Information Sharing Proof of Concept

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Report to the Department for Transport: June 2014

This report describes an investigation of whether there are tangible benefits to the physical transport infrastructure from the better sharing of data. The investigation builds on the STRIDE project, an *Internet of Things* Technology Strategy Board project, looking at the collation of disparate data via an information hub to produce enhanced information sources for re-use, and applies this to physical infrastructure in the Cambridgeshire A14 corridor as a test of its wider applicability. The possible benefits extend both to better use of existing assets and to better-informed drivers. Both technology, and human issues concerned with governance, privacy and cooperation are considered in the report.

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Appendices (at http://www.damtp.cam.ac.uk/user/pvl/APPENDICES/):

The work was undertaken by BT Research and Innovation and Cambridgeshire County Council, with additional contributions from Atkins, Cloud Amber, Neul and Steria. It was coordinated by Peter Landshoff, Professor Emeritus at Cambridge University.

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Contact: Professor Peter Landshoff, pvl@damtp.cam.ac.uk

1 Summary of key findings and recommendations

It is important to make better use of information to increase the effective capacity of the road system, so as to avoid the environmental and monetary costs of laying more tarmac. The road system should be treated as a single entity even though many organisations have responsibility for it[1]. (No journey begins or ends on a Highways Agency road.) The potential for conflicting and inconsistent actions by different stakeholders will always be present but one can aim to reduce this by making sure that people make decisions based on the best available information.

There should be an aim to make good traffic flow information available for every road. Drivers should be told of the causes of delays they encounter and their likely duration, so as to take informed decisions. They need advice on whether to take a diversion and, if so, what is the best route, taking account of road conditions at the time. This entails converting raw information into a form that is easily understandable, and is neither too little nor too much to be actionable. Variable-message signs are too widely-spaced and all too often display information that is not relevant to a particular driver.

Where possible, information should be transferred electronically rather than person to person, so that it is made available rapidly and to all that need it. This is best achieved through the use of data hubs and, as far as possible, by machine-to-machine processes. Each organisation connected to a hub decides what information it is willing to share and who is allowed to see it.

We recommend that the following actions be put in place in the immediate future:

- There is an urgent need to provide more, and more expeditious, exchange of information among those involved in the handling of incidents – the police, Highways Agency traffic officers, fire service etc. In particular it is important to bring in the knowledge of local authorities on the appropriateness and availability at the time of previously-agreed diversion routes.
- More work needs doing on the most appropriate technologies to give drivers continually-updated information about the road system, particularly warnings about incidents and their expected clear-up times.
- The route to universal adoption of such new technologies, and the means to cope with their inevitable obsolescence, needs careful planning. New systems will need to run in parallel for several years with existing ones.
- The low level of information infrastructure on local authority roads compared with Highways Agency roads needs addressing.
- Steps should be taken to overcome the problems resulting from the unavailability of local authority staff out of hours when an incident occurs.
- More work needs doing on the most appropriate technologies to replace obsolescent methods of monitoring traffic flows, such as MIDAS loops, and particularly on technologies that can be applied effectively and cheaply to

[1] This is in line with the Department for Transport's *Action for Roads* policy, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/212590/action-for-roads.pdf

local authority roads. There should be tests of how many sensors are needed and of what kind, both roadside and in-vehicle.

- It is important to avoid the need for numerous local negotiations, and therefore to decide at national level[2]
    - the system architecture, data formats, procedures and protocol
    - which agencies should participate
    - what different agencies should be able to see
    - how to bring together networks with different security restrictions.
- As part of this, there is a need for all agencies, especially public sector, to clearly define their key objectives and needs so that data and information services can be designed or adapted to meet these purposes.
- While better means of connectivity remain to be developed, adequate means already exist but international standards need to be agreed.
- A set of scenarios should be modelled for each strategic route, so as to inform the best diversion strategy when an incident occurs.
- It should be mandatory for those undertaking road works to transmit notification electronically to the road authority concerned immediately after they have begun and after they have ended.
- The barriers to getting people to share data need to be overcome, by giving wide publicity to the benefits. There should be a web site for easy discovery of both commercial and open data, with minimal metadata descriptions of them.
- There must be debates on privacy issues, and the benefits from people cooperating should be made widely known.

The importance of the last point needs emphasising. More work needs doing on drivers' attitudes and behaviours, and on their likely level of adoption of facilities that lead to some loss of their privacy in exchange for benefits to themselves and to the wider community.

2 Approach and scope

The general approach of the study is to treat the road network as a single entity with multiple domains of control[1]. The Cambridgeshire part of the A14, which is highly congested, was used as a laboratory, but the findings are applicable to the whole of the UK road system. Specific issues that were addressed include

- Examining the existing information and data architecture, and business process, and identifying where changes could be made to make better use of them to manage the road system
- Engaging with the various stakeholder organisations and understanding what their existing processes are and how they consider they could undertake their role better

[2] The Cabinet Office project MAIT (Multi-Agency Information Transfer), http://mait.org.uk/, is appropriate for this. It now includes a previous project DEIT (Direct Electronic Incident Transfer).

- Evaluation of other potential information sources: sensors and social media.
- Analysing the management of incidents to see whether the duration and effect of an incident could be reduced by the better sharing and use of available information.
- Better sharing and processing of diverse data sources to enable motorists to make more informed decisions – 'how does a driver know what is happening at the front when they join the back of a queue?'
- Making existing transport models more effective by enabling results of actual incidents and events to be dynamically fed into models instead of updates being provided as one-off events each few years

The main issues with the use of information are not just the development of better technologies, but persuading people of the need to collaborate and creating governance processes to handle questions such as privacy and data ownership. A great deal of data is already available; the challenge is to bring it together in a way that makes it available for re-use in a way that enables others to makes best use of it.

3 Background

The study is under the umbrella of East of England Transport Information (EETI), a collaboration that began in 2009 at the instigation of the Department for Transport. Among its active public-sector partners are

Cambridgeshire County Council
Essex County Council
Suffolk County Council
Department for Transport
Highways Agency.

BT Research and Innovation is key to the collaboration, and there is active involvement also from a number of freight organisations.

EETI's central aim is to make more effective use of the road network, without laying more tarmac, in particular to

- Reduce congestion
- Reduce transportation costs

Experience with information-technology projects has been that it is mistake to try to do too much at the outset. Therefore EETI's general strategy has been to start with something simple and localised (initially the eastern half of the A14) and then gradually add in more functions and extend the area – first to the whole region, ultimately the whole country. A key aim is to prove that there are incremental steps to wide deployment, with each step kept small and simple.

A particular focus of the work of EETI has been on the better handling of incidents. Work carried out by EETI in 2009-10 showed that

- There is an urgent need to provide better communication and exchange of information among those involved – the police, Highways Agency traffic officers, fire service etc

- In particular it is important to bring in the knowledge of local authorities on the appropriateness and availability on the day of using previously-agreed diversion routes.

The study makes use of the output from a project funded by the Technology Strategy Board as part of its *Internet of Things* activities and led by BT, named STRIDE[3]. It began in April 2013 and it included the creation of an information hub that allows the input of every kind of information, from a variety of sources, so that it can readily be made available to all those with a need to know or those who create applications to use the data.

The study reported here was funded by the Department for Transport to build on these initiatives and to explore the benefits of implementing both EETI's recommendations and the outputs of the STRIDE project.

4 Key principles

Managing road networks involves considering the infrastructure, the traffic that moves on it and the people and goods that are conveyed in the vehicles. There are therefore a large number of independent stakeholders, each with their own organisational objectives, processes and systems. A traditional IT approach would be to try and define an optimised process between these organisations. This is highly complex, time-consuming and difficult to manage, partly due to the potentially conflicting priorities of the organisations involved. This proof of concept has taken as key premise a different approach. Namely, a more effective overall solution can be achieved by enabling each of the involved organisations to make improvements to their own processes.

The key principles underlying the study are therefore:

1. Organisations and individuals are able to make more effective and efficient decisions if they have immediate access to the information they require
2. Much of the required information is already available; however it is typically locked into separate systems.
3. Decision makers are the best judges of which information they do and do not need. Decoupling information provision from information usage will simplify the cost and speed of integrating organisations.
4. In line with the government's Open Data principles[4] making information available will create an environment for innovation, enabling entrepreneurs to develop new services and applications that support the wider roads and communities ecosystems.
5. Where possible, information should be transferred electronically rather than person to person over the phone.

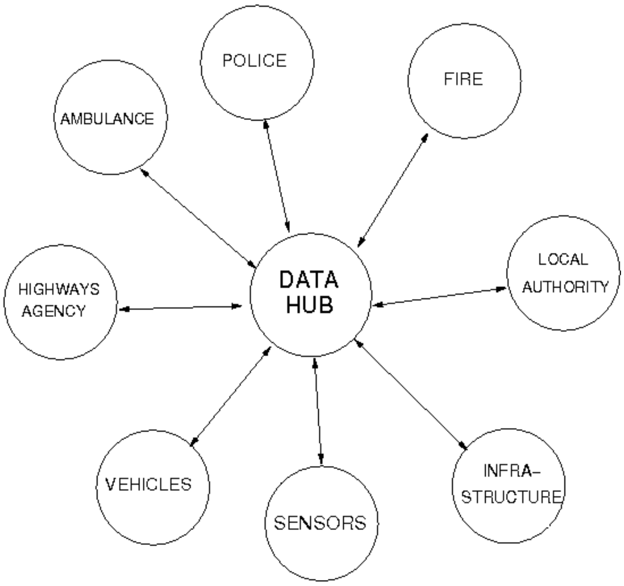
[3] STRIDE (Smart Transport Internet of Things Data Ecosystem): http://www.stride-project.com/tag/transport/

[4] *Open Data – Unleashing the Potential*, Cabinet Office, June 2012, http://www.cabinetoffice.gov.uk/resource-library/open-data-white-paper-unleashing-potential

5 Information hub

A central element to this architecture is the information hub, which is built on the *Internet of Things*[5] principle and whose purpose is to facilitate the rapid exchange of continually-updated information, via a publish and subscribe regime, among all those concerned with managing an incident, as well as giving information to road users to allow them to make informed decisions on whether to try to avoid the incident.

The role of the information hub is to make it relatively simple to set up and exchange information with a number of other interested parties. Traditionally this has been a complex, costly and time-consuming activity, with individual agreements having to be put in place between each pair of cooperating organisations. An information hub helps address this by requiring organisations to establish only a single connection to the hub. The hub then takes on the responsibility of managing the information flow to other appropriate partner organisations, with each deciding what



information it is willing to share and specifically who is allowed to see it. Subject to these permissions, organisations can then choose which elements of the information they wish to extract to help them with their processes. The hub must ensure that the confidentiality and security policies for the information supplied are explicit, agreed and delivered.

Projects such as DEIT[2] (Direct Electronic Information Transfer) have already started along this route, showing how hub architectures can help with the specific issue of reducing the cost of connecting organisations together. The difference with the approach being followed in this study is that DEIT essentially requires the information provider to direct information to allowed information consumers – the decision to share information sits with the information provider. The model described here makes it more of a joint responsibility.

Details of how the hub is used to manage information are given in Appendix A.

[5] https://connect.innovateuk.org/web/internet-of-things

6 Management of incidents

A key part of the study was to understand what additional information organisations need, and in what time frame, to enable them to improve their part of the overall management of incidents and consequential congestion.

Discussions with the Cambridgeshire police revealed that when they arrive at an incident they tap details into a hand-held device. They then spend up to 10 minutes phoning Fire and Ambulance, and so the police suggested that there is an obvious need to set up automatic exchanges of information via a hub. The study set out to prove this concept, to seek evidence that where data and knowledge are shared and combined in an intelligent and efficient manner there are tangible, beneficial outcomes for the physical transport infrastructure, for example by improving the effectiveness of diversion routes.

Negotiations with both the Cambridgeshire police and fire services, and to some extent also with the East of England Ambulance Service, turned out to be time-consuming and complex. A particular concern to the police is the confidentiality of personal data, such as people's names or car registration details. It was eventually agreed that the police control room system should have a direct connection to the data hub, but that only certain of its data fields should be fed into it. At the time of writing, this is still awaiting Home Office approval.

When the outputs from the proof of concept are deployed more widely, decisions about cooperation among the three emergency services will need to be taken at national level. Ideally, all emergency service control rooms should be designed so that they can easily interface with each other and with appropriate information hubs in such a way that data confidentiality is secure.

A meeting in Cambridge on 13 March 2014 brought together officers from the Cambridgeshire and Suffolk police forces, the Highways Agency Regional Control Centre, Cambridgeshire County Council Highways Management Centre, the Department for Transport and BT. The meeting reviewed the process for managing incidents and confirmed the need greatly to improve the automatic sharing of information. Among the detailed points made were:

- It is important to sort out at national level what different agencies should be able to see (at present it tends to be all or nothing) and how to bring together networks with different security restrictions.
- The responsibilities of different agencies in the case of an incident need documenting. At present there is wasteful effort because the default is to assume, often correctly, that others have not taken necessary actions.
- The arrival of connected cars increases the urgency to supply information to individuals that is both relevant to them and more understandable. A particular problem is with specifying location: "Junction 23" means little to most road users or to local authorities.
- Incidents on local-authority roads are generally handled much less efficiently than on Highways Agency roads. There is wide variation among local authorities, between having 24-hour control centres to having none at all. Not all local authorities even have a single phone number that the police or the Highways Agency can call in case of need.

We attended a cold debrief about an oil spill on the M11 in September 2013, which was described as a particularly difficult incident. The incident lasted 13 hours, though that it would do so was not apparent at the start. Present at the debrief were Essex police, Highways Agency and Amey (which took over from Skanska as contractor to the Highways Agency on 1 April 2014). Among the points made were:

- Airwave[6] has problems. Not only is it expensive, it is complicated to use because it has several channels, each for different purposes and with different ownerships.
- Conference calls between all the parties, including the media, were a great help. Automating the exchange of information would be valuable.
- Identifying what was happening on stretches of the road between cameras was a problem, though it was helped by photos tweeted by drivers.
- Closure of the Essex control room at 7 pm did not help. It would have been useful also to use the Cambridgeshire variable-message sign system, but it was not yet available. It was agreed to recommend that the Highways Agency should have access to local authority variable-message signs out of hours.
- It is up to the contractor to decide how to restore the road. This usually works but can sometimes cause tension if police or Highways Agency think it should be done differently. Procuring specialist equipment can be difficult: locating the nearest may need several calls and none might be available nearby. The Highways Agency's new asset support contracts are financially driven and limit what is available on standby.
- Data technology should help allocate more efficiently both resources and who does what.
- The police are good now at freeing lanes as quickly as possible, though forensics still take priority in the case of a crime scene.

More details of our work on the management of incidents may be found in Appendix B.

7 Information sources

To improve the visibility of the network outside the strategic road system requires more data from third parties, or additional sensors. A step change should be anticipated in the number of sensors on the road system and attention must be paid to associated systems, such as street lighting, that may have use for traffic flow detection or data collection.

Sensors must be added cost effectively, to provide sufficient detail, coverage and accuracy. For example, today

- GPS location is increasingly available on smart phones so, with user consent, a smart app could provide location data. Even with out this, tracking through mobile phone cell identification is now good enough to help inform decision making.

[6] http://www.cambridgewireless.co.uk/directory/orgprofile/default.aspx?objid=36227

- Satellite navigation units identify the specific road but at present only a small number are networked for real-time use. Satellite navigation companies sell this data but it can be costly and can be limited in how it can be used.
- Fleet-management companies use satellite navigation, so they know the specific road a vehicle is on and they have a network connection, but the data set may be very small and of limited value if the fleet is primarily on the strategic network rather than smaller roads.

The existing sensors on the strategic network have non-trivial installation requirements. They are typically mains powered and are close to network connection points; to replicate this onto more of the UK road network would be prohibitively expensive. We looked at the options for collecting information cost effectively from new sources; those studied were traffic sensors and social media.

The work on traffic sensors was split into two parts, a paper-based evaluation and a later field trial to test selected sensors in real world scenarios – optical fibre, and wireless devices based on Bluetooth and Wi-Fi. The object was to assess whether different sensors can cost-effectively provide information that will help both the local authority and road users. We concluded that a fibre sensor can potentially cover a large number of roads from a central location, but more work needs doing to conclude that this is a practical means to detect traffic. Wireless detection methods are promising, but to achieve the necessary accuracy it may be necessary to combine wireless data with other vehicle-counter data. Details are in Appendix C. More work is needed to evaluate wireless detection against existing vehicle detectors and to assess ways to reduce running costs while allowing enough information to be transmitted to management centres.

The purpose of the analysis of social media was to understand whether information sources such as twitter can be mined for valuable information. Interviews with the organisations involved in managing incidents indicated that some tweets, especially those containing pictures, can provide them with valuable information. We have created an automated filter that can deliver a stream of traffic-relevant information. Our experiments showed that our approach gives an accuracy for traffic-relevant tweets of approximately 90%, at the expense of some loss of accuracy for non-traffic-relevant tweets. This compares very favourably with other known approaches. In most real-world applications, it is the accurate identification of relevant tweets that is most important. Thus the loss of accuracy for non-relevant tweets is less critical. Further information is in Appendix D. More work is needed to determine if and how social media data can add significant value in traffic management.

8 Direct communication with vehicles

This activity looked at information interchange between vehicles and the information hub. The aim of this work was to explore the use of new machine-to-machine technologies, along with novel wireless connectivity solutions, to demonstrate innovative ways to gather and distribute information. The study looked at what information can be provided from the hub to the vehicle, whether information can be cost-effectively provided from vehicles about road conditions, whether machine-to-machine protocols can be used to transfer data in small packets (to minimise the network costs), and whether TV White Space can be used as a low-cost carrier network for this information.

We investigated how much data is needed to provide a core transport information service to and from vehicles, and what a wireless network solution architecture might look like. We developed a smartphone-based application, built upon existing work from the STRIDE[3] project, that can send and receive relevant data to and from vehicles, and a message protocol that can send this information with a limited amount of data. We then created a demonstrator based on this application, plus an information distribution component with the capability to route different information to different devices, based on the source of information or the location of a device.

Part of the STRIDE project was to use smartphone acceleration monitors, GPS capability and other smartphone sensors, to analyse drivers' behaviour, and we have extended this to provide information about traffic flows. If a sufficient number of drivers can be incentivised to install the smartphone application, this should be a good method to gain information about traffic flows on poorly-instrumented local authority roads.

Finally, we demonstrated the use of TV White Space to send and receive small data packets (time, location, direction and speed within 40 characters) to and from a moving vehicle along the A14 over unlicensed spectrum. However, there are outstanding issues such as the regulatory environment and the so-far limited number of vendors; therefore there is still a large degree of uncertainty around the best radio solution to use. The most suitable protocol for machine-to-machine applications appears to be Weightless[7], though it is lacking in major industry players support for chips and devices, and there are issues over real-world coverage ranges, size of antenna needed at the terminals and cost of power amplifiers. Also it is not optimised for mobility management and fast handover between cells.

Details of this work are in Appendix E. Further trials should be carried out using standard cellular-phone communications, to determine for example what information should be sent to vehicles. And more work needs doing, in consultation with Ofcom, on issues related to spectrum, antenna and transmitter power.

9 Network modelling

The purpose of this work was to set out the current extent to which the geometry and theoretical capacity of the A14 corridor can be assessed and mapped, using available data sources to understand the current usage and operational characteristics. The study focused on two specific incidents on the road network in 2011 and 2012. Low sample sizes and breadth of data for specific days in the past made it difficult to obtain a full view of all of the impacts of an incident, although the traffic model was configured to represent the metrics that are available.

It was concluded that there are a number of areas along alternative routes in the corridor that have low levels of residual capacity, and that it is these pinchpoints that determine the capacity of the whole diversion route. This indicates that even if the motorist had greater knowledge and ability to divert, the quality of the routes then available to them would not necessarily be high. There are also specific areas along the A14 itself that have low levels of residual capacity and therefore are likely to react more significantly to any incident along that particular length of road.

7 http://www.weightless.org/

While a number of data sources are available, the data which they hold for defining the level and pattern of diversion due to an incident are limited. For example, the sample size of the TrafficMaster data on any specific incident day is comparatively small, and there are a limited number of traffic count sites that cover historical days including those of an incident. Currently, only the long-term Highways Agency Traffic Information Database for the A14 and A428 is used in analysing flow changes due to an incident, which leaves uncertainty in the level of diversion onto other alternatives.

This analysis has shown that between 30% and 35% of the traffic that diverts from the A14 due to an incident, or is held within a queue on the A14, diverts to the A428 corridor at Caxton Gibbet. This level of direct A428 transfer increases closer to Cambridge, indicating that there is also some diversion taking place through more minor routes between the A14 and A428. It can be seen that there is also higher flow on the A14 after an incident than is typical for that time of day, and that this is potentially representative of the level of traffic that is held in a queue on this route.

The ability of adjacent roads in the corridor to absorb additional traffic that has been diverted from the A14 due to an incident was analysed. A number of areas of low residual capacity were highlighted that have the potential to exhibit increased delay if an incident occurs on the A14 and traffic diverts onto these alternative routes. Initial analysis has highlighted that there are limited options for providing temporary or permanent alternative arrangements at these key pinchpoints. While improvements to specific movements could potentially be made, this would come at the detriment to other movements and road users.

The levels of residual capacity in key routes parallel to the corridor are restricted by these key pinchpoints. Analysis has shown that the level of available capacity on each of these routes is restricted to between 500 and 1000 Passenger Car Equivalents[8] per hour across the day, indicating that the primary alternative routes to the A14 would be unable to operate effectively should all of the A14 traffic attempt to divert due to an incident. This demonstrates that if a more effective methodology of communicating an incident to the public is developed and more people are able to divert, this diverted traffic is still likely to be faced with a low-quality route and hence it is import that such eventualities are well managed.

The impact of roadworks on the network during the time of the incidents was analysed; they had little to no impact.

Further information about the modelling exercise may be found in Appendix F, including a recommended strategy for its enhancement.

10 Advances in technology

Consideration should be given to how new technologies can challenge well-established practices. For example, automated information distribution could enable new approaches to identification and allocation of available resources, such vehicle-recovery contractors, or repairs on the local-authority network.

A meeting in Cambridge on 26 March 2014 brought together experts in technology and in transport to discuss how developments in technology will change the way that

8 http://en.wikipedia.org/wiki/Passenger_car_equivalent

the road system is managed and how information is conveyed to drivers. The discussion focused on Highways Agency roads. Some of the points made were:

- Motorways are well serviced, but not A roads. The challenge is how to improve the latter without large capital investment.
- A possible solution is to put wireless infrastructure onto roads. An assessment would have to be made of how much bandwidth would be needed and what would be the smallest useful data package to transmit into vehicles.
- In-vehicle equipment should not only give information to the driver; it should also encourage adjustment to driving to make better use of road space. The transition period with partial vehicle/ driver communications coverage is a challenge; one cannot rely on people having latest smartphones.
- It was suggested that floating-vehicle information, which already largely exists, might replace loops for signal control.
- A policy and governance framework is needed to prevent data silos being created, perhaps by creating a data market.
- Autonomous vehicles and road trains are potentially important, but fragmentation[9] is an issue, and who has the responsibility and carries the risk?
- Parking spaces should be instrumented, and people informed with the same technology used for public transport information.
- More attention should be given to prevent drivers falling asleep. This becomes the more important as the number of elderly drivers increases. An issue is the business case for safety improvement.
- As the time needed for the gathering and analysis of data decreases, real-time network modelling will become increasingly important for network management, if it can be demonstrated to make a difference.
- Data should be used to review the success, or otherwise, of past decisions.

A further meeting on 30 May 2014 paid particular attention to the problems with local authority roads. Among the points that were made were:

- Local authorities need better information to help them make good decisions. But they have very little recurrent spend money, so in particular there is a need for cheap connectivity.
- More intermediaries are needed to aggregate data and turn them into services, particularly for local authorities. But they should not have to deal separately with the different local authorities.
- A market place should be created for those who have data to sell.
- There should be a web site for easy discovery of both commercial and open data, with minimal metadata descriptions of them[10].

[9] See, for example a talk by Martin Green, http://www.cambridgewireless.co.uk/Presentation/Martin-Green15.05.14.pdf

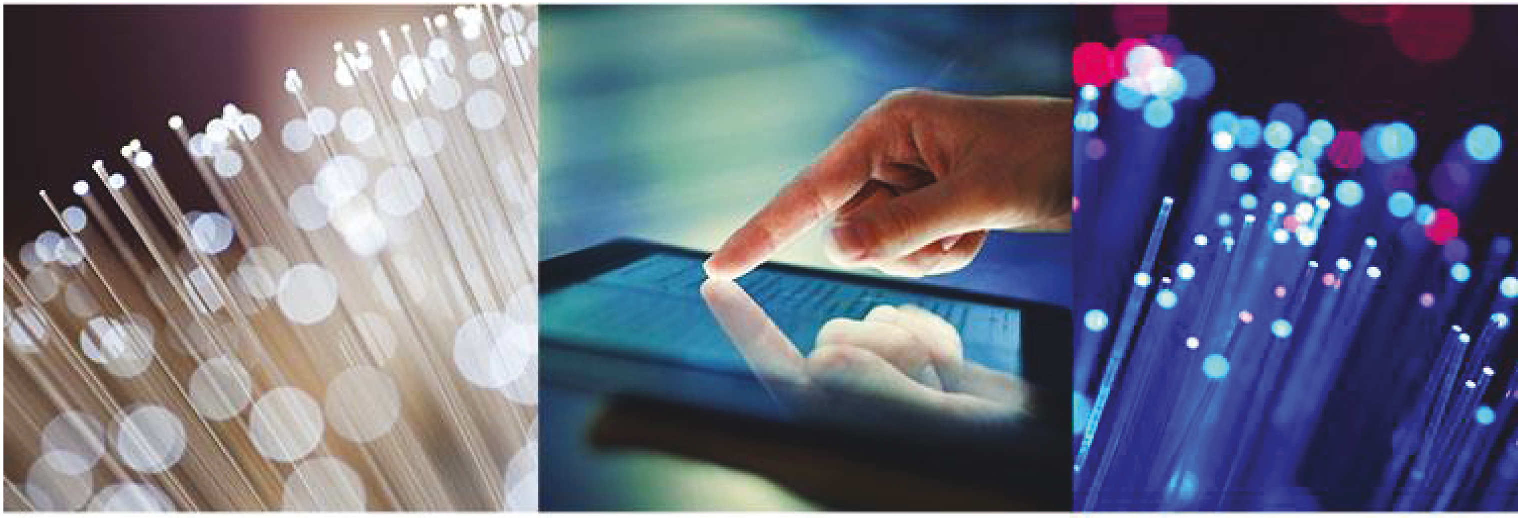
[10] This recommendation is not new: see http://www.escience.cam.ac.uk/projects/transport/ntdffinalreport.pdf

- Work should be done to uncover and overcome the obstacles to sharing best practice – governance, intellectual property protection etc. Business models should be created to help different organisations work together.
- Sensor points should be set up where a variety of devices can be plugged in.
- On average cars are only about 25% occupied. There should be a study of what makes people comfortable to share journeys, and whether getting better information would make them readier to use public transport.

It was pointed out that most of these issues are relevant not just for transport.

More complete notes of the meetings are in Appendix G.

Appendix A: Information Management



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1. Introduction

The road network in the UK is a critical component of national infrastructure and is relied on by many people and businesses.

Congestion is a serious problem in many parts of the country, whether routine or as a result of incidents. It has an impact on business, quality of life and the environment.

Various organisations and individuals are involved in managing and using the road network – their actions all interlinked in ways that are often poorly understood. This includes the Highways Agency, local authorities, police forces, fire and ambulance services, vehicle recovery companies, road maintenance contractors, freight operators and ordinary motorists. Each has their own area or domain of responsibility and makes independent decisions when problems occur.

There are opportunities to improve the use of the road system and to better respond to incidents by giving various stakeholders timely access to accurate and relevant information. This will allow them to make better decisions based on a more complete view of the situation and the actions of others.

The basis of the general technical approach proposed here is to treat the road network as a single entity with multiple domains of control. It is clear that there is no overall centre of control for all roads and for all types of incident. Each stakeholder has its own concerns and responsibilities with regard to the road network. However, they cannot focus just on their own interests without regard for the impact on others. The potential for conflicting and inconsistent actions in response to any incident will always be present in this sort of environment but we can aim to reduce this by making sure that people make decisions based on the best available information.

This chapter describes some of the characteristics of the information sharing problem and its technical solution in the context of the road network.

2. Information Sharing

Different stakeholders have very different motivations with respect to the road network. Emergency services are typically concerned with crime and public safety. The Highways Agency and local authorities are responsible for the free movement of traffic on the roads for which they are each responsible. Road users are interested in avoiding delays to their journeys. They therefore each have access to, and interest in, different sources of information. Each organisation typically collects and manages the information it requires for its own operations. They naturally represent it in terms that make sense within their own processes and focus on doing their own job. However, across all the organisations involved in the road network we suggest that there is a common core of information that could be potentially useful to all of them. Clearly there is a need to exclude sensitive information that cannot be exposed outside particular organisations but there will remain valuable information which, if available in an understandable form and in a timely way, could allow better decisions to be made.

One of the problems with information sharing is that organisations have very different systems deployed already, including processes, working practices, security policies, IT and networks. Sharable information is typically embedded somewhere in these systems.

Each organisation has its own set of procedures and protocols. These are often well documented and define current working practices. Relationships with other organisations are generally on the basis of bilateral agreements and understandings of how other organisations work. There is considerable variation – even between organisations of similar type, such as different local authorities – and documentation is limited.

Where information sharing does occur today, it is (implicitly) limited by technology. Typically it happens by means of manual (e.g. telephone) communication which is expensive in terms of people's time – particularly when dealing with an urgent response to an incident. This means that only the most obviously relevant information (from the point of view of the organisation with the information) is passed on. A wide range of information may be required to provide sufficient context for a robust decision to be made in each of the independent organisations – and the people making the decision are best placed to assess relevance (supported by automation as processes develop).

The goal should be to enable information sharing that is more open and better matched to the needs of the receiver. The sender should define who is allowed to receive what information, and make this available. Each (authorised) receiver can then decide what they want to receive and under what conditions. In some cases there will still be a need for explicit messages constructed by the sender for each recipient as is done now.

There are some important information management principles behind this approach which need to be discussed and agreed:

- Commitment to making data available outside organisational boundaries – default position should be to make anything non-sensitive open and to allow potential recipient to decide if it's useful to them
- Information sharing should be automated as far as possible, with distribution controlled by policy (e.g. who is allowed to see what information and under what conditions)
- Independent organisations should make their own decisions – there is no need implied here to impose coordinated control. (Such coordinated control may be of value longer term but that is not currently envisaged).

So far in this section, the discussion has centred on organisations with an involvement in management of the road network. Road users are also important stakeholders. There is rapidly increasing interest in connected cars (and certainly commercial vehicles) which we can expect to see on the roads over the next few years. It is important that communications capabilities in vehicles are complemented by those in the road network infrastructure so that drivers can be given the right information at the right time to make decisions about their journeys. There is the potential here to be more intelligent in the advice given to individual drivers and therefore to influence their behaviour so that traffic incidents and congestion are managed more effectively.

3. Types of data

There are two broad classes of time-sensitive information of relevance to managing the road network:

- Measurements: values of parameters associated with the state of the physical world or some other system at a particular time. The intent is monitoring of characteristics of the system of interest. A typical example is the speed of traffic at a particular location.

- Notifications: Notification of some situation or state change in the physical world or some other system. The intent is to convey a specific piece of information which may require a response. A typical example is an alert of a road traffic collision at a particular location.

In addition, other information classes are required, particularly those providing less volatile context. These might include:

- conversion from identifiers for locations used by an organisation to geographical coordinates (eastings/northings, longitude/latitude) or standard gazetteer entries
- diversion routes
- planned road closures
- local events, school holidays etc.

Currently, different organisations generate and maintain information in each of these classes in the context of their own operations using representations appropriate to the systems and processes they run. There is therefore at least a requirement to fully document the information that is shared with other organisations or, preferably, to use standard representations or transformations before delivery to the information receivers.

4. Messaging Styles (Distribution Patterns)

Sharing of information between organisations involves a number of considerations at the business process level that have implications on the technical architecture. The details depend on the requirement of each of the stakeholders involved in managing the road network. Current processes (based on, for example, phone calls or email) have implied semantics in terms of what each party to the exchange expects of the other. It is reasonable to assume that if you have spoken to someone on the phone, they have heard and understood what you said at the time of the call. This is less clear with email unless there is an explicit acknowledgement – the message may have been delayed, overlooked or not read. These semantics (and others) need to be capable of replication in an automated system. Experience with existing processes can give a starting point but as opportunities for improved information sharing are identified and processes changed to exploit them, it is important that the information management infrastructure has sufficient flexibility. It should be an enabler of improved processes rather than a barrier.

Message Style

Since flexibility in information distribution is a primary goal, the basic message style should be asynchronous. In other words a sender of information can publish data without waiting for a response from any potential receivers. This means that the sender (human or automated system) does not have to wait for acknowledgement of receipt but can continue with other work. This accommodates any delays in delivery, either due to the IT systems and networks or waiting for a person to confirm receipt and acceptance. Synchronous semantics can be built up from exchange of asynchronous messages. The details will depend on the operational processes involved. In particular, the question of acknowledgements is an important one. Acknowledgements of receipt of a message can come from a number of different parts of the system – and each conveys a different meaning. At the network level, the TCP/IP protocol acknowledges that a packet has been delivered to the destination system. At a higher level, software may acknowledge that a message has been successfully received by an application programme. Finally, a person may explicitly acknowledge that a message has been received and understood – possibly accepting a role in dealing with an incident. Which of these (if any) is required by the sender of a message depends on the usage scenario. It is important to be aware of the assumptions underlying existing communications – for example, changing from a phone call to an automated message exchange may mean that it is not safe to assume that the receiver has actually got the message.

Reaching an appropriate level of consensus on what information is known to each of a set of independent stakeholders is achievable with a (more or less complex) set of asynchronous messages.

Message distribution patterns

Messaging between a set of senders and a set of receivers can be classified in a number of dimensions

Geometry

Messaging geometry describes which links exist between senders and receivers

- 1:1 each message is sent to a single receiver
- 1:m each message from a single sender is sent to a group containing m recipients a fan out structure
- 1:(m from n) each message in sent from a single sender to m receivers from a group of n potential receivers.
- m:1 a number of messages from a set of senders may all arrive at a single receiver a fan in structure
- (m from n) :1 m senders from a group of n potential senders all send to one receiver.

Channels

Message channels describe the characteristics of the links between senders and receivers

- Point to Point – one sender and one receiver
- Publish/Subscribe – multiple receivers of each message, according to interests of receivers
- Broadcast/Multicast – send a single message to a large number of receivers
- Dead letter – channel to a special receiver of messages that could not be correctly delivered for some reason. These may need to be dealt with separately.

- Guaranteed delivery – deals with the receiver not being reachable when the message is sent. Messages will be stored (for some time period) and delivery retried. The sender can expect that the message will eventually be delivered if possible

Message Types

Message types describe the intent of the message. Some of those most relevant to information distribution in the context of managing the road network are:

- Command message – invoking control
- Document message – transfer of data (e.g. a value or collection of values)
- Event message – notification of an occurrence or change of state
- Request-Reply – interaction requiring explicit response (involves at least two messages)

Delivery modes and reliability

The goal of the messaging infrastructure is that a single infrastructure should be able to support the wide range of delivery modes and guarantees that may be required. The range of messages will span the spectrum from informational messages of limited scope and lifetime (relevance) through to critical messages that must be reliably and provably delivered and the contents of the message recoverable. An information distribution system should ideally offer delivery mechanisms that both ensure the lifetime of messages can be defined, and that the number of messages delivered can be controlled, options such as “at most once”, “exactly once”, and “at least once” should be selectable by the sender. It should also be possible to use reliable network protocols or message queues to offer reliability guarantees.

5. Networks

A wide variety of different networks are involved in collecting and distributing information relevant to the road network. The range is likely to increase as communication to and from vehicles becomes more prevalent. From the point of view of information management, it is important that any available network technology can be accommodated. An awareness of the requirements for security, latency, bandwidth etc. for a particular information exchange is important and should constrain the behaviour of the information distribution system.

With a focus on management of the road network and relatively open exchange of information, networks of relatively low security are assumed. The focus in managing the road network is assumed to be non-sensitive data so in principle this assumption should be sound. However, separation of data into potentially sensitive and non-sensitive (and therefore able to be shared) may not currently be carried out in organisations dealing with both. This means that there are some issues to be addressed in connecting to organisations that use more secure networks by default (e.g. Criminal Justice Extranet used by police forces, IL2/IL3 networks[1]). Controlled interactions (e.g. gateways?)

[1] HMG Information Assurance Standard No.1, Technical Risk Assessment, Issue 3.5.1 October 2009 (Unclassified)

between networks with different security levels will need to be implemented as required or the messaging infrastructure itself may need to run in an appropriate environment.

6. Message Formats

The use of standards to represent information relevant to managing the road network is clearly desirable since it simplifies the mapping between the representations and models used by different stakeholders. This mapping is required because of the range of different systems used. Similar quantities and concepts may be represented in different terms and with different interpretations. It is desirable to identify (or develop) a small set of standards that can accommodate the information models relevant to all the stakeholders involved in sharing information. If these standards are not used in current systems, developing transformations to a single canonical representation is far superior to developing transformations between all pairs that might want to share information.

For measurements related to the road network, the DATEX II standard (www.datex2.eu), maintained by CEN, appears to be a sound choice. It is already used by the HA and at least some local authorities. It was originally designed and developed to standardise the interface between traffic control and information centres and has since been extended with the aim of supporting all "applications requiring dynamic traffic and travel related information in Europe".

The situation for notifications is less clear. The related UK initiatives, DEIT (Direct Electronic Incident Transfer) and MAIT (Multi Agency Information Transfer) (mait.org.uk) specifications are addressing coordination between public safety organisations (e.g. emergency services). There is clearly an overlap in terms of some of the stakeholders between this and management of the road network and it appears that there is scope to use it. However, with a focus on the road network, only some of the information in a typical DEIT or MAIT message would be required. CAP (Common Alerting Protocol) standardised in OASIS is also relevant and is probably flexible enough to accommodate the requirements of road-related incidents.

7. End-to-End information flows

We can divide the end-to-end information flows through the information management system into three phases: collect, manage and disseminate.

Collect

As discussed above, information relevant to building up a rich picture of the state of the road network or of a specific incident will originate in a multiple independent systems. These collect information originally intended for use within a single organisation and possibly some intended for communication to other organisations. However, in the latter case it is likely that not all potentially interested recipients have been identified. Our hypothesis is that more effective sharing of information has the potential to deliver significant benefit without major investment. An evolutionary approach is envisaged. Initially, no changes should be made to existing collection mechanisms. Instead, information that can be safely shared should be identified and made available with a lightweight approach to integration – having as little impact on existing systems as possible. The aim is to share a limited subset of information across multiple organisations in a consistent way, using accepted standards where possible. Experience gained in this phase should allow informed decisions on what additional data would be of value and a coordinated approach to its collection could be taken.

Manage

The manage phase is concerned with the handling of information by the information management system itself – taking as input data collected by systems operated by various stakeholders and sending appropriate messages out to others in the disseminate phase.

Data lifecycle management is the process of managing the flow of data in a system, throughout its lifecycle from creation and initial storage to the time when it ceases to be useful and is either destroyed or archived. This is illustrated in Figure 1. Data is typically stored on and moved between different storage systems and media depending on criticality of use, frequency of access and many other factors. These details may vary with time.

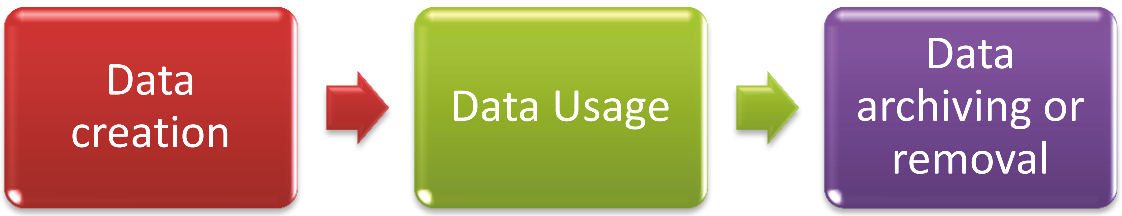


Figure 1 Basic Data Lifecycle

The primary motivation in responding to incidents on the road network is near real time decision making to support public safety and convenience, while making efficient use of resources. This emphasises the creation and usage stages.

Anonymisation and filtering of data may be carried out in the information management system. This may also be done by the sender of the information to remove details that should not be shared. Where parts of the information can only be shared with selected receivers (e.g. emergency services only), the information management system has a role in enforcing policies.

The information management system may also be involved in encryption, signature verification and signing, logging and auditing.

Stored data will become increasingly important in providing the context for near real time events in smart communities, as well as the basis for modelling and analysis. There is also the need, in many situations, to store data for regulatory compliance and audit purposes. On the other hand, there may be requirements to delete certain data once it is no longer relevant. Appropriate ways of defining, managing and enforcing data lifecycle management policies are required.

Messages include data items that track the state of real world objects. There may be applications that require historical views of data not envisaged by the data provider. Records of data may be stored to generate (for example) time series, history or summary sets of information from real-time measurements.

Disseminate

The disseminate phase includes enforcing policies for access control – who is allowed to see what data and for managing address lists and subscriptions to particular types of information. It is also concerned with delivery mechanisms so that they match the requirements of the receivers' systems. Several options may need to be supported including push and pull mechanisms, communication with appropriate endpoints and message format transformations according to rules specific to each receiver.

8. Experiences with Information Sharing

Several workshops were held with a wide range of different stakeholders, aimed at exploring the opportunities for improved information sharing in managing the impact of incidents on the road network. A significant amount of relevant data is already openly available, in particular from the Highways Agency, which provides good coverage of the trunk road network in England. Most other Information sharing is currently directly aimed at supporting coordination between responders to incidents. In these cases, the organisations involved have specific needs for sharing information which are explicitly included in their incident response processes. Frequently this results in local, bilateral arrangements between pairs of organisations. There was general consensus that there is value in harmonising these interactions and broadening their scope so that each organisation has as complete and reliable a view of the context of an incident as possible.

From the point of view of traffic and road network management, information from police, fire, ambulance and local authorities has significant potential value in providing early indications of the development of incidents. Traffic management is not the top priority for most of these stakeholders, so current arrangements for dissemination of potentially useful information are generally informal and *ad hoc*. When considering the implications of extending information sharing, a number of concerns were widely shared:

- what information can be shared (from a legal/regulatory point of view)
- constraints on connection of systems and networks defined in current policies
- impact on IT systems (typically managed by third parties) and the cost of any required changes
- impact on people with responsibility for managing incidents according to existing processes
- need for the owner of the information to perceive benefit from wider sharing

General conclusions were that improved information sharing is a desirable goal overall. The ideal outcome would be an automated system which does not require any additional work from the people running existing services. There is clearly a need to build confidence in such a system, however, and to identify detailed technical and operational requirements. Exercises to assess feasibility and identify any specific barriers were undertaken with a number of individual stakeholders as a first step.

