on traffic issues, highway maintenance faults and other issues which are impacting the network. Taking the crowd sensed data one step further is the ability to create user defined monitored routes for journey time monitoring. All of this can be achieved with a modest investment for data processing and presentation, but with at no cost for the Waze data itself.

From the Waze API to ingestion of alerts, irregularity and jam points, the creation / addition of geospatial referencing provided a starting point for the visualisation and graphical representation of the data. Using a PostgreSQL database, with PostGIS, geospatial extensions, connections to both open source and readily available off the shelf (OTS) commercial products then becomes possible.

1. Crowd Sourced Data



2. Data Transformation

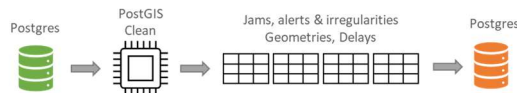


Figure 1. Waze API data processing

Findings: Within the UK the uptake of the Waze for Cities has been relatively limited, this can be attributed to three key factors, firstly Local Authorities not being aware of the data availability, secondly, the level of complexity of working with the raw data, third and finally the data feed provision back to Waze (as part of the Waze for Cities agreement). Initial exploratory analysis of the Waze for Cities data product has a relatively high degree of complexity in the extraction, transformation and load process to create useful applications through accessible data. A reproducible data tool kit has now been created for the rapid deployment and access to the Waze for Cities data to enable local authorities to progress from data to information, to insight to finally action.

Outcomes: The positioning of an outcome-based approach to create a repeatable and a reduced technical barrier to make the best use of current, new and emerging data products is essential. Combining new and novel data sources such as the Waze for Cities in combination with existing, but typically in accessible data products from SCOOT UTC and the championing the use of crowd sourced data is expected to provide Local Authorities with significant benefits. Data driven, not devices as a focus for making the best use of currently available data products requires a combination of data access, domain knowledge and appetite for innovation which provides material benefits. The immediate benefits are presented in Figure 2.

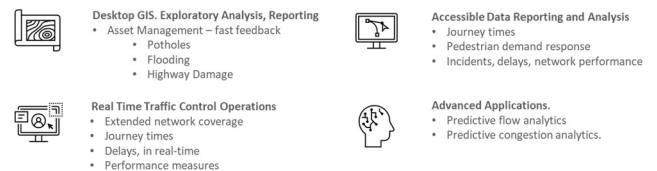


Figure 2. Combining Open Data Use Cases and Outcomes

The ability to expand network monitoring and visibility **without the requirement for additional roadside equipment** installation is significant. The benefits to be realised with this approach not only reduced the cost of effective network management for urban areas, but brings additional value through:

- Rapid identification of incidents / loss of network capacity for traffic operators.
- No cost journey time monitoring of key routes for KPI measurement.
- Traffic analysis and studies using an automated data process for congestion analysis.
- Incident analysis, from phase change of traffic states to resuming normal conditions.
- Highway asset fault reporting.

Presented as small incremental steps, automation of the repetitious and the combining of open data products, data →

information → insight → action becomes possible, in a repeatable, low cost, near turnkey way. Data, not devices.

3.3 Incident Detection Automation

TRL Software, a part of TRL, has a long history of working in collaboration across industry and academia in progressing the state of knowledge for the betterment of society. Our partnership with the Alan Turing Institute, the UK’s national institute for data science and artificial intelligence, has been a major focus for the past 12 months in undertaking applied research and development across two key focus areas, the first of these is in respect of **network incident detection**.

With increasing traffic volumes in urban areas, addressing network delay and capacity optimisation is set to become even more challenging. Where network availability is impacted by an incident, the rapid identification, location and response are key to returning the network to normal as quickly as possible.

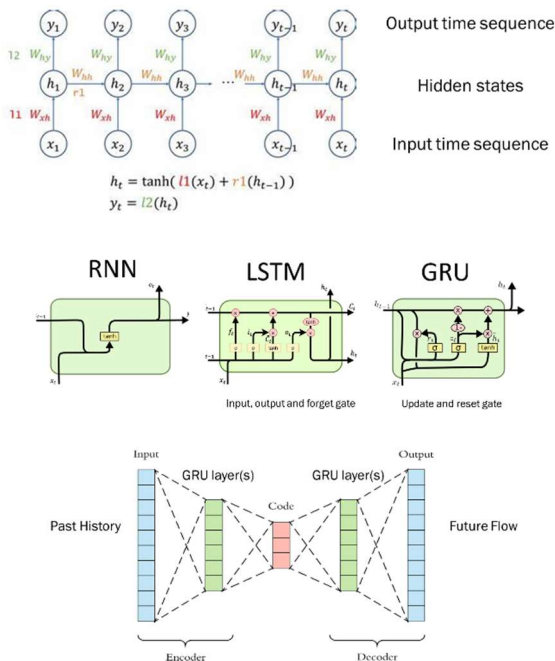


Figure 3. Forecasting Model – Main components

Research and development undertaken to date has shown positive incremental benefits in the identification of incidents occurring on the network. Initial work using a variant of a traditional neural network (that is trained on input sequences to predict behaviour of future sequences), known as Recurrent Neural Network (RNN) see Figure 3 showed promise, however in working with high-dimensional, nonlinear and large real time datasets, it was found that event detection was unstable, therefore unsuitable.