Police

Cambridgeshire Constabulary has an existing system for incident management (STORM). This is managed by their systems supplier, Steria. In general, incident records used in STORM contain sensitive information that must be carefully managed. It is clear that any sharing with other organisations or individuals must not allow inappropriate information to be exposed. Traffic management only requires limited details of police incidents, so in principle this should not present a fundamental problem. Current operational processes make use of free text fields to record incident details in STORM. In other words, details are logged in narrative form as information on a developing incident is received. This makes it difficult to separate out potentially sensitive information reliably. However, some information is recorded in a more controlled way (e.g. selection from pre-defined options on a form). This allows constrained items of information on each incident (e.g. location, time, broad type of incident) to be extracted. Cambridgeshire Constabulary already has experience of providing an automated interface to Cambridgeshire County Council. It was therefore agreed to open a similar interface to BT, with the aim of moving towards an information hub, such that all information that can be freely shared is automatically collected and made available to other stakeholders according to their interests.

The agreed interface between Cambridgeshire Constabulary and the BT information hub uses existing features of the STORM system and therefore follows the DEIT[2] specification for protocol and message formats.

A sample incident creation message illustrates the kind of information provided:


```xml
<?xml version="1.0"?>
<IncidentCreation>
  <MessageId>CC-10032014-0014</MessageId>
  <OrigOrganisation>Local</OrigOrganisation>
  <OrigIncidentURN>CC-10032014-0014</OrigIncidentURN>
  <OrigIncidentDate>10032014</OrigIncidentDate>
  <OrigIncidentTime>150945</OrigIncidentTime>
  <CallOrigin> </CallOrigin>
  <Description>R.T.C. - DAMAGE ONLY</Description>
  <Easting>543095</Easting>
  <Northing>260077</Northing>
  <Type>RTC DAMAGE</Type>
  <Location>TRAFFIC INTERNATIONAL, ENTOMOLOGICAL FIELD STATION, 219 HUNTINGDON RD,
CAMBRIDGE, CB3 0DL</Location>
</IncidentCreation>
```


[2] DEIT - Direct Electronic Incident Transfer, http://standards.data.gov.uk/proposal/direct-electronic-incident-transfer-deit-0

This expects a system-level acknowledgement such as:


```
<?xml version="1.0"?>
<IncidentCreationAcknowledgement>
  <MessageId>CC-10032014-0014</MessageId>
  <OrigOrganisation>Local</OrigOrganisation>
  <OrigIncidentURN>LC-20140310-0005</OrigIncidentURN>
  <OrigIncidentNum>LC-20140310-0005</OrigIncidentNum>
  <OrigIncidentDate>10032014</OrigIncidentDate>
  <DestinIncidentURN>CC-10032014-0014</DestinIncidentURN>
  <Successful>Y</Successful>
  <ErrorDescription/>
</IncidentCreationAcknowledgement>
```


There are similar exchanges to support updates to an existing incident. Prototyping of client and server systems was undertaken and some testing between Steria and BT was completed during the project, prior to deployment on Cambridgeshire Constabulary systems. Messages were received correctly over TCP, and appropriate acknowledgements constructed and sent in response. Some issues remain with network configuration to allow the message acknowledgement to be received by the STORM system. This is anticipated also to be an issue with connection to the live police systems. Constraints on, and procedures for, configuring network interconnections are relatively complex, particularly between networks at different security levels. Improved understanding of what is feasible and additional time is therefore required to resolve these issues.

Fire

Cambridgeshire Fire and Rescue Service (CFRS) also has automated systems for incident management. In discussion, it became clear that these existing systems could not easily be modified to allow incident information to be shared. It was therefore agreed that a semi-manual approach should be adopted. The aim is for people in the control room to provide appropriate information via a simple interface. The aim, similar to the approach taken with Cambridgeshire Constabulary, is to publish any information relevant to traffic management that can be openly shared with other stakeholders to a BT information hub, allowing them to use this information in their own processes as appropriate. Following a number of discussions and feedback on initial prototypes, the following requirements were identified:

- System is in addition to existing systems and processes for inter-agency communication. It does not replace phone calls etc. and is not to be relied on for operational purposes.
- User interface to run as a tab in a web browser
- Current browser version is Internet Explorer 8 (others may be available in future)
- User interface to combine adding/updating fire incidents and viewing relevant incidents from other agencies
- Incidents from different agencies to be kept separate - hub should not attempt to correlate
- Clickable map for identifying locations of incidents - rather than text entry (existing system gives them location on map). Text entry for coordinates still needs to be possible.
- Location needs to be identified by using OS Eastings and Northings (10 digits for their use, other agencies, e.g. ambulance, use fewer)
- Incidents on map need to graphically represent (e.g. via colour/icon): responsible agency; status - open/cleared

- Updated incident must be visible in current map view, not somewhere off screen requiring zooming out.
- Input information to create a new incident (with check boxes/drop down etc. rather than text entry where possible)
    - location (click on map)
    - incident type (only RTC with persons trapped, vehicle fire/fire on highway, chemical spill, flooding are relevant to traffic management)
    - attending/not attending
    - indicate whether assistance required from police, ambulance, HA
    - Free text box, with a check box to indicate who can see the text (police, ambulance, HA, local authorities,...) with default to nobody - i.e. check boxes must be explicitly checked or free text will not be sent
- Ability to update and existing incident (e.g.)
    - Sending additional resources
    - Leaving scene (clear incident)
- Audible alert when incident is updated - tab may be hidden
- Clicking on an incident should show a time stamped sequence of updates
- Ability for an agency to acknowledge seeing someone else's incident
- Clearance notifications from other agencies are of interest
- Need for two kinds of user – admin and normal
    - Admin user can specify which events from other agencies are displayed on fire interface (only those in list above to start with, for example, although others could be added later if they prove to be useful. There may be an interest in road closures).
    - Admin can specify when the closed incident is not visible on the map (time as number of minutes after closure)

A prototype interface meeting these requirements was developed. This is illustrated in the following figures:

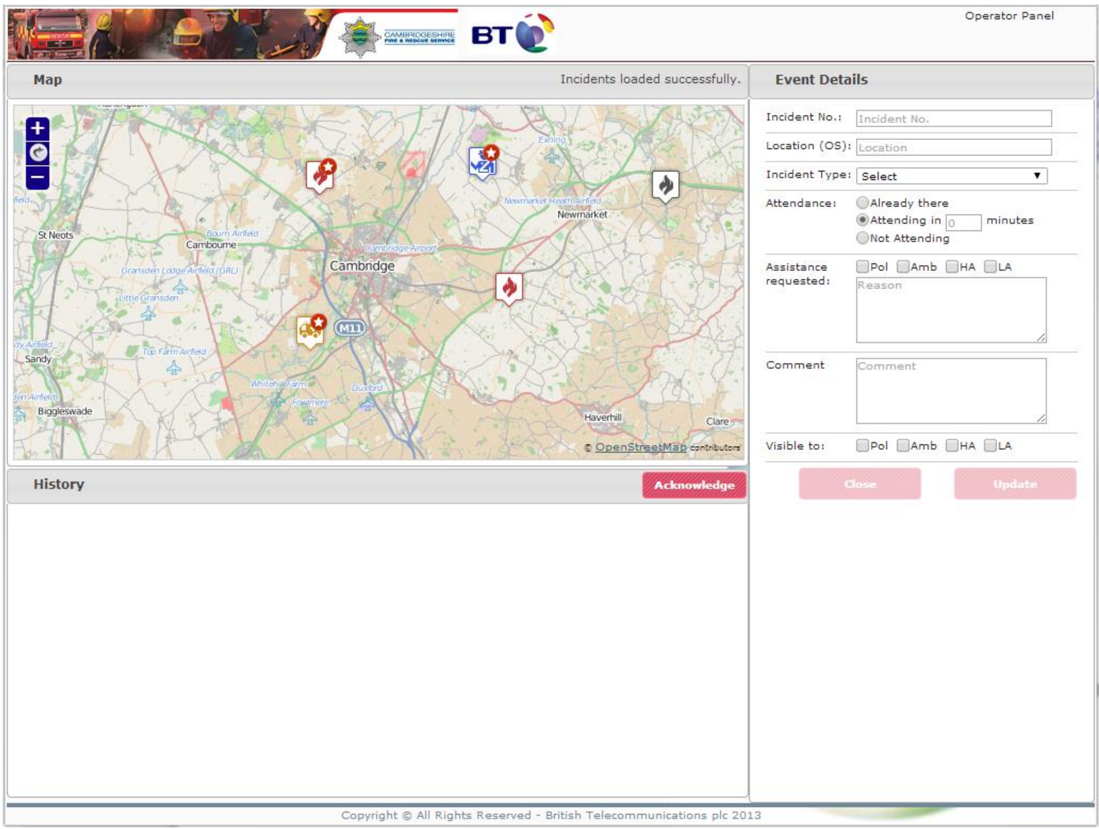


Figure 2. User interface – displaying incidents from various agencies

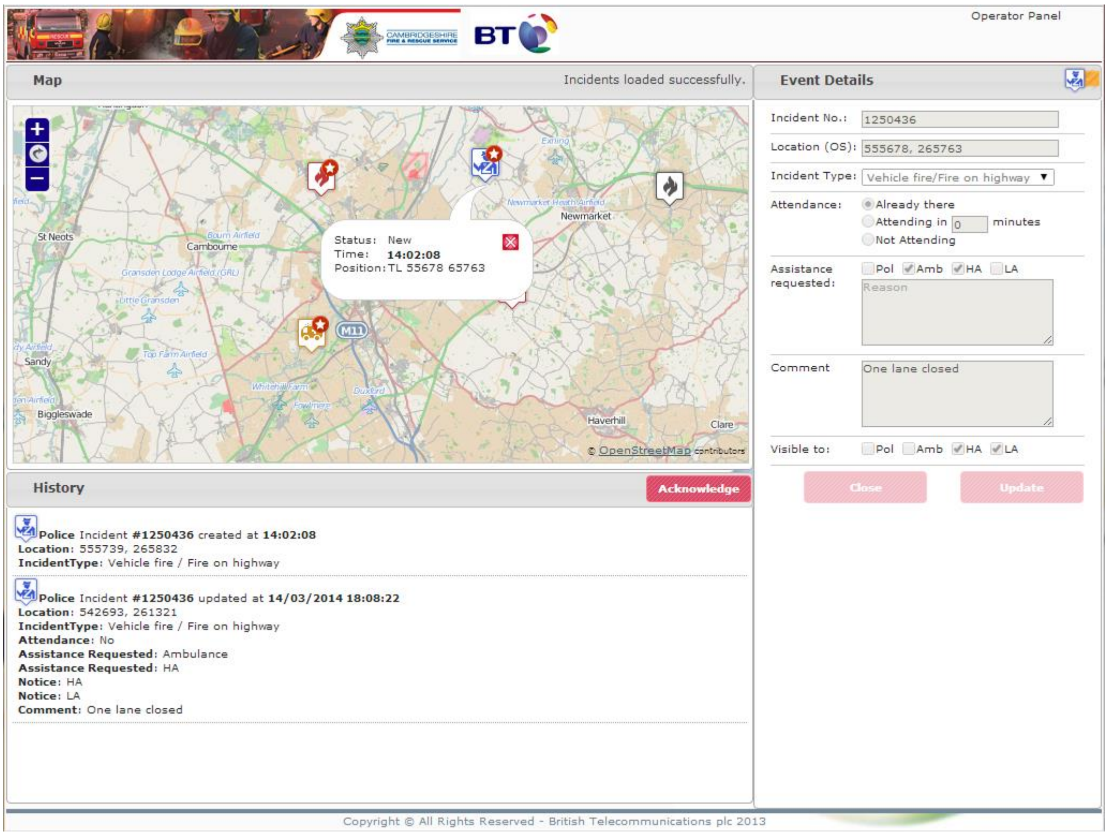


Figure 3. User interface – Selected incident (displaying incident information and log)

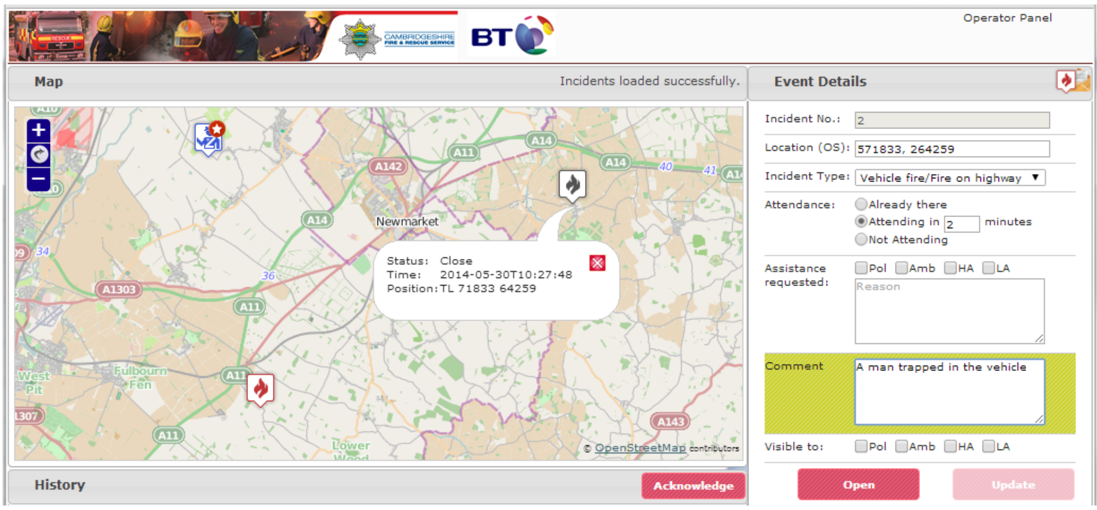


Figure 4.Close up – Incident opened vs incident closed

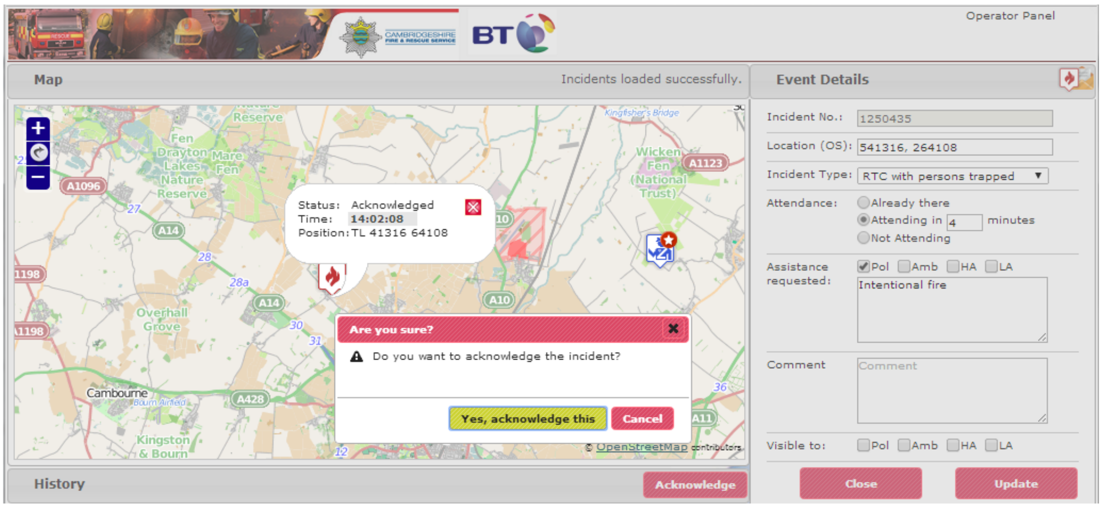


Figure 5.Close up – Incident acknowledged

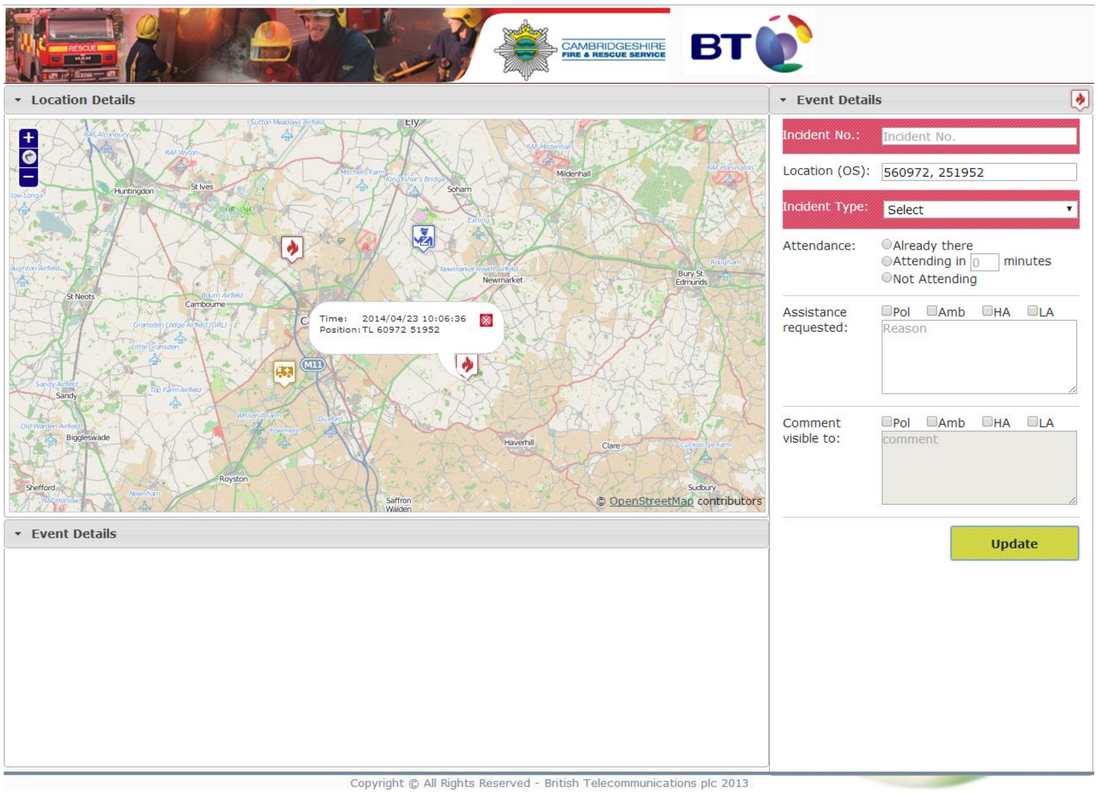


Figure 6.User interface – Form errors

This interface can be adapted to meet similar requirements from, for example, ambulance services, other fire services or local authority traffic control rooms.

For consistency with the information to be collected from Cambridgeshire Constabulary and anticipating likely moves toward automated incident transfer more generally, information collected from the CFRS web interface was represented as MAIT[3] messages and communicated to the BT information hub over HTTP (MAIT specifies raw TCP – the BT Hub prototype supports both TCP and HTTP). The MAIT specification is a work in progress, aimed at exchanging incidents between emergency services' control rooms, not necessarily the same problem as providing stakeholders with an interest in managing the road network with information they can use to enhance their own operations. The approach taken in the current exercise – focused on the road network – is to exploit whatever information resources are available. Initial experiences with the draft specification are generally positive but have also identified a number of issues. Most important is an implicit assumption of a 1:1 messaging geometry which does not obviously fit with a more flexible information hub.

Local Authority

Cambridgeshire County Council has outsourced their transport data management function to IT suppliers. As discovered within the Stride project[4], "the Councils have long standing commercial data sharing agreements in place with such data suppliers or 'curators' that subscribe to and synchronise data from the Council's databases. The data 'curator' may further process the data enhancing it and combining it with other data sources from third parties, and then disseminate it through value added services for the general public such as real time bus information, traffic analysis and route checkers"[5].

The data owner (Cambridgeshire County Council) was interested to share traffic-related data but this required an agreement with the data curator (Cloud Amber), and associated payment, to carry out the necessary work on the IT systems to enable this. This was resolved during the project and relevant data is now published to the BT information hub via a custom adapter accessing web services (REST/HTTP) exposed by Cloud Amber[6]. This data includes:

- Events - planned or unplanned events that could have material effect on the operation of the Cambridgeshire road network
- Transport Route Journey Time – measured journey times when available
- Traffic Measurements – vehicle speed, flow and occupancy over instrumented parts of the road network

[3] MAIT – Multi Agency Incident/Information Transfer http://mait.org.uk/
[4] Stride was a project funded by the Technology Strategy Board as part of its Internet of Things Ecosystem Demonstrator https://connect.innovateuk.org/web/internet-of-things-ecosystem-demonstrator
[5] www.stride-project.com, Value chains and business models Final (D6.1.2)
[6] Cloud Amber UTMC Data Exchange v13

- Car Park Definition and Car Park Dynamic – Live information for instrumented car parks
- Roadworks/Incidents/Accident – known information about roadworks, incidents and accidents relevant for the Cambridgeshire road network
- Variable Message Signs – VMS under control of the e.g. car park status and availability

Data is generally provided as XML, following versions of the DATEX II[7] schema. This is similar to the data provided by the Highways Agency with which BT has previous experience. The aim is to expose Cambridgeshire County Council traffic data via REST/HTTP interfaces, alongside similar data from the Highways Agency to enrich the overall traffic and transport data set.

9. Challenges

There are significant challenges in realising a common approach to information management that can support all the stakeholders involved in using and managing the road network so that their combined actions result in near optimal outcomes in response to incidents – both predictable and unpredictable.

Engineering challenges centre on the scale and performance requirements of large, complex systems with direct impact on public safety and experience.

Integration is a major issue. Established organisations have their own independent systems and processes for distributing information with some other stakeholders. These have been designed or evolved to meet the specific requirements of today's processes. These processes work so there is often no pressing need for change. Investment cycles are not synchronised. A top-down national system for integrating transport information and incident response is unlikely to be feasible. Instead, a lightweight and flexible approach to integration based on common patterns and standards is preferred. This should allow each stakeholder to increase sharing of their own information and to make use of information from others at a pace appropriate to their own circumstances. The principles and direction of travel should be clear, however.

It is clear that standardisation of incident-related information and associated message formats is beneficial in enabling improved information sharing. Initiatives such as DEIT and MAIT are therefore valuable in harmonising the activities of some key stakeholders. Broadening the applicability of these emerging standards would be welcome but is not essential. Provided the underlying conceptual models are consistent and explicitly expressed, an information hub can transform between related representations in a straightforward way.

Information providers need to have confidence in their ability to retain control of the way their data is used. Some information should only be shared with particular stakeholders and under specific conditions, and there may be legal or regulatory responsibilities on the information provider. Once information has left the direct control of an organisation, it is harder to manage these

[7] http://www.datex2.eu/

responsibilities. Technical solutions are required to assure compliance with policies defined by the information provider.

The principal function of the approach to information management described here is to get the right information to the right place at the right time to enable effective decision making. A fundamental design decision in this approach is to separate information processing and distribution from the decision making process. The information management infrastructure does not know the meaning of the data it carries - just its structure and transport requirements. The meaning of the information is left to the organisations making the decisions where we can reasonably expect that it is understood in their own context. This significantly simplifies the integration problem. There may be future opportunities for semantic processing within the information management system, particularly as mappings and required transformations between representations used by different stakeholders become better understood.

Mike Fisher (mike.fisher@bt.com), Sandra Stincic Clark, Mohammad Zoualfaghari

June 2014

Offices worldwide

Appendix B: Incident Management Process

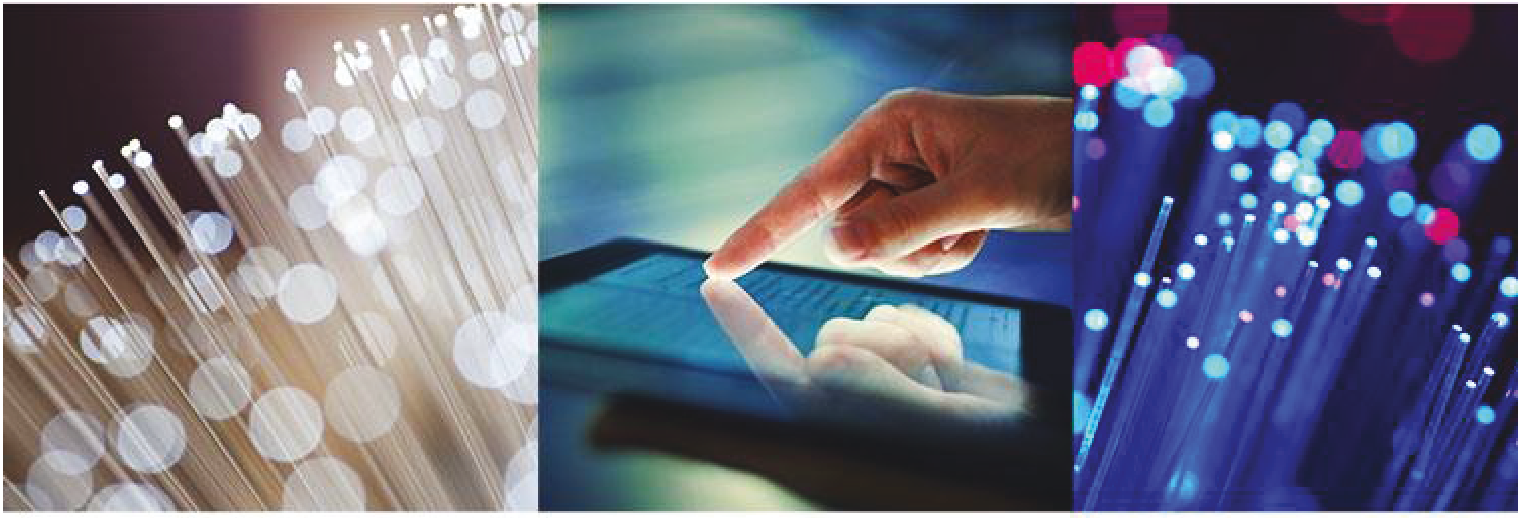


Table of Contents

1. Introduction

This work-package focused on the information processes that are currently in practice when dealing with major road incidents, with specific attention paid to the A14. Face to face interviews were held with Cambridgeshire Constabulary Force Control Room team, Cambridgeshire County Council Highways Management Centre and Highways Agency Eastern Region Control Centre to establish current work practice in the Cambridgeshire area. The focus of the discussions was the management and resolution of road traffic incidents on the major road network.

The outline process described below was derived through these interviews and is largely limited to that data.

A Highways Agency Cold Debrief for two incidents in the Eastern Region was attended on 27 March which has also contributed to understanding in this area.

2. Cambridgeshire Constabulary Force Control Room (FCR)

Context

The FCR is located at Police HQ in Huntingdon. Cambridgeshire & Suffolk Fire control is located on the same campus, but in a different building. The FCR consists of approx. 26 workstations, each equipped with 4 screen displays. The FCR is home to the Police dispatchers, aides and call handers, who manage incident response, determine the grade of response required and which resources to deploy. The FCR deals with all Police incidents not only traffic incidents. Despatchers are often working across multiple incidents, of various types, and have to make judgement calls about the deployment of resources across all of those requirements (e.g. burglary, violence, RTC).

Information inputs to the FCR

- Main information inputs are calls from the public who are witness to, or involved in, an incident.
- Electronic text exchange with Highways Agency (once dialogue has been initiated).
- STORM is the Steria provided Cambridgeshire Police incident management system and contains the demographic data of callers, locations of an incident and the verbatim records of dialogue between the Police dispatcher and the caller. It also retains a record of every action undertaken within each incident.
- STORM has a linked high resolution mapping application used to determine the precise location of an incident.
- Cellphone caller's location data can be derived, but based on mast location only; this is rarely used (used as confirmatory means of establishing a location).
- Feedback from officers once they have arrived on scene.
- Real-time video feeds from the HA cameras on strategic are available from one workstation (Oscar3), but these are rarely used during the management of an incident (used more as a confirmatory tool to establish exact location and nature of incident).

Information outputs from the FCR

- Electronic transfer of demographic and verbatim data from STORM into the Highways Agency C&C system. This is an electronic transfer but requires a manual enactment by the despatcher, who will remove any personal information from the record before transfer.
- Telephone calls are made to Fire and Ambulance Trust for all traffic incidents, unless the despatcher can determine that one or both are not required. Calls to the Ambulance Trust can be problematic as answers to a Q&A script are always required (e.g. how many casualties, are the casualties conscious etc.)
- Telephone calls are made to INRIX to provide high level information such as "Serious RTC on A14 EBC at St Neots". INRIX are a provider of real time traffic and travel information to broadcasters, business and government, see: http://www.travelradio.org.uk/
- @Cambscops twitter feed (14,000 followers)
- Telephone calls to RMSL vehicle recovery contractor when required.
- Automated abbreviated data from STORM is now emailed into Cambridgeshire County Council traffic management centre (although this was not yet widely known).

Traffic Control capabilities

- Diversions can be established on strategic roads, usually in coordination with HA. HA officers are often not available in the very early stages of incident management due to their limited resources across Cambridgeshire.
- Diversions normally follow the agreed HA official diversion routes.

Typical Incident Scenario (focus on information flow)

1. Highway incidents usually start with a call to 999, Police are most often first responders.
2. Call Handler creates a STORM record, captures information and location data
3. Call Handler assesses the information available and determines which grade of response is required.
4. Dispatcher assesses Police resources to deploy and whether to alert Ambulance and Fire Services. These decisions are usually made within the first 1-2 minutes of the incident call (dynamic actions happening simultaneously depending on staff availability within the room).
5. Dispatcher uses STORM to provide a direct electronic alert into HA Traffic Officer Service if the incident is on a strategic road.
6. Call Handler's and aides may now be fielding other calls from further witnesses or involved parties. Dispatcher has to determine whether they relate to the same incident and what new information they might contain.
7. Police attend the incident scene and assess the situation, and report back by radio to the dispatcher.
8. If the incident is minor the dispatcher will update Fire and Ambulance and they will stand down if they have not arrived on the scene.
9. Police will provide information to INRIX (by manual telephony)
10. HA will assess the situation and determine their response based on resources available.
11. Police will issue Twitter updates
12. INRIX will call Police back for regular updates
13. HA and Police exchange updates electronically via STORM

14. Where an incident requires investigation Police will retain control of the scene until all evidence has been captured
15. For major incidents lasting hours Police will stand down once HA TOS have taken over management of the incident.
16. For minor incidents Police will retain management, and will arrange for vehicle recovery using contractor RMSL if required (usually recovered within 30 mins of request call).
17. On strategic routes traffic can build up at the rate of 1 mile of tailback per minute

Observations

Police would prefer to be able to issue pertinent information in a single action to be accessed by multiple agencies (as per Information Spine concept).

Police would make use of useful information published by other agencies only if it was all available through a single interface and log-in (i.e. easy to use, not time consuming).

Police consider that automated extraction of pertinent information from STORM is likely to be highly problematic, but would be prepared to consider doing this as a manual intervention of free text entry by a dispatcher

Police dispatchers are often working under highly pressurised situations and are motivated to assess and manage situations as fast as possible. They often have to make resource deployment decisions in less than 2 minutes based on limited information. Whilst managing the first 15-30 minutes of an incident there is little time/dispatcher resource available to interact with the third party agencies.

The main incident response grades are:

- Immediate – within 15 mins
- Prompt – within 1 hour
- Scheduled – within 72 hours

A strategic road RTC would almost always be graded as immediate response, and are usually attended to in much less than 15 min.

Police are keen to have an electronic incident information transfer solution into Ambulance and Fire services so that the decision to respond is entirely within the expertise and remit of each emergency service. This would also save time in the FCR (it was noted that in one worst case scenario a telephone call to the Ambulance Trust had taken 12 minutes).

Police are only just becoming aware of the relevance of the Cambridgeshire County Council HMC facilities and the potential benefit of their VMS signage and traffic signals control capability. Greater awareness of how CCC HMC can assist the management of incidents would be beneficial.

A representative incident response in 2013 was reviewed; the approximate timings are shown below:

Time (m)	Action
0.00s	Initial 999 call received (major RTC on strategic route)

1.00s STORM entry created

2.00s Second 999 call received

2.30s HA informed

3.00s Three police units deployed

4.00s Ambulance call completed

4.30s Third 999 call received with some deviation regarding location of incident

5.00s Fire service call completed, INRIX call completed

30.00 HA had taken control of the traffic management

The FCR do not do routine retrospective analysis of incident management/response times etc. A 3 month review of such data could be made available but would have to be requested as a specific funded task by the Police information services unit.

3. Cambridgeshire County Council Highway Management Centre (HMC)

Context

The CCC HMC team were formed 5-6 years ago but the HMC only started 2-3 years ago. The HMC is manned from 07:00 to 17:30 Monday to Friday only. The HMC is based in a converted office room within CCC Shire Hall. There are 3 workstations and one multiscreen display showing HA camera feeds, local Cambridgeshire camera feeds, free access traffic web map from TomTom (http://www.tomtom.com/livetraffic/). All the information feeds are managed within the Cloud Amber Argonaut Common Database.

Information inputs to the HMC

- Real-time video feeds from the HA cameras on strategic roads in the area (A14, M11 and A1). The video feeds are monitored manually; there is no automated feature detection.
- Real-time video feeds from approx. 10 cameras on non-HA roads around Cambridgeshire, with the majority of those in Cambridge, further Cameras are to be installed in March/April
- ELGIN roadwork notifications
- STORM Automated emails from Cambridgeshire Police (initiated end Feb 2014)
- Occupancy data from five large city centre car parks
- Journey time data from AVLS equipped busses across Cambridgeshire
- BBC travel news web sites
- Cambridgeshire police real time incidents – via manual telephony
- Highways Agency real time incidents – via manual telephony
- Highways Agency NILO reports
- Highways agency TIS reports
- ANPR systems are in place on 2 roads in Cambridge but are deemed too expensive to continue to support, therefore are to be removed

- Data feeds from Traffic Signal Systems, including UTC SCOOT

Traffic Control capabilities

- VMS signs on main entry and exit routes around Cambridge city and on Local Authority roads that link towns and Cities, such as Huntingdon, St Neots and Ely
- Traffic signals including the throughout the city centre and on two A14 feeder routes can be controlled by the CCC signal team located in a separate room within Shire Hall. Although a long term aim would be an element of control through the HMC.
- CCC Street works team are located in Huntingdon who will respond to requests to clear carriageways when possible (e.g. elective maintenance).
- Direct line to Cambridgeshire Travel news desk (radio and Twitter)
- Twitter @Cambs_Traffic (Cambs Travel News: 3000 followers)

Typical Incident Scenario (focus on information flow)

1. Highway incidents usually start with a call to 999,Police are most often first responders.
2. Police attend the incident scene and assess the situation
3. Police provide a direct electronic alert into HA Traffic Officer Service
4. Police will provide information to INRIX (by manual telephony)
5. CCC will become aware of the incident by observing the effect through video or social media reports or via public information sites such BBC Travel News web site
6. CCC will attempt to contact HA by manual telephony, this is usually successful and HA will respond to ongoing calls from CCC for updates
7. CCC will attempt to contact Cambridgeshire police control room but usually this is not available
8. CCC will issue a Tweet with factual information about the incident to inform the public
9. If appropriate CCC will put factual information onto the relevant VMS signs (using LPEG protocol). Usage of the VMS signs occurs on a daily basis.
10. If necessary CCC will seek re-prioritisation of traffic signals (via manual intervention with Traffic signal team). On average this occurs once per week over a year, although not all related to A14 incidents.
11. If necessary CCC will seek clearance of street works from a route via manual intervention with the team in Huntingdon. Actual clearance of non-urgent elective works will be undertaken by 3rd party contractors or utility companies.
12. CCC may become aware of the end of an incident only through observation of normalised traffic flows rather than a proactive notification from HA or Police.

Observations

CCC would like to have improved vehicle journey time data on both HA and non-HA roads. ANPR and Tom-tom type solutions have been tried in the past and work well but are too expensive.

CCC have a good holistic view of traffic flow on the Network at any time and believe that they could provide useful advice to HA and Police regarding diversions around incidents.

Agreed HA diversion routes are often not updated to take account of changes to conurbations etc.

CCC does have the capacity to store data associated with incidents for post event review. The facility is in Argonaut is greatly underused. Better use could be used to support the business case for the extension of the CCC HMC into a 24 hour facility.

CCC are investigating the possibility of providing richer travel information to bus passengers via the RTPI signage.

CCC have never been contacted by Fire or Ambulance services in context of a traffic incident.

The Argonaut Common Database contains ability to define and automate the response to relatively complex scenarios but this feature is not used at present.

The STORM automated emails from Cambridgeshire Police are a useful new information feed, however, they do not contain any contextual information other than "highway disturbance" and location, therefore likely scale of impact is impossible to determine.

4. Highways Agency – Regional Control Centre (RCC)

Context

The HA RCC for Eastern England is located at the South Mimms interchange (A1/M25). The RCC includes a large control room with more than 10 workstations each with multiple (5) screens. The room also has a giant video wall showing multiple camera feeds. Some allied agency staff are also based in the control room e.g. Connect+. Highways Agency is an executive agency of DfT, but is in the process of becoming a Government owned company. HA are in mid-procurement for a new Command and Control system for all of England (project CHARM). The procurement is in partnership with Rijkswaterstaat, the HA equivalent agency in Netherlands. Any new information exchange application will have to be conformant with the new C&C system on a national basis.

Information inputs to the HA

- Electronic text exchange with Police FCRs across England.
- Telephone calls from emergency phones along the side of strategic roads (1000s)
- ANPR cameras measuring average speed along all strategic routes (data via Traffic England website)
- Real-time video feeds by direct access at full frame rate to HA owned PTZ CCTV cameras along the strategic road network
- Electronic notifications from NTIC for major nationally impacting incidents
- ELGIN road works data via internet map
- Feedback from HA TOS officers once they have arrived on scene
- Voice based interaction with some Council highway management centres (e.g. Essex and Oxfordshire are both well-established county wide management centres)

Information outputs from the HA

- Electronic transfer of demographic and verbatim data from Highways Agency C&C system into Police FCR systems.
- Telephone and electronic information exchange with the regional MAC
- Twitter @Highways_Agency (25,000 followers) and @HAtraffic_east (5200 followers)

- Email alerts/bulletins to haulage companies etc.
- Camera services to public via webpage
- Regional information widgets
- Traffic information RSS feeds

Traffic Control capabilities

- Diversions can be established on strategic roads, based on HA official diversion routes.
- MAC are used to provide cone/signage deployment resources

Typical Incident Scenario (focus on information flow)

1. Highway incidents usually start with a call to 999, Police are most often first responders.
2. Police dispatcher creates an incident record, captures information and location data
3. Police dispatcher provides a direct electronic message into HA Traffic Officer Service if the incident is on a strategic road.
4. HA review the incident, make use of cameras and ANPR data if available.
5. HA review their resource capability and make a decision about whether to deploy HATO
6. HA take a view on what VMS messages are appropriate and activate those on the network
7. HA interact with MAC if required
8. HA update external channels as required via traffic England, INRIX etc.
9. HA and Police exchange updates electronically via electronic transfer
10. HA will interact with County Council HMCs when requested by the Council
11. Major problems are reported to NTIC

Observations

HA received a significant amount of negative publicity in response to the announcement of the TVWS trial along the A14. Many members of the public were concerned that the trial would involve tracking of members of the public and an invasion of their privacy.

Strategic roads have MIDAS (Motorway Incident Detection and Automatic Signalling) loops buried in the road. The MIDAS loops detect abnormally slow moving traffic and will automatically generate warnings for display on nearby VMS units.

There are four varieties of signage deployed on the network called MS1, MS2, MS3 and MS4. MS1 are signals, not VMS and only display the speed, wickets, END or FOG. These are the old central reservation signs and are generally being replaced with the newer signs (MS3 and 4's mostly) which can give a variety of information. MS4 signs are the latest type able to display both pictograms and text.

ELGIN data is useful indicator of whether an official diversion route is viable at a given time and date (e.g. some roads within an agreed diversion route can be subject to overnight closure for road works etc.).

HA would benefit from real-time incident data on diversion routes to supplement the ELGIN data when HA are making a decision about which diversion route to implement, but would require simple log-in procedure and all new information to be collocated to avoid time wastage.

INRIX are a data provider who take the free data feed from Highways Agency National Traffic Information Centre at Quinton (Birmingham). INRIX add value to the data and then sell it onwards.

HA will interact with County HMCs, but prefer to have only one point of contact for any given location. They do not want to have to navigate between County, District and Borough Councils where they all have some aspect of HMC.

HA have worked with Information Logistics Inc to create a prototype information service for use by smartphones, which provides location based voice updates using the same factual data that would be displayed on the VMS. See Hands Free Traffic England in the Google and Apple iStore or http://infologisticscorp.com/appdev/hftEngland.html

HA do not regularly review incident response times and activity unless this relates to a major incident that might last more than 5 hours. More granular detail may be available but would need to be requested through a funded task.

Oxfordshire and Essex Traffic Control Centres have Traffic Bulletins for their local Radio Stations broadcast from their Control Centres in the morning and evening rush hour periods

MACs agree the official diversion routes with relevant Councils.

5. Strategic Road responders Agreement

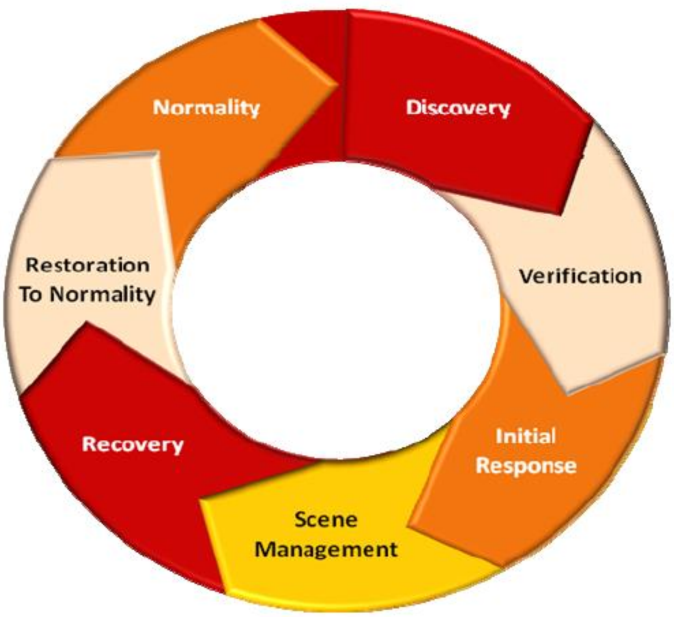
Incident management processes differ between strategic roads managed by the Highways Agency in England, relative to non-strategic roads which are the responsibility of Local Authorities. Throughout the discussions in Cambridgeshire all parties referenced their adherence to the CLEAR initiative. In 2012 Highways Agency (HA) issued an aide memoire booklet known as the CLEAR (Collision, Lead, Evaluate, Act, Re-open) initiative. This aide memoire outlined the roles and responsibilities of the key organisations involved in traffic incident management on the strategic road network, and was a joint publication with Association of Chief Police officers (ACPO), Chief Fire officers Association (CFOA), Association of Ambulance Chief Executives (AACE), Department for Transport (DfT) and the Home Office. This high level articulation of responsibilities was further enshrined in the Strategic road responders agreement in October 2013, which was signed by the national leads for HA, ACPO, CFOA and AACE.

CLEAR Guidance (reproduced from HA document)

A traffic incident can be split into a number of phases developing from and returning to normality as follows:

- *Discovery*
- *Verification*
- *Initial Response*
- *Scene Management*
- *Recovery*
- *Restoration to Normality*

These phases are shown separately in the diagram below although in reality, it is unlikely that each phase will be so clearly identifiable and distinguishable.



Joint Outcome

To minimise the impact of incidents on road users, neighbours, communities and the economy through an integrated, co-ordinated approach to safe partnership working.

Joint Responsibilities

Ensure due regard for personal safety and the safety of others throughout the co-ordination of the incident response.

Co-operate, co-ordinate and collaborate to ensure effective and efficient partnership working between responders

Support other responders in achieving their objectives, ultimately contributing to timely carriageway re-opening

Establish effective leadership from each responders' scene commander to co-ordinate the incident response

Warn and inform with regular updates to control rooms on:

- *Incident management progress*
- *Traffic management measures*
- *Estimating accurate times for carriageway re-opening*
- *Off network issues*

Participate in timely debriefing with handover of control and scene transfer to appropriate partner responder

Identify, agree and allocate time bound actions to address emerging issues

Execute allocated actions

Enable and facilitate operations of Smart Motorways as per the National Smart Motorway Strategic Agreement.

Engage in joint multi agency debriefing to review and reflect on the joint management of incidents. Identify lessons, share best practice and review working practices where necessary as part of continuous improvement to strive to deliver efficient joint incident management.

Responder Priorities: Highways Agency Traffic Management

Role

The Highways Agency leads the resolution of none police led incidents on the strategic road network to keep traffic moving by:

- *Keeping road users moving safely through helpful, accurate and timely information*
- *Providing appropriate traffic management*
- *Efficiently restoring the strategic road network capacity through incident management*

Responsibilities

- *Working with partners to restore safe use of the carriageway as soon as possible*
- *Traffic management at the inner cordon i.e. the scene*
- *Traffic management at the outer cordon including the approach to the incident and wider national/ regional intervention across the strategic road network*
- *The implementation of diversion routes (in collaboration with HA Maintenance Contractors and local Highways Authorities)*
- *Co-ordinating the emergency response with the other core responders and supporting the lead agency*
- *Scene clearance after Police handover*
- *Assessing, planning and implementing the restoration of:*
    - *The carriageway for safe use*
    - *Infrastructure at the scene including declaration of the asset as being of a standard safe for use*

Responder Priorities: Police

Role

The Police will lead the resolution of incidents on the strategic road network which involve:

- *Death or injury including collisions and suicides*
- *Suspected, alleged or anticipated criminality*
- *Threats to public order and public safety*
- *Occurrences where the powers in law or skills of a constable are required*

Responsibilities

- *Working with other agencies including the Highways Agency to create a safe and sterile rescue and work environment*
- *Preserving the life of those present*
- *Preventing escalation*
- *Co-ordinating the emergency response with the other core responders and supporting agencies*
- *Securing, protecting and preserving the scene, maintaining control and ensuring the integrity of the scene for any subsequent investigation where necessary*
- *Acting on behalf of HM Coroner*
- *Investigating the incident in a timely fashion – this includes obtaining and securing evidence in conjunction with other investigatory bodies (where applicable)*
- *Handing over the scene or sections of the overall scene to the Highways Agency as soon as practicable*
- *Working with partners to restore safe use of the carriageway as soon as possible*
- *Being mindful at all times of the economic pressures surrounding protracted road closures*

Responder Priorities: Fire and Rescue

Role

The Fire Services support incident resolution by:

- *Extinguishing fires and protecting life and property*
- *Rescuing people from a fire and its consequences including a range of other hazards and road traffic collisions*

Responsibilities

- *Save life through search and rescue*
- *Rescue people trapped in road traffic collisions and emergencies*
- *Extinguish fires and protect life and property in the event of fires*
- *Respond to, contain, mitigate effects and prevent further escalation of incidents involving hazardous materials and loads including radioactive substances*
- *Assist with casualty handling*
- *Undertake body recovery if it is in a dangerous position, such as road traffic collisions which are only accessible by FRS equipment*
- *Ensure the health and safety of persons within the inner cordon*
- *Conduct mass de-contamination when required*

Responder Priorities: Ambulance

Role

The Ambulance Services support incident resolution by:

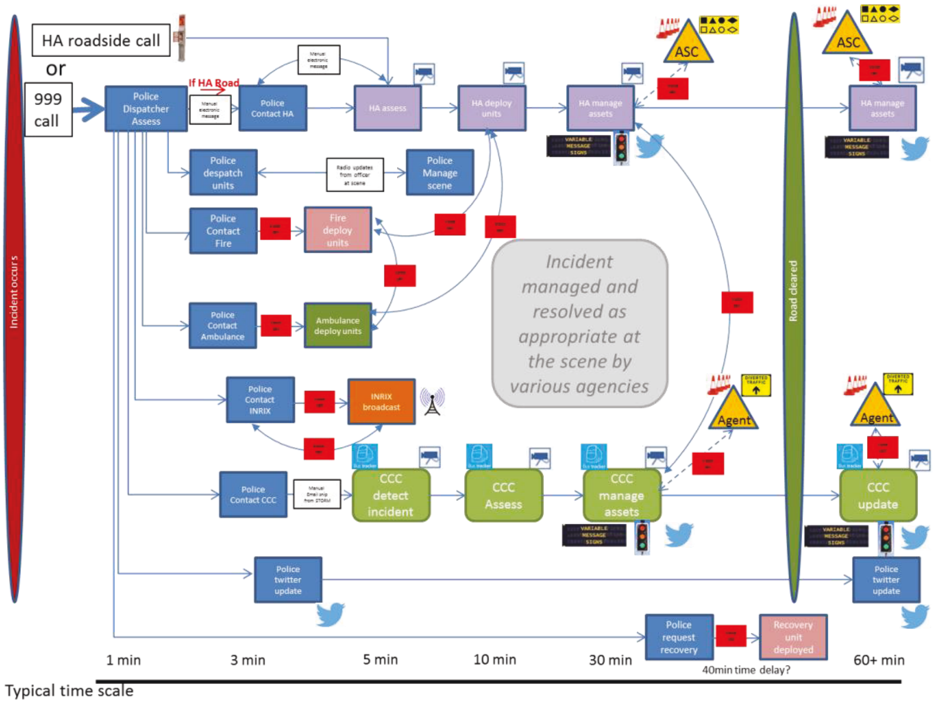
- *Ensuring the initial health needs of those people who become ill or injured whilst travelling on the network are met*
- *Initiating and seamlessly delivering rapid assessment, response and where required, treatment of those individuals involved*

Responsibilities

- *Save life together with the other emergency services*
- *Accurately assess and triage calls received to incidents*
- *Protect the health, safety and welfare of ambulance staff as far as is reasonably practicable*
- *Provide triage, treatment, stabilisation and care of those injured at the scene*
- *Treat those involved as individuals and respond to their needs as such*
- *Arrange the most appropriate means of transporting those injured to the receiving and specialist hospitals (involving use of Helimed when required)*
- *Provide a focal point at the incident for all National Health Service (NHS) and other medical resources*
- *Where required, nominate and alert the receiving hospitals to receive those injured*
- *Act as a portal into the wider health services including specialist health advice when required*
- *Responsible for decontamination of casualties in a Hazmat or chemical, biological, radiological and nuclear incident*

6. Practical realities in East of England

The chart below outlines the major interactions between service providers during a road traffic incident.



Much of the early activity is coordinated by the first response agency; usually the police or less often the Highways agency. The initial allocation of resources to the scene and requests to other blue light agencies is determined by experienced call handlers and their supervisors working on timescales of minutes. The diagram indicates those interactions which currently take place by manual voice telephony in red. During the first tens of minutes of a major incident there are multiple calls between agencies to provide or requested status updates. It is highly likely that many of these voice calls could be replaced by the use of an information service with appropriate safeguards over data confidentiality. During the early phase of response when threat to life and property is being mitigated, the automations of information flow could have some impact on overall response time and reduce possibility of human error. During the later phases of incident management where contractor resources are required to close lanes, repair carriageways and remove obstructions the scope for service improvement may be higher, particularly on non-HA roads.

There is a significant disparity in the treatment of incidents between HA strategic road network and LA managed local road networks. On HA roads, the HA will take charge of vehicle removal and instruct their ASC to carry out the task. On Council maintained roads the responsibility for recovery of obstructive vehicles falls between the Police and the vehicle owner. The following procedure is reproduced from Suffolk Police as an example:

Recovery of vehicles on non-HA roads

Officers at scenes will contact Force Operations Room (FOR), who will contact RMSL, who will allocate the recovery to an Operator. RMSL will allocate a Recovery Operator, who shall be expected to attend the scene of a call out as soon as practicable, normally 30 minutes for light vehicles and 45 minutes for heavy recoveries.

Broken Down Vehicles

The vehicle will usually be recovered at the request of the owner. This will normally be by the owner's nominated recovery operator (AA, RAC etc). If Police are asked to arrange recovery, then RMSL will be called and the owner/driver will be told that they will be responsible for the recovery costs.

Where the vehicle is causing an obstruction or danger and the vehicle cannot be recovered within an appropriate time, or the owner's Recovery Operator cannot recover the vehicle, the Officer can override the owner's request and call RMSL to allocate a VRO to remove the vehicle.

Vehicles involved in a fatal, potential fatal or life-changing RTC should be recovered and taken to the designated Operator premises assigned by RMSL.

Where vehicles are removed under statutory powers, the removal will be at the owner's expense.

Where vehicles are seized under Police and Criminal Evidence Act (PACE), costs associated with removal and storage will be the responsibility of the Force.

Vehicles involved in minor RTCs will normally be recovered at the request of the owner. This request will normally be by the owner's nominated Recovery Operator (AA, RAC etc). It is important all vehicles are removed from the highway as soon as possible and officer's time is not wasted by remaining at the scene of the RTC.

Under no circumstances will an officer state that Police will pay recovery charges.

Where the vehicle is causing an obstruction or danger and the vehicle:

- *Cannot be recovered within an appropriate time; or*
- *The owner's Recovery Operator cannot recover the vehicle.*

The officer can override the owner's request and call FOR to arrange for RMSL to remove the vehicle.

Where a vehicle is removed at the owner's request FOR will call RMSL for recovery. Any vehicle removed under statutory powers will be at the owner's expense.

7. Conclusions

Mitigating the impact of road traffic incidents requires the rapid coordination of resources from multiple service providers

Dealing with the initial threat to life and limb is a highly tuned manual operation. Automating the information distribution between agencies may enable each agency to make better informed decisions about what resources to deploy to an incident.

Voice communications are an inefficient means of relaying information across the stakeholder group responding to a given incident, particularly in the latter phases of major incidents where information needs to be disseminated to road users.

Automated information distribution could enable a new approach to identification and allocation of available resources, particularly contractors for recovery of vehicles or road repairs on the non-HA network.

Offices worldwide

Appendix C: New Information Sources

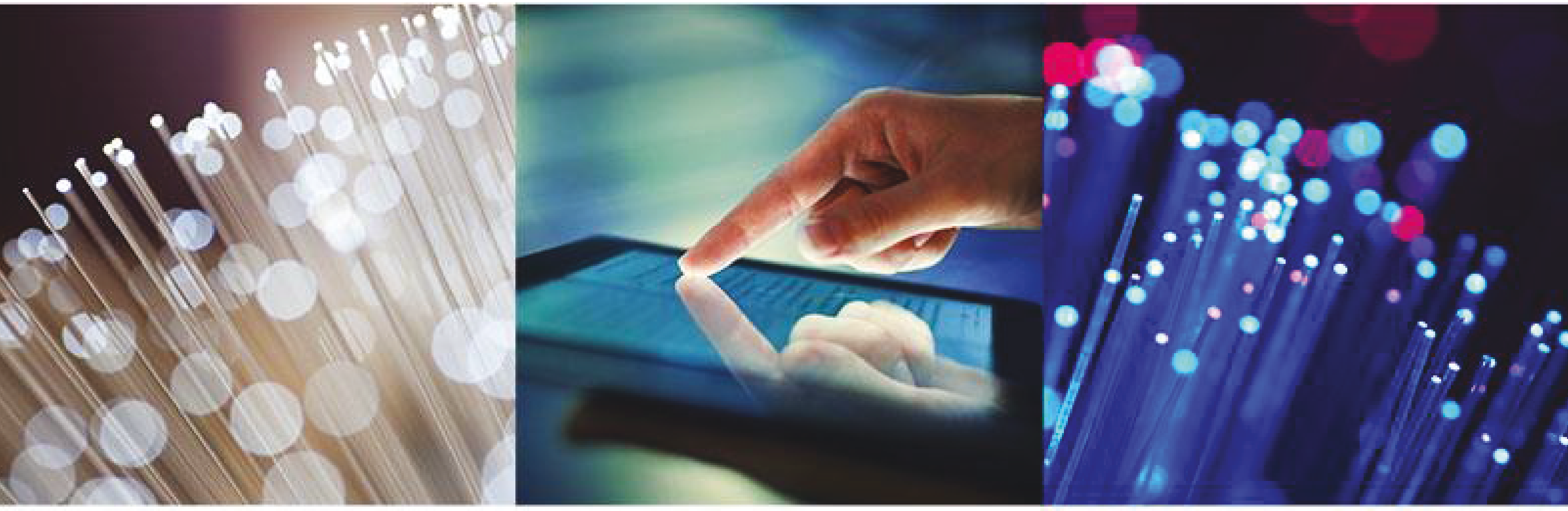


Table of Contents

1. Introduction

The UK road network is congested and this is predicted to increase. In order to reduce congestion and transportation costs we need to enable better traffic management and make greater use of the existing road network without laying more Tarmac. This management is of even greater importance during incidents when different organisations need rapid and accurate access to the same information.

During congestion / incidents, traffic may start to leave the strategic network through:

- Being directed (i.e. official pre-arranged diversions).
- Through the driver's own decision to find a better route.
- Via a satellite navigation product.

As more vehicles leave the strategic network, the HA traffic management centres lose visibility of the traffic, as these roads have fewer sensors or the HA management centre may not have ready access to the data, in effect the knowledge of traffic flow is hidden from the HA.

Incidents have occurred where traffic has been directed onto previously agreed diversion routes, which unknown to the HA, had temporary reduced capacity and so were not suitable diversion routes at that time. This exacerbated problems that would have been preventable if more information from non-strategic road network was available. This section will examine:

- What data could be cost effectively provided to the HA and Local Authority management centres about traffic flows on the non-strategic road network
- The range of scenarios that could make use of this data

2. The Strategic and Non-Strategic Road Network

The strategic road network in England consists of most motorways and significant trunk A roads, it has a length of approximately 4,300 [1]miles (≈ 2% of the total physical road length) but accounts for approximately 34% of all road travel and 67% of lorry freight travel by mileage; approximately four million vehicles use it every day.

It is managed using a network of regional and national control centres around England with access to a variety of permanently installed vehicle detection systems, CCTV and 3rd party data (e.g. fleet management data). The sensors used include inductive loops cut into the road, radar/IR [2] units installed on gantries / bridges and ANPR (automatic number plate readers). UK roads (strategic and non-strategic) are also audited using manual or automatic traffic counts (MTC & ATC); these counts are non-real time and are typically used for planning and modelling purposes. Such audits may also contain vehicle classification, occupancy and journey data. All the traffic data is collected from the various sources and used for incident management, alerting drivers and for future traffic planning as shown in Figure 1.

[1] http://www.highways.gov.uk/our-road-network/managing-our-roads/
[2] InfraRed detectors

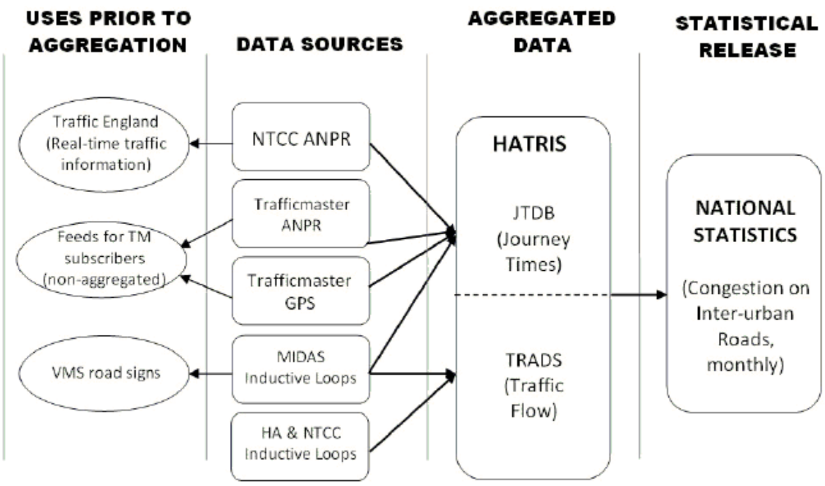


Figure 1 relationship between data sources

HATRIS, Highways Agency Traffic Information System

JTDB (Journey Time Database), contains aggregated journey time data from

- Trafficmaster Automatic Number Plate Recognition (ANPR) cameras
- Motorway Incident Detection Automated Signalling (MIDAS) inductive loops
- Trafficmaster Global Positioning System (GPS) in-car tracking devices
- National Traffic Control Centre Automatic Number Plate Recognition (ANPR) cameras.

Traffic flow Database System (TRADS), contains traffic flow data from

- MIDAS inductive loops
- National Traffic Control Centre Traffic Monitoring Unit inductive loops
- Highways Agency Traffic Appraisal Modelling & Economics inductive loops

Traffic Master, a fleet management company with traffic data
VMS, (variable/vehicle messaging sign), used on strategic network to alert drivers

By having an accurate view of the strategic network, the management centre operators make decisions to manage the road network to keep traffic flowing. As the road network becomes greater utilised and more congested, it is necessary to either build more traffic capacity (extremely expensive and slow to achieve) or improve the visibility of the road network outside of the strategic network.

To improve the visibility of the network outside the strategic network requires access to additional data from commercial sources such as Satellite Navigation providers, or the addition of new technology to the non-strategic road network , which must be added cost effectively, to provide sufficient detail, coverage and accuracy. For example, today

- Mobile phone operators know the approximate geographic area that a mobile phone is in but not necessarily the specific road[3]
- Satellite navigation units know the specific road but at the moment only a small number are networked for real time use. NB Satellite navigation companies do sell this data but it can be costly and can be limited in how it can be used.
- Fleet management companies use satellite navigation and telemetry, so they know the specific road a vehicle is on and its state of flow. The fleet is primarily on the strategic network rather than non-strategic rural roads and therefore the data set related to traffic flow may be very small and of limited value.
- The existing sensors used on the strategic network have non-trivial installation requirements. They are typically mains powered and are close to network connectivity point (grey boxes beside the motorways as seen in Figure 2); to duplicate this installation methodology onto more of the UK road network would be prohibitively expensive, as explained below.

[3] GPS location is increasingly available on smart phones, so with user consent, a smart app could do this

Figure 2 powering and network points for traffic detectors on strategic network

The 245,000[4] miles of roads in Great Britain can be categorised as shown in Figure 3 and the ratio of road miles to road traffic shown in Table 1.

4 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/9072/road-lengths-2011.pdf

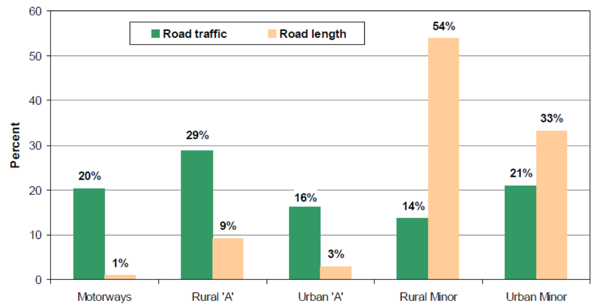


Figure 3 Road traffic and length by road type in GB 2011

Road Type	Road Miles Travelled	Road Length	Approximate Ratio of road miles /length
Motorways	20%	1%	20:1 short length of road has a lot of traffic
Urban A class	16%	3%	5:1
Rural A class	29%	9%	3:1
Urban Minor	21%	33%	2:3
Rural Minor	14%	54%	1:4 long length of road has little traffic

Table 1 ratio of road miles to road length for GB 2011

To increase sensor coverage of the road network takes disproportionately more sensors and therefore cost, e.g. to cover all the Motorways and Rural A roads would mean having detection capability on 10 % of all the roads, which is about 5 times what is present today on the strategic network.

In summary, to extend the view of the roads outside the strategic road network requires new data from either 3rd parties or sensors. Due to the scale of the problem and 3rd party data restrictions, it is not cost efficient to simply replicate the existing traffic sources onto these roads; a different approach may be needed.

3. What is needed?

Discussions with Cambridgeshire County Council to understand their challenges and operational needs highlighted three basic requirements from a solution, namely:

1) A low cost solution within the geographic region of interest
2) Near real-time traffic flow data on specific roads and journey information
3) An open data approach to prevent restrictions on the use of the data by the Council

3.1 Low cost solution

To determine the cost constraints, typical costs of existing traffic detectors and data sources were investigated.

A USA paper[5] from 2007 *"A Summary of Vehicle Detection and Surveillance Technologies used in Intelligent Transportation Systems"* compares detection technology vs data, cost and bandwidth requirement for nine traffic detection methods from 2001 (as shown in Figure 4). Inductive loops are widely used around the world and are seen as a mature technology, they are listed as the cheapest detector in Figure 4, priced at 5-800 USD, though this does not include installation, powering costs etc. So, any new sensor must have significantly lower installation, maintenance and networking costs compared to inductive loops in order to be considered cost effective.

[5] https://www.fhwa.dot.gov/policyinformation/pubs/vdstits2007/vdstits2007.pdf

Traffic output data (typical), communications bandwidth, and cost of commercially available sensors (Klein, 2001).

Sensor Technology	Output Data: Count	Presence	Speed	Occupancy	Classification	Multiple Lane, Multiple Detection Zone Data	Communication Bandwidth	Sensor Purchase Cost[a] (each in 1999 U.S. $)
Inductive loop	✓	✓	✓[b]	✓	✓[c]		Low to moderate	Low[i] ($500 to $800)
Magnetometer (Two-axis fluxgate)	✓	✓	✓[b]	✓			Low	Moderate[i] ($900 to $6,300)
Magnetic (Induction coil)	✓	✓[d]	✓[b]	✓			Low	Low to moderate[i] ($385 to $2,000)
Microwave radar	✓	✓[e]	✓	✓[e]	✓[e]	✓[e]	Moderate	Low to moderate ($700 to $3,300)
Active infrared	✓	✓	✓[f]	✓	✓	✓	Low to moderate	Moderate to high ($6,500 to $14,000)
Passive infrared	✓	✓	✓[f]	✓			Low to moderate	Low to moderate ($700 to $1,200)
Ultrasonic	✓	✓		✓			Low	Low to moderate (Pulse model: $600 to $1,900)
Acoustic array	✓	✓	✓	✓		✓[g]	Low to moderate	Moderate ($3,100 to $8,100)
Video image processor	✓	✓	✓	✓	✓	✓	Low to high[h]	Moderate to high ($5,000 to $26,000)

[a] Installation, maintenance, and repair costs must also be included to arrive at the true cost of a sensor solution as discussed in the text.
[b] Speed can be measured by using two sensors a known distance apart or estimated from one sensor and the effective detection zone and vehicle lengths.
[c] With specialized electronics unit containing embedded firmware that classifies vehicles.
[d] With special sensor layouts and signal processing software.
[e] With microwave radar sensors that transmit the proper waveform and have appropriate signal processing.
[f] With multi-detection zone passive or active mode infrared sensors.
[g] With models that contain appropriate beamforming and signal processing.
[h] Depends on whether higher-bandwidth raw data, lower-bandwidth processed data, or video imagery is transmitted to the traffic management center.
[i] Includes underground sensor and local detector or receiver electronics. Electronics options are available to receive multiple sensor, multiple lane data.

Figure 4 vehicle detection technologies matrix

ANPR (Automatic number plate reading) cameras (or video image processors) are the most expensive detection method in Figure 4. They typically cost several thousands of pounds e.g. a four lane number plate reading system in USA (2010)[6] listed the installation cost as 25k USD, which was accepted by a UK local authority as a likely cost. In 2014; the maintenance and networking costs for ten cameras covering two UK roads were estimated as 16k GBP per annum. Installation costs for ANPR cameras can be high as the cameras require a suitably elevated position e.g. pole or gantry to mount the camera and a mains electrical feed is required as the power requirements can be higher than other detection methods. These costs are offset on the strategic network as locational may already have elevated mounting positions and power may be available

The Local authority questioned also uses commercial data data, which covers all of the A and B roads in the region, typical annual costs were around 40k GBP per annum however, the number of vehicles on the roads at any one time is likely to be low and the authority is restricted on reusing the data. A different provider of data [7] advertises a fleet of over 100,000 vehicle probes (a vehicle that is transmitting location/speed data), but as Table 1shows the motorways and strategic network account for most of the vehicle miles travelled, therefore at any one time the chance of a vehicle probe being on a non-strategic road is very low.

3.2 Traffic flow data and journey information

The requirement of providing journey information requires either:

- A vehicle identity to be determined at the start and end of a journey e.g. via a number plate, satellite navigation identity.

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[6] http://www.itsinternational.com/sections/nafta/features/bluetooth-speed-and-travel-data-collection-shows-cost-savings/
[7] http://www.trafficmaster.co.uk/content/1/82/real-time-and-historic-data-feeds.html

- A number of speed readings along the connecting roads of a virtual journey need to be added together

The first approach may have privacy implications whereas the latter approach would require more sensors, which would add costs and only allows a “typical” journey time to be inferred from the speeds of the connecting roads. Of the detection methods in Figure 4 the low cost loop detectors would not allow a vehicle to be identified whereas the higher cost number plate reading cameras could. To alleviate privacy concerns, automatic number plate readers used for traffic detection rather than speed enforcement only transmit part of the number plate and they encrypt the data. This allows traffic speeds and routes to be determined in a region, to be of use across a wider road network it would be necessary for each camera system to follow an agreed standard to allow journey information to be used across the wider road network whilst maintaining privacy.

3.3 Open data approach

With limited competition amongst commercial providers of traffic data on non-strategic roads, the cost of the data service is beyond what’s affordable by the Local Authority. If alternative data sources for the non-strategic roads were available then existing commercial data providers may have to reduce the costs and limits they place on data reuse.

In summary, the aim of the work is directed at providing low cost, near real-time traffic flow data in a format that is open, primarily for incident/congestion management, archived data would also be of use for planning and strategy purposes.

4. Four scenarios of traffic

In order to understand the issues for a management centre, four likely scenarios of road traffic will be considered to explore the expected data that would be generated, i.e.:

1) Expected everyday traffic. Traffic is flowing at a rate where the flow is not impaired by other users, speed is variable within expected limits; the management centre may expect this to be the case for most of the “off peak” times.
2) Busy traffic. Traffic is still flowing but the road is more fully occupied, vehicles are moving at a more uniform speed as overtaking becomes harder; the management centre may expect this to be the case during “peak” times.
3) Slow moving traffic. Traffic is moving but the amount of cars or other issues mean vehicles are moving slower than expected, traffic may be bumper to bumper and perhaps having to momentarily stop. Drivers may turn to satellite navigation for rerouting, more hands free calls may be made, e.g. to alert of journey delay. The management centre would want to be alerted to this scenario before it happens and also when it ends e.g. traffic starts to flow faster.
4) Stopped traffic, i.e. traffic jam, incident. Traffic has stopped, engines may be turned off, phone calls are made to alert of delays, and satellite navigation/maps may be used to see if an alternative route is possible when traffic starts to move. The management centre is seeking to avoid this state, as grid lock can occur making it very difficult to get traffic flowing again.
   N.B. traffic can build [8] at the rate of 1 mile/minute on the strategic network

[8] Observation made in A14 information sharing pilot draft report March 2014, contract ref TDTI 1/13

Looking at the four scenarios, the data expected may be as follows:

- Normal / expected free flow traffic.
  - Vehicle count may be sporadic within the expected range
  - Vehicle speed would vary but would tend towards the maximum speed for that road.
- Busy traffic.
  - Vehicle count would be higher and sustained but still within expected range.
  - Vehicle speed may be lower as traffic synchronises.
- Slow moving
  - Vehicle count would be low and sustained.
  - Vehicle speed would be low and may even have elements of stationary traffic.
- Stopped i.e. traffic jam, incident
  - Vehicle count and speed would be low tending to zero.

As the non-strategic network covers a wider variety of roads, some of which may be very remote, this raises some cost challenges on installation, powering and networking for sensors, i.e.:

1. Powering sensors and network: Access to power on these hidden roads may be restricted to existing streetlights or poles where renewable power may be an option (e.g. solar cells). If power is not available, then battery life must be such that operational costs and size are not prohibitive.
2. Networking: The data provided must be timely, which may require frequent transmissions back to a central location and impacts on powering and location requirements, i.e. a sensor installed on (or in) the road may not be able to connect directly to a central location, therefore an intermediate pole based device may be necessary to forward data back to a control station, adding more cost and complexity.

4. Powering, networking and installation

A vehicle detector will need to access an existing power supply e.g. an illuminated road sign or streetlamp or use a battery. Batteries may need regular replacement or will need to be recharged by other means, such as solar power. In order to get data back to a management centre from remote locations, an access network will be required; this could use the cellular network or other radio network, e.g. telemetry bands, TVWS (TV White Space).

Promising solutions to the powering/ installation challenge are emerging e.g. a logging stud[9], as shown in Figure 5. This uses solar power to top up an internal battery and uses a short range wireless link to a control box. Installation is simplified to drilling a hole, inserting the sensor and sealing but is unknown how water ingress, gritting etc. may damage the sealants used and the device over time

[9] http://www.clearviewtraffic.com/golden-river/products-golden-river/art/46/m210-solar-powered-logging-stud.htm

Figure 5 solar powered vehicle logging stud

Sensors placed on or in the road have an advantage in detecting traffic as they are close to the vehicles; however, radios installed in the ground can typically only cover short distances. Therefore, it is likely as in the case with the logging stud in Figure 5 that road based sensors will require an additional installation of a relay network to facilitate the longer network link back to the control room, which will increase costs. If an elevated point is needed for the network, then it may make economic sense to use a detection method that works at this location as well.

On the strategic network power and network comes from "grey boxes" at the side of the road as previously shown in Figure 2. Vehicle detectors are also often placed on dedicated poles or on other transport infrastructure, e.g. bridges or VMS (vehicle messaging signs) as shown in Figure 6 where CCTV and ANPR cameras can be seen.

Figure 6 vehicle detection placed on transport infrastructure

Such installation is likely to be prohibitively expensive for rolling out onto the length of roads required, so ways to reduce costs associated with installation, powering and network need to be found. One way to reduce costs would be to utilise existing infra-structure, perhaps the examples shown in Figure 7, which shows the poles used by telephone, energy, street lighting and postal services, which may have advantages.

Figure 7 Other poles found near roads e.g. telecom, energy, streetlights and postal boxes.

Such poles would offer an elevated mounting point, which is advantageous for networking and potentially the sensing position itself, plus the poles may reduce installation costs as devices could be potentially strapped onto them. They may also allow access to a power/ network source if available, or in the case of the postal boxes, perhaps utilise the frequent visits made to these boxes by postal workers to change a battery or collect stored data.

In addition, there are increased roll outs of smart street lighting, which offers the opportunity of:

- Raised location in which to position vehicle sensors.
- Power source.
- Network, smart lighting may include a network path that the vehicle sensors could utilise.

As such, vehicle detectors that may in the past have been ruled out on power / network grounds may become cost effective in some locations. The suitability and location of these street assets would need to be further investigated.

5. Detection methods

Examination of the commercially available vehicle detection technologies for sale today (Figure 4), transport department recommendations[10i] and various research papers show that new technologies e.g. infra-red, Ultra-Sonics etc. have been proposed before but have not been widely adopted. The 2010 paper[11]"*A study on vehicle detection and tracking using wireless sensor networks*" includes a table reproduced as Figure 12, this table lists the strengths and weaknesses of commercially available sensors for vehicle detection; unfortunately none appear to have any advantages / lower costs compared to traditional detection methods.

A more recent Chinese paper[12] from 2012 "*Common Vehicle Detectors of Highway Performance Comparison and Development Trend Analysis*" makes no mention of the more novel detection technologies mentioned in the 2010 and 2007 papers. The 2012 paper compares coil, video and radar based vehicle detectors and in summary, the paper reports that *"video and microwave detectors were*

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[10] E.g For example US Dept of Transport Traffic Control Systems handbook, http://ops.fhwa.dot.gov/publications/fhwahop06006/chapter_6.htm
[11] http://www.scirp.org/journal/PaperDownload.aspx?paperID=1385
12 http://www.ier-institute.org/2070-1918/lnit15/v15/478.pdf

expensive; video is susceptible to the weather and that coil systems required the road to be closed for installation and had the lowest average service life of 5-7 years".

Since these earlier reviews have been undertaken, a range of new vehicle detection methods has not been successfully marketed to the vehicle detection customer base. It is likely that audio, ultrasonic, infra-red etc. could detect vehicles, however, whilst their raw output is related to vehicle proximity they have not been developed sufficiently for use in a field trial of traffic counting and were therefore regarded as beyond the scope of this project.

There are also two methods of vehicle detection that are not referenced in these earlier papers, namely, wireless detection and fibre sensing, which are discussed in the next section.

5.1 Fibre sensing

The increased roll out of fibre around the UK offers a novel traffic detection possibility. A fibre sensor is comprised of an optical fibre (as used in telecommunications) with specialist detection electronics at one end. The detection electronics allow vibrations to be measured along the full length of the optical fibre. This is useful as fibre routes often follow the road layout and the level of vibration should relate to the amount, type and speed of traffic. Figure 8 shows an early optical fibre trial deployment and a road map of the same area. The fibre route (shown as a dark line) can be seen to follow the road.

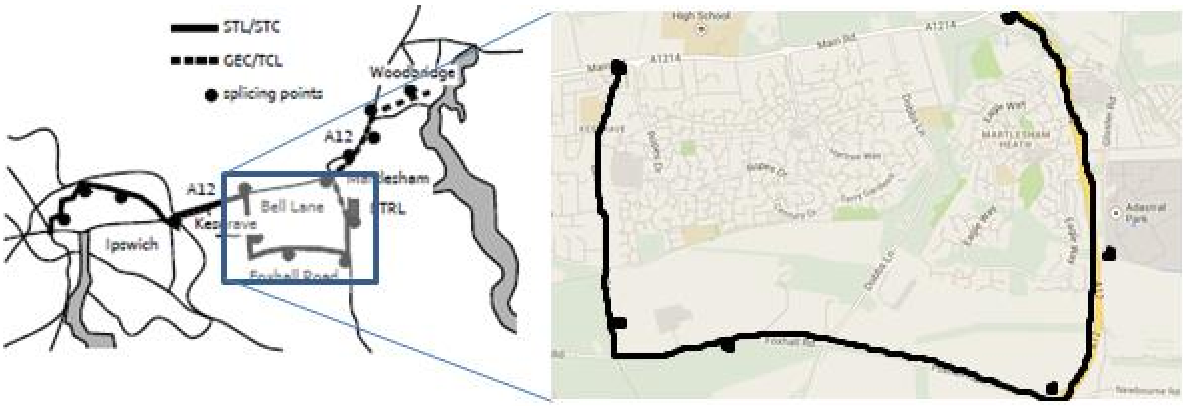

Figure 8 Fibre trials and a modern road map showing part of the same area

5.1.1 Advantages of a fibre sensor

- A fibre sensor can be up to 50km long, which could cover a number of roads. In addition, a number of fibres could be multiplexed into a single box of detection electronics, allowing one fibre sensor to potentially cover a large number of roads from a central location. Assuming that existing Telecommunications fibres can be re-used for this purpose.
- The fibre sensor is an inherent network in itself, requiring power only where the detection electronics are located, which is likely to be the safe environment of a telephone exchange. Therefore, the ongoing costs of a fibre sensor are likely to be extremely low.

5.1.2 Disadvantages of a fibre sensor

- As yet, there is no published research that shows that a fibre sensor could be used to detect change in traffic flow, therefore work would have to be undertaken to determine if this method is practical.

- Cost. At present the detection electronics are proprietary and have a high capital cost (estimated at 50-100kGBP unit cost); if proven to work, traffic detection applications would create a larger market and so significantly reduce the capital cost of the equipment.

5.2 Wireless Detection

A relatively new detection technology has been making inroads into the vehicle detection industry is wireless detection. As shown in Figure 9 an increasing amount of vehicles, drivers and passengers are carrying wireless equipment, this is mainly Bluetooth, though other wireless standards may be of use in vehicle detection.

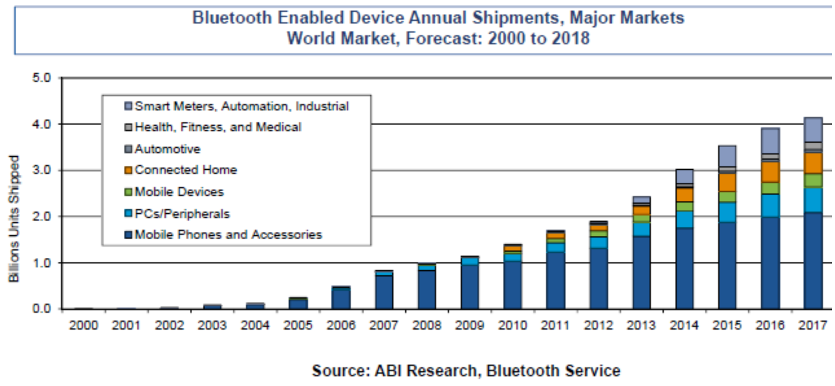

Figure 9 Bluetooth enabled device sales and predictions from 2013

These devices are either built into the car at manufacture, installed accessories or carried by the driver or passenger(s), these devices can be simply detected by receivers placed along the road. An experiment [13] in 2011 using off the shelf Bluetooth device to monitor the Bluetooth devices in a typical urban environment detected nearly2,000 unique devices, over five days which could be broken down to manufacturer a shown in Figure 10

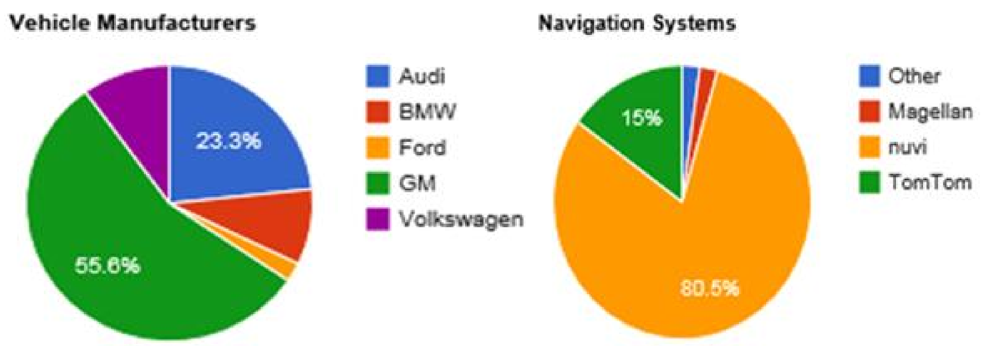

Figure 10 breakdown of device for an urban study

This highlights that low cost wireless detection should be possible on the road network. A number of larger case studies [14] [15] using commercial sensors as shown in Figure 11 have indicated that a significant number (between 25% and 43 %) of vehicles can be detected in this manner and, given the rising number of smart devices as shown in Figure 9 using Wi-Fi/Bluetooth, it is likely that this detection rate will rise.

[13] http://www.digifail.com/research/streetsweep.shtml

[14] http://www.transportscotland.gov.uk/files/Bluetooth_Report_-_S_Cragg.pdf

[15] Vehicular traffic estimation through bluetooth detection the open-source way Paolo Valleri, Patrick Ohnewein, Roberto Cavaliere paolo.valleri@tis.bz.it TiS Innovation Park – Italy FOSDEM_valleri.pdf
An Appraisal of Emerging Bluetooth Traffic Survey Technology, Alasdair Kay SIAS Ltd Paul Jackson, Sky High Traffic Surveys

Figure 11 Typical wireless detection product with solar panel

A manufacturer did say that one study had only achieved a 10% detection rate; this was attributed to low penetration of enabled devices for the region on that route. Given these widely different detection figures, it may be necessary to do further studies of how accurate wireless detection would be in different regions, on different roads and if this changes over time or during different traffic scenarios. If the wireless detection of vehicles can be sufficiently correlated to actual vehicles then models may be able to take the low or varying detection rates into account. As mentioned in the four scenarios section, during slow/ stopped traffic greater use of Bluetooth equipment may occur as hands free calls are made or satellite navigation units are turned on, which would increase the number of devices to be detected.

5.2.1 Advantages of wireless detection

Wireless detection mechanisms have a number of inherent advantages

- Mass market of components leads to cheap[16], low power operation of detectors.
- Open-source software availability.
- Growing number of detectable devices on the roads.
- Detection range of the technology enables multiple lanes to be covered by one detector.
- Device identification allows journey times and routes to be calculated (though privacy concerns must be addressed).
- Pole installation makes a network back to the control centre simpler and allows rapid deployment and recovery if required.
- Reduced need for calibration of a sensor.
- Non-invasive.

Manufacturers of wireless detectors are quoting prices of 1-2k GBP for wireless detectors in low numbers which is equivalent to that of loop detectors; however installation costs are significantly lower. Installers of the wireless equipment say that installations typically take in the region of 20 minutes per site allowing for set up and calibration. Detectors are either fixed to various items of street furniture using steel or plastic banding or a free standing mast.

5.2.2 Disadvantages of wireless detection

There are two major concerns with using wireless for vehicle detection; detection rate reliability and issues over potential invasion of privacy.

16 a Bluetooth Installation 16in USA in 2010 is listed as 2,000 USD.

Bluetooth traffic detection is being rolled out around the EU and USA, so the technology does work but, to be of value, the data has to be accurate. The suitability of this method will be dependent on the installed user base of WiFi/Bluetooth in vehicles in that region and if the data can be correlated with a real traffic count. Not every vehicle will be detected; some vehicles may have multiple devices detected whereas some wireless devices may be in the proximity of the detector but have no relationship to traffic flow. It may be necessary to fuse wireless data with other vehicle counter data at some locations (including the strategic network), to generate dynamic models, which relate wireless detections to vehicle count in that area at that moment.

Bluetooth in cars is predicted to increase with ABI Research estimating the majority of new cars being Bluetooth enabled by 2016

5.2.3 Privacy

Wireless detection systems using Bluetooth and Wi-Fi may be seen as invading privacy as personal data may be associated with the base traffic data. An installation of wireless detectors in refuse bins in London raised major concerns in the national press[17] and privacy has already been raised as an issue [18] for other trials. Therefore, methodologies will be needed to protect user privacy whilst allowing information on journey times over wider areas to be used. Automated Number Plate Recognition (ANPR) cameras encrypt parts of the number plate before transmission, so a journey can be tracked without identifying the vehicle. If a wireless detection system followed the same methodology then the privacy issues may be alleviated.

6. Conclusion and recommendations

This interim paper has presented a brief overview of some of the issues involved with detecting traffic on the non-strategic network roads. A table of previous alternative vehicle sensing methods has been provided in Figure 12, which has not identified a readily available suitable vehicle detector that will become commercially available in the near future.

The paper does highlight the potential of wireless detection methods and fibre sensing, though notes that the former requires deeper correlation and modelling activity and the latter requires further research.

It is proposed that the following is carried out:

Evaluate wireless detection against existing vehicle detectors sensors to gain a deeper understanding of its practical use,.e.g. what is the detection range /speed relationship, how the chance of detection increases during different road scenarios etc. and that the information provided is of use to the highways agency and local authorities.

Investigate how privacy concerns can be addressed

Assess ways to reduce running costs e.g. where suitable locations for detectors that may have an existing power source, what and when data should be sent to allow enough information to satisfy the management centres whilst reducing overall costs.

17 http://www.bbc.co.uk/news/technology-23665490

[18] Mentioned in A14 information sharing pilot draft report March 2014, contract ref TDTI 1/13 relating to TVWS trials

Monitor development of sensor products and associated systems (e.g. smart street lighting) that may have practical use in traffic flow detection or in the data collection.