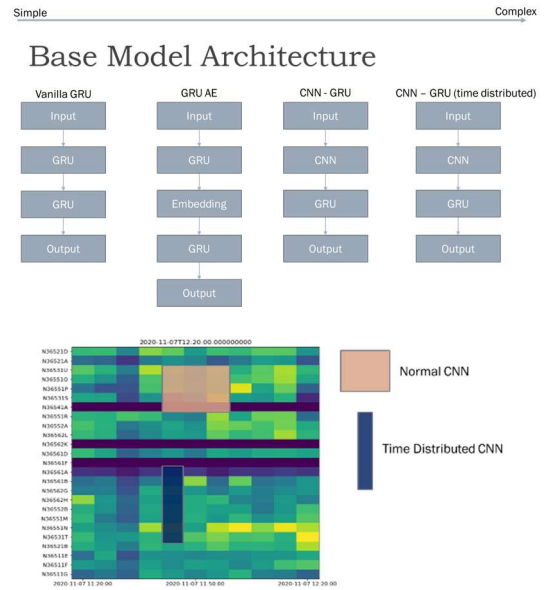


Figure 4. Revised Forecasting Model – Main components

Using a revised approach, Figure 4, experimentation in the application of an initial Gated Recurrent Neural Network (GRU) to Convolved Neural Network (CNN) is now starting to present stable detections which are comparable with currently used techniques. Where an incident is given as any event which impacts network normal flow at approximate incident time occurrence +10 minutes and +5 minutes, with consideration of the spatial relationship detection results:

	Predicted	
	FALSE (0)	TRUE (1)
N=125		
FALSE (0)	11	12
TRUE (1)	22	80

Table 1. Confusion Matrix +10-minute experiment.

Precision	87%	Recall	78%
Accuracy	73%	F1	81%

Table 1. Results +10-minute experiment.

Whilst initial results show promise, in particular when applying a rolling 10 minute time horizon, see Table 1, when looking to further reduce the time to detection, it is clear that further work is needed.

At incident time occurrence + 5 minutes:

Precision	57%	Recall	58%
Accuracy	64%	F1	57%

Table 2. Results +5-minute experiment.

The impact of incidents on a given network are well understood, from secondary collisions, distracted drivers, loss of capacity, environmental and societal harms. The mechanics of flow breakdown, congestion and delay are as

well understood today as they have ever been. The need for a network operator to have identified anomalies and incidents in a timely manner remains ever more critical today.

One of the outcomes from the initial incident detection R&D is the ability to forecast with a high level of precision and accuracy, traffic flows on a link by link, junction by junction scale at 5, 10, 15-minute intervals.

3.4 Validation / Revalidation Automation

In consideration of incident detection and how the shape and form of a network is expressed as well as the characteristics of traffic flow, there is a direct application for the validation and revalidation of SCOOT UTC networks. **A subsequent update paper is to follow in Winter 2021.**

4. Conclusions

The policy agenda set in the Future of Mobility Urban Strategy and the subsequent Decarbonisation of Transport policy is clear.

- A safe and efficient transport system.
- A better, more integrated public transport system.
- A more environmentally sustainable transport system; and
- Better and more strategic integration of transport and land use planning.

The single most important additions from the policy direction of the 1990s is in the application and use of data. Technology will continue to drive change in transportation with increasing pace and significant implication for transport users and business. Electrification, decarbonisation, connectivity, urbanisation, climate change, automation, and real-time data collection and analysis are driving the development of new modes of travel and how and where people work.

Policy needs to maintain pace with technology to avoid the risk of constraining the future of transportation / mobility and better use of data available today needs to be made in order for a more connected tomorrow. For all of the focus on **Autonomous** in the CAV, today, **Connected** is the single most important enabler for change.

Making use of in-vehicle data from future connected vehicles is understood to have the potential to improve the individual journey through to addressing the growing challenges of congestion, delay and pollution in urban areas. This is not going to happen overnight and potentially within the next decade, instead a series of incremental steps where innovation is realised and enabled at scale is one likely route to the future of mobility and in achieving cleaner, more efficient and sustainable transportation

There are benefits which can be achieved in significantly shorter timescales from the increased awareness of on-road conditions that even fairly low penetrations of connected vehicles can provide.

There is clear need for standardisation around how data will be collected (collected and distributed), what can and will be collected, data ownership, usage rights and retention. There are significant privacy implications to be considered in ensuring that the future of mobility does not become the method of enabled surveillance capitalisation

These issues all require policy and policy needs to maintain pace with technology to avoid the risk of constraining the future of transportation.

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