Strengths and weaknesses of existing commercial vehicle detectors

Technology	Strengths	Weaknesses
Inductive loop	Flexible design to satisfy large variety of applications. Mature, well understood technology. Large experience base. Provides basic traffic parameters (e.g., volume, presence, occupancy, speed, headway, and gap). Insensitive to inclement weather such as rain, fog, and snow. Provides best accuracy for count data as compared with other commonly used techniques. Common standard for obtaining accurate occupancy measurements. High frequency excitation models provide classification data.	Installation requires pavement cut. Improper installation decreases pavement life. Installation and maintenance require lane closure. Wire loops subject to stresses of traffic and temperature. Multiple loops usually required to monitor a location. Detection accuracy may decrease when design requires detection of a large variety of vehicle classes.
Magnetometer (two-axis fluxgate magnetometer)	Less susceptible than loops to stresses of traffic. Insensitive to inclement weather such as snow, rain, and fog. Some models transmit data over wireless radio frequency (RF) link.	Installation requires pavement cut. Improper installation decreases pavement life. Installation and maintenance require lane closure. Models with small detection zones require multiple units for full lane detection.
Magnetic (induction or search coil magnetometer)	Can be used where loops are not feasible (e.g., bridge decks). Some models are installed under roadway without need for pavement cuts. However, boring under roadway is required. Insensitive to inclement weather such as snow, rain, and fog. Less susceptible than loops to stresses of traffic.	Installation requires pavement cut or boring under roadway. Cannot detect stopped vehicles unless special sensor layouts and signal processing software are used.
Microwave radar	Typically insensitive to inclement weather at the relatively short ranges encountered in traffic management applications. Direct measurement of speed. Multiple lane operation available.	Continuous wave (CW) Doppler sensors cannot detect stopped vehicles
Active infrared (laser radar)	Transmits multiple beams for accurate measurement of vehicle position, speed, and class. Multiple lane operation available.	Operation may be affected by fog when visibility is less than ≈ 20 feet (ft) (6 m) or blowing snow is present. Installation and maintenance, including periodic lens cleaning, require lane closure
Passive infrared	Multizone passive sensors measure speed.	Passive sensor may have reduced vehicle sensitivity in heavy rain, snow and dense fog. Some models not recommended for presence detection.
Ultrasonic	Multiple lane operation available Capable of over height vehicle detection. Large Japanese experience base.	Environmental conditions such as temperature change and extreme air turbulence can affect performance. Temperature compensation is built into some models. Large pulse repetition periods may degrade occupancy measurement on freeways with vehicles travelling at moderate to high speeds.
Acoustic	Passive detection. Insensitive to precipitation. Multiple lane operation available in some models.	Cold temperatures may affect vehicle count accuracy. Specific models are not recommended with slow-moving vehicles in stop-and-go traffic.
Video image processor	Monitors multiple lanes and multiple detection zones/lane. Easy to add and modify detection zones. Rich array of data available. Provides wide-area detection when information gathered at one camera location can be linked to another.	Installation and maintenance, including periodic lens cleaning, require lane closure when camera is mounted over roadway (lane closure may not be required when camera is mounted at side of roadway). Performance affected by inclement weather such as fog, rain, and snow; vehicle shadows; vehicle projection into adjacent lanes; day-to-night transition; vehicle/road contrast; and water, salt grime, icicles, and cobwebs on camera lens. Reliable night-time signal actuation requires street lighting. Requires 30- to 50-ft (9- to 15-m) camera mounting height (in a side-mounting configuration) for optimum presence detection and speed measurement. Some models are susceptible to camera motion caused by strong winds or vibration of camera mounting structure. Generally cost effective when many detection zones within the camera field of view or specialized data are required.

Figure 12 Strengths and weaknesses of commercially available sensor technologies from

http://www.scirp.org/journal/PaperDownload.aspx?paperID=1385

Offices worldwide

Appendix D: Social Media

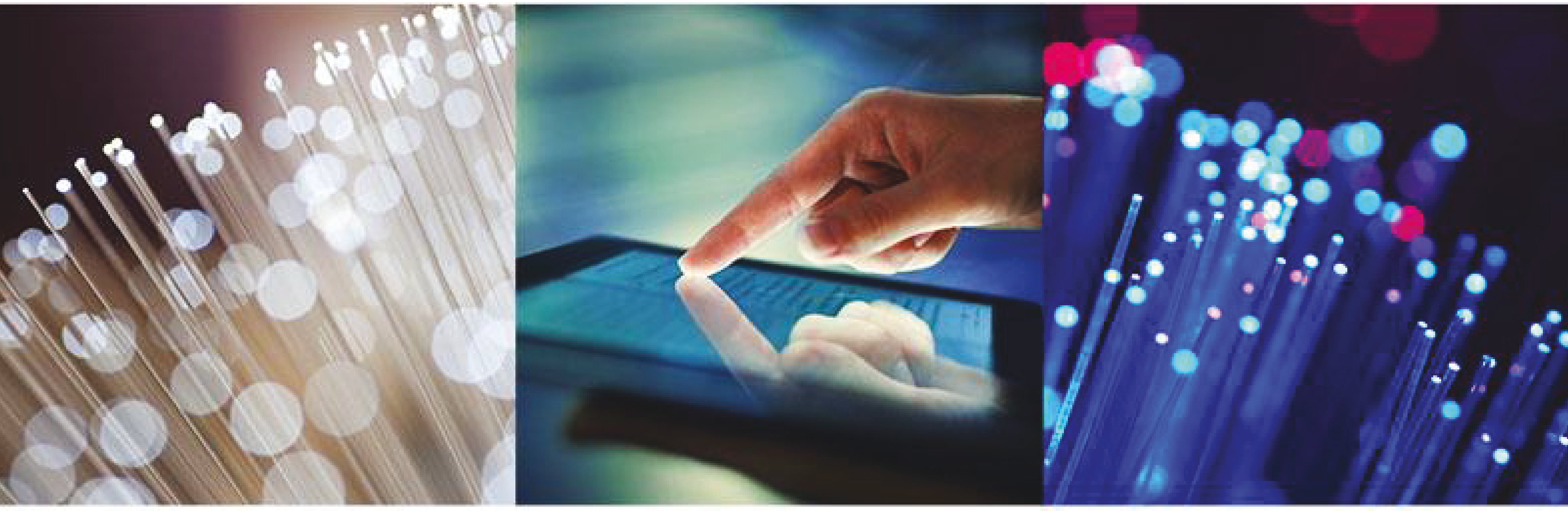

Table of Contents

1. Introduction

This workpackage researches the viability of using of Twitter data for accident and traffic incident detection. The scope includes background research, collecting and collating the social media data and conducting experiments to provide a view on the value and feasibility of using Twitter information in road traffic applications.

This report describes work done between January and March 2014, followed by a brief description of next steps and possible future work.

2. Key Findings

The key findings of the social media analysis workpackage are summarised here, with further detail available in the remainder of the report.

- Percentage of traffic-relevant tweets is about 2-3% of all tweets on average;
- Tweets from road users offer information very immediately following an event, but these need to be filtered from a high volume of non-relevant tweets;
- In general, tweets to/from official organizations contain more information (time, location, event) and are more accurate but may be sent some time after an incident first occurs;
- It is possible to filter 'non-official' tweets to find traffic-relevant tweets with a high degree of accuracy;
- There is anecdotal evidence that traffic organisations (e.g. Highways Agency) find some unofficial tweets highly valuable (e.g. those containing images of incidents);
- Having established that relevant tweets can be successfully identified, the key next step is to evaluate their usefulness to traffic organisations, probably by developing and deploying a pilot system.

3. Work breakdown

The work was divided into a number of subtasks:

Task 1.1: Background research looking into the total number of tweets within the UK and the feasibility of collecting such tweets and the degree of accuracy. Determining the numbers/percentage of tweets that can be harvested using Twitter's APIs. Assessing the possibility of accessing all available tweets and identifying methods and techniques to achieve this if possible.

Task 1.2: Analysis of the various available methods to detect the location from the tweet content (e.g. location information can be the exact GPS coordinates if the user has enabled this; time zone information; or extracted from the tweet content using text mining techniques).

Task 1.3: Initial assessment of the number or percentage of tweets that contain traffic-relevant information.

Task 2.1: Analysis of the extent to which tweets are useful for traffic incident early detection, including collection of tweets a) around the M25; and b) along the key trunk routes in the East of England region: M11, A12, A14 and M25 (Jn2-Jn27). Including tweet count and separation of the tweets into geographic information traffic relevant and irrelevant tweets; and also geographic information traffic relevant and irrelevant tweets to selected road.

4. Analysis of available data

The main aspect of the work is to understand where (and if) there is valuable information in the twitter generated data. We examine 3 categories of tweet data:

- Official sources (e.g. the Highways Agency twitter account)
- Official sources plus their immediate followers (both to and from)
- All tweets

A Twitter harvester has been implemented by BT to gather the required tweet data for analysis. Data is being collected along the M25 (and specially M25 J2-J27), M11, A12 and A14 (starting from mid Jan 2014) by filtering tweets based on a radius of 0.1 mile from the selected roads, with each road being characterised by a set of latitude and longitude coordinate pairs at intervals along the road. Non geo-tagged tweets are thus ignored. Our analysis shows that of the tweets we harvested, approximately 24% are geo-tagged.

The percentage of traffic-relevant tweets is about 2-3% on average. In comparison, the same test done on data for the whole M25 shows 7% traffic-relevant tweets. This may be due to a higher number of traffic incidents on the M25.

Previous work by BT from earlier M25 data had generated a classifier to classify tweets into traffic-relevant and traffic-irrelevant categories. Detailed experimental information is provided in *Additional Information*

Testing collected tweets with M25 model*.* The predictive accuracy of this model was low with many noisy irrelevant tweets being wrongly classified as traffic-relevant tweets.

We also analysed the proportion of users who tweet about traffic, and results are also shown in Appendix I. In summary, about 5% of users tweet about traffic and of those users 50% of their tweets are traffic relevant.

5. Keyword extraction for tweet classification

Given the relatively low accuracy achieved by the original BT classifier, we investigated other classification techniques to determine whether more accurate detection of traffic-relevant tweets could be achieved. Specifically, the use of automatic keyword extraction using a variety of techniques and using these keywords in combination with the earlier classifier was investigated. We tested this approach against a manual (human) classification of traffic-relevant tweets and a high degree of accuracy was obtained.

Detailed information about the work can be found in *Appendix II: Experimental comparison results for automatic keyword extraction.*

In brief, our experiments have shown that our proposed classification approach ("Tweet LDA" with defined keywords set) gives an accuracy for traffic relevant tweets of approximately 90% at the expense of some loss of accuracy for non-traffic relevant tweets. This compares very favourably with other known approaches. In most real world applications, it is the accurate identification of relevant tweets that is most important (thus the loss of accuracy for non-relevant tweets is less critical).

6. Possible future work

Several routes for possible future work have been identified. Below is a list of potential tasks that can continue and build on work completed so far:

Task 2.2: Assess whether tweets detection and classification is better than other existing systems.

Task 2.3: Tweet location detection: where tweets are not automatically geo-tagged, investigate techniques for inferring the tweet location.

Task 2.4: Automatic keyword detection: the current system relies on keywords extracted manually from traffic-relevant tweets. Automatic keyword detection would be necessary to completely automatize the system.

Task 2.5: Automatic event detection (based on Task 2.1 and Task 2.3). Analyse 1 or more tweets relating to a specific event and automatically extract event time, location, duration and event summary. Also compare and correlate automatic event detection with other, more formal data sources available on Stride platform.

Task 2.6: Event severity and duration detection: automatically infer the severity of a traffic event from twitter data.

Task 2.7: Event severity analysis: determine whether the severity of the event (and the duration) is related to the number of relevant tweets and/or the words used in the tweets; compare inferred severity with actual severity from events reported in formal data sources.

Task 2.8: Tweet sentiment analysis: analysing tweets to understand user sentiment towards a given event. This task and 2.9 are more ambitious and the subject of longer term research.

Task 2.9: Event sentiment analysis: combine sentiment from multiple users (tweets) and analyse the relationship between event sentiment and other factors including, for example: event severity, time, duration, travel type (work, business, holiday, etc.), user type (gender, age, etc.).

7. Concluding Remarks & Next Steps

As general conclusion, in comparison to official channels, tweets from road users offer information more immediately following an event, but these need to be filtered from a high volume of non-relevant tweets. The number of traffic–relevant tweets is relatively low.

In general, tweets to/from official organizations are more useful: they contain more information (time, location, event), though it should be noted there are still some noisy tweets that need to be filtered out (e.g. complaints about the organization concerned). Tweets from official organizations offer better information but may be sent some time after an incident first occurs.

Our experiments have shown that it is possible to filter 'non-official' tweets to find traffic-relevant tweets with a high degree of accuracy.

However, currently, our approach relies on manually extracted keywords: that is, human intervention is required to extract the keywords occurring most frequently in traffic-relevant tweets. An important next step is thus combining *automatic* keyword extraction with our classification system. Other proposed future tasks are discussed in detail above.

Notwithstanding the proposed next steps, we have created a tweet filter that can deliver a stream of traffic-relevant tweets to be used in an application. Any such application should then be evaluated with trial end-users to determine if the tweet data adds significant value.

Additional Information

1. Testing collected tweets with M25 model

Dataset

The preparation stage included the collection of the tweets and the manual tagging of those tweets. Tweets along M25 were collected by grabbing 11510 geo-location collecting points along M25, with 0.1 miles between neighbouring collecting points. Those conditions were set to ensure there were no gaps and all tweets along M25 were collected.

Figure 1. Locations along M25

Tweets were then tagged manually (half were used for training and remaining half for testing, random distribution). In total, 9709 tweets were collected. Of these, 741 were tagged as relevant, while 8968 were tagged as irrelevant.

EBTIC tagged parts of the collected tweets for testing (number of tagged tweets shown in the following tables). Tweets were tested against a model obtained from the M25. The results are shown in tables 1 to 5.

The experiments showed that positive predictive value is very low, which means although the total accuracy for both traffic relevant tweets and non-relevant tweets is reasonably good, many noisy irrelevant tweets are wrongly classified as traffic tweets. Due to the high unbalanced data, generally, one out of three tweets classified by the model is a true traffic tweet, while the remaining two tweets might mention road, location, journey (and some other noisy tweets), but not really report a traffic issue or an accident. Additionally, the reported accuracy is expected to be improved by narrowing the search range, using more accurate geo-coordinates and smaller radius, and through more diligent manual work for the geo-coordinates setting.

Table 1. M25 (J2 to J27) total tweets = 544; 3.3% are traffic relevant

	Relevant	Irrelevant	
Output Relevant	TP: 14	FP: 28	Positive predictive value = 0.333
Output Irrelevant	FN: 4	TN: 498	Negative predictive value = 0.992
	Sensitivity = 0.778	Specificity = 0.947	

Table 2. M25 total tweets = 2590; 2.9% are traffic relevant

	Relevant	Irrelevant	
Output Relevant	TP: 67	FP: 128	Positive predictive value = 0.344
Output Irrelevant	FN: 9	TN: 2386	Negative predictive value = 0.996
	Sensitivity = 0.882	Specificity = 0.949	

Table 3. M11 total tweets = 509; 2.95% are traffic relevant

	Relevant	Irrelevant	
Output Relevant	TP: 14	FP: 18	Positive predictive value = 0.434
Output Irrelevant	FN: 1	TN: 476	Negative predictive value = 0.998
	Sensitivity = 0.933	Specificity = 0.964	

Table 4. A12 total tweets = 5939; 0.56% are traffic relevant

	Relevant	Irrelevant	
Output Relevant	25	201	Positive predictive value = 0.111
Output Irrelevant	8	5705	Negative predictive value = 0.966
	Sensitivity = 0.758	Specificity = 0.966	

Table 5. A14 total tweets = 1685; 2% are traffic relevant

	Relevant	Irrelevant	
Output Relevant	30	74	Positive predictive value = 0.288
Output Irrelevant	4	1577	Negative predictive value = 0.997
	Sensitivity = 0.882	Specificity = 0.955	

By using the M25 model, most of irrelevant tweets (specifically more than 95%) can be filtered out, whilst keeping reasonably good prediction accuracy for relevant tweets, which is about 75-93% (sensitivity) for the selected road. However, accuracy can be improved by collecting more data and applying long term manual correction on the newly collected data. Note: the above accuracy is not a stable result due to the limited number of traffic-relevant tweets tested.

Twitter User Analysis

We also analysed users who tweet about traffic. The results are shown in the Table 6 and Table 7. As we draw our conclusions on the selected roads, and only use a limited number of manually tagged tweets, the reported figures only give a rough estimation about the overall situation.

Table 6: Percentage of users who tweet about traffic

Road	all_users	traffic_users	percentage
M25	1196	73	0.061037
M25(J2-J27)	280	16	0.057143
M11	270	14	0.051852
A12	1548	28	0.018088
A14	541	30	0.055453

Table 7: Percentage of traffic tweets vs. percentage of traffic tweet users

Road	Percentage of traffic tweets	Percentage of traffic users
M25	2.90%	6.1%
M25(J2-J27)	3.30%	5.7%
M11	2.95%	5.1%
A12	0.56%	1.8%
A14	2.00%	5.5%

Table 8: Percentage of users who tweet about traffic

M25-Traffic tweets per user	User number
0	1123 (93.9%)
0.5	71(5.9%)
0.666666667	1(0.084%)
0.75	1(0.084%)
M25_Traffic tweets per user	**User number**
0	264 (94.3%)
0.5	14(5%)
0.666666667	(0.71%)
M11-Traffic tweets per user	**User number**
0	256 (94.8%)
0.5	13(6.3%)
0.666666667	1(0.38%)
A12-Traffic tweets per user	**User number**
0	1520 (98.2%)
0.5	24 (1.55%)
0.666666667	3 (0.19%
0.75	1(0.065%)
A14-Traffic tweets per user	**User number**
0	511 (94.5%)
0.5	27(4.99%)
0.666666667	2(3.7%)
0.75	1(1.8%)

In summary, about 5% of users tweet about traffic incidents. The exception to this is the A12, where 1.8% of users tweet about traffic. Table 8 shows average number of tweets from each user. Only 5% of the users tweet about the traffic, and out of those only one out of two tweets is traffic relevant.

Tweets from official traffic organisations have also been collected during the same period, together with tweets from users who sent tweets to official traffic organisations. After removing re-tweets (because Twitter API automatically hides geo-coordinates for all re-tweets), 24% of tweets have geo-coordinate information (663 out of 2705 tweets).

2. Experimental comparison results for automatic keyword extraction

This experiment is based on all 9707 tagged tweets on the M25 (see the first part in 0). Half of the tweets are used as a training dataset, the remaining half are used as a testing dataset. A manually defined set of keywords was selected from the training set, with automatic keywords extraction from whole training tweet collection set (divided into relevant/irrelevant tweets). A tweet is classified as relevant ("y") if one or more keywords from list occur in the tweet content.

Thee tweet classification technique we developed was compared against three popular and widely-used word weighting methods: Bi-Normal Separation (BNS), Pointwise Mutual Information (PMI) and Naïve Bayesian, and extracted keywords from tweets with and without n-gram. All were tested on the same M25 tweets with manual tagging.

A list of the top 10 keywords (ranked by weights) for traffic relevant tweets without n-gram for each method is shown below:

BNS: *accident, gridlock, queuing, fuckin, lanes, rush, carpark, distance, 2hrs, 10mph*
PMI: *stuck, moved, traffic, avoid, standstill, jam, closed, clockwise, jams, ge2*
Naïve Bayesian: *carpark, accident, distance, 2hrs, 10mph, junc, inch, m11, m4, anticlockwise*

N-grams are not listed. Keyword extraction with n-gram does not work well due to the fact that there are too many patterns of word combinations (as n-gram), and a long list of words is needed to obtain enough information to cover all needed keywords (with n-gram keywords).

The next comparison included SVM on top of automatic keywords extraction. Unfortunately, SVM does not cope well when too many keywords are used as input (a high dimensionality problem); the processing time increases significantly. Therefore, we only use the word weighting methods without n-grams for automatic keyword extraction and the following SVM classification.

Generating Keywords Set

The top 50 keywords (ranked by word weights) acquired through the previously mentioned word weighting schemes obtained good classification accuracy by using pure key word filtering without any further processing such as SVM. Experiments using different numbers of top keywords were made, including tests using selection of n-grams. Experiments have shown that BNS and NB perform similarly, while PMI yielded lowest results. Best classification accuracy was achieved using 100 keywords (50 from relevant set, and 50 from irrelevant set). Therefore, we use the 50 top relevant keywords[1] in the following experiments and discussions.

Using Keyword Filtering Methods

Performance was compared with the manually defined keywords set, as shown in Table 9. Both BSN and Naïve Bayesian attain on average approximately 86.5% accuracy for traffic relevant tweets and 97.1% for non-relevant tweets. Other than PMI, overall accuracy is about 96.3% (calculation based on the total number of tweets). When the manually defined keywords set was used, a very high accuracy in traffic relevant tweets was found, but this was at the expense of loss of accuracy for non-relevant tweets. The manually defined keywords aim at identifying as many traffic relevant tweets

[1] keywords from irrelevant set include free text and have no contribution in the SVM stage

which introduces error to the other category of non-traffic relevant tweets. Therefore, all possible keywords which are potentially relevant are defined as “key words”.

Table 9. Accuracy for pure filtering with 50 top keywords by the word weighting method

Method	Relevant	Irrelevant	Overall
PMI	0.674	0.962	0.938
BNS	0.865	0.971	0.963
Naïve Bayesian	0.865	0.971	0.963
Manually defined keywords	0.948	0.929	0.931

Using Keyword Filtering with SVM

The 50 top keywords obtained from the above keyword extraction schemes were then applied as keywords to SVM. The result is shown in Table 10. The accuracy for SVM is highly depended on the selected keywords set (the keyword set is required for SVM to work). The use of SVM improved the overall accuracy but, as expected, this did not improve accuracy for traffic relevant tweets (by using SVM on top of the above keyword extraction scheme). SVM is a very good classification method for numerical problems (and classification with long documents, i.e., the same key words occur many times in the same article) which aim to optimise the overall accuracy numerically. However when SVM is applied to tweets, as almost all specified keyword only occurs once (if occur at all) in each tweet, the problem becomes a binary one rather than a numerical one; the SVM aims to optimise the overall accuracy numerically, so overall accuracy is improved by decreasing the accuracy for relevant tweets.

Table 10. Accuracy for SVM using 50 top keywords by the word weighting method

Method	Relevant	Irrelevant	Overall
SVM with PMI	0.572	0.986	0.953
SVM with BNS	0.796	0.983	0.968
SVM with Naïve Bayesian	0.796	0.983	0.968
SVM with Manually defined keywords	0.804	0.984	0.973
SVM by using LDA top 50 words	0.532	0.993	0.958

Using Keywords Extraction with Tweet LDA

A comparison of the proposed Tweet LDA using the manually defined keyword set and the automatically extracted keyword set is shown in Table 11. By using automatic keyword extraction (BNS and Naïve Bayesian weighting), proposed Tweet LDA has a similar overall accuracy as SVM, and performs better than SVM in accuracy for traffic relevant tweets. Accuracy for LDA without keyword filtering is 71% for traffic relevant tweets and 90% for non-traffic relevant tweets. However, SVM cannot be used for tweets classification without keywords. The same accuracy would be achieved if the keyword set for training wasn’t available, and LDA was used for classification.

Table 11. Accuracy for LDA using 50 top keywords by the word weighting method

Method	Relevant	Irrelevant	Overall
LDA with no keyword extraction	0.711	0.899	0.885
LDA with PMI	0.641	0.976	0.949
LDA with BSN	0.845	0.979	0.968
LDA with Naïve Bayesian	0.850	0.978	0.968
LDA with manually defined keywords	0.913	0.964	0.960

Our proposed Tweet LDA with defined keywords set improves the accuracy for traffic relevant tweets up to 90% (which is the best) at the expense of losing some accuracy for non-traffic relevant tweets; a requirement of many real world applications.

Summary

All experiments were undertaken on the random partition of the whole dataset, with partition chosen evenly and randomly to perform training and testing. Different training and testing random separation will result in variations in accuracy. In order to provide a fair comparison, all of the results we present are based on exactly the same training and testing separation.

3. Creating traffic alerts from three categories of tweets

The proposed system separates tweets into three categories:

A. tweets from the official traffic organisations,
B. tweets throughout UK mentioning the road name, hence possibly reporting traffic to the official traffic organisations,
C. tweets from road users instantly collected on the road.

We applied our tweet LDA to identify traffic relevant tweets for all three levels by using their respective models. The overall accuracy for categories A and B are very high. We can always get useful traffic information from tweets from official traffic organisations (marked as A). So far manual check the results marked as B traffic relevant tweets. We manually checked a sample of tweets (604 traffic relevant tweets and 311 traffic irrelevant tweets, totally 915) from all tweets including the words of “M25”, and we obtains an accuracy of 95.7% (578 out of 604) for traffic tweets and an accuracy of 92.0% (286 out of 311), which is an indication that tweets from categories A and B give a reliable traffic alert. The accuracy of category C has lower reliability (0), but it is useful to supplement instant information for traffic alert.

In conclusion, we can consider tweets marked category A and category B as highly reliable traffic alerts. The tweets marked as category C are marked by 3 levels, with C_1 as more reliable and C_3 as least reliable. We can see that the tweets from category C give instant information and are a useful supplement as a traffic alert, although there are only a few useful tweets among the many noisy tweets from the road users (as shown in Table 7).

Figure 2 shows a sample screenshot of the traffic alert tweets database from our current system, which includes tweets from categories A to C.

<table>
<tr><th>id</th><th>author</th><th>time</th><th>location</th><th>tweet</th><th>confidience</th></tr>
<tr><td>442781822087593984</td><td>Traffic_M25</td><td>2014-03-10 01:59:47</td><td></td><td>On the M25 anti-clockwise between junctions J27 an...</td><td>A</td></tr>
<tr><td>442781291889852418</td><td>OZcab1</td><td>2014-03-10 01:57:41</td><td>Epping Forest, Essex(51.65363718 0.11363259)</td><td>#m25 after J27 anticlockwise avoid! Standstill!</td><td>B</td></tr>
<tr><td>442780977962946560</td><td>M25Info</td><td>2014-03-10 01:56:26</td><td></td><td>RT @volcanoclub007: To the fools that have caused ...</td><td>B</td></tr>
<tr><td>442780211621666817</td><td>volcanoclub007</td><td>2014-03-10 01:53:23</td><td>Epping Forest, Essex(51.68627555 0.05851298)</td><td>To the fools that have caused the tailback on the ...</td><td>B</td></tr>
<tr><td>442780138842099713</td><td>alexbarker7</td><td>2014-03-10 01:53:06</td><td>Bracknell</td><td>Just what you want on a Sunday night. The m25 is a...</td><td>B</td></tr>
<tr><td>442779614851522560</td><td>twitraffic_</td><td>2014-03-10 01:51:01</td><td></td><td>Traffic Alert: M25 Anti-clockwise. Junctions: 12,...</td><td>A</td></tr>
<tr><td>442779542697299968</td><td>Traffic_East</td><td>2014-03-10 01:50:44</td><td>East of England</td><td>M25 anti clock 26-25 one lane closed due to an acc...</td><td>B</td></tr>
<tr><td>442777973494919169</td><td>Turn_burner</td><td>2014-03-10 01:44:29</td><td>Epping Forest, Essex(51.67913627 0.02834713)</td><td>They still don't open the fucking motorway</td><td>C_1</td></tr>
<tr><td>442777195640274944</td><td>M25Info</td><td>2014-03-10 01:41:24</td><td></td><td>RT @iiAylaSky: The longer I'm in this standstill t...</td><td>B</td></tr>
<tr><td>442776856752701440</td><td>twitraffic_</td><td>2014-03-10 01:40:03</td><td></td><td>@Mini_lawsy18 thank you for your traffic tweet abo...</td><td>A</td></tr>
<tr><td>442776067561246720</td><td>iiAylaSky</td><td>2014-03-10 01:36:55</td><td>Sheffield, UK</td><td>The longer I'm in this standstill traffic, the mor...</td><td>B</td></tr>
<tr><td>442775937592328193</td><td>M25Info</td><td>2014-03-10 01:36:24</td><td></td><td>RT @iiAylaSky: Damn you #M25</td><td>B</td></tr>
<tr><td>442775593755889665</td><td>iiAylaSky</td><td>2014-03-10 01:35:02</td><td>Sheffield, UK</td><td>Damn you #M25</td><td>B</td></tr>
<tr><td>442775396430659584</td><td>Skolflen</td><td>2014-03-10 01:34:15</td><td>Madrid, ES</td><td>RT @watch_weather: Eastern | M25 anti-clockwise be...</td><td>B</td></tr>
<tr><td>442775081039978498</td><td>lucykaysoprano</td><td>2014-03-10 01:33:00</td><td>Epping Forest, Essex(51.67777429 0.02687263)</td><td>Loving the traffic on my way home to notts. Not li...</td><td>C_2</td></tr>
<tr><td>442774640189247489</td><td>MelissaCoomber</td><td>2014-03-10 01:31:15</td><td>Maidstone, Kent</td><td>m25 is so shit</td><td>B</td></tr>
<tr><td>442774264320917504</td><td>Traffic_M25</td><td>2014-03-10 01:29:45</td><td></td><td>On the M25 anti-clockwise between junctions J27 an...</td><td>A</td></tr>
<tr><td>442773768478687232</td><td>Traffic_East</td><td>2014-03-10 01:27:47</td><td>East of England</td><td>Accident on the anti clock M25 26/Waltham Abbey to...</td><td>B</td></tr>
<tr><td>442773299555483648</td><td>ZFonseka</td><td>2014-03-10 01:25:55</td><td>Ipswich</td><td>On the M25, shit is gridlocked. I just want to sle...</td><td>B</td></tr>
<tr><td>442773177387982848</td><td>IBPTSFelixstowe</td><td>2014-03-10 01:25:26</td><td>Felixstowe Suffolk England</td><td>21:25 #NationalExpress Coaches 21:10 (250) Heath...</td><td>B</td></tr>
<tr><td>442772666089766912</td><td>JamesGeddes</td><td>2014-03-10 01:23:24</td><td>London, England</td><td>M25 is at a standstill. Yay for the M25 #epicfail</td><td>B</td></tr>
<tr><td>442772610258964480</td><td>motorwaytraffic</td><td>2014-03-10 01:23:11</td><td></td><td>M25 anti-clockwise between J27 and J26 | Anti-cloc...</td><td>A</td></tr>
<tr><td>442772607432019968</td><td>motorwaytraffic</td><td>2014-03-10 01:23:10</td><td></td><td>M25 anti-clockwise between J26 and J25 | Anti-cloc...</td><td>A</td></tr>
</table>

Figure 2. A sample screenshot of our current traffic alert database

4. Acquiring twitter data

Twitter claims that the twitter APIs only make a proportion of all tweets available; this is consistent with our experimental conclusion. We set up our experiment, trying to collect as many tweets as possible in the city of London (within M25 area). The initial assessment for Twitter REST API shows that not all tweets are indexed and accessible, although with careful adjustment of query parameters we expect to reach the retrieval rate of around 90-95%.

Theoretically speaking, by using twitter REST APIs, each account is able to obtain 100 tweets per query, with a maximum of 180 queries per 15 minutes, which means each account is able to obtain up to 72,000 tweets per hour. However, the experimental results show that normally we cannot achieve this maximal figure. We tried using four twitter accounts within the tweets harvester both sequentially and in parallel.

The experiment results show that parallel accounts are able to obtain more tweets, with each account arriving at more than 50,000 tweets per hour, with sets of tweets collected from different accounts containing overlapping tweets. However, by using those four accounts sequentially, we obtained about half the number of tweets with large overlap in the middle accounts (say in the case of using 4 accounts, accounts 2 & 3 show large overlap with accounts 1 & 4 respectively as well as each other). Naturally, by adjusting the time delay between queries for sequential account usage will yield more tweets, but will not necessarily resolve the overlap issue for the middle accounts.

The key finding is that the timing of the queries (for all of the accounts) needs to be adjusted to make sure that the delay between 2 sequential queries for each account is exactly 5 seconds to maximise the query efficiency, coming to total of 180 queries for every 15 minutes.

After maximising the query efficiency per account, a parallel experiment was completed by adding more accounts until there were no more unique (or significant) tweets, i.e. adding one more account makes no difference as almost all tweets obtained by the additional account overlap with at least one of pervious accounts.

Offices worldwide

Appendix E: Communications To/From Vehicles

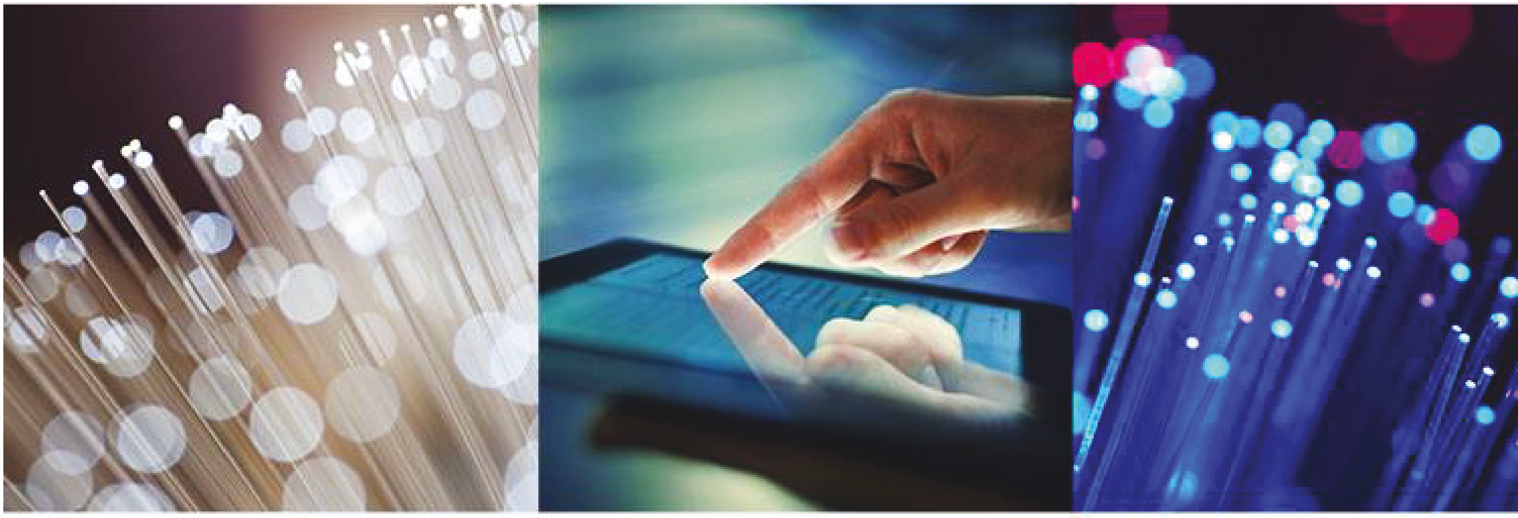

Table of Contents

1. Executive Summary

BACKGROUND

- Strategic HA managed roads are "sensored", but these are expensive to install and maintain.
- Non HA roads (managed by Local Authorities) are hardly sensored at all, so there is very little data, especially when traffic is diverted off HA roads.
- There are options to acquire data from devices such as satellite navigation systems, but these are viewed as expensive, and not available to all. They also suffer from the issue that when major events occur, cellular networks become over loaded so data connections could be lost.
- There is a desire to pilot novel ICT solutions with the aim of demonstrating it is possible to deliver an information distribution service to and from vehicles in a cost effective manner that could lead to a compelling business case to justify wider deployment on a national scale.
- This part of the project was set up to explore how ICT innovations such as smartphones, the internet of things and Machine to Machine technology can change the way in which road infrastructure is both used and managed and substantially reduce costs of information acquisition and distribution to drivers through applying new Internet of Things IT architectures.

Outputs

- Investigated how much data is needed to provide a core transport information service to and from vehicles, and the associated wireless network solution architecture.
- Developed a smartphone based application that can send and receive relevant data to and from vehicles, and a message protocol that can send this information with a limited amount of data.
- Created a demonstrator based on this application plus an information distribution component with the capability to route different information to different devices, based on the source of information or the location of a device.
- Demonstrated sending and receiving small data packets (time, location, direction and speed within 40 characters) in a moving vehicle along the A14 over TV White Space (TVWS) spectrum.
- Created a high level outline model for deployment of a network to cover Highway Agency roads with a set of assumptions about spectrum availability (bandwidth, power, duty cycle) and the availability of suitable locations for base station deployment along the HA road network that have power and backhaul capability.

FINDINGS

- Whilst such a solution has been demonstrated over TVWS, the on-going uncertainty around TVWS regulation both with respect to timing and operational parameters such as output power has meant that a number of technology suppliers are looking at other unlicensed spectrum options, such as the 458 and 868 ISM bands. Whilst they operate in a slightly different spectrum, they have many of the same characteristics as TVWS, such as long range and low power consumption.

- Trials using the current technology cannot be taken any further due to lack of equipment, as suppliers move to new equipment based on using different radio spectrum.
  Issues remain over the best choice of spectrum and wireless technology to enable such a service and more work is required to enable accurate business models to be produced. TVWS is dependent on regulations from Ofcom on output power, and the size of antenna that could be produced for vehicles. Alternative options include other unlicensed bands, specific spectrum as in the GSM-R solution for rail or general cellular data networks such as 3G and 4G.

NEXT STEPS

- Further trials could be carried out in the short term using standard cellular communications.
- Longer term opportunities still exist around new M2M protocols, and given suitable spectrum (bandwidth, transmit power and duty cycle), then such information could be sent over radio networks using unlicensed spectrum..

2. Introduction

The major strategic roads operated by the Highways Agency are well instrumented and provide a range of data about current conditions and journey times. However, this infrastructure is relatively expensive to install and maintain, and there is little data provision away from major roads, making it difficult for local authorities and drivers to understand current conditions of local roads, especially when incidents occur.

The key aim of this work is to explore whether the use of new “machine to machine” technologies, along with novel wireless connectivity solutions, could be used to demonstrate innovative ways to gather and distribute information, enabling road infrastructure owners to manage their assets more efficiently in both normal and abnormal circumstances, and for drivers to have better information relating to their journeys.

The technical work within the demonstrator was broken down into three areas:

a) An application that could run on a smartphone, combined with a suitable protocol and API so that information can be received and displayed, and also autonomously gather information about vehicle location and speed.
b) An information distribution platform to collect information from vehicles and other sources and which implements various rule sets around distribution and access to information; and to demonstrate that it is possible to develop an information distribution service that can be used by developers to create new applications.
c) Exploration of new cost effective network technologies. Research whether unlicensed spectrum, such as TV Whitespace, could be used as a cost effective means to provide a level of communication with vehicles and travelers; understand the trade-off between bandwidth and information sent and received; consider the options for economic deployment of base stations to cover all vehicles within an area with an adequate bandwidth – this includes in extreme circumstances i.e. major congestion.

3. Demonstrator Requirements

The requirements for this report and the demonstrator were broken down into several work streams:

1. Develop an application to collect and receive transport related information
    a. Be able to automatically generate information about the vehicle (speed, location, direction).
    b. Be able to display information in an easy to understand and non-distracting manner.
    c. Develop an API and protocol to pass information over a low bandwidth network to an information hub.
2. Use of low power wide area unlicensed spectrum as a cost effective means to provide communication to and from vehicles
    a. Develop a mechanism to enable a mobile phone to connect to terminals that use such a spectrum.
    b. Test coverage patterns on the Highways Agency and local council controlled roads around Ipswich from base stations at Kirton, Martlesham, and Belstead.
3. Develop an information service with a process model that demonstrates collection of data and how this can be shared with a data hub and then onwards to a range of devices. Demonstrate receiving messages from a variety of sources, including in-vehicle devices, to an Information Distribution platform and onward display of these messages to different devices depending on the rule set within the Information Distribution platform.
    i. Demonstrate that trusted information can be distributed to all interested parties.
    ii. Demonstrate that vehicle generated data can be distributed to specific other vehicles.
    iii. Demonstrate that private data, such as from the emergency services, can be sent to the hub but only shared with other parties that have the relevant access permissions to that data.
4. Build a concept demonstrator to show how a trial application could work with an Information Distribution architecture.
    a. Ability to demonstrate in a stand-alone environment using local connectivity (Wi-Fi).
    b. Demonstrate working on a road using TVWS.
5. Develop an outline architecture and model for a national system covering highways agency and local authority managed roads (bandwidth and coverage requirements, number of base stations etc.).

4. Machine to Machine Technologies

Machine to Machine (M2M) technologies cover the broad area of connecting devices and sensors to a network, which then operate without human intervention. This could be uplink only (such as a sensor sending data from a fire alarm to a back end server) or include a downlink (to an actuator or something that carries out actions, such as automatic fire extinguishers). There are many analyst reports about the expected huge number of connected devices (expected to be measured in billions), which leads to some general characteristics that distinguish machine to machine networks from traditional communication networks, the key ones being:

1. Large number of nodes (sensors, actuators)
2. Each generates small amounts of data
3. Autonomous operation

4. Energy efficient (run off battery for several years)
5. Good coverage (long range and in building)
6. Global standard
7. Cost effective (low £ per year for connectivity)
8. Small latency acceptable (few seconds)

M2M devices will be used for an enormous variety of applications with different communications requirements. However, connecting all the potential end devices, wherever they may be, is a significant engineering challenge. These devices will be spread across a wide variety of locations, some of which will be hard to reach – either because they are remote and outside the range of most communications networks, or because they are underground or deep inside buildings. There isn't one single technology that can connect all of these devices and current applications use a patchwork of different approaches. However, new solutions are emerging that are designed specifically for M2M and one of the innovative aspects of the trial was to look at using unlicensed low power spectrum in the sub 1GHz band, as this should have the long range and low cost characteristics required for several use cases.

Figure 1 shows how the different wireless technologies compare to each other for data rate and transmission range. This report focusses on the bottom right portion – long range and low data rate.

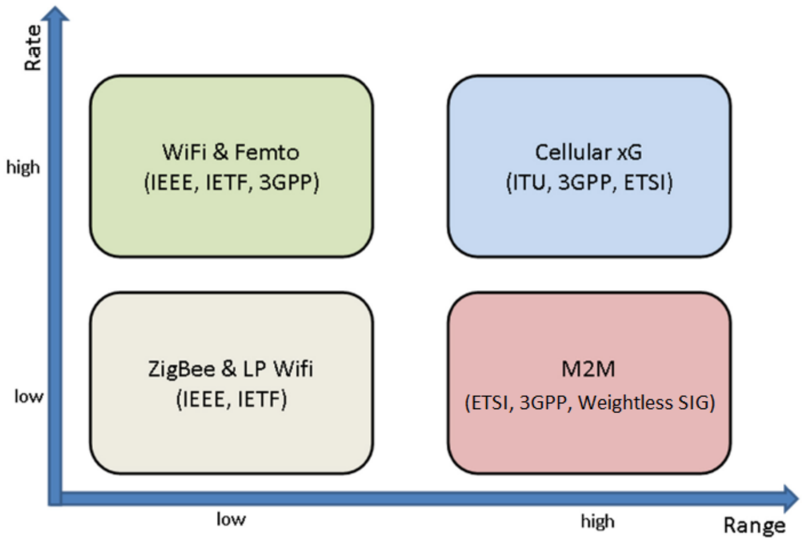

Figure 1: Wireless Taxonomy

5. TV White Space (TVWS)

TV White Spaces are gaps left between broadcast channels in different places on different channels and are not being used for the delivery of digital terrestrial television services in a given geographic area. Usually, the white spaces have only been used by wireless microphones (for Program Making and Special Events, referred to as PMSE), on a licensed basis.

TVWS has the following characteristics that make it favourable for M2M system:

- Good propagation of radio waves in UHF band.

- Deep penetration inside buildings (1<GHz).
- Globally harmonised (allow devices to roam internationally and for economies of scale).

Figure 2 illustrates the opportunities for shared spectrum in TVWS between 470 MHz and 790MHz.

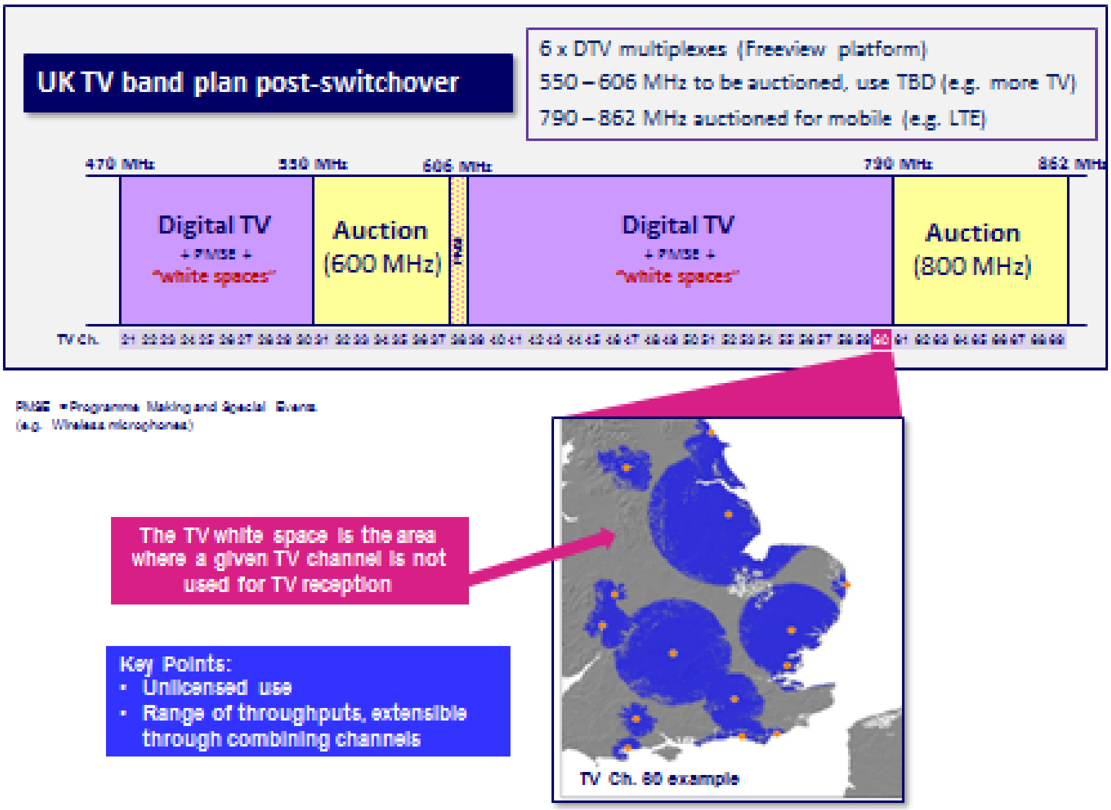

Figure 2: Overview of TVWS

5.1. Weightless: a new radio protocol designed for M2M

Weightless has been created as a protocol to meet requirements of M2M, as there was a lack of suitable standards, and as explained above, M2M solutions are different from existing technologies both technically and commercially.

The key requirements that drove the creation of Weightless were:

- Ultra-low cost: <$10 modules reducing to <$5 in a few years
- Excellent coverage: Up to 10km with 1W BS and ~40mW terminals
- Long battery life: 20-40uA average from 2xAA batteries implying >5 years

- QoS: Bi-directional communication link, with ACK/NACK
- Scalable: Lightweight and high availability
- Data rate: Few Kbits/s

5.2. Regulatory Environment

The extent of protection afforded to existing licensees is unknown, which will impact both the amount of spectrum available and also the output power levels that transmitters can use. The proposed UK regulatory environment will be based on a database containing allowed channels and power levels for every location in the UK (based on a 100m square). Any given white space transmitter will need to consult this database and will receive back information on available frequencies and powers which are available for use, as shown below.

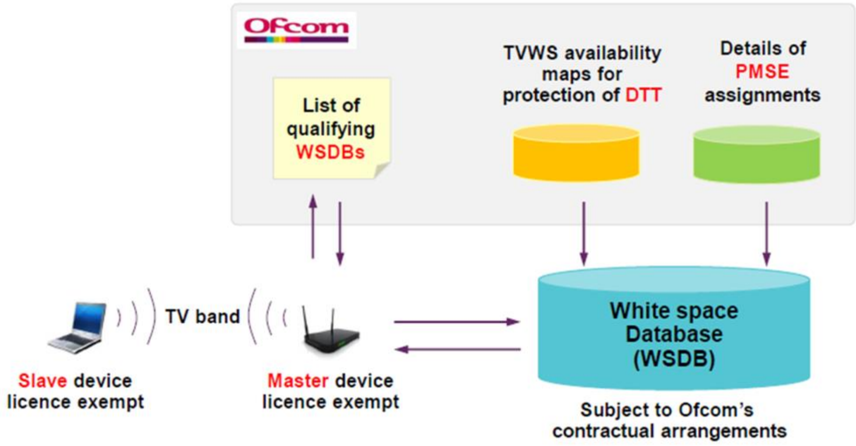

Figure 3: Framework for access to TVWS in the UK

5.3. Outstanding issues

There are a few outstanding issues in relation to TVWS

- Regulatory Environment: Timing – the timetable for regulation of TVWS has been delayed and is still uncertain
- The spectral range of TVWS impacts the practical deployments, in that power amplifiers that operate across the band are relatively expensive, and a large antenna is needed for tuning across the entire band, impacting size and cost of terminal equipment
- There are no QoS guarantees in unlicensed spectrum
- Limited number of vendors (chipsets, base stations and terminals)
- Weightless has not yet been endorsed by standard bodies (IEEE, ETSI, etc.)

Whilst this section has focussed on TVWS, there are other unlicensed bands available that offer similar coverage characteristics that can also be used.

5.4. Future work

There is still a large degree of uncertainty around the best radio solution to use. This can be split into the protocol and then spectrum. Weightless appears to be a suitable protocol for M2M, has a reasonable number of application developers in the SIG, but is lacking in terms of major industry players support for chips and devices, as well as issues over real world coverage ranges, size of antenna needed at the terminals and cost of power amplifiers.

There is also the issue of spectrum. Under the current proposed Ofcom regulations, the need for a terminal to tune over the whole spectrum range of TVWS (490MHz to 780MHz) is the cause of the antenna and power amplifier issues, and the expected allowed level of transmit power may cause coverage issues (low transmit power = less coverage).

It may be worth exploring other wireless solutions and potential spectrum options, such as:

a) Dedicated channels from current TVWS spectrum being allocated for M2M use.
b) Using other unlicenced bands and modifying existing regulations (such as raising duty cycle from 2.5% to 10% for ISM bands).
c) Exploring other industry initiatives, such as DASH7 or Low power Wifi (802.11ah) or other potential suppliers of long range wireless networks suitable for M2M, such as Sigfox, SilverSpring or Onramp to determine whether they could provide variants suitable for moving vehicles.
d) Option to transition Weightless from TVWS to other unlicensed or licenced spectrum if needed, e.g. when 700MHz auctioned, or as a licensed shared user of military spectrum.
e) Use of existing cellular data.

Further work is required to explore these options to understand the impact on technical operation of the application proposed, and impact on business model (cost and number of base stations, coverage patterns and bandwidth required, cost of terminal devices).

6. Demonstrator application for vehicle information

The application developed built upon existing work from the STRIDE[1] project. A demonstrator was built to show various features such as

1. Distribution of information to devices in vehicles.
2. Ability to control what information is distributed to which devices.
3. Display of information to driver in a useable non-intrusive manner.
4. Collation of data from devices in vehicles.
5. Ability for drivers to easily input simple information.

The example application was built to be independent of the underlying network connectivity. For the demonstrator, Wi-Fi is used to provide local connectivity between devices. There are a number of devices needed for the demonstrator:

a. A PC acting as the Information hub to collect and distribute information. The PC has a Wi-Fi access point to which all other devices connect.

[1] http://www.stride-project.com

b. A Nexus 10 tablet, acting as a graphical interface onto the Information distribution platform.
c. A Nexus 7 tablet, acting as the National Operations Centre to provide trusted information.
d. A Nexus 7 tablet, acting as an example Highways Agency gantry sign to display the information.
e. Two Nexus 4 phones, acting as two vehicles, to demonstrate information generated by a vehicle and the ability to send information to a vehicle but not to a gantry sign.

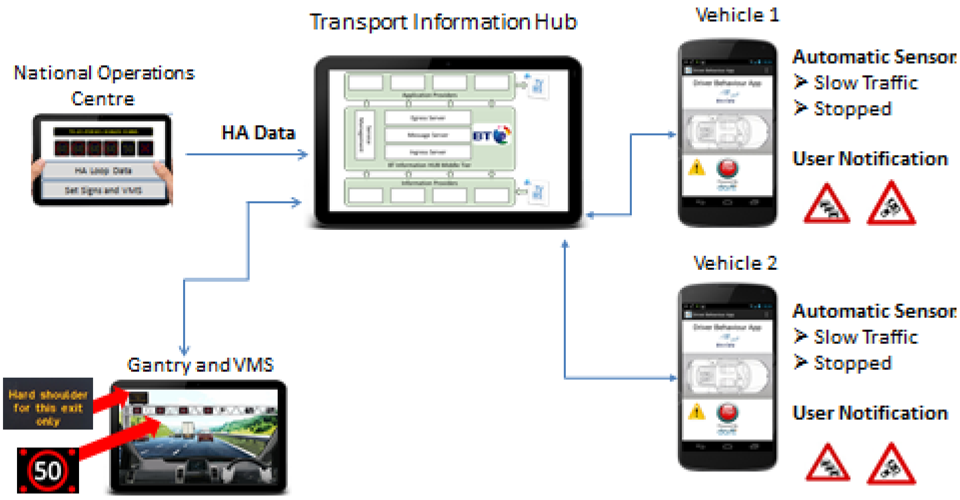

Figure 4: Overview of demonstrator devices

The Transport information Hub emulates the Information Distribution Platfrom built in the STRIDE project. It displays all messages received from the various sources, and carries out simple information routing rule sets. For the demonstrator, three rule sets were implemented. Firstly, information from the National Operations Centre was sent to gantry signs and all vehciles as this was viewed as a trusted source. Secondly, information from a vehicle was only sent to the other vehicle (not to the gantry sign). Thirdly, information from emergency services wassent to the hub but not distributed to either the gantry signs or the vehicles.

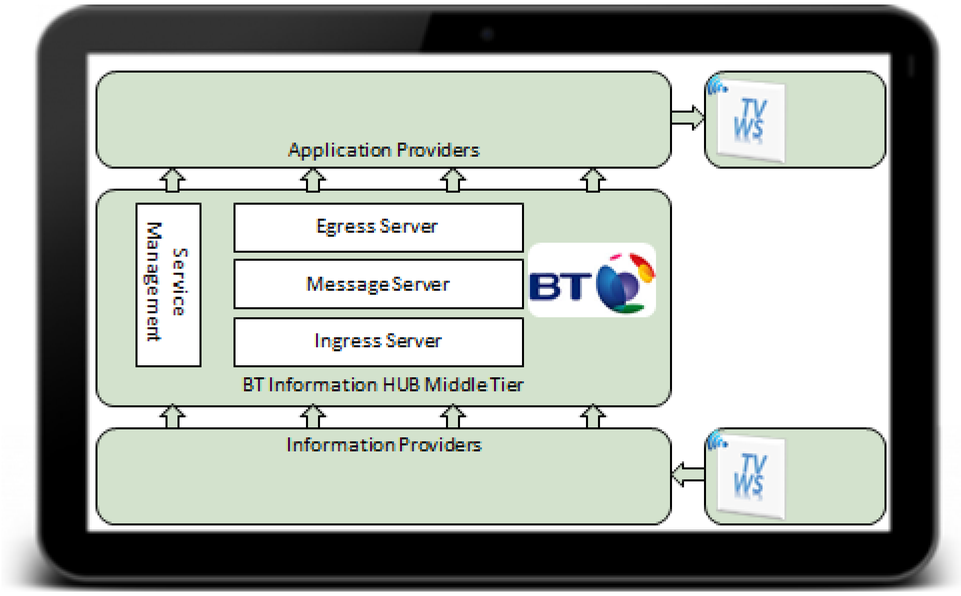

Figure5: Transport Information Hub with no information present

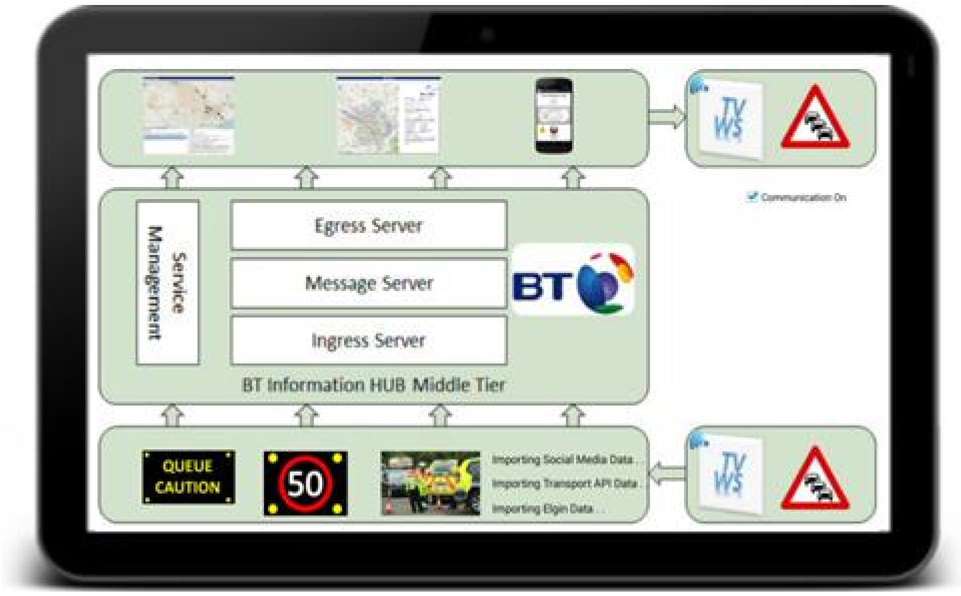

Figure 6: Transport Information Hub with a range of information sources

The tablet acting as the Operations Centre enables various standard messages to be sent to the information hub. The messages that could be sent for the demonstrator are any of the signs shown in Fig 7.

Figure 7: Information options from tablet acting as National Operations Centre

The tablet acting as a gantry then receives and displays any messages sent from the National Operations Centre tablet to the Information Hub tablet.

Figure 8: Example Gantry signs displayed

The next part of the demonstrator shows information generated by a vehicle being sent to the Information Distribution platform. For a live trial, the Driver Behaviour Application from the STRIDE project would be used to generate data from a vehicle, such as slow or stopped traffic. In order to generate messages for the demonstrator, a simple display board was constructed, using RFID tags to represent different conditions, such as free flowing, slow or stationary traffic, and also to provide simple driver responses, such as press a button to indicate an accident or queue. By touching one of the phones representing a vehicle to the appropriate RFID tag on the display board, the phone would generate a message according to the information contained within the tag and as represented by the pictures on the display board. The display board is shown in Fig 9.

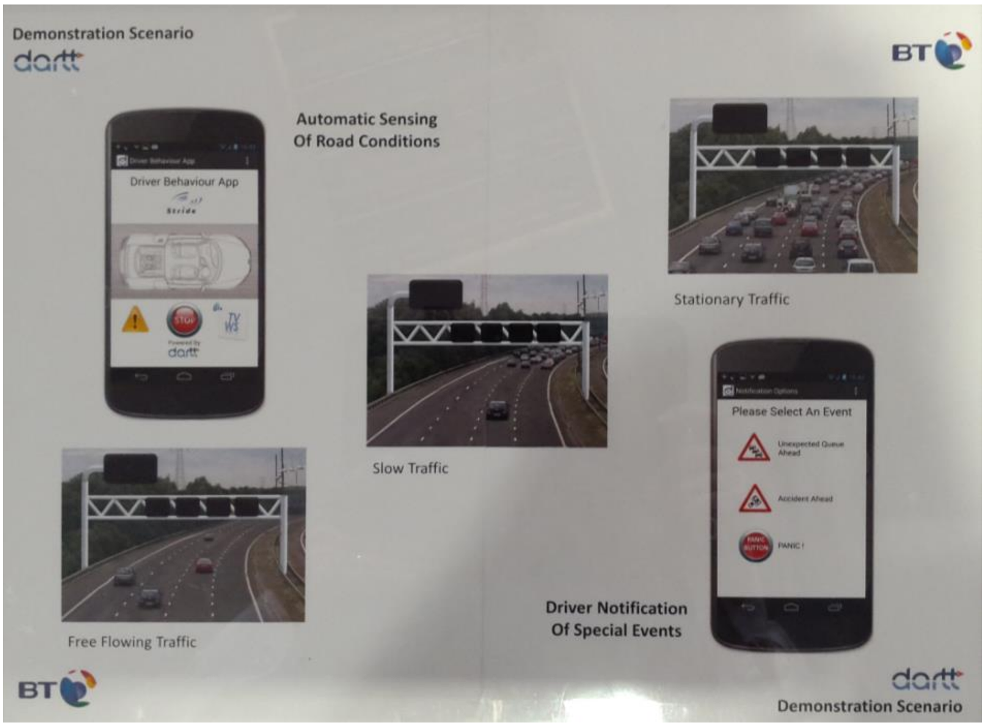

Figure 9: Display board to illustrate different road conditions

Either of the phones can be touched against the three images of roads, and this will result in an appropriate message (free flowing, slow or stationary traffic) being generated by the phone and sent to the Information hub. The rule set in the Information Hub is that this message should only be sent to the other phone, and not to the gantry.

The phone being touched to the display board will display an appropriate image (see Fig 10).

Figure 10: Example of different road conditions detected by phone

The other phone will receive the message and display an appropriate sign, and there is also a text to speech capability so that an audio representation of the message is heard by the driver, and the driver is not distracted by having to look at the screen.

Figure 11: Example of phone displaying road condition information

6.1 TV White Space coverage testing

As a second phase to the work, coverage of the TV White Space signal was measured along the A14 and A12 and various roads in Ipswich. For this, the existing STRIDE Driver behaviour application was amended to enable the GPS location, date, time, vehicle speed and direction to be sent to the Information Spine platform over TV White Space, which then responded with an acknowledgement. The total transit time for the message was also recorded as a crude measure of system coverage and reliability.

The process flow for this was as follows:

1. The phone creates a message containing GPS location, speed, direction and time.
2. This is sent over TVWS to an application where a response is generated.
3. The response, including a timestamp, is sent back to the phone over TVWS.
4. The total time taken for the message to be sent and received is then recorded, and plotted against the location when the message was received.

This is shown in the following diagrams.

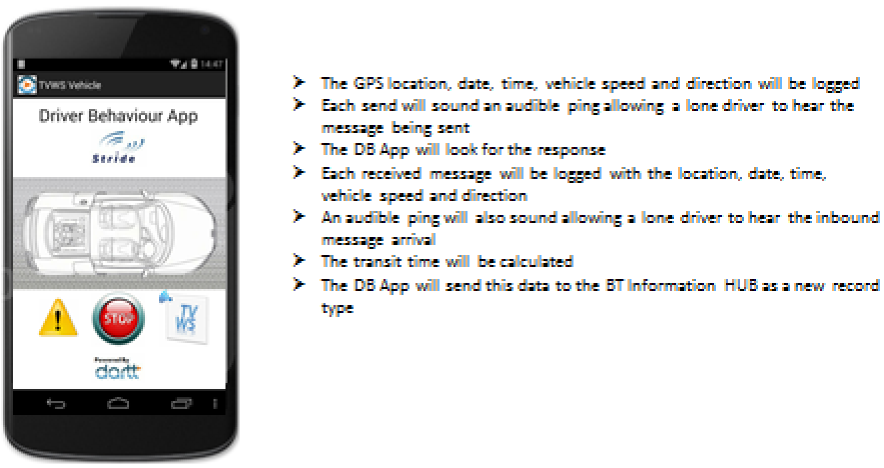

Figure 12: STRIDE Driver Behaviour Application as used to test TVWS coverage

The details of the messages transmitted are shown below.

Figure 13: Message format from phone

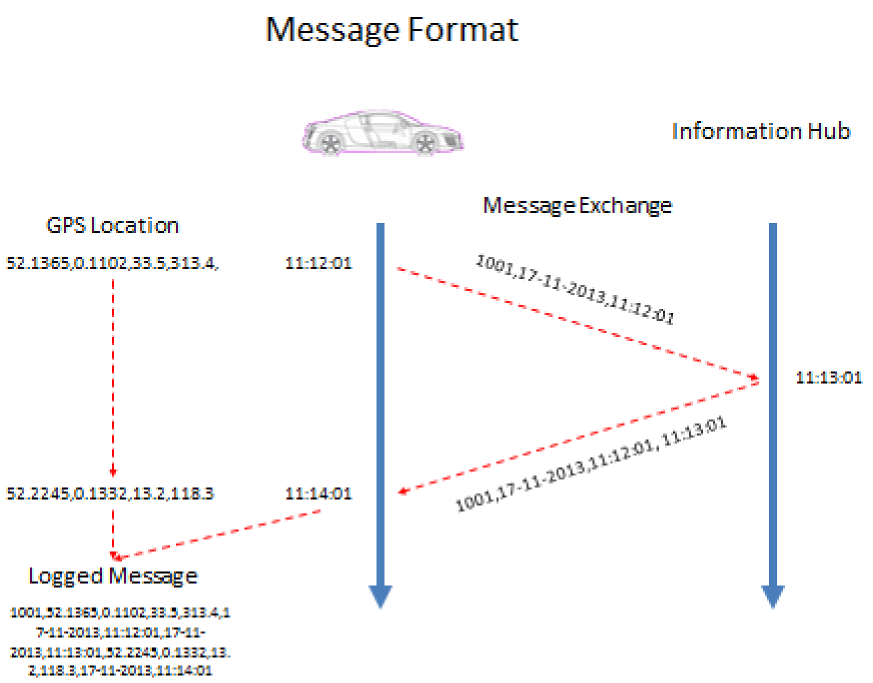

Figure 14: Overview of end to end message formats

In order to test the coverage, journeys were made around Ipswich on the A12, A14 and local roads, making use of three TVWS base stations located at Adastral, Kirton and Belstead (top right, bottom right and top left red circles in figure below). The route taken for the test is shown below, along with the location of the three base stations. Each blue arrow represents a GPS measurement.

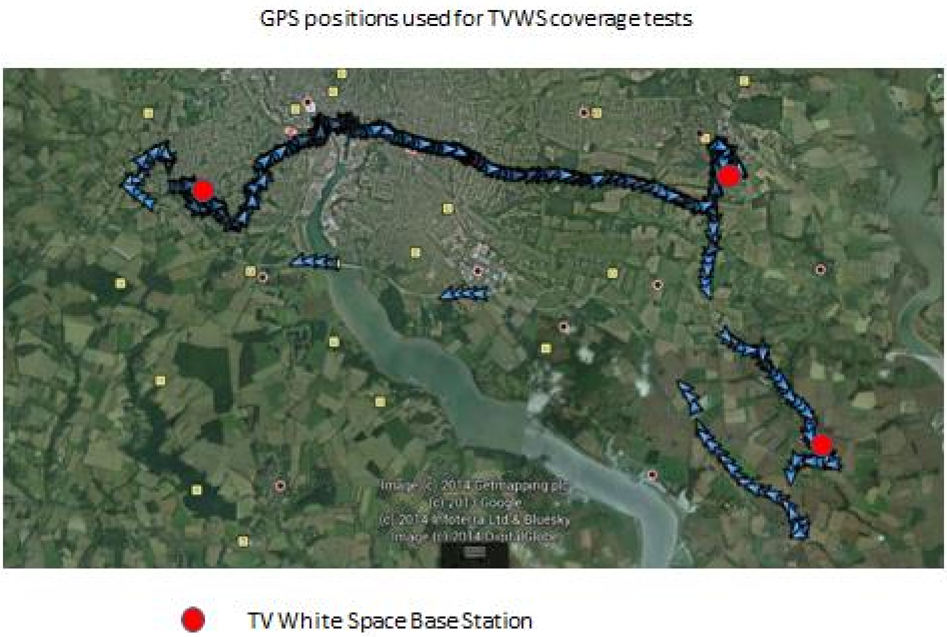

Figure 15: Coverage obtained from TVWS base station on roads around Ipswich

These GPS positions were sent using TVWS to the Information Hub, which then responded and the total time taken for the acknowledgment to be received in the vehicle was recorded, using the messaging protocol above. The delay was then colour coded depending on the length of time taken, and plotted against the original GPs positions to give an indication of coverage.

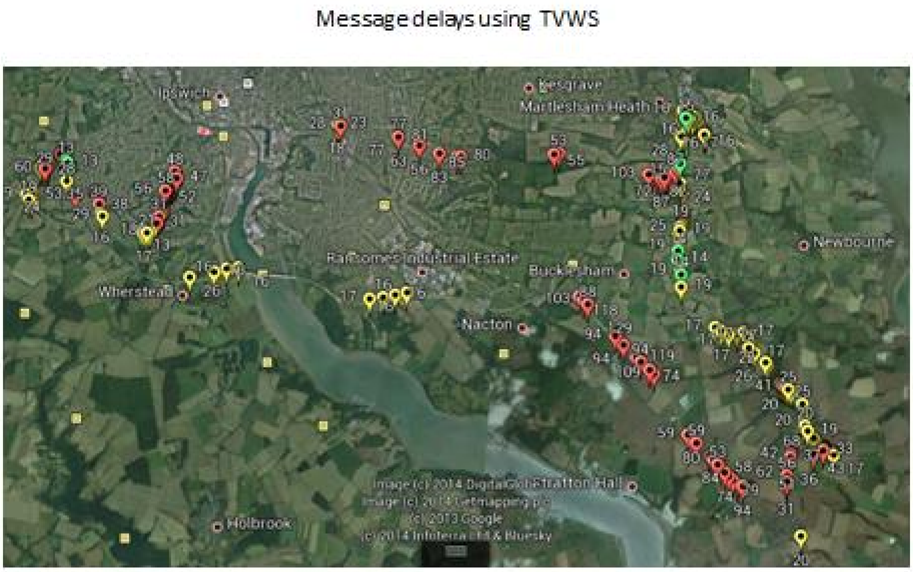

Figure 16: Overview of coverage (colour coded based on delay times)

It can be seen there are several gaps in coverage, due to:

a. Signal degradation due to local terrain (buildings, trees).
b. Time taken to handover between base stations.

c. General signal propagation loss as distance increases from base station.

7. High Level Design for national network

In order to create an outline network design, several assumptions need to made, many of which require further validation to ensure robustness. The key considerations relate to the coverage and bandwidth needed.

In terms of bandwidth, it can be assumed that within a "cone of interest" (such as Eastbound along the A14 within a 5 mile stretch), then the same information would be sent to all vehicles (e.g. queue ahead) and as such could be broadcast, so bandwidth to vehicles is not considered a major issue. In terms of information from vehicles, it is necessary to allow for messages from multiple vehicles. A worst case situation could be envisioned as a three lane motorway, with stationary traffic in both directions.

Key requirements as input to the high level design were as follows:

- Ability to collect vehicle information on position, speed, direction and time.
- Ability to broadcast sign/warning messages.
- Data requirements:
  - Individual uplink messages from vehicles every 30s.
  - Occasional broadcast downlink messages.
- Coverage of UK motorways, trunk and principal A-roads:
  - 3618km motorways
  - 8507km Trunk A-roads
  - 38235km principal A-roads

In order to translate these requirements into a capacity estimate, there is the need to make further assumptions on location and design parameters:

- Base stations located at optimal positions (e.g. bridges) with power and backhaul network available.
- Directional base station antenna.
- 6dB base station antenna gain.
- Unidirectional, compact vehicle antenna with 0dB antenna gain.
- In-vehicle loss 5dB.
- Standard path loss and Doppler models.
- Suitable clean licenced spectrum available in the <1GHz range with 200kHz bandwidth, 1W transmit power (uplink and downlink) and no duty cycle constraints.

The Uplink Link budget is the key parameter to define the overall path loss, which in turn drives the coverage patterns. Another set of assumptions are used:

- Transmit power 30dB.
- Vehicle antenna gain, 0dB.
- Base station antenna gain, 6dB.
- Base station thermal noise floor @ 200 kHz, -121dBm.
- Base station noise figure, 3dB.
- Base station sensitivity -117dB.

- Implies a maximum path loss of 153dB.

Taking these assumptions as a reasonable starting point to base a design on, a summary of the findings is that:

- Broadcast downlink payload is negligible.
- Downlink capacity for acknowledgement/security/control dominates.
- Aggregate Uplink capacity much greater than downlink.
- ~2091 base stations required for UK motorways and trunk A roads.
- ~8683 required to include principal A roads.
- More detailed geographic coverage/overlap analysis is required when details of base station installation locations would be known.

8. Use of existing cellular data networks

Even though one of the starting points for this work is that existing cellular data networks become overloaded during incidents (e.g. people in vehicles start using smart phones for various applications and use up all available bandwidth), it is instructive, and a sanity check, to carry out a high level analysis of whether such an application as described above could run over existing cellular networks, especially as any further trials in the short term would use smart phones which are already connected to such networks.

In order to estimate the amount of data that would be required to support a national service, the following assumptions were made. These are indicative only, and need to be further validated, but can be used as a rough sizing model.

For information from a vehicle (speed, location, time)

Message size (bytes)	50
Message frequency (seconds)	30
Average number of hours in use per day	3
Number of vehicles in UK	30 million
Percentage of vehicles on road at peak time	50%

If it is assumed that information sent to vehicles in 50% of the total traffic that is created by the vehicles (i.e. vehicles send twice as much data as they receive), then the total data per day to run a national service is the order of 130,000MByte. This is a single figure percentage of total data expected to be passed over cellular networks in the UK by 2018, and it is also expected that the cost of transmitting this data would be in the low millions of pounds per year.

9. Conclusions and Next Steps

Further trials could be carried out in the short term using standard cellular communications. Such trials would validate the application and back office requirements and data processing systems and features such as what information is needed from vehicles and how often, how is the information gathered and collated, what information is required to be sent to vehicles, how to define a cone of interest for a vehicle to determine what information to send, how many vehicles would need devices to make meaningful comparison against existing data on road conditions etc.

Longer term opportunities still exist around new M2M protocols, and given suitable spectrum (bandwidth, transmit power and duty cycle), then such information could be sent over radio networks using unlicensed spectrum. Assuming a TVWS or other suitable unlicensed spectrum scenario, a very high level initial analysis, assuming availability of suitable base station locations with power and backhaul network, and 200kHz of spectrum with ~1W output power in a <1GHz band, showed around 9,000 base stations would be needed for a viable future national network to support communications to and from moving vehicles across the UK road network, but further work is required to validate the assumptions and prove the model. The cost of such a network roll out is highly dependent on transmit power (the more power the larger the coverage area, hence fewer base stations) and availability of suitable sites/locations for the base stations.

Offices worldwide

A14 Incident Management Work Package 5

Final Report

Cambridgeshire County Council

20 June 2014
Final

Plan Design Enable

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Rev 1.1	Initial Draft for Review	SA	NP	JML	-	14/04/14
Rev 2.0	Final Report (Draft)	SA	NP	-	-	30/04/14
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Introduction

The A14 Incident Management Study Work Package 5 aims to set out the current extent to which the geometry and theoretical capacity of the A14 corridor can be assessed and mapped, using available data sources to understand the current usage and operational characteristics.

Executive Summary

Introduction

The A14 Incident Management Study, Work Package 5, aims to set out the current extent to which the geometry and theoretical capacity of the A14 corridor can be assessed and mapped, using available data sources to understand the current usage and operational characteristics.

Data Collection and Analysis

Data has been collated and used from a variety of different data sources including:

- Highways Agency TRADS (Traffic Flow Data System) database;
- TrafficMaster Journey Time Data;
- Cambridgeshire County Council (CCC) Accident Database;
- The Cambridge to Huntingdon 2011 Present Year Validation SATURN Model; and
- Roadworks Information provided by CCC Streetworks.

This data has been processed and has allowed analysis of the impacts of two specific incidents on the road network in 2011 and 2012. While a number of data sources are available, the data which they hold for defining the level and pattern of diversion due to an incident is limited. For example, the sample size of the TrafficMaster data on any specific incident day is comparatively small, and there is a limited number of traffic count sites that cover historical days including those of an incident. Currently, only the long-term TRADS data on the A14 and A428 is utilised in analysing flow changes due to an incident, which leaves uncertainty into the level of diversion onto other alternatives such as the A1123.

This analysis has shown that between 30% and 35% of the traffic on the A14 during an incident is either held within a queue on the A14 or diverts to the A428 corridor at Caxton Gibbet. This level of direct A428 transfer increases closer to Cambridge, indicating that there is also some diversion taking place through more minor routes between the A14 and A428, such as Elsworth, Boxworth, Knapwell and Dry Drayton. It can be seen that there is also higher flow on the A14 after an incident than is typical for that time of day, and that this is potentially representative of the level of traffic that is held in a queue on this route.

Incident Replication

A methodology to replicate the diversionary impacts of these incidents within the A14 Cambridge to Huntingdon 2011 Present Year Validation SATURN model has then been developed. Comparisons against the level of diverted traffic on to the A428 corridor and the changes in average speed from TrafficMaster data have shown that the model is able to replicate these aspects of the diversion from the sample of incidents analysed.

There remain further enhancements that can be incorporated into this modelling process to further automate the process to model incidents of different nature and also capture feedback from ongoing monitoring of new incidents and their effects.

Residual Capacity on Alternative Routes

The ability of adjacent roads in the corridor to absorb additional traffic that has been diverted from the A14 due to an incident has been analysed. A number of areas of low residual capacity have been highlighted that have the potential to exhibit increased delay if an incident occurs on the A14 and traffic diverts onto these alternative routes. These areas include:

- Ramsey Road / A1123 junction, St Ives;
- B1049 / A1123 junction;
- A1421 / A1123 junction; and
- A1198 and A428 adjacent to Caxton Gibbet.

The levels of residual capacity on key routes parallel to the corridor such as the A1198 / A428 and A1123 are restricted by these key pinchpoints. Analysis has shown that the level of available capacity on each of these routes is restricted to between 500 and 1000 PCUs per hour across the day, indicating that the primary alternative routes to the A14 would be unable to operate effectively should all of the A14 traffic attempt to divert due to an incident. This demonstrates that if a more effective methodology of communicating an incident to the public is developed and more people are able to divert, this diverted traffic is still likely to be faced with a low quality route and hence the importance that such eventualities are well managed.

There are also areas along the A14 itself which also exhibit lower levels of residual capacity and therefore are likely to have a greater impact should any incident occur on those sections that does not involve a full closure of the road – full closures will remove all residual capacity irrespective of their location.

Impact of Roadworks and Alternative Arrangements

The impact of roadworks on the County's road network during the time of the incidents that have been analysed has also been considered, and it has been determined that those present would have had little to no impact on any diversionary effects observed.

Initial analysis has highlighted that there are limited options for providing temporary or permanent alternative arrangements or infrastructure at the key pinchpoints. While improvements to specific movements could potentially be made, this would come at the detriment of other movements and road users.

Future Enhancements

A number of future enhancements and areas for further work have been proposed which include:

- Identification of how model output data may be used in the future to inform the development path and understand the metrics that should be obtained from the model;
- Modifying the model assignment through "tuning" assignment parameters to allow a better fit of observed and modelled response to incidents plus the ability to replicate incidents of a different nature and duration;
- Developing an automated assignment procedure that allows the user to select the location of the incident that they wish to model from a selection of pre-defined locations; and
- Understanding how best to capture feedback from incidents that occur on the network that can then be fed back into the assignment criteria.

Conclusions

Data has been collated to enable analysis of incidents along the A14 corridor and to allow these to be replicated within the A14 Cambridge to Huntingdon 2011 Present Year Validation SATURN model. Low sample sizes and breadth of data for specific days in the past have made it difficult to obtain a full view of all of the impacts of an incident, although the traffic model has been configured to represent the metrics that are available.

There are a number of areas along alternative routes in the corridor that have low levels of residual capacity, which indicates that even if the motorist had greater knowledge and ability to divert, the quality of the routes then available to them would not necessarily be high. It has also been noted that there are specific areas along the A14 itself that have low levels of residual capacity and therefore are likely to react more significantly to any incident along that particular length of road.

Some areas for further enhancement of the modelling process have been identified to inform the future direction of the model and its further use in helping to manage incidents in the corridor.

0. Introduction

The A14 Incident Management Study, Work Package 5 aims to set out the current extent to which the geometry and theoretical capacity of the A14 corridor can be assessed and mapped, using available data sources to understand the current usage and operational characteristics. This work package is broken down into 5 elements.

Element 1 of the study contains five objectives, as listed below.

- Identify a number of medium-to-long-distance routes in the A14 corridor (i.e. those roads that could be used as an alternative to the A14 in the event of an incident);
- Assess the capacity of these routes;
- Assess the journey time reliability of these routes;
- Use the Cambridge Highway Assignment Model (HAM) and historical incident data to examine the range of diversionary effects on partial and full closure of the A14; and
- Provide an estimate of users who actively divert during an incident compared to those who hold their original route.

Element 2 of the study focussed on analysis of the potential diversion routes, should there be an incident on the A14. The aim was to analyse the traffic model to determine under which circumstances these routes would be unable to absorb any increased traffic levels.

Element 3 looks towards the impacts of alternative arrangements that could be put in place during an incident to help mitigate increased delays on alternative routes as a result of re-routed traffic. These measures could include changes to priorities at junctions, signal timing or part-time signalisation, or allowing junctions to come under manual control from Police Officers. The model will then help to identify the impact of such a measure, of if it is viable for use.

Element 4 of the study aims to analyse the impacts that existing roadworks may have on diversions. By utilising available data sources for sample incident days, any roadworks in the area should be analysed to determine if they are like to have an impact on the diversions used by drivers, and if the model can or should account for these.

Element 5 of the model is to consider how the model can be developed in the longer term to become a dynamic and learning model that is able to accumulate feedback and use updated assumptions based upon future data that will be made available during incidents on the network.

1. Element One – Incident Analysis

1.1. Identify Alternative Routes

A number of alternative routes exist which allow traffic to avoid using the A14 when travelling between Cambridge and the area to the west of the city. The key primary routes identified as being likely diversionary routes are:

- A1123 / B1050 (north of A14);
- A1123 / A142 (longer diversion to the north); and
- A428 / A1198 (south of A14).

Once a vehicle has reached the outskirts of Cambridge there is a number of further alternative routes which could be considered for travel into central Cambridge, these can be summarised as:

- A1303 (Madingley Road);
- A1307 (Huntingdon Road);
- A14 (northern bypass); and
- M11.

The locations of these routes can be seen in Figure 1-1 below.

It is acknowledged that there will also be a degree of diversion on to more minor roads in the network; however it is not possible to accurately monitor the level of diversion on to these routes with data that is currently available. Therefore the analysis has concentrated on the primary routes listed above.

1.2. Capacity Assessment

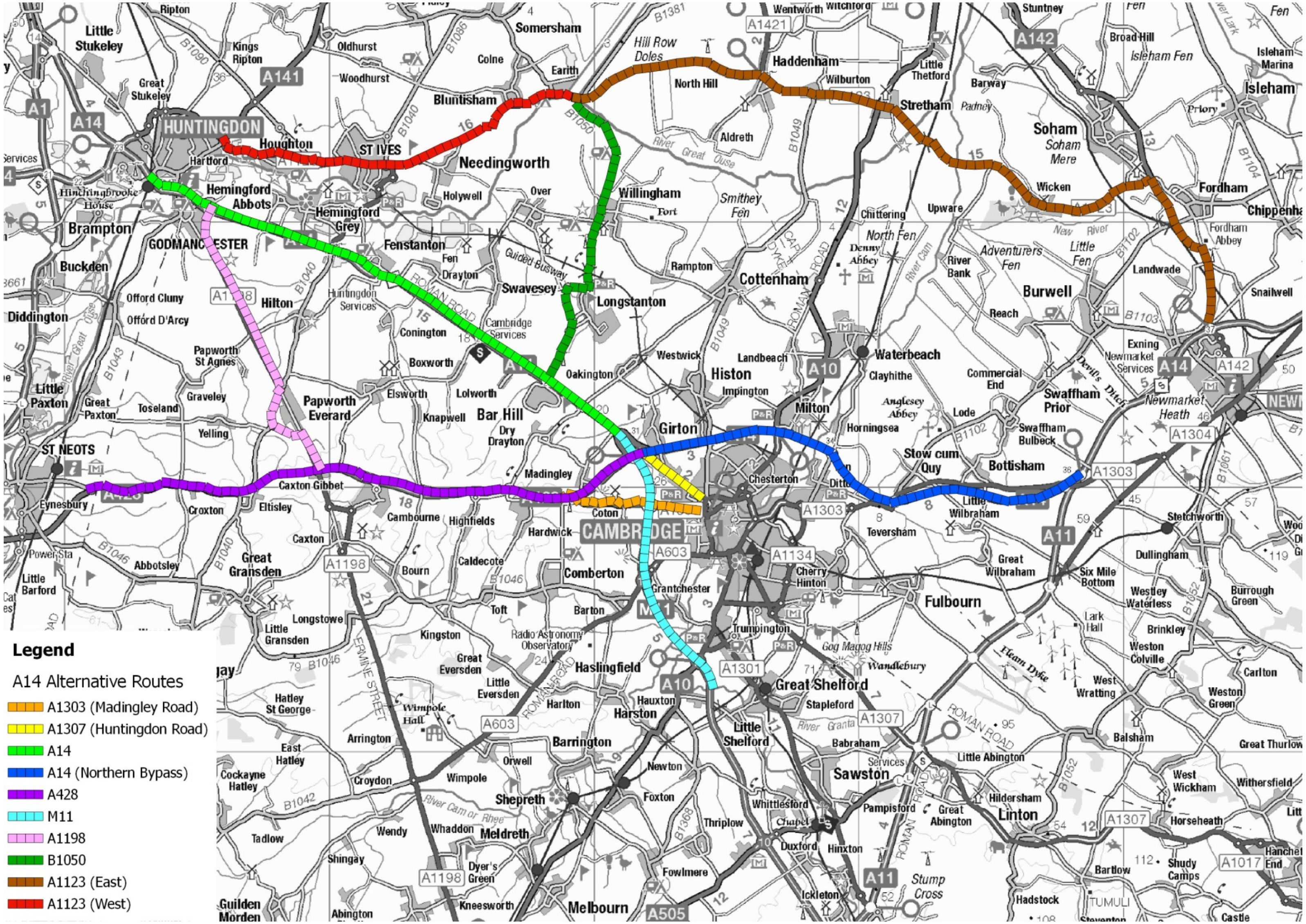
The capacities of the A14 and the primary alternative routes identified have been assessed by extracting the coded link and appropriate turn capacities within the A14 Cambridge-Huntingdon 2011 Present Year Validation SATURN model. Fluctuation of the capacity along each route can be seen in Appendix A.

Graphs to represent the capacity trends along the length of the route can be found in Appendix A. Paragraphs 1.2.1– 1.2.8 give a qualitative description of the available theoretical overall capacity of the key routes.

1.2.1. A14 between Huntingdon and Girton

Capacity along the A14 is fairly consistent, as expected, due to the consistent number of lanes within the Huntingdon to Bar Hill segment. The capacity jumps to approximately 6,000 PCUs per hour east of Bar Hill as the A14 widens to three lanes from this point in the eastbound direction. Queues are known to form on the westbound carriageway from Bar Hill in the PM peak due to the bottleneck caused by the reduction in lanes from three down to two.

Figure 1-1 A14 Alternative Routes



1.2.2. A428

Capacity on the A428 is consistently in the region of 2,000 PCUs per hour to the west of Caxton Gibbet where the A428 is single carriageway. To the east of Caxton Gibbet the A428 through to the A14 Cambridge Northern Bypass is consistently around 4,000 PCUs per hour following the road being upgraded to dual carriageway in May 2007. Access between A428 and M11 for southbound traffic is limited by the single carriageway A1303 route and the priority junction linkage to the M11 slip road at J13.

1.2.3. A1123 / B1050 – St Ives, Earith, Willingham, Longstanton to A14 at Bar Hill

Capacity along the A1123 / B1050 route is generally between 1,000 and 2,000 PCUs per hour depending on the classification of the road. One exception to this is the roundabout where the A1123 and B1050 meet where the turn capacity is less than 300 PCUs per hour going EB in the PM peak and less than 450 PCUs per hour going WB in the PM peak. This is due to the high flows on the circulatory reducing the entry capacity on the southern and western arms.

1.2.4. A1123 East / A142 – Earith, Haddenham, Stretham, Fordham to A14 at Newmarket

The capacity along the A1123 from the B1050 to the A142 is around 1000 PCUs per hour in both directions. This increases to nearer 2000 PCUs per hour on the A142 to and from the A14. The section between the A1421 and B1381 is the area of lowest capacity in both directions, while the route west of the A10 displays reduced capacity in the AM peak due to the congested roundabout operation.

1.2.5. A1198 Godmanchester to Caxton Gibbet

Capacity along the A1198 is between 1,000 and 2,000 PCUs per hour depending on the location. The entire route is single carriageway, however the classification of the road (urban, rural, narrow etc) causes the capacity to fluctuate. Graphs have not been presented for this route.

1.2.6. M11 Girton to A11 Stumps Cross

Capacity along the M11 is, again, consistent as the number of lanes does not fluctuate along the stretch within the area of interest. The entire stretch is two lanes wide in both directions and therefore the capacity is estimated to be approximately 4,000 PCUs per hour. Graphs have not been presented for this route.

1.2.7. A14 Cambridge Northern Bypass

Capacity on the northern bypass is less consistent compared to the Huntingdon section of the A14 due to the need to merge into a single lane on the northern bypass access slip road. This is demonstrated in the graphs in Appendix A. A similar pattern can be seen when travelling westbound as the use of the single lane clover leaf is required to access the A14 WB from the A14 northern bypass WB.

1.2.8. A1307 (Huntingdon Road)

Capacity on Huntingdon Road varies by direction. It is reasonably consistent travelling eastbound into Cambridge where the only change occurs where the two-lane A14 becomes the single lane A1307 and consequently the capacity reduces from 4,000 PCUs per hour to 2,000 PCUs per hour.

Travelling westbound, the numbers of lanes fluctuates more. Huntingdon Road crosses the city boundary as a single two way road at Girton Corner and then becomes a dual carriageway where it crosses the A428. It then reduces back down to a single lane where it merges with the M11 which then increases to three lanes where the M11 merges with the A14.

1.3. Journey Time Reliability

1.3.1. Residual Capacity

Part 3 of this element of the work package provides for analysis that can feed in to the potential journey time reliability of key diversionary routes. By assessing the residual capacity, those routes with limited or no residual capacity are likely to have a propensity to suffer greater delays and therefore greater fluctuation in journey time across the course of the day.

Analysis of the residual capacity and commentary on how this may relate to journey time variability can be found in section 2.

1.3.2. TrafficMaster Analysis

The variability of journey times in each of the three peak periods has been analysed using TrafficMaster data which is supplied using pre-defined 'links' of variable length depending on their location and changes in road characteristic. The data taken forwards is for non school-holiday weekdays.

Analysis has compared the peak journey time to the off-peak (uncongested) journey time, to demonstrate how the congestion of the peaks increases the journey times. Further analysis of the variability of each section of the route has been undertaken to determine the sections of the route which experience the greatest variability in journey time. The following sections describe the variability shown in the TrafficMaster data, which can be seen graphically in Appendix B. There are 54 plots showing cumulative journey times for nine key routes with three time periods, with each route being illustrated by direction. Paragraphs 1.3.2.1 to 1.3.2.8 provides a commentary to critical time periods and highlights poorer performing sections of the routes, with Figure 1-2 to Figure 1-17 showing the critical direction relating to peak traffic flow to illustrate the text..

Each graph presents the average peak and off-peak journey time along the route for the specified time period, as well as a link-by-link representation of the variability in journey time of each link (in seconds per kilometre).

1.3.2.1. A14 Cambridge to Huntingdon (Excluding the Cambridge Northern Bypass)

This section of road is known for congestion, and this can be seen in the analysis undertaken. Variability is high eastbound in the AM peak from Spittals to Bar Hill, where the additional lane reduces the variability experienced. The non-tidal westbound direction does not show such great variability.

The inter peak has limited jouney time variability in either direction.

The PM peak has lower overall variability than the AM peak, with the westbound section between Girton and Bar Hill displaying the greatest levels of variability.

Figure 1-2 A14 Cambridge to Huntingdon Eastbound Journey Time Variability – AM Peak Hour

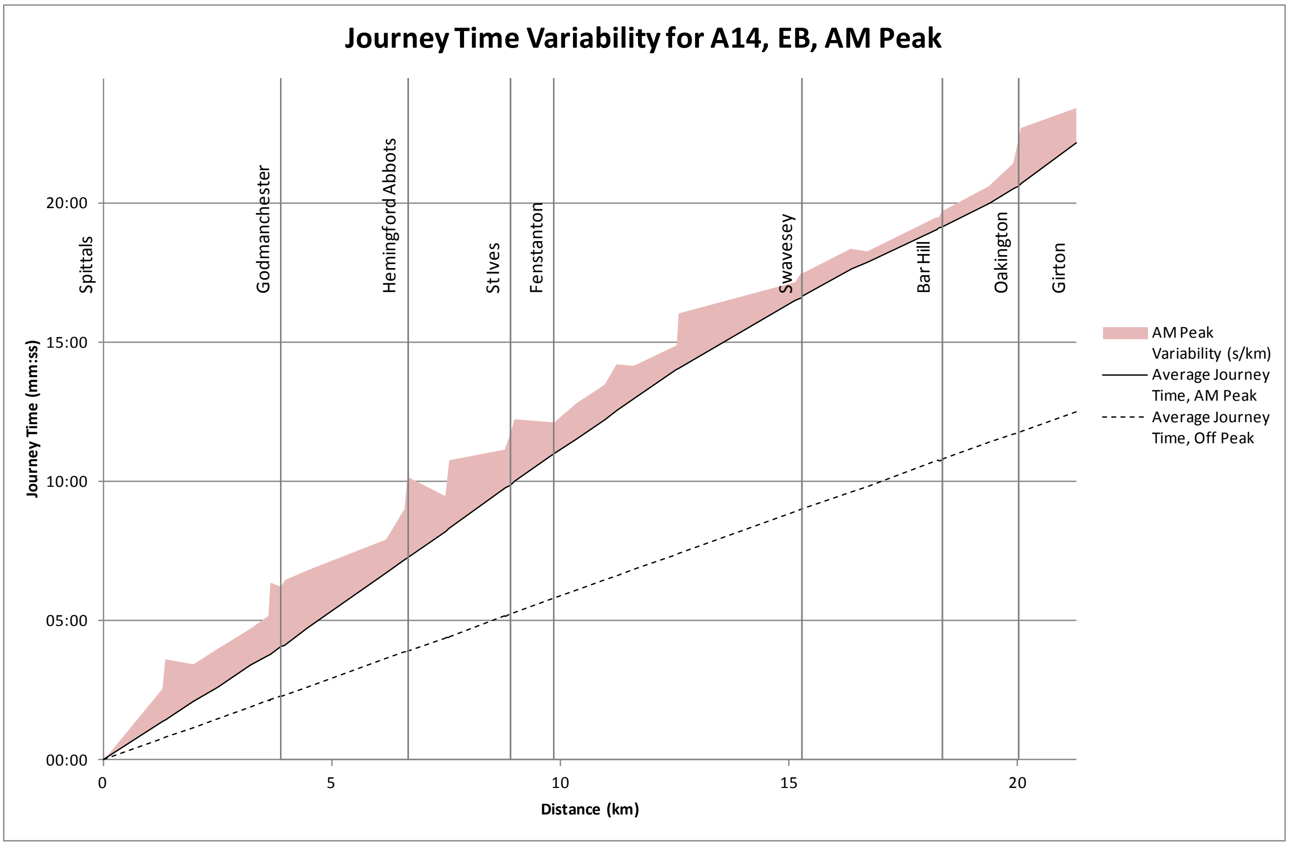
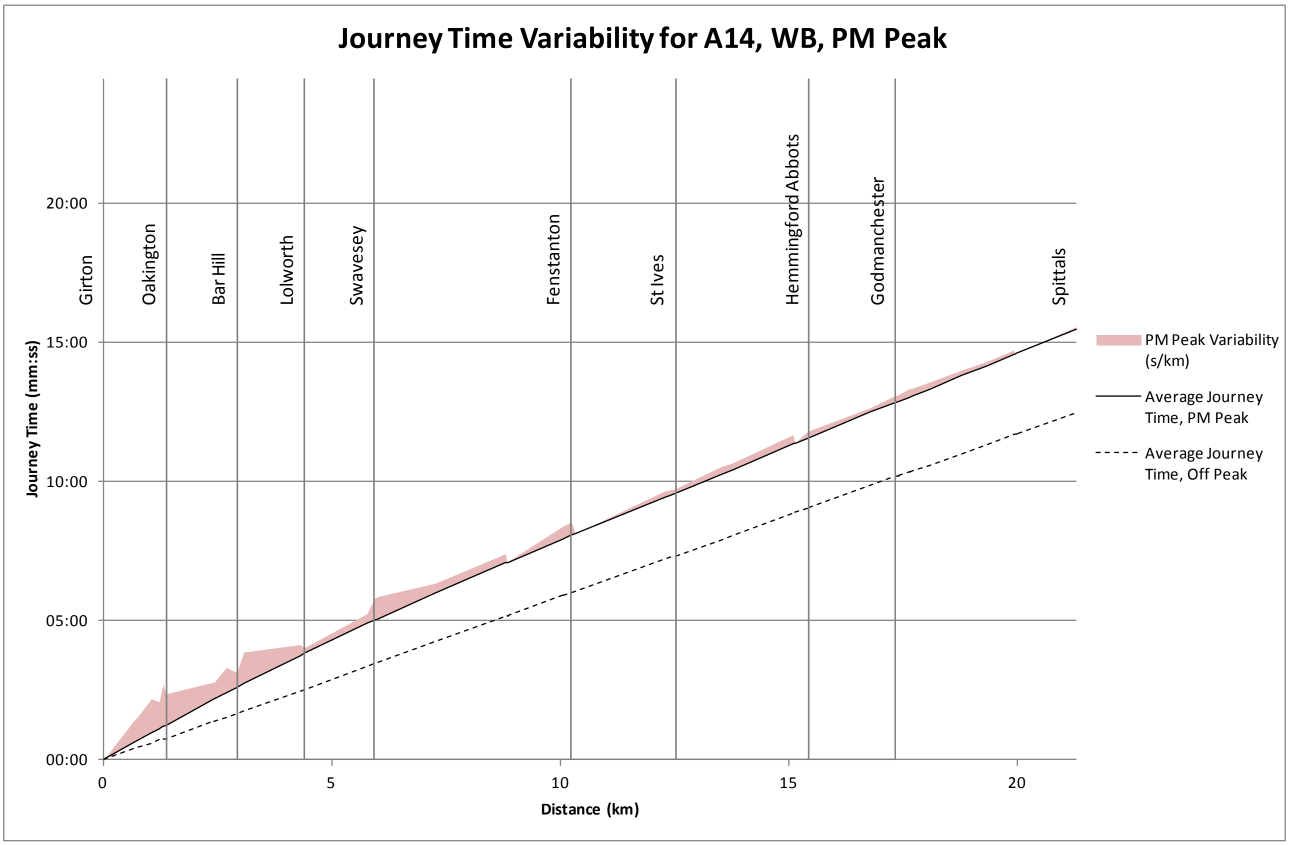


Figure 1-3 A14 Cambridge to Huntingdon Eastbound Journey Time Variability – AM Peak Hour



1.3.2.2. A428 (Both east and west of Caxton Gibbet)

As with the A14, the greatest variability is seen in the peak tidal directions. The AM peak in the eastbound direction displays high variability, particularly on the single carriageway section between the B1428 and Caxton Gibbet. There is also greater variability on the dual carriageway section from east of Hardwick towards the Girton Interchange. The Westbound direction does display some variability on the southern side of St Neots.

The inter peak displays lower levels of variability, although variability can still be seen. It should be noted however that the journey time difference between the inter peak and off peak (uncongested) time periods is minimal along the dual carriageway section.

The PM peak does show some variability, although less than the AM peak. The areas around Eltisley and Caxton Gibbet heading eastbound and Barford Road, St Neots and Caxton Gibbet in the westbound direction display the highest levels of variability on the single carriageway section. The westbound approach to the Caxton Gibbet roundabout is the area with greatest variability on the dual carriageway section.

Figure 1-4 A428 West Eastbound Journey Time Variability – AM Peak Hour

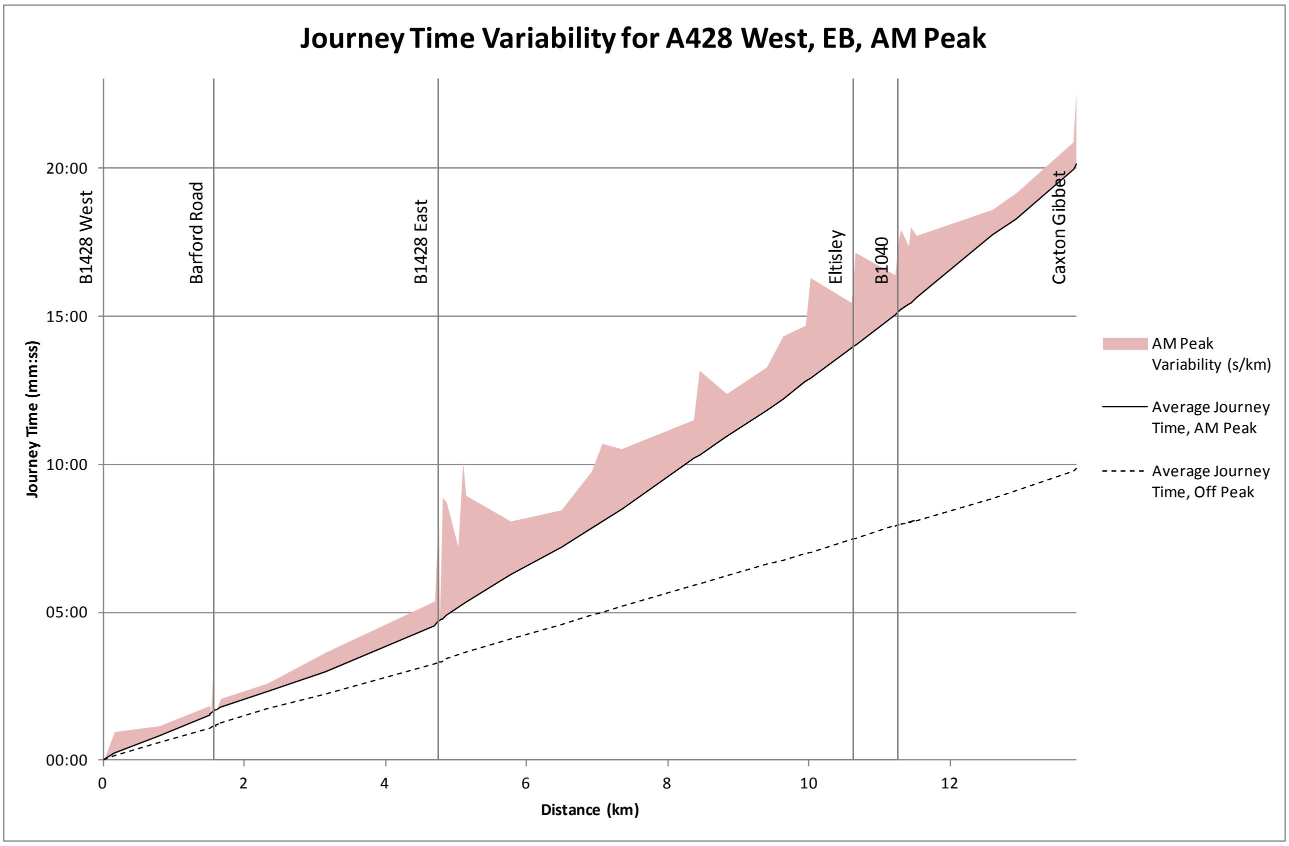


Figure 1-5 A428 East Eastbound Journey Time Variability – AM Peak Hour

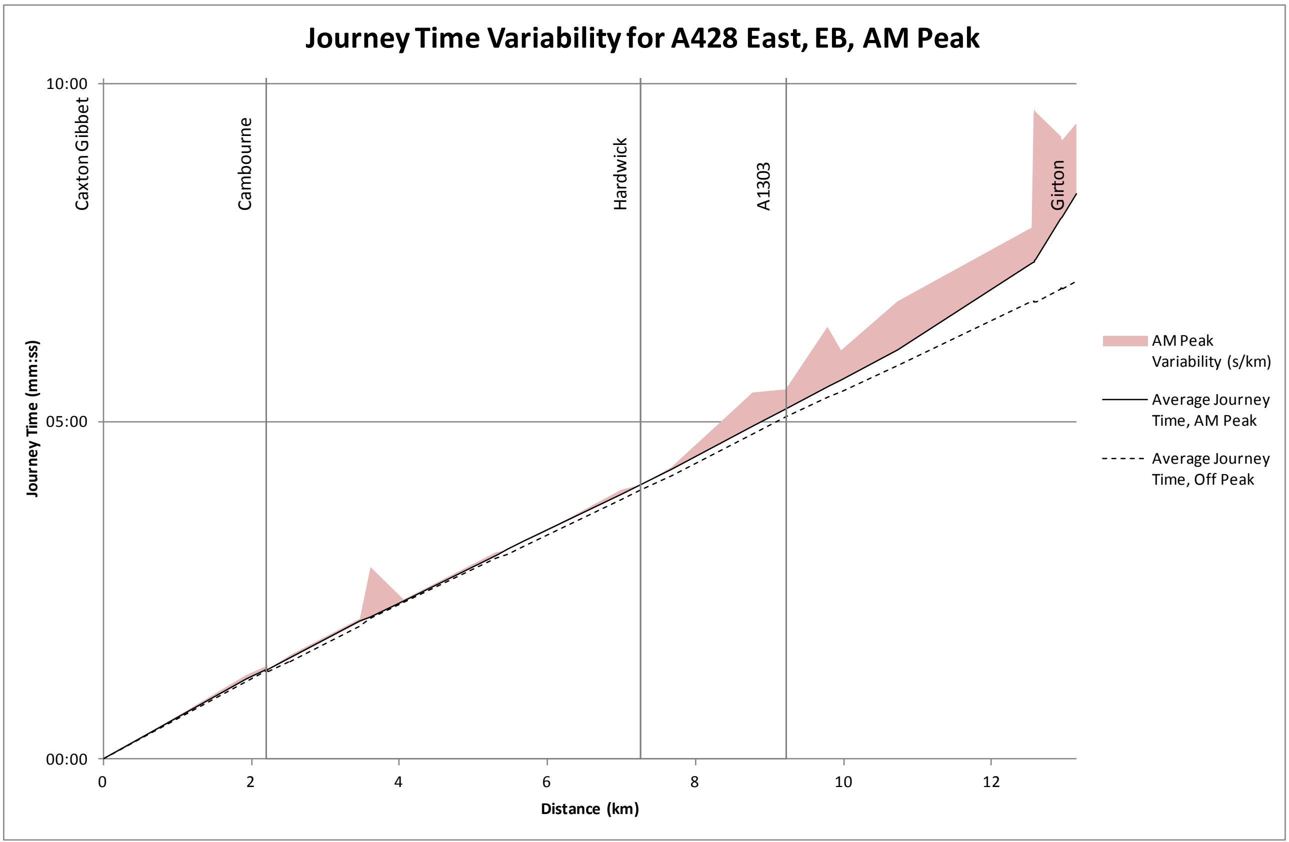


Figure 1-6 A428 West Westbound Journey Time Variability – PM Peak Hour

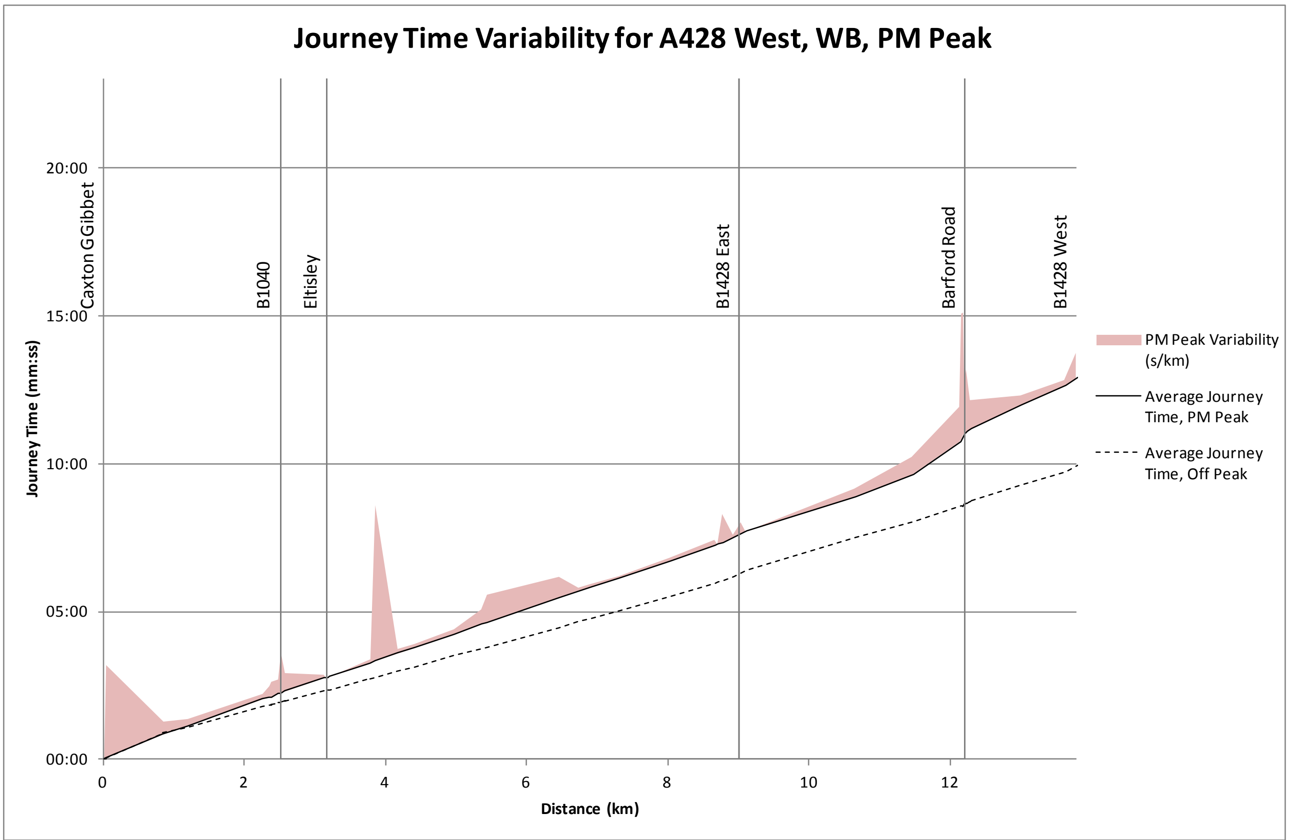
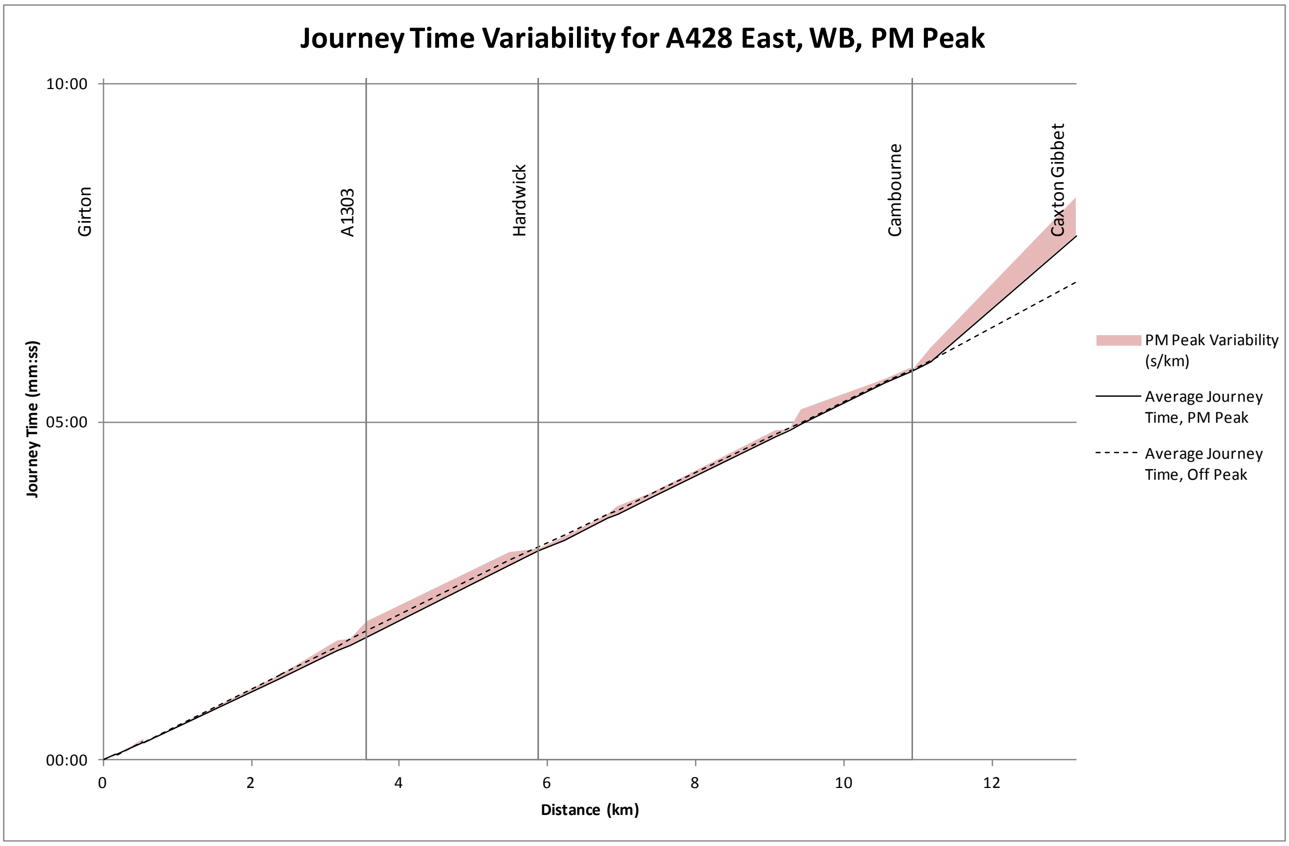


Figure 1-7 A428 East Westbound Journey Time Variability – PM Peak Hour



1.3.2.3. A1123 – St Ives to Earith

The level of variation in the eastbound direction is seen to build on the approach to St Ives, with higher levels of variation approaching Hill Rise and Ramsey Road throughout the day. The areas through Bluntisham and Earith do show some variation, although this is limited to relatively short stretches.

There is a similar pattern in the westbound direction, although the AM peak also shows higher variability to the east of Ramsey Road and the approach to the A141.

Figure 1-8 A1123 West Eastbound Journey Time Variability – AM Peak Hour

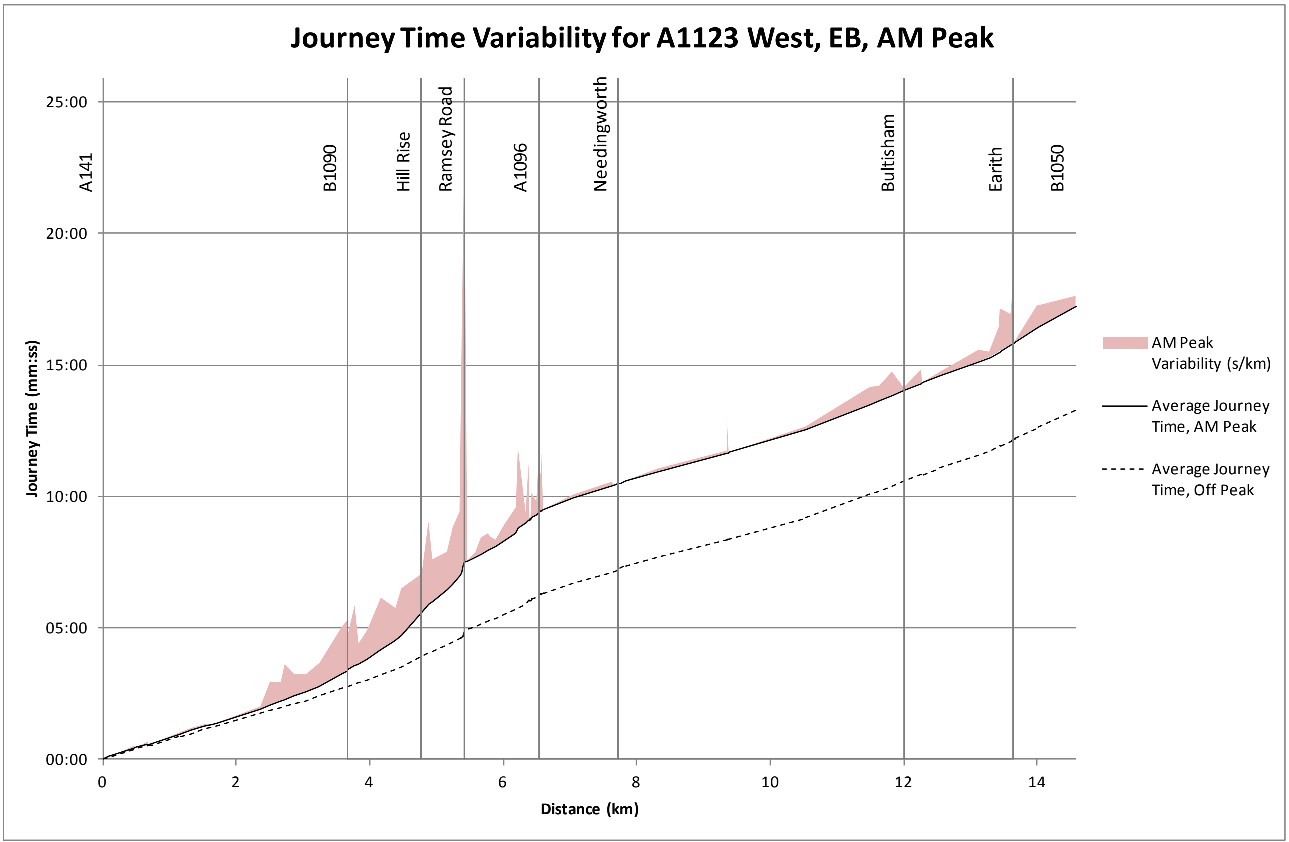
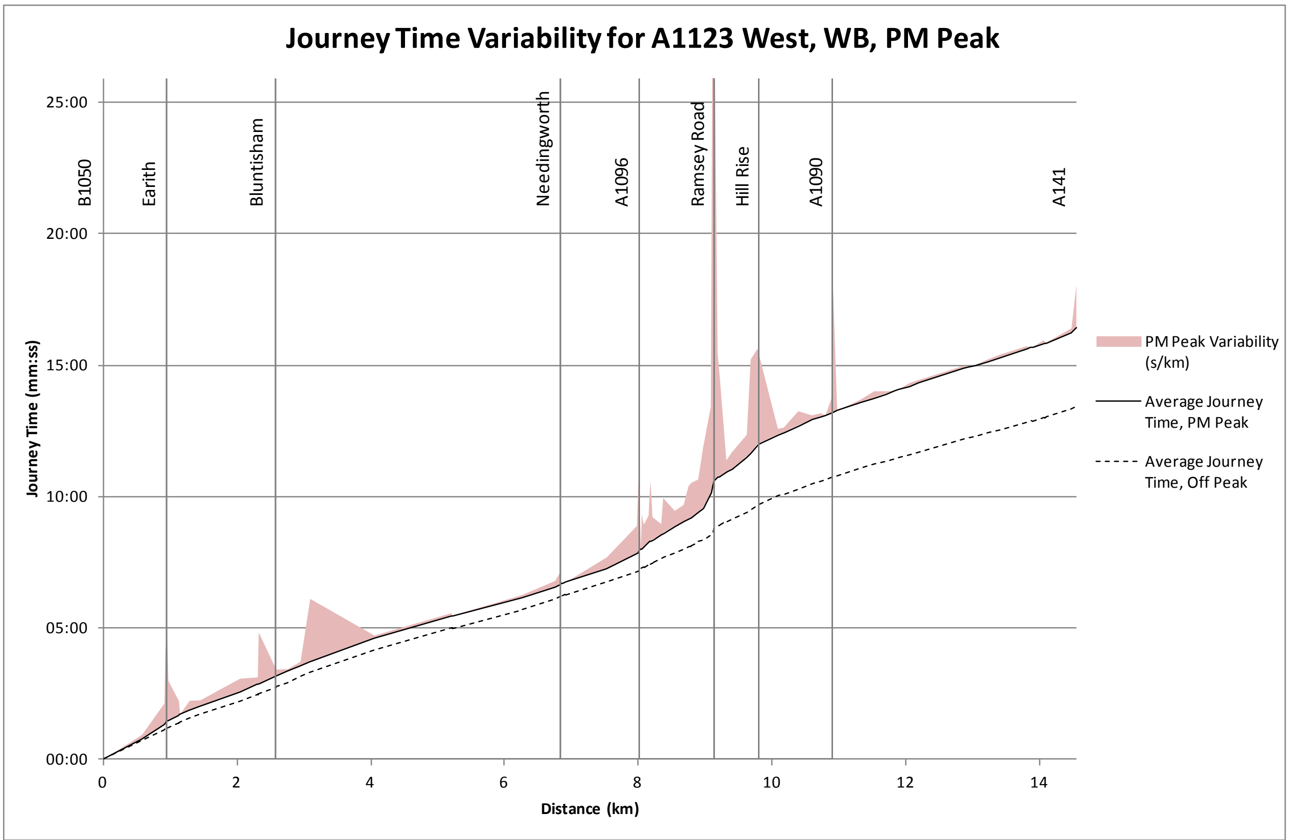


Figure 1-9 A1123 West Westbound Journey Time Variability – PM Peak Hour



1.3.2.4. B1050 – Earith to A14 at Bar Hill

Heading southbound, the highest variability in journey time can be seen on the approach to the signalised crossroads in Willingham in the AM peak. There is also some variability in the AM peak on the southern section of the Longstanton Bypass and on the approach to the A14 at Bar Hill. The inter peak and PM peak do not show the same levels of variability.

In the opposite direction, there is once again variability through Willingham, which is greatest in the PM peak. There is also evidence of increased variability on the approach to the A1123 junction in Earith.

Figure 1-10 B1050 Southbound Journey Time Variability – AM Peak Hour

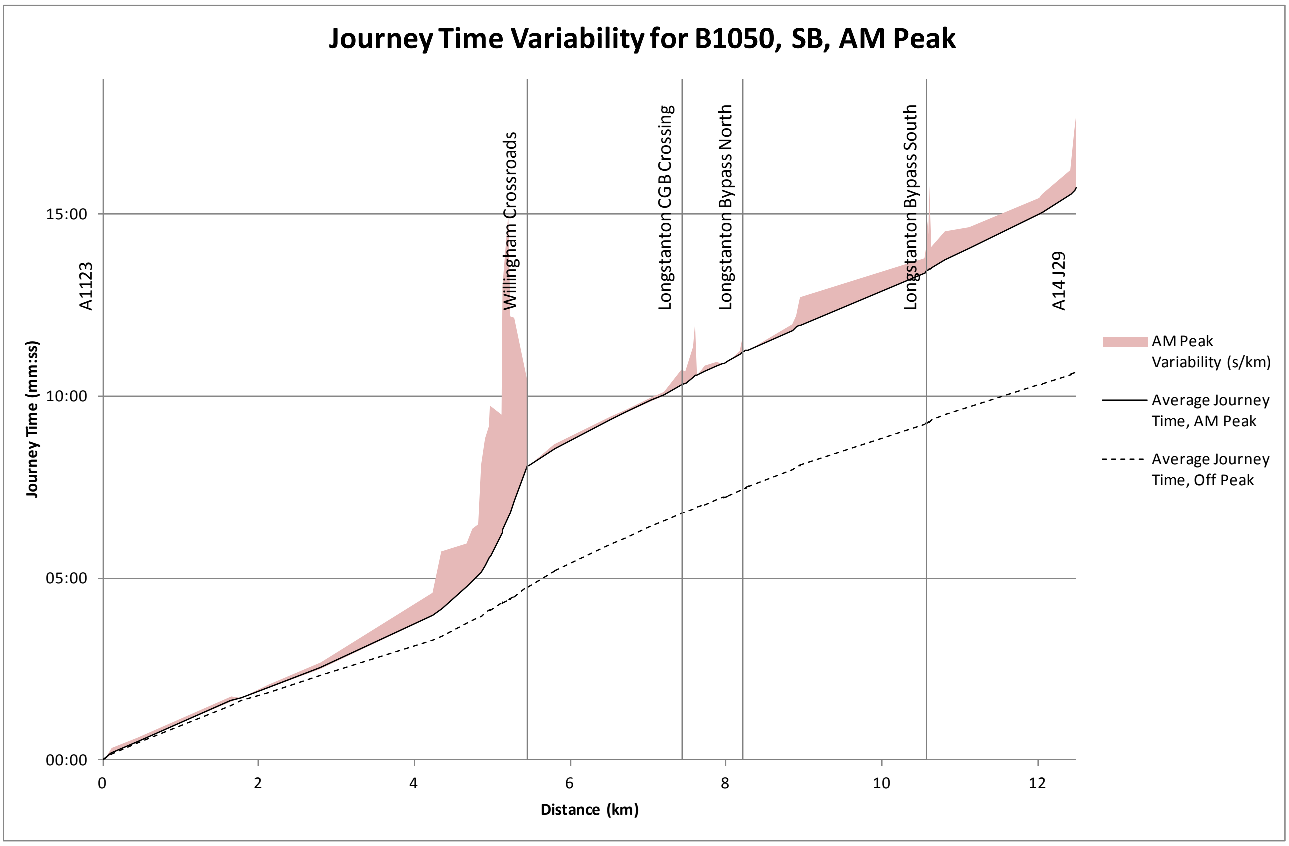
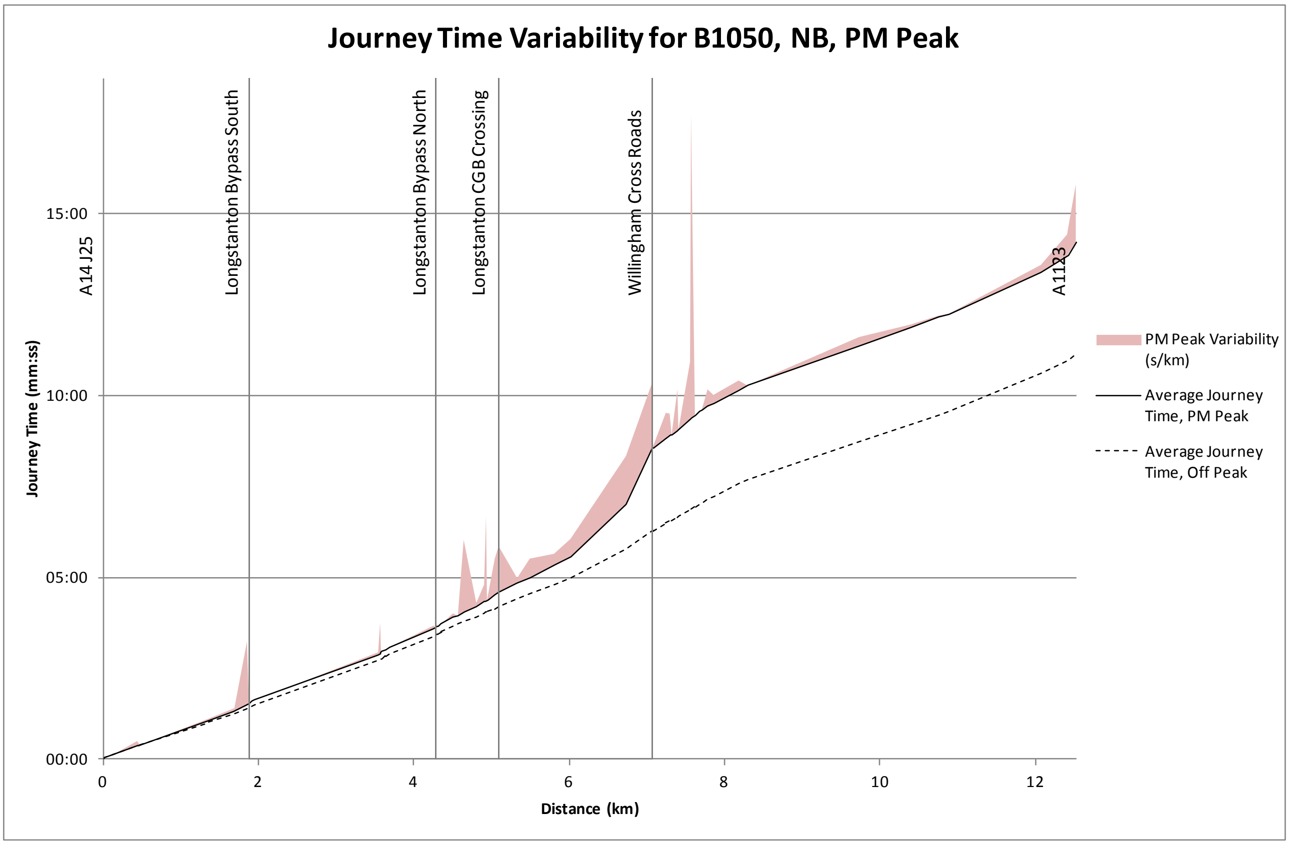


Figure 1-11 B1050 Northbound Journey Time Variability – PM Peak Hour



1.3.2.5. A1123 / A142 – Earith, Haddenham, Stretham, Fordham to A14 at Newmarket

The highest areas of variability can be seen on the areas of the route that pass through the villages of Haddenham and Wilburton, as well as the junction with the A10 and the approach to the A14. This pattern is consistent across each time period and direction.

Figure 1-12 A1123 East Eastbound Journey Time Variability – AM Peak Hour

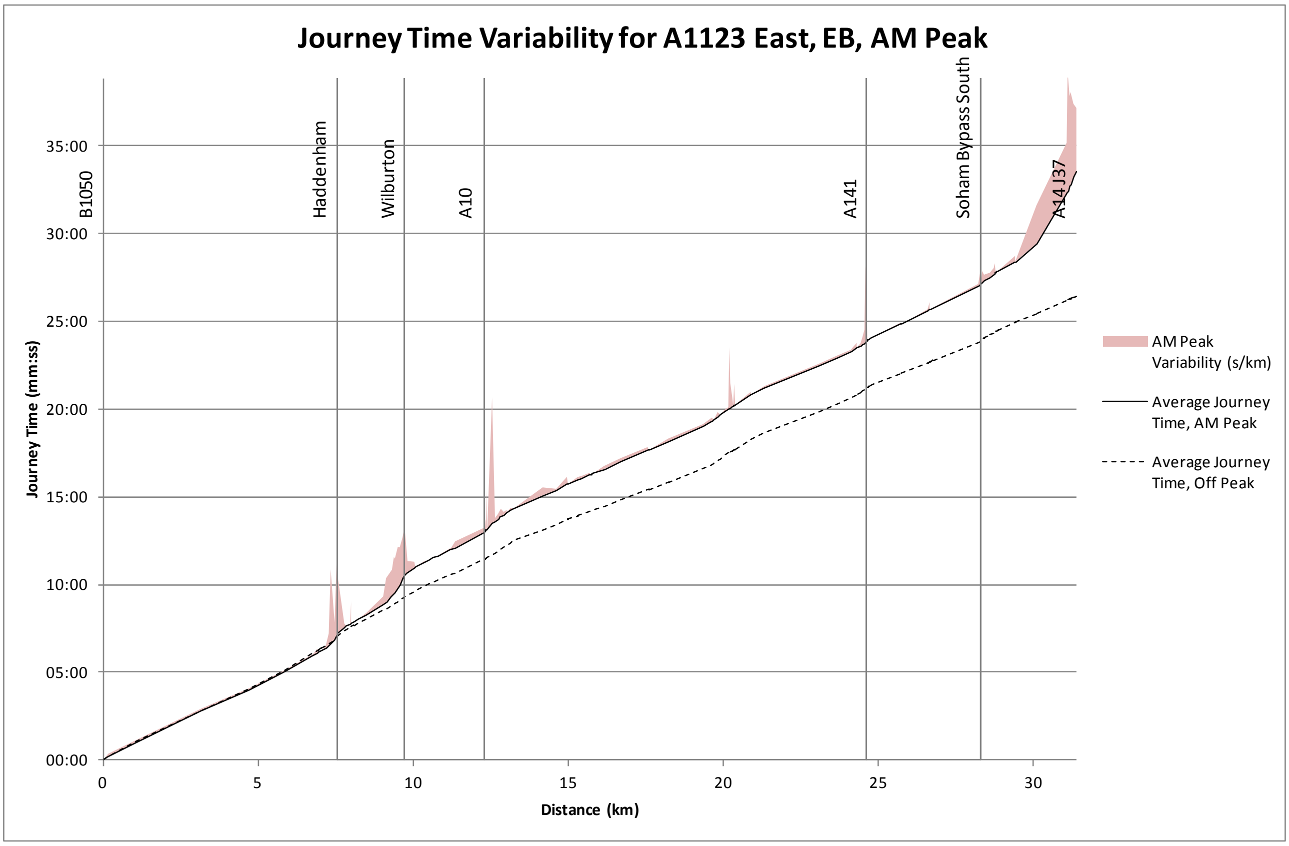
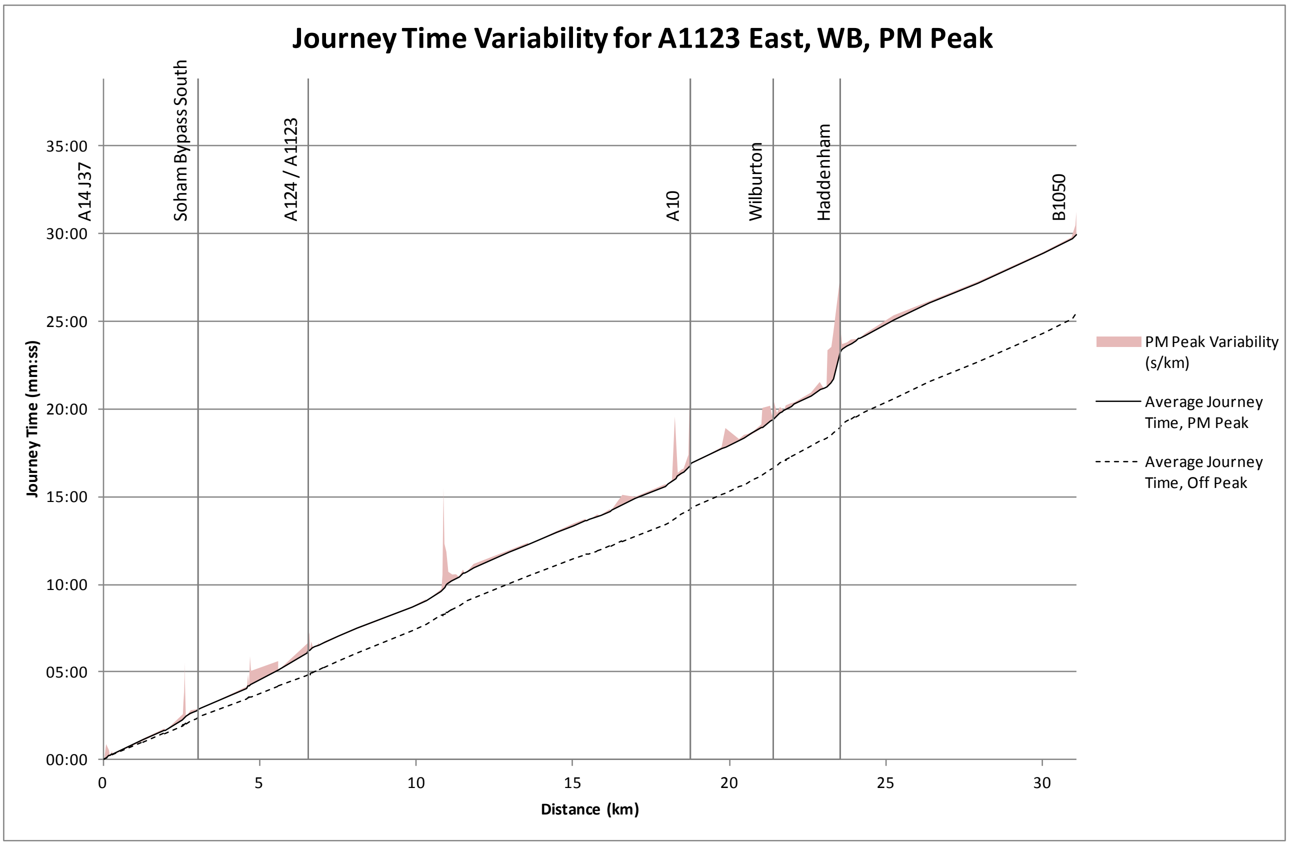


Figure 1-13 A1123 East Westbound Journey Time Variability – PM Peak Hour



1.3.2.6. A1198 Godmanchester to Caxton Gibbet

The greatest level of variability can be seen southbound in the AM Peak on the second half of the Papworth bypass and approach to Caxton Gibbet. There is also some variability in this direction in the PM Peak, although to a lesser extent. The northbound direction has greatest variability in the PM Peak in the areas around the junctions with roads to Hilton and Hemingford Grey.

Figure 1-14 A1198 Southbound Journey Time Variability – AM Peak Hour

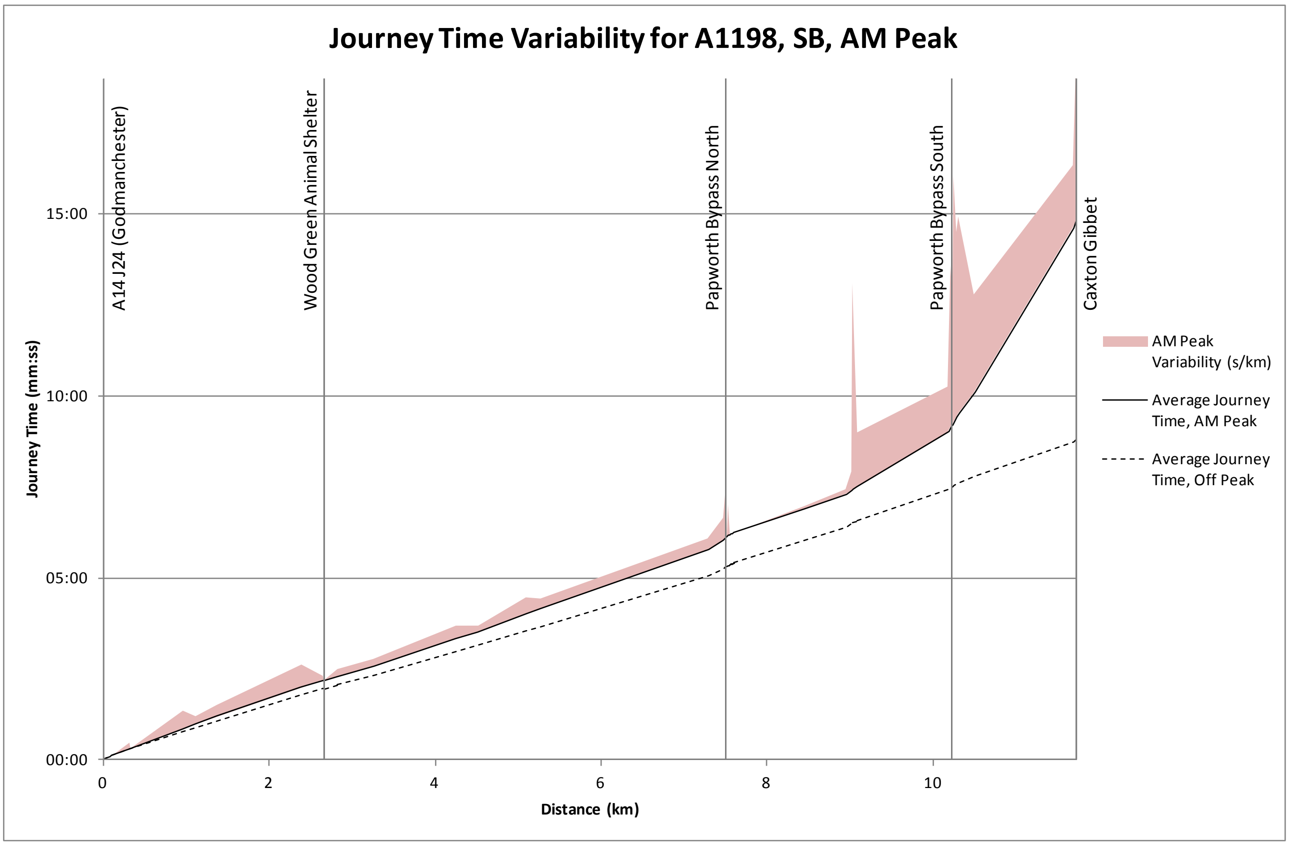
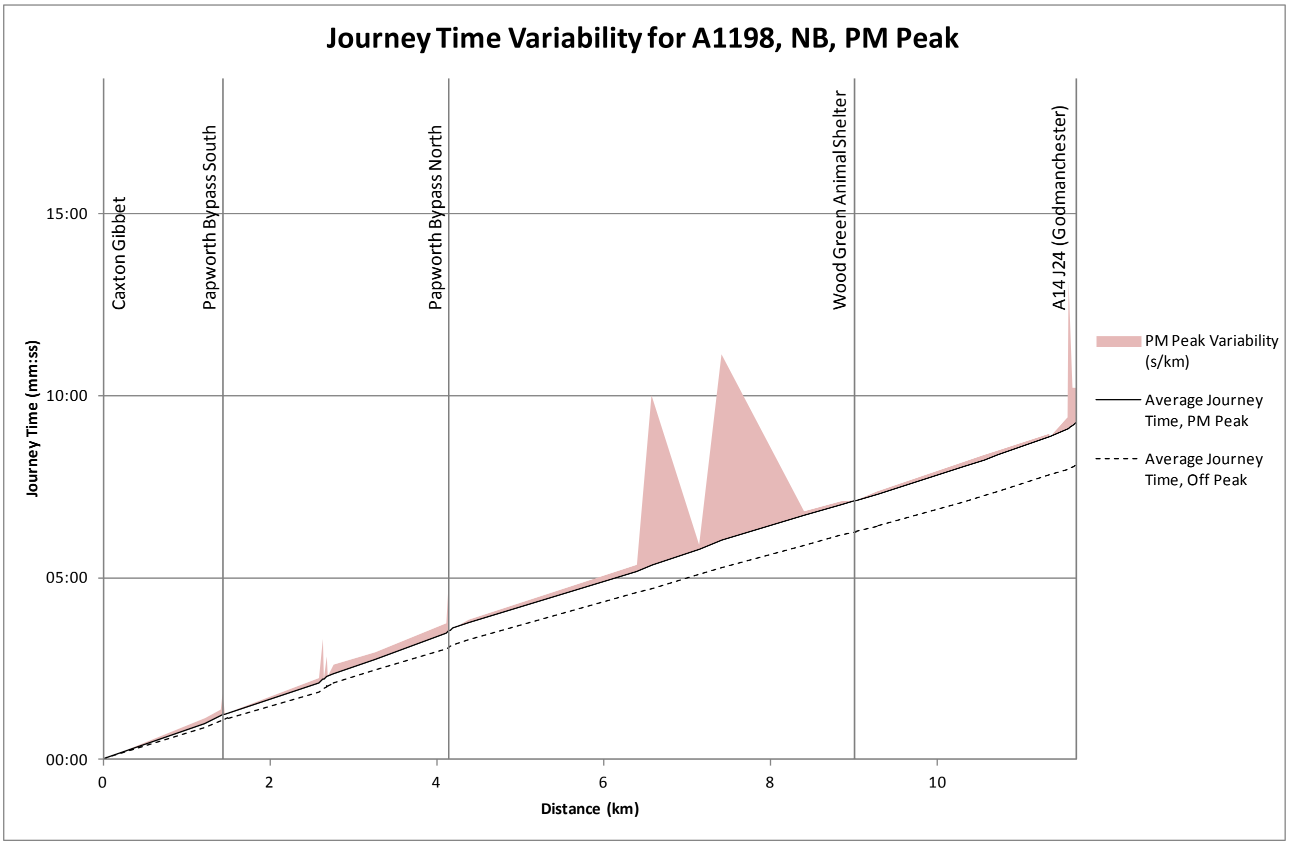


Figure 1-15 A1198 Northbound Journey Time Variability – PM Peak Hour



1.3.2.7. M11 Girton to M11 Junction 13

The area of greatest variability is in the northbound direction approaching junction 14 of the M11 (Girton Interchange). This is shown to be the case most notably in the AM and PM peaks, although there is still some variability southbound in the AM peak in addition.

Figure 1-16 M11 Southbound Journey Time Variability – AM Peak Hour

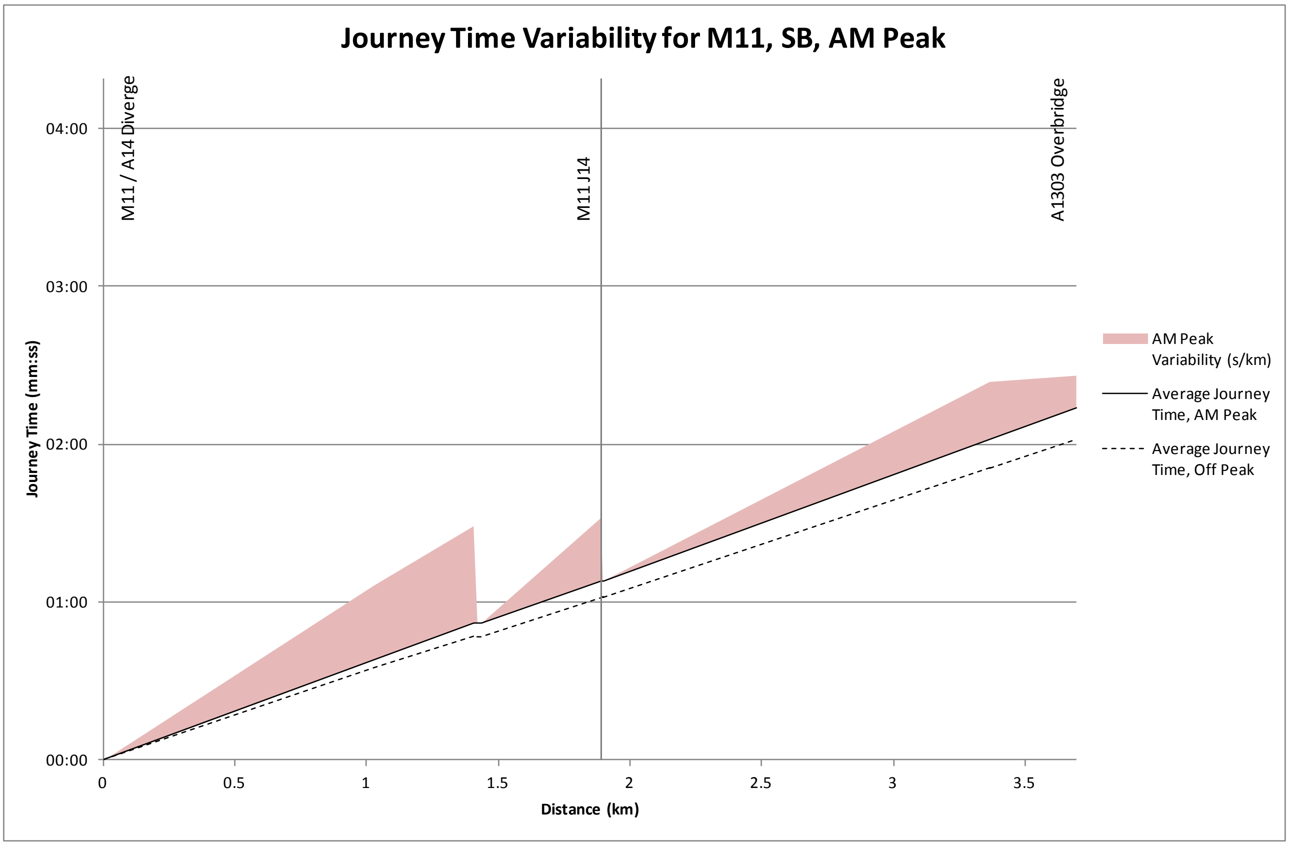
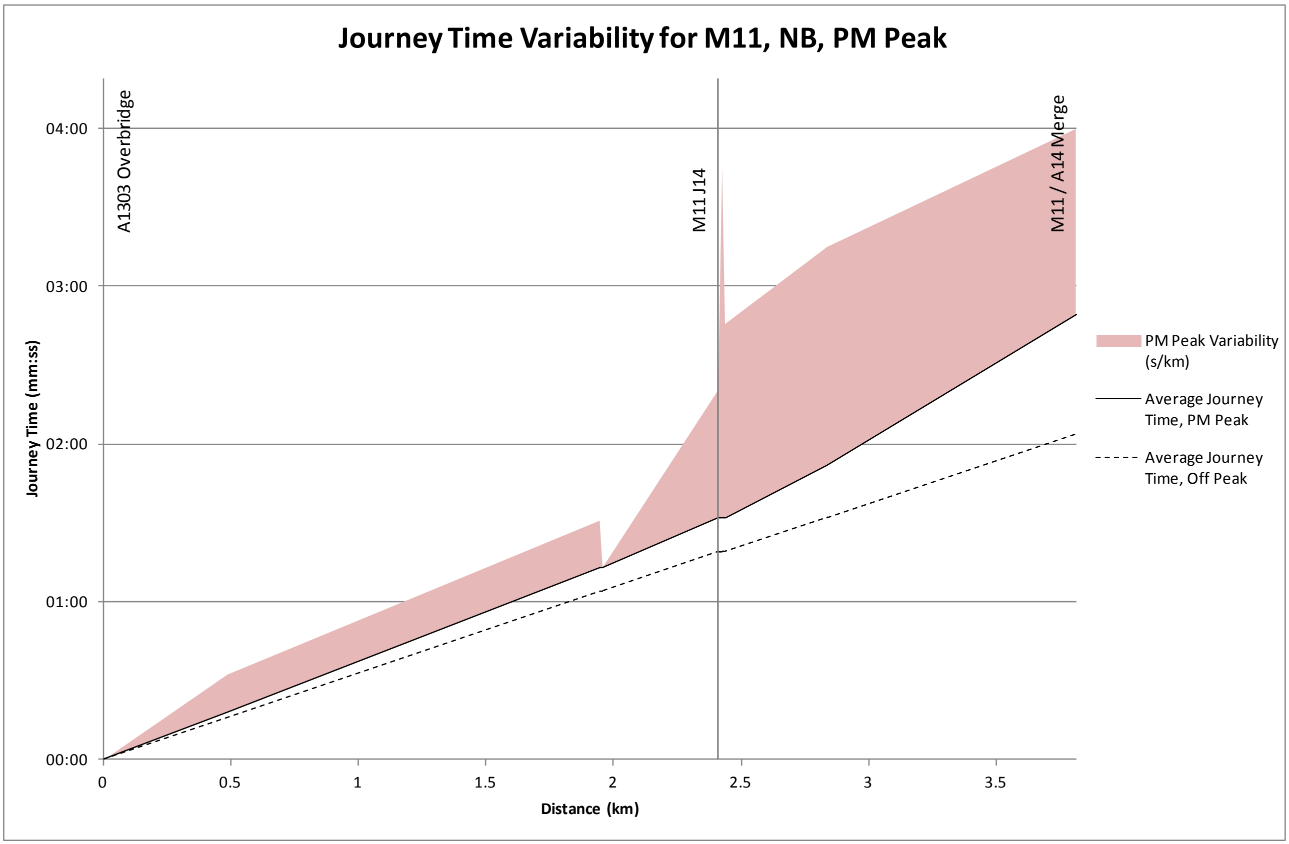


Figure 1-17 M11 Northbound Journey Time Variability – PM Peak Hour



1.3.2.8. A14 Cambridge Northern Bypass (Girton Interchange to Quy Interchange)

The AM peak displays variability along the length of the route in the westbound direction (see Figure B-4), with the section between Quy and Fen Ditton displaying the highest variability. The eastbound direction has the greatest levels of variability between Girton and Milton.

Figure 1-18 A14 Cambridge Northern Bypass Eastbound Journey Time Variability – AM Peak Hour

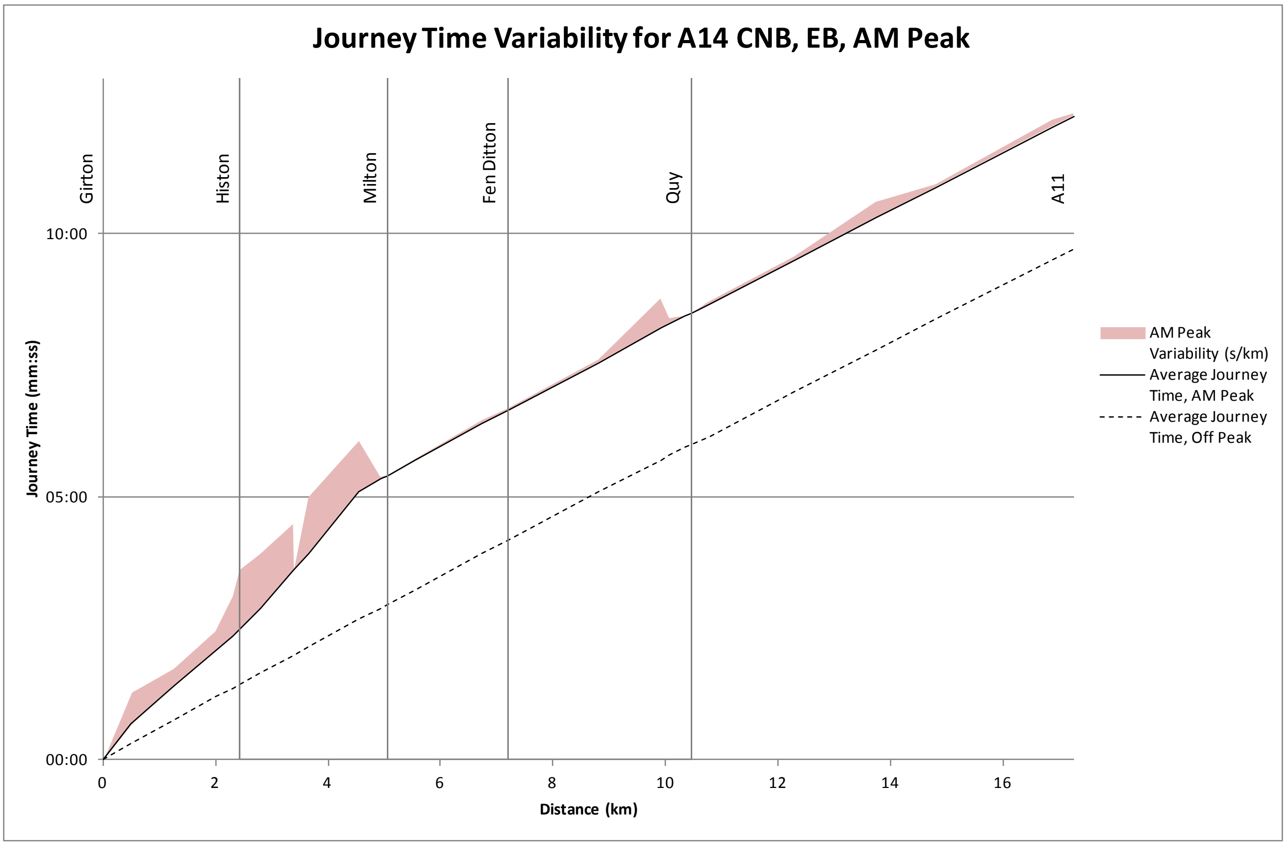
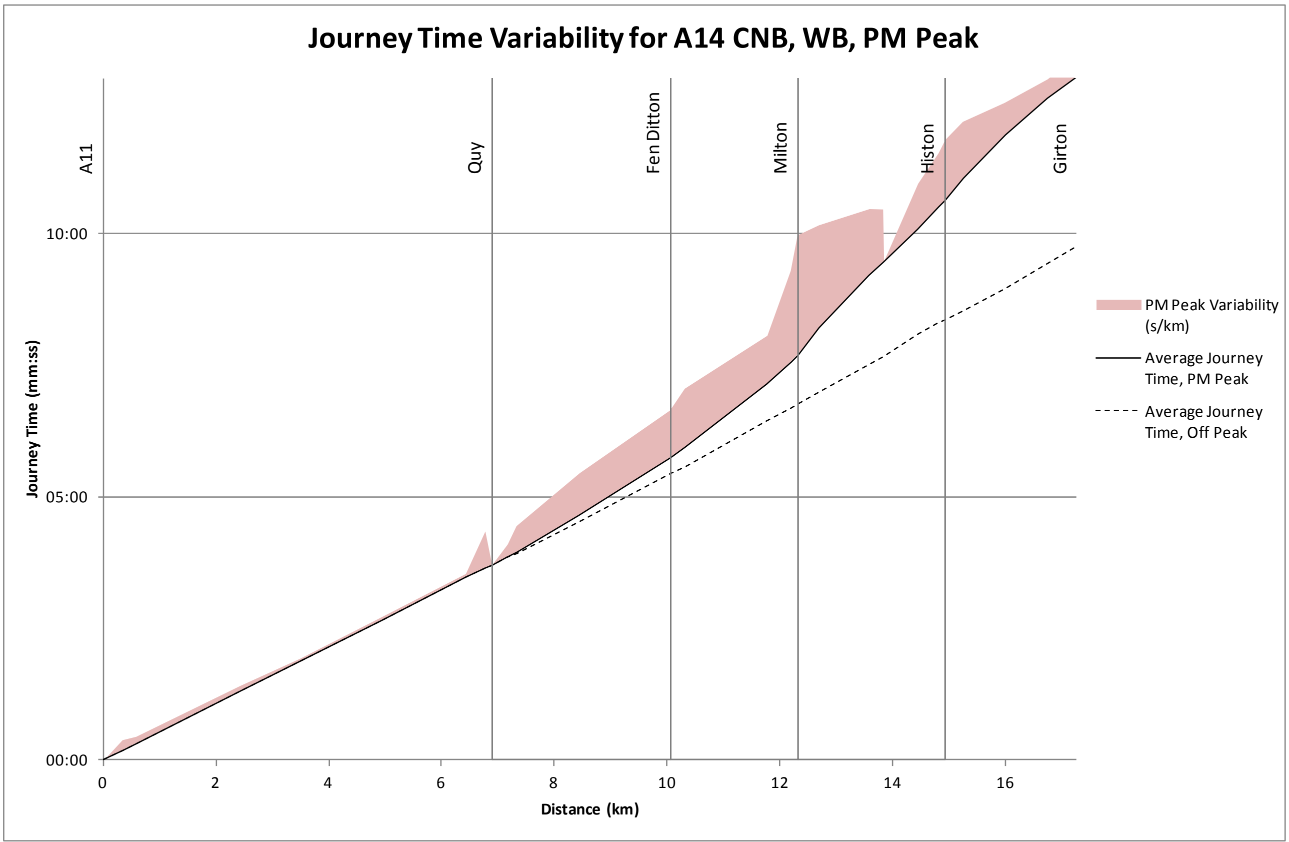


Figure 1-19 A14 Cambridge Northern Bypass Westbound Journey Time Variability – PM Peak Hour



1.4. Compare Modelled and Observed Diversionary Effects of Closures

1.4.1. Observed Diversionary Effects

Accident data was provided to Atkins by Cambridgeshire County Council (CCC) for the period including October 2007 to August 2013. The data included records of 1,510 accidents on the A14 and surrounding area.

The data was sifted to remove any accidents outside of the Huntingdon to Girton stretch of the A14 which left a total of 356 accidents in the (almost) six year period. The purpose of analysing the accident data is to identify any accidents which may have caused significant rerouting of vehicles from the A14 to one of the alternative routes identified. For this reason, it was decided that only severe and fatal accidents would be considered as slight accidents were unlikely to cause a significant level of diversion and no details were available that related to the nature of any closure that took place as a result of the incident. Of the 356 accidents on the A14, 44 were found to be classified as severe and 5 as fatal.

Once the data had been sifted down to only those records of accidents on the A14 that were likely to have caused re-routing (severe and fatal only), 49 records were left. In order to narrow down the data further a second sifting exercise was conducted to remove any accidents that occurred outside of the neutral weekdays Tuesday, Wednesday and Thursday to provide data that was more comparable to the SATURN model. This reduced the number of records from 49 to 15. Any records occurring well outside of the peak periods (i.e. before 05:00 and after 18:00) were also removed from the search in an attempt to focus the study on accidents which had an impact on peak flows and therefore be more comparable with the model. This reduced the number of records from 15 to 11.

With 11 accidents in mind for consideration of diversionary effects, Atkins used the Highways Agency TRADS database to extract relevant traffic flow data for those days on which the accidents occurred and also for the day one week prior to and one week after the accident so that a comparison could be made with normal conditions.

One of the incidents identified on the A14 WB and the two days either side did not have any TRADS data available, so this incident has been discarded, leaving ten incidents to assess for levels of diversion.

Of the ten incidents, analysis of the data showed that the majority caused only slight re-routing between the A14 and A428, however, two were found to have caused significant levels of diversion and have therefore been selected as good examples to replicate within the model. Of the two incidents selected, one occurred on the A14 eastbound at Hemingford Abbots in the AM peak and the other occurred on the A14 westbound at Hemingford Grey during the inter peak, but affecting flows well into the PM peak.

1.4.1.1. Incident – A14 Eastbound at Hemingford Abbots in the AM Peak

This incident occurred late in the AM peak hour at Hemingford Abbots on the eastbound carriageway in early November 2011. The effects of the accident and resultant closure were observed to last until early afternoon. The hourly period with the lowest traffic flow past the scene was between 09:30 and 10:30 as shown in Figure 1-20 as shown by a long term automatic traffic counter site immediately east of the incident identified.

Figure 1-20 A14 EB at Junction 24, TRADS Data Summary

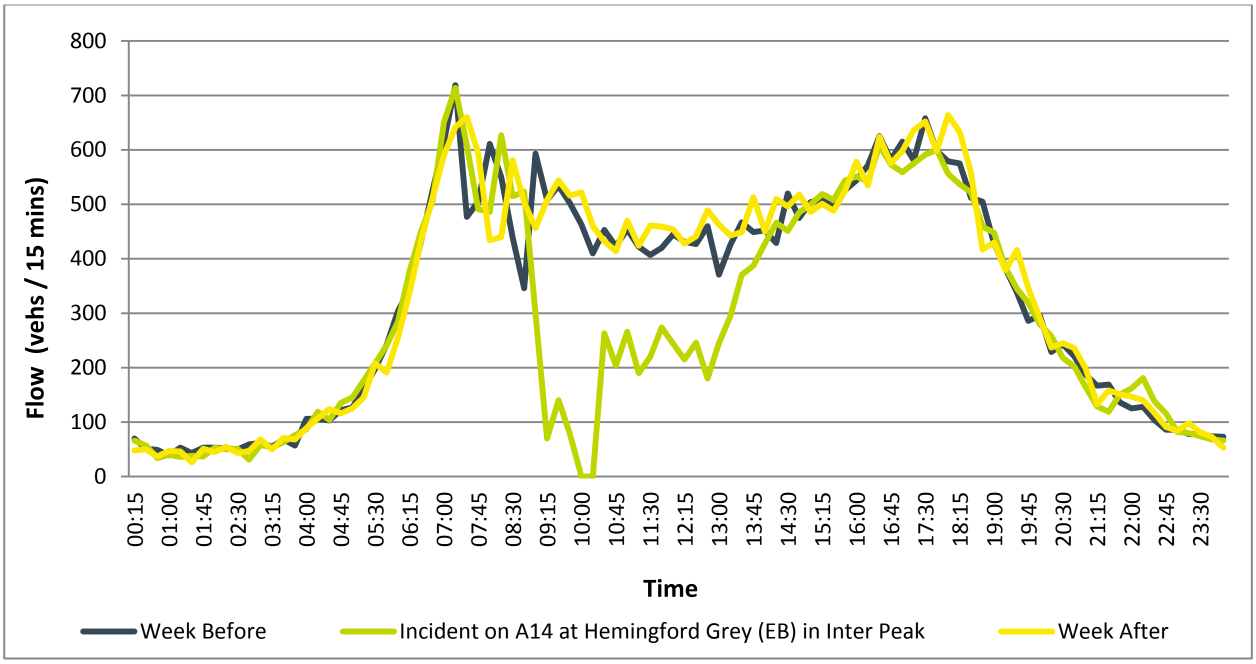
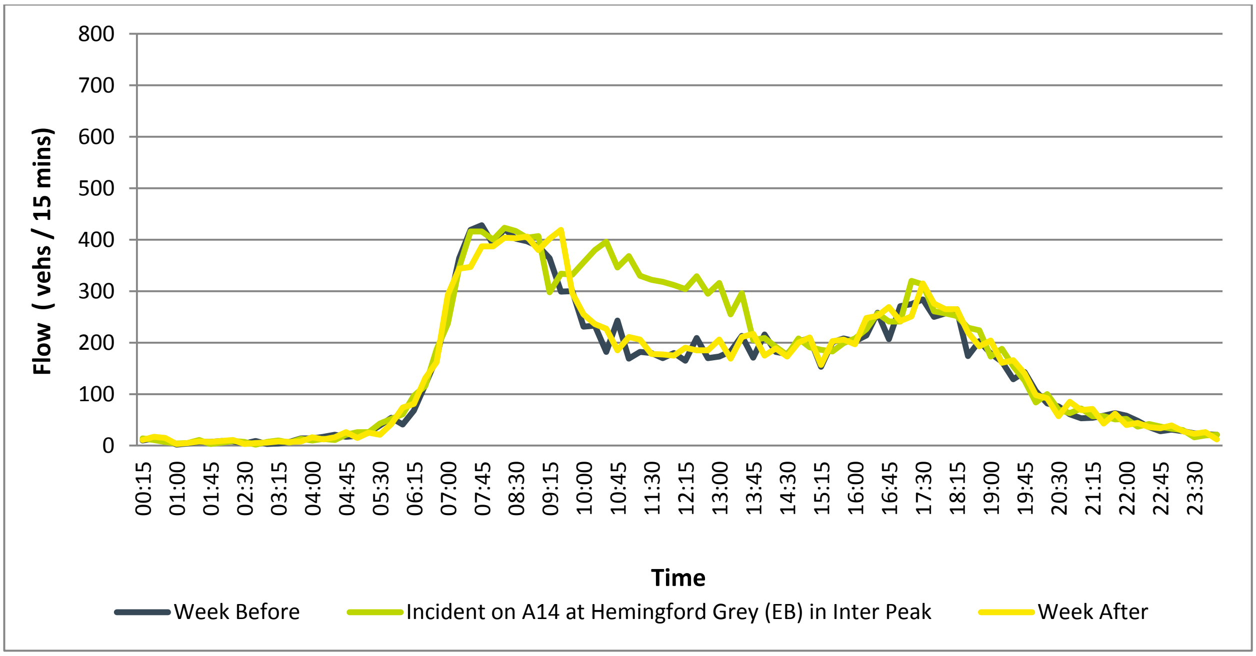


Figure 1-21 A428 EB at Caxton Gibbet, TRADS Data Summary



It can be seen that on the day of the incident, flows on the A14 were disrupted quite severely and flows were as low as zero in the mid morning. Shortly after the incident, flows on the A14 decreased from 2151 vehicles per hour to 280 vehicles per hour. This is a decrease of 1933 vehicles per hour. It can be seen that flows increased on the A428 during this time from 776 to 1440 vehicles per hour between 10:15 and 11:15 which represents an approximate doubling of traffic on the A428 during the inter-peak, or an extension of the normal AM peak traffic levels further into the day.

If around 1900 vehicles per hour divert away from the A14 and around 650 vehicles per hour divert to the A428, then it is likely that there would be significant volumes of traffic diverted onto routes other than the A428, such as those identified in section 1.1. The lowest flow on the A14 occurred at approximately 10:15 and the highest (absolute rather than diverted) flow on the A428 occurred at approximately 10:30, which would suggest a large number of vehicles re-route from the A14 almost immediately towards the A428 in this period. At this time, the A14 has approximately 2000 fewer vehicles per hour compared with normal conditions. The A428 has approximately 670 more vehicles per hour compared with normal conditions, so it can be said that roughly 34% of those avoiding the A14 choose to use the A428 instead, with the remainder of traffic either diverting onto more minor roads or remaining queued on the A14 itself.

If the same comparison is made between the A14 and the A428 on the western fringes of Cambridge then a similar pattern can be seen. The flows on the A14 eastbound at Dry Drayton reduce by 1750 vehicles whilst the combined flows using the eastbound A428 at Madingley (+320 vehicles per hour) and the A428 eastbound off-slip to access the A1303 / Madingley Road (+440 vehicles per hour) increase by 760 vehicles per hour. This switch to the A428 represents 43% of those diverting to avoid the A14.

The main diversion route to switch from the A14 to the A428 is anticipated to be the A1198 which connects the A14 at Godmanchester to the A428 at Caxton Gibbet. However, for vehicles that have already passed this turn-off, there are a number of more rural cut-through which are likely to have been utilised as the number of extra vehicles on the A428 increases with proximity to Cambridge.

It is noted that once the incident is removed from the A14, the recovery of both the A14 and A428 is quite controlled which may be a result of travel information management regarding the re-opening of the route.

1.4.1.2. Incident – A14 Westbound at Hemingford Grey in the AM Peak

This incident occurred during the middle of the day at Hemingford Grey on the westbound carriageway in early March 2012. The effects of the accident and resultant closure were observed to last until around the start of the PM peak period. The hourly period with the lowest traffic flow past the scene was between 12:45 and 13:45.

Figure 1-22 A14 WB at Hemingford Grey, TRADS Data Summary

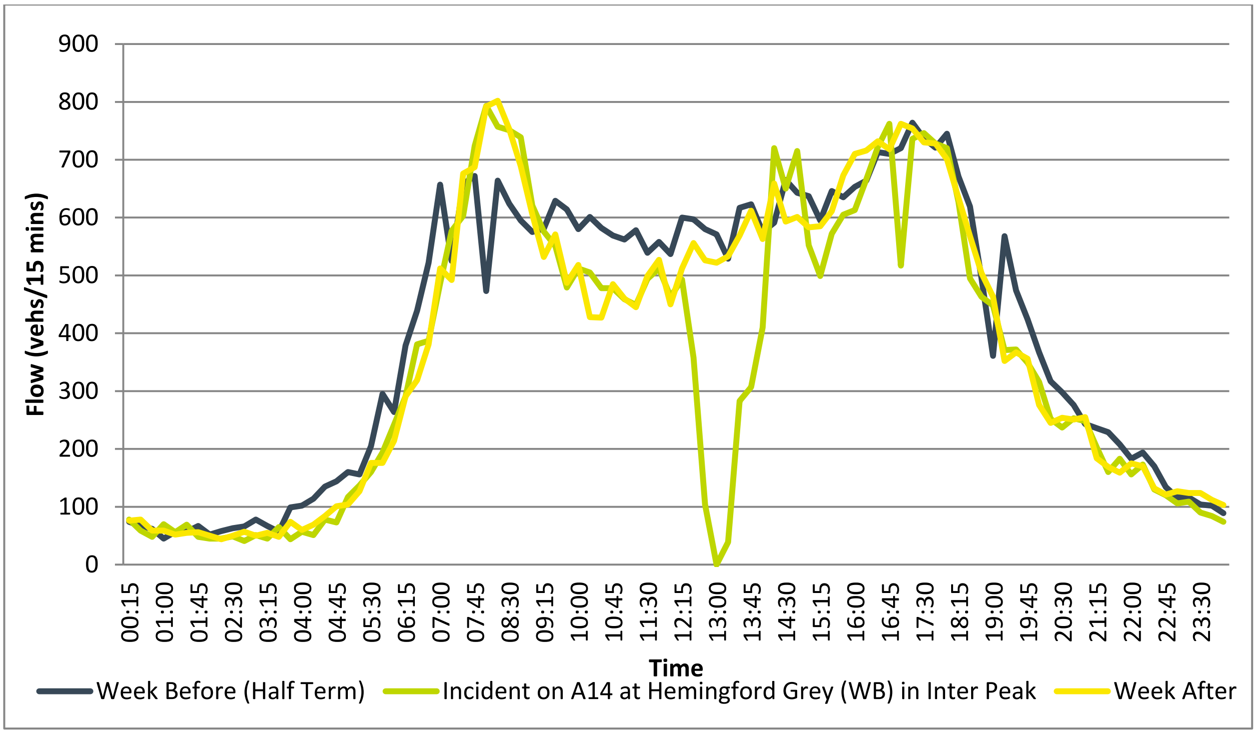
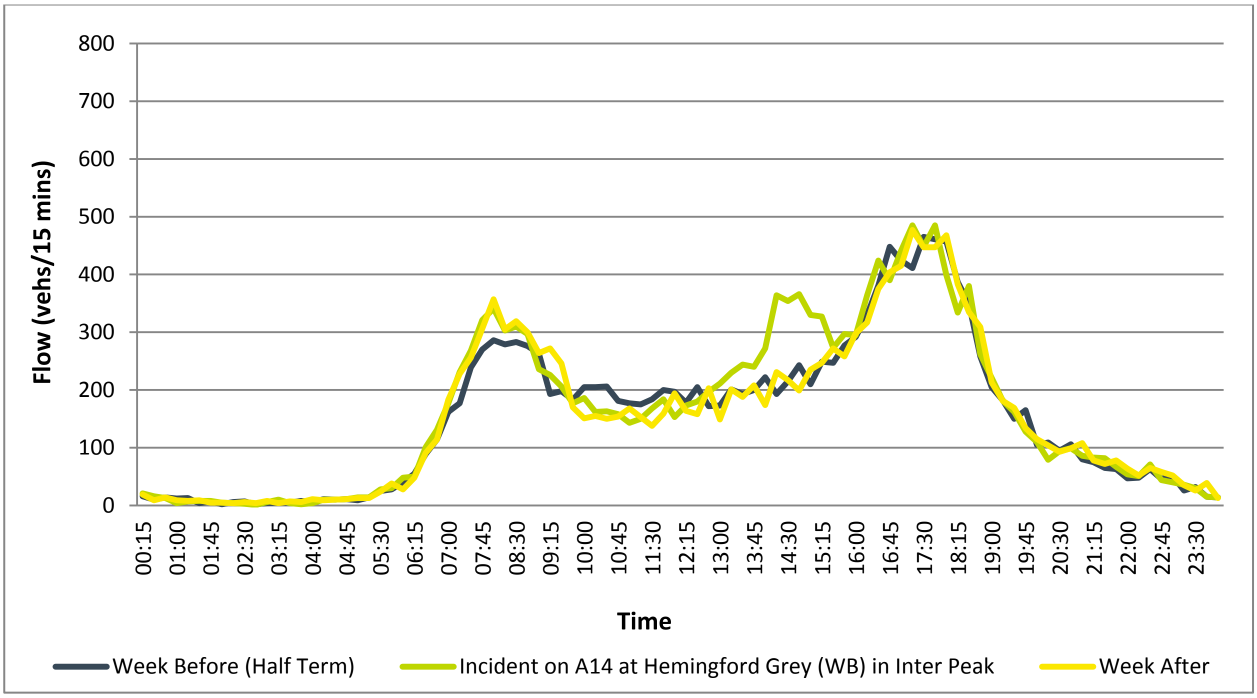


Figure 1-23 A428 WB at Caxton Gibbet, TRADS Data Summary



The westbound incident identified happened during the first week of school term and consequently the traffic flows from the week prior, provided for comparison, are those during Half Term. For this reason, flows from the week before are lower in the peaks and higher in the inter peak, particularly on the A14. As this set of data does not reflect a typical day it has not been used as part of the comparison. The flow data for the week after the incident falls within a neutral week and has therefore been used in the comparison with the incident data.

Figure 1-22 shows at 13:00 flows were severely restricted on the A14. At this time, a peak can be seen to form in Figure 1-23 in the corresponding flows on the A428. A14 traffic is reduced from a typical average of

556 to 0 vehicles during the 15 minutes with lowest flow. For the duration of one hour with the lowest traffic flow due to the incident, traffic levels fall from a typical average of 2150 to 426. The peak in flows on the A428 during this period also lasted for approximately 1 hour and appears to have increased flows from 741 to 882 vehicles during the same hour.

It should be noted that there is evidence to suggest that the diversion of traffic onto the A428 continues after the end of the incident on the A14. As such, the maximum hourly flow on the A428 occurred between 14:15 and 15:15, with an hourly flow increase to 1414 from 882 vehicles. The 532 vehicles that divert onto the A428 represent 31% of the 1724 vehicles diverting away from, or unable to pass along the A14. It is also noted that the recovery of the A14 is not smooth. Initially flow is higher than normal which appears to saturate the road leading to continued fluctuations in the subsequent half hour periods suggested continued unreliability of the A14 operation.

Looking in more detail at the flows counted on the outskirts of Cambridge, 200 extra vehicles per hour can be seen using the A428 in the inter peak period and an extra 430 vehicles per hour using the A1303 (Madingley Road) on-slip to access the A428 westbound. Of the 1724 vehicles per hour that are assumed to be avoiding the A14, 200 (12%) use the A428 (northern bypass) and 430 (25%) join the A428 westbound at Madingley, meaning that around 37% of diverted traffic re-converges at the A428/A1303 diverge point.

1.4.2. Modelled Diversionary Effects

1.4.2.1. Methodology Development

The A14 Cambridge to Huntingdon 2011 Present Year Validation SATURN model was taken as the base model to use for testing of methodology to represent incidents along the A14 corridor.

Tests were undertaken to manipulate the SATURN Highway Assignment Model (HAM) to endeavour to replicate the traffic diversion and resultant impacts of an incident on the A14. The model aimed to replicate the two closures that were identified above so that comparisons of the impacts could be made.

Different methodologies were tested to attempt to determine the most suitable method that could be used to accurately represent the type of disruption caused by an incident. These methodology tests included variations on:

- Banning all traffic from the modelled link representing the closure location;
- Reducing the capacity of the modelled link representing the closure location; and
- Utilising the Pre Load function (PLOD) within SATURN to maintain traffic on its original paths either through the closure or on parallel/conflicting routes.

It was noted that a full closure was not necessarily representative (unless a long-term full closure was actually in place), since while there may have been a total closure of the road at some point during the incident, this is unlikely to have remained in place for an entire hour which is the time period covered by the model. The following methodology was therefore developed.

The first stage was to undertake analysis of the TRADS data for the A14 mainline close to the location of the incident, to identify the level of traffic that passed through the incident site compared to an average incident-free day. This yielded a percentage of traffic that was able to pass through the incident site, and the saturation flow of the relevant movement in the SATURN network was reduced by this percentage to replicate the reduction in available capacity that was caused by the incident.

The assignment algorithms that SATURN uses mean that every ‘driver’ has near perfect knowledge and visibility of the network. Therefore when a closure or restriction was put in place, the tendency was for all traffic to divert away from the A14 and use alternative routes. These alternatives were also not simply adjacent roads, since traffic was observed to divert to using other strategic routes such as the M25/A1 as opposed to M11/A14. While this may be a plausible diversion route, this would be dependent upon a high degree of knowledge for these drivers most likely representative of well publicised alternative signed routes. In reality not all drivers are aware of an incident and able to take alternative routes, either locally or more strategically. This is supported by the level of diversion that is shown by the TRADS traffic data on the day of the incidents identified. A further impact of this is that traffic on alternative routes also then re-routes as a secondary impact of the initial re-routing traffic. Once again, this is unlikely to occur to such a large extent in reality due to lack of driver information on the prevailing delay.

Therefore the use of the PLOD function within SATURN was investigated to identify if it would be possible to maintain a percentage of traffic on its original route, despite the incident restriction. The PLOD function takes traffic from a previous assignment and assigns this flow to the network as a fixed flow. This methodology has been incorporated into this testing by fixing all traffic other than that which uses the modelled link representing the incident location.

It is also the case that not all of the traffic that uses the link representing a closure would divert to an alternative route. Therefore, a percentage of this traffic is also 'held' on its original path along the A14 and therefore experiences the delays associated with the incident. This percentage factor is a parameter that can be tuned to govern the proportion of traffic that diverts during an incident, and can be used to replicate the level of information that is received by drivers and how they respond to this.

There is limited data in terms of traffic flows for specific days of an incident in the past, therefore calibration of the model has largely been based upon analysis of traffic flows on the A14 and A428, combined with analysis of TrafficMaster journey time data provided by CCC. As further data becomes available, then this can be fed into the calibration process and used to refine the way in which the model responds.

1.4.2.2. Initial Test Results

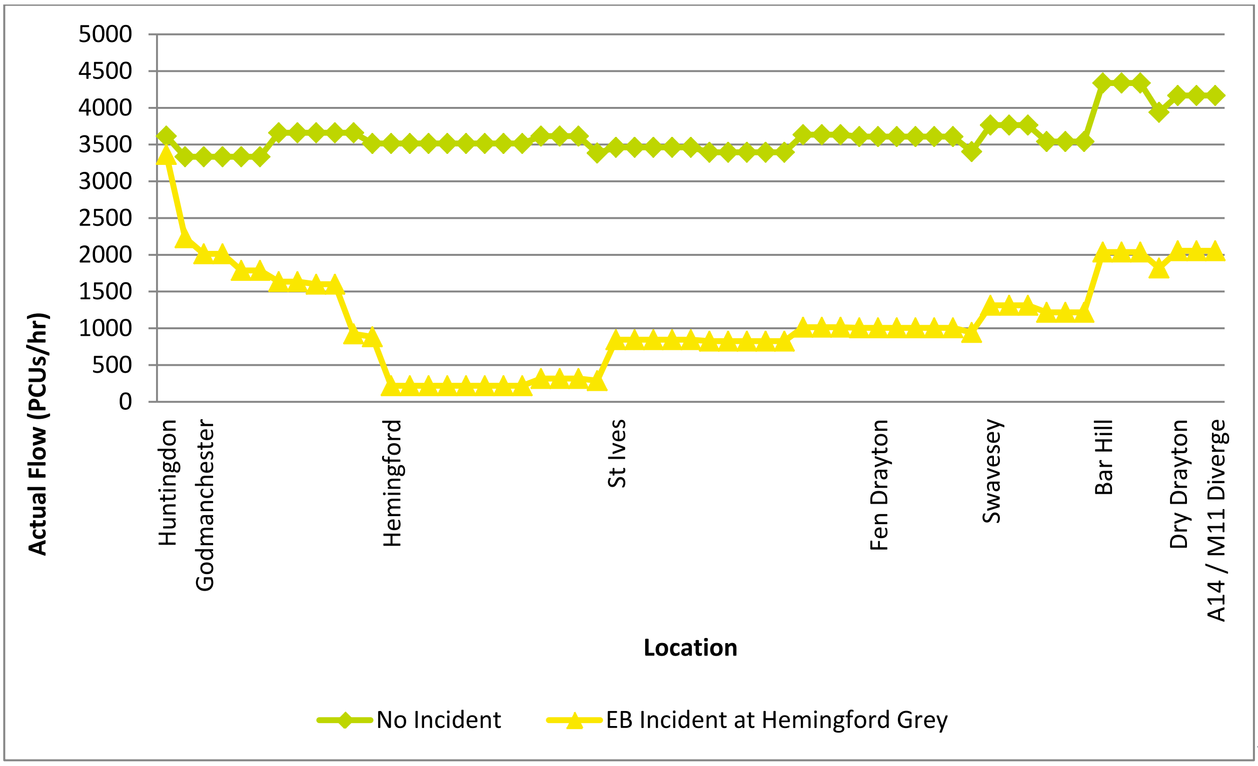
Tests have been run to attempt to replicate the level of traffic diversion onto the A428 from the incidents discussed above.

1.4.2.2.1. Eastbound Incident at Hemingford Abbots

This incident occurred in the latter stages on the AM peak, with the majority of the diversionary effects being seen within the Inter Peak period. As such, the Inter Peak SATURN model was used to replicate this incident.

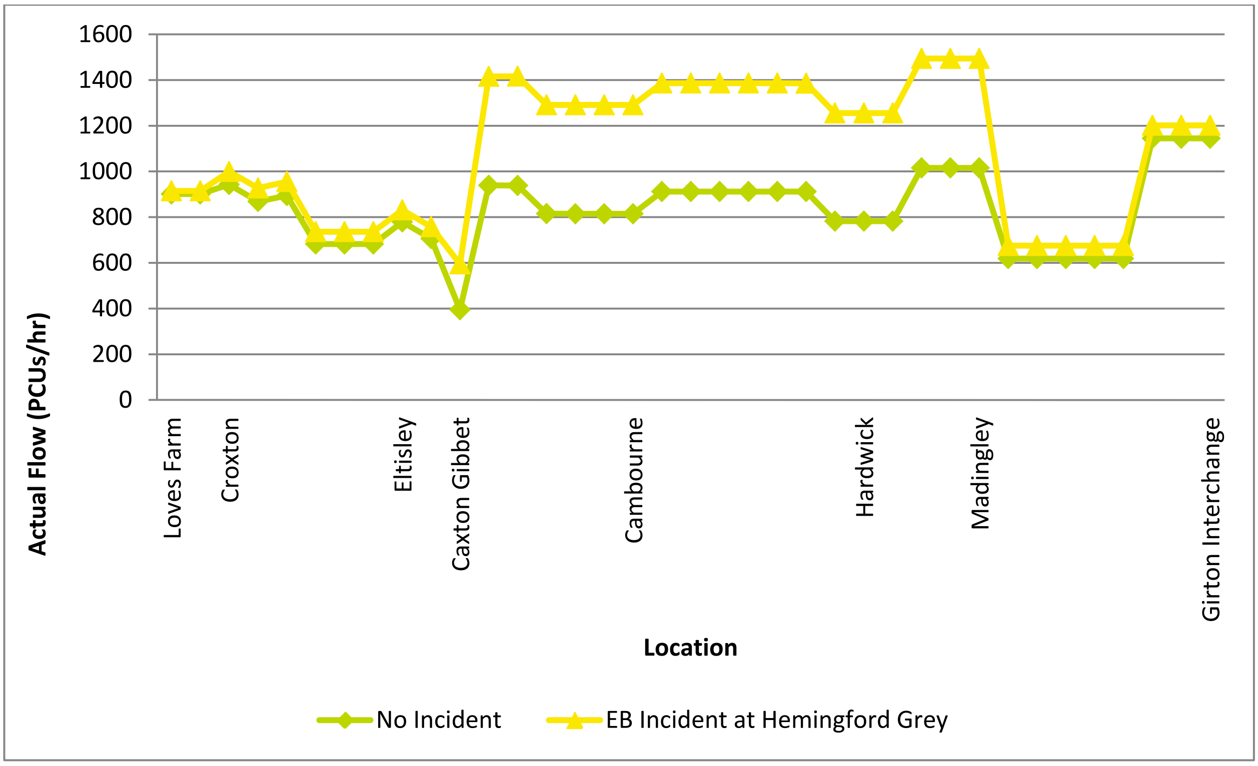
The following graphs show the level of diversion that was predicted from the model.

Figure 1-24 A14 EB Modelled Incident at Hemingford Abbots – Inter Peak Period, A14 EB Modelled Flows (Actual Flow per Hour (PCU))



v

Figure 1-25 A14 EB Modelled Incident at Hemingford Abbots – Inter Peak Period, A428 EB Modelled Flows (Actual Flow per Hour (PCU))



It can be seen from Figure 1-24 and Figure 1-25 above that the change in flow on the A428 at Caxton Gibbet captured by the assignment model is largely representative of that observed in the TRADS data analysis during the incident. This indicates that the model can be configured to replicate the diversionary effects of an incident on the A14 in the eastbound direction.

The effects of this diverted traffic can be analysed along the identified alternative routes to understand where the bottlenecks are and the highest delays are likely to be encountered. The figures in Appendix C highlight the volume to capacity (V/C) ratios of various routes in the direction of diversion, displaying where sections may become susceptible to increased delay.

It can be seen that both the A1198 and A428 show there to be increases in V/C ratio above those of the non-incident case. However, the predictions here do not indicate any area where the V/C ratio approaches 100%, indicating that while there will be some additional delay, these are unlikely to be significant.

In contrast, the V/C ratio for the A14 is significant at the incident location and surrounding area as shown in Appendix C.

A further validation of the impact of the diversion can be to compare the TrafficMaster recorded speeds for the day of the incident to the link speeds predicted from SATURN. The figures below display the average link speeds from both TrafficMaster (Figure 1-26) and SATURN (Figure 1-27).

Figure 1-26 TrafficMaster Average Speed Data, Incident EB at Hemingford Abbots, 09:00 - 10:00

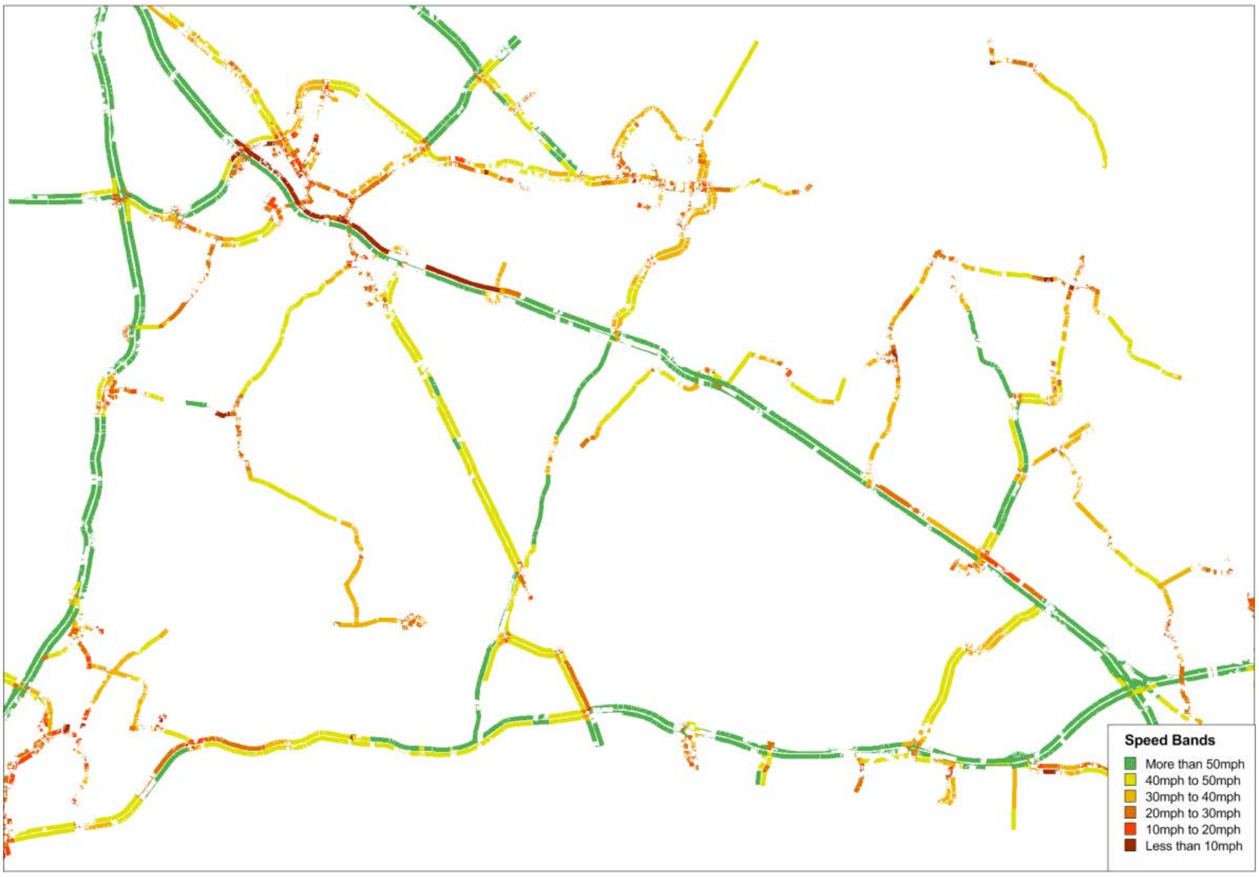
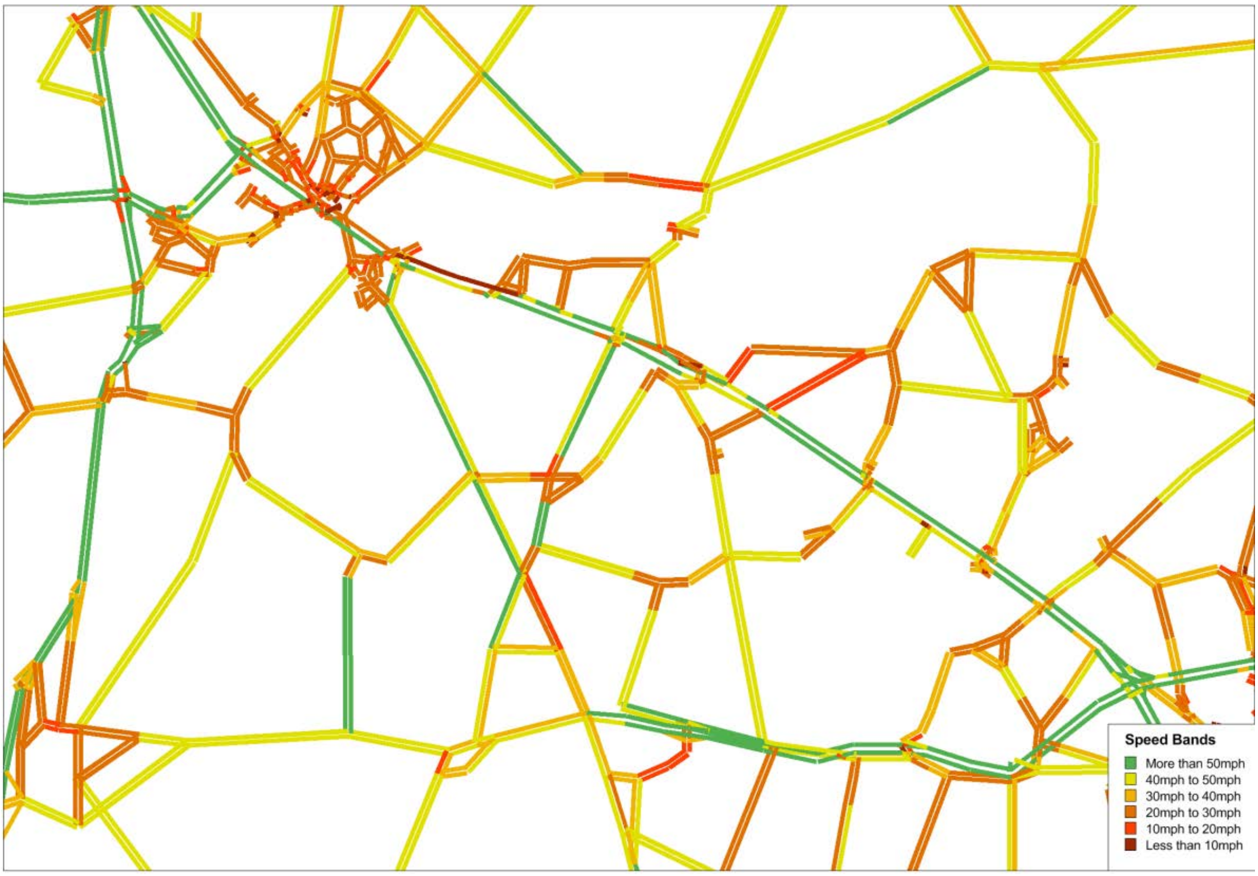


Figure 1-27 SATURN Model Average Speeds, Modelled Incident EB at Hemingford Abbots, Inter Peak Period



It can be seen that there in areas where there is data available from both TrafficMaster and SATURN, that there is generally good correlation between the model and observed speed data.

The differences in link speed that were caused as a result of the incident can be seen below from both the TrafficMaster and SATURN model data.

Figure 1-28 TrafficMaster Average Speed Difference Between Incident and Average Non-Incident Days, Incident EB at Hemingford Abbots, 09:00 - 10:00

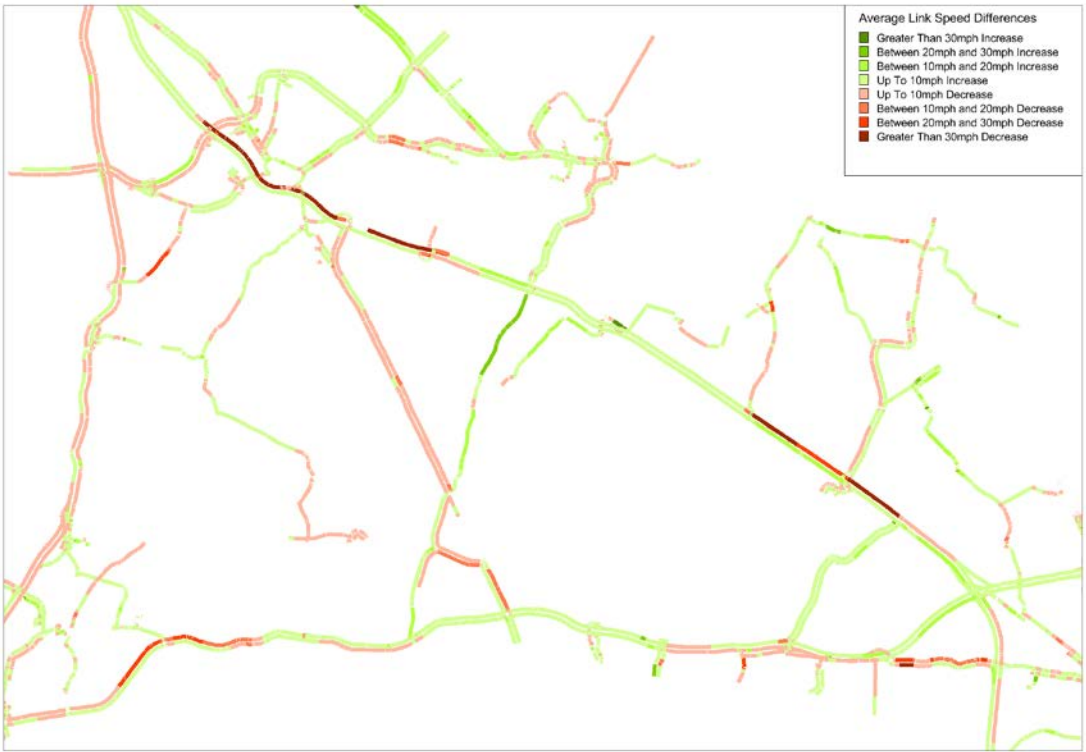


Figure 1-29 SATURN Model Average Speed Difference Between Incident and Average Non-Incident Days, Incident EB at Hemingford Abbots, 09:00 - 10:00

It can be seen that the A1198, A428 and the A1 all show reductions in average speed on the date of an incident, indicating that there may be diverted traffic that is causing delays on these sections that would not normally be present. There is also evidence of diversionary routes to the North are reducing speeds through St Ives and Willingham/Longstanton. The area of the incident on the A14 naturally shows reduced speeds, although it is interesting to note that the area between Cambridge Services and Dry Drayton also has a speed reduction. This could be as a result of diverting traffic rejoining the A14 at these junctions, giving rise to additional delay due to increased levels of merging traffic.

1.4.2.2.2. Westbound incident at Hemingford Grey

This incident occurred during the Inter peak period, so the Inter Peak SATURN model has been used to replicate this incident. The same methodology was applied to this incident as to the previous incident to determine the suitability of the methodology for a different incident.

Figure 1-30 and Figure 1-31 show the level of diversion that was predicted from the model.

Figure 1-30 A14 WB Modelled Incident at Hemingford Grey – Inter Peak period, A14 WB Modelled Flows (Actual Flow per Hour (PCU))

Figure 1-31 A14 WB Modelled Incident at Hemingford Grey – Inter Peak period, A428 WB Modelled Flows (Actual Flow per Hour (PCU))

It can be seen from the graphs above that once again, the change in flow on the A428 at Caxton Gibbet is largely representative of that which was observed in the TRADS data analysis during the incident. This indicates that the model can be configured so as to be able to replicate the diversionary effects of an incident on the A14 in the Westbound direction onto the A428.

The effects of this diverted traffic can be analysed along the identified alternative routes to understand where the bottlenecks are and the highest delays are likely to be encountered. The figures in Appendix D highlight the volume to capacity ratios of various routes in the direction of diversion, displaying where sections may become susceptible to increased delay.

As with the previously analysed eastbound incident, it can be seen that both the A1198 and A428 show there to be increases in V/C ratio above those of the non-incident case. These graphs highlight that the A428 and A1198 close to Caxton Gibbet do show increased in V/C ratio that approach 80%, so there may be instances where delays will begin to become significant in these areas. There are no significant changes on V/C ratio along the A1123 however.

In contrast, the V/C ratio for the A14 is significant at the incident location and surrounding area. While the V/C ratio is lower in areas either side of the incident, this is to be expected due to the diverted traffic. The area of the incident itself shows a marked increase in V/C ratio to in excess of 100%, indicating that there would be significant delays in this area.

A further validation of the impact of the diversion can be to compare the TrafficMaster recorded speeds for the day of the incident to the link speeds predicted from SATURN. Figure 1-32 and Figure 1-33 below display the average link speeds from both TrafficMaster and SATURN.

Figure 1-32 TrafficMaster Average Speed Data, Incident WB at Hemingford Grey, 12:45 – 13:45

Figure 1-33 SATURN Model Average Speeds, Modelled Incident WB at Hemingford Grey, Inter Peak Period

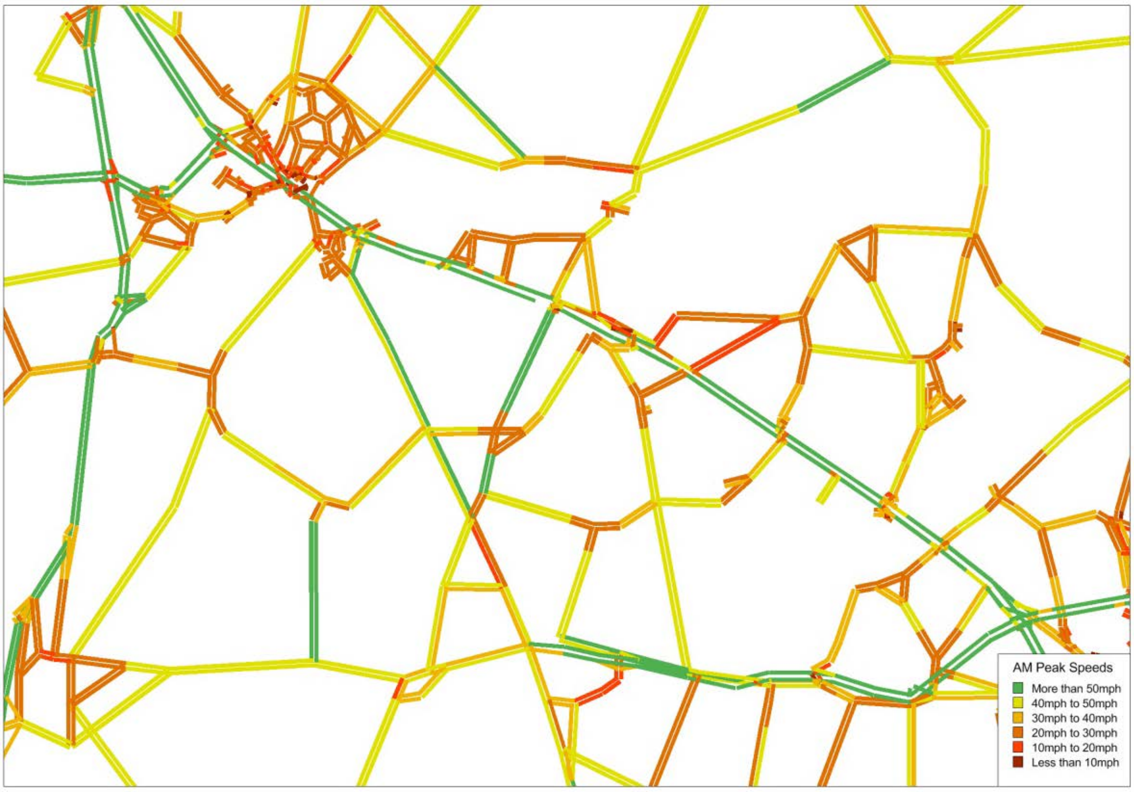
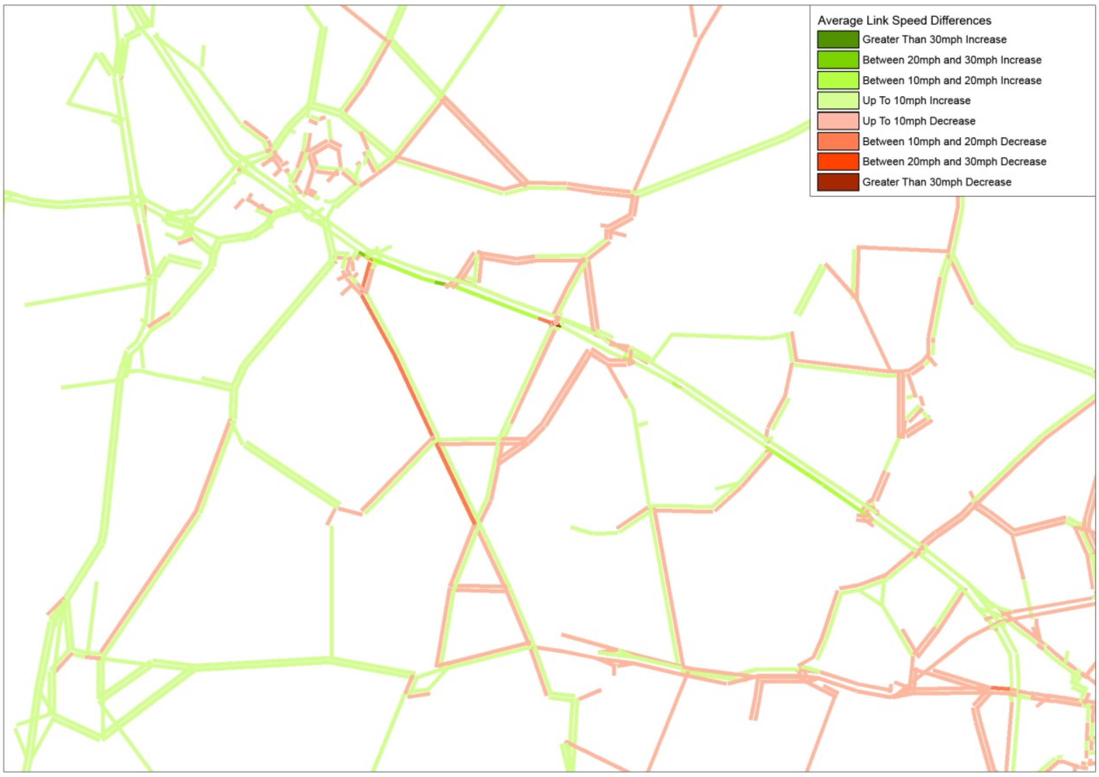


Figure 1-34 TrafficMaster Average Speed Difference Between Incident and Average Non-Incident Days, Incident WB at Hemingford Grey, 12:45 - 13:45

Figure 1-35 SATURN Model Average Speed Difference Between Incident and Average Non-Incident Days, Incident WB at Hemingford Grey, 12:45 - 13:45



It can be seen that the data from the SATURN model displays a less obvious queue (and therefore reduced speed) along the A14 itself upstream of the incident. This is due to the proximity of the incident to the A1096 junction on the A14, allowing a large number of vehicles to easily divert away from the mainline. The SATURN model therefore does not predict the level of blocking back through the junction that may occur in reality, and this is something that should be considered in future tests, development and use of the model.

As with the eastbound incident, the A1198 and A428 both display reduced speeds compared to an average non-incident day.

1.5. Estimation of Vehicles Diverting Compared to Those Continuing on Original Path

Table 1-1 highlights the level of traffic flow that diverts from the A14 onto the A428 during an incident. TRADS sites were available on the A428 immediately east of Caxton Gibbet and on the slip-roads and mainline immediately east of Madingley. The Madingley TRADS sites are well positioned and quite detailed to gain good understanding of where the diversionary traffic comes from / goes to in terms of whether it uses the A14 northern bypass or A1303/ Madingley Road route. Further analysis is provided below.

Table 1-1 Vehicle Diversion Levels

Traffic Flow	During the Eastbound Incident on the A14 at Hemingford Abbots	During the Westbound Incident on the A14 at Hemingford Grey
Flows on A14 at Godmanchester	08:15 ~ 2508 vehs / hr (typical)	12:00 ~ 1692 vehs / hr (typical)
	09:00 ~ 1196 vehs / hr	12:30 ~ 1172 vehs / hr
	09:15 ~ 280 vehs / hr	12:45 ~ 304 vehs / hr
	09:45 ~ 312 vehs / hr	13:00 – 13:15 ~ 64 vehs / hr
	10:00 ~ 0 vehs / hr	13:15 – 13:30 ~ 372 vehs / hr
	10:30 – 12:45 ~ 800 to 1000 vehs / hr	13:30 – 13:45 ~ 1120 vehs / hr
	13:30 ~ 1484 vehs / hr	13:45 – 14:00 ~ 1144 vehs / hr
	14:15 ~ 1864 vehs / hr (typical)	14:00 – 14:15 ~ 1688 vehs / hr
	-	14:15 onwards ~ 2692 vehs / hr (typical)
Selected Route	**During the Eastbound Incident on the A14 at Hemingford Abbots**	**During the Westbound Incident on the A14 at Hemingford Grey**
Divert to A428 at Caxton Gibbet	34%	31%
Divert to A428 (northern bypass)	18%	11%
Divert to Madingley Road and A428	25%	23%

It can be seen from the second half of the table above, that there is a disparity between the total traffic diversion level at Caxton Gibbet and that further east on the A428 at the approach to the Girton Interchange or Cambridge via the A14. During the eastbound incident, an additional 9% of the diverted traffic joins the A428 eastbound between Caxton Gibbet and Madingley. Similarly, an additional 4% of the diverted traffic leaves the A428 westbound between Madingley and Caxton Gibbet during the westbound accident. This suggests that a small proportion of those vehicles diverting onto the A428 do not use the A1198 and perhaps use some of the local roads to travel between the A14 and A428. The model suggests that a small number of vehicles are likely to cut through Knapwell, Elsworth, Hilton and Boxworth which seems to mirror what the TRADS data suggests.

1.6. Further Incident Replication

The model has been further developed to allow incidents to be modelled between every major junction on the A14 from the A1 to the west to the A11 in the east, see Table 1-2. Incidents can be modelled during the AM peak, inter-peak and PM peak hour periods, and in either direction.

All incidents are modelled at the junction of the A14 with the off-slip, with capacity restraints applied to the main A14 carriageway only. For the purposes of this initial study, it has been assumed that incidents will reduce the capacity of the main A14 carriageway by 75%. The model has been developed with the ability to adjust this percentage to reflect the severity of an incident for further testing.

Table 1-2 Modelled A14 Incident Locations

Junction	Location
22	Brampton
23	Huntingdon
24	Godmanchester
25	Hemingford Abbots
26	A1096 St Ives
28	Cambridge Services
29	Bar Hill
30	Oakington
31	M11
32	Histon Interchange
33	Milton Interchange
34	Horningsea
35	Stow Cum Quy
36	A11

1.6.1. Sensitivity Testing

Sensitivity tests have been carried out to understand the impact of varying the percentage of both the main demand and select link demand that has the option to reroute. The test scenario assumes an incident on the A14 at junction number 25, Hemingford Abbots.

Initial tests of the model assumed 35% of the select link and 5% of all other traffic had the option to reroute in the event of an incident. It has been assumed that a higher proportion of the demand for the link of an accident would reroute and outweigh any wider rerouting effects as a knock-on impact of this initial rerouting.

The percentage change from the A14 Cambridge to Huntingdon 2011 Present Year Validation Model (A14_C2H_2011) model is reported for total travel time, total travel distance, average speed and delay. These are summary values for the whole modelled network. The A14_C2H_2011 model outputs are reported as a baseline for reference.

1.6.1.1. Select Link Demand Rerouting

To assess the impact of varying the percentage of the select link demand that can reroute, the percentage of the main demand that can reroute has been fixed at 5%. The percentage of the select link demand that can reroute has then been set at 5% intervals in the range 20-50%.

Table 1-3 to Table 1-5 present the headline model outputs for an incident modelled in the eastbound direction on the A14 at junction 25. In the AM peak the impact of the incident can clearly be seen with total network delay increasing by 46.5% and average speed falling by 2.1% with 20% of the select link demand able to reroute. As the percentage of select link demand that has the option to reroute is increased, the impact of the incident on the network can be seen to diminish. The PM model gives similar results, demonstrating that as the percentage of the select link matrix that is allowed to reroute increases, the impact on the network diminishes. This confirms the scale of improvement of network performance that can result from advance warning of unexpected delays.

The impact of the incident in the inter-peak model is more pronounced given that delay in the base network is at a lower level than experienced in the busier AM and PM peaks.

Table 1-3 Effects ofIncreasing Diversion Response to an Incident on A14 Eastbound, J25 Hemingford Abbots (AM peak)

Percentage of Transfer from the A14	Total Travel Time		Total Travel Distance		Average Speed		Delay	
	(PCU hours)	% Change	(PCU kms)	% Change	(km/h)	% Change	(PCU hours)	% Change
A14_C2H_2011	76,219	-	4,314,535	-	57	-	4,016	-
20%	-	+2.4%	-	+0.2%	-	-2.1%	-	+46.5%
25%	-	+2.2%	-	+0.3%	-	-1.9%	-	+42.0%
30%	-	+2.1%	-	+0.3%	-	-1.8%	-	+38.6%
35%	-	+2.0%	-	+0.3%	-	-1.6%	-	+35.3%
40%	-	+1.9%	-	+0.3%	-	-1.6%	-	+33.0%
45%	-	+1.8%	-	+0.3%	-	-1.4%	-	+31.0%
50%	-	+1.8%	-	+0.3%	-	-1.4%	-	+29.8%

Table 1-4 Effects of Increasing Diversion Response to an Incident on A14 Eastbound, J25 Hemingford Abbots (Inter-peak)

Percentage of Transfer from the A14	Total Travel Time		Total Travel Distance		Average Speed		Delay	
	(PCU hours)	% Change	(PCU kms)	% Change	(km/h)	% Change	(PCU hours)	% Change
A14_C2H_2011	69,856	-	4,136,355	-	59	-	1,796	-
20%	-	+3.0%	-	+0.3%	-	-2.5%	-	+118.6%
25%	-	+2.7%	-	+0.3%	-	-2.4%	-	+106.8%
30%	-	+2.5%	-	+0.3%	-	-2.2%	-	+95.5%
35%	-	+2.3%	-	+0.3%	-	-1.9%	-	+83.6%
40%	-	+2.0%	-	+0.4%	-	-1.7%	-	+70.9%
45%	-	+2.0%	-	+0.4%	-	-1.5%	-	+65.9%
50%	-	+1.8%	-	+0.4%	-	-1.4%	-	+53.6%

Table 1-5 Effects of Increasing Diversion Response to an Incident on A14 Eastbound, J25 Hemingford Abbots (PM peak)

Percentage of Transfer from the A14	Total Travel Time		Total Travel Distance		Average Speed		Delay	
	(PCU hours)	% Change	(PCU kms)	% Change	(km/h)	% Change	(PCU hours)	% Change
A14_C2H_2011	80,543	-	4,576,993	-	57	-	3,759	-
20%	-	+2.9%	-	+0.2%	-	-2.5%	-	+64.4%
25%	-	+2.7%	-	+0.3%	-	-2.3%	-	+59.8%
30%	-	+2.6%	-	+0.3%	-	-2.1%	-	+55.4%
35%	-	+2.3%	-	+0.3%	-	-1.9%	-	+48.6%
40%	-	+2.0%	-	+0.3%	-	-1.6%	-	+39.6%
45%	-	+2.1%	-	+0.4%	-	-1.8%	-	+42.3%
50%	-	+1.8%	-	+0.4%	-	-1.4%	-	+34.2%

Table 1-6 to Table 1-8 present the headline model outputs for an incident modelled in the westbound direction on the A14 at junction 25. The westbound incident has a more severe impact on the network than the eastbound incident. In the AM peak the impact of the westbound incident can clearly be seen with total network delay increasing by 61.5% and average speed falling by 3.0% with 20% of the select link demand able to reroute. As the percentage of select link demand that has the option to reroute is increased, the impact of the incident on the network can be seen to diminish. The PM model gives similar results, demonstrating that as the percentage of the select link matrix that is allowed to reroute increases, the impact on the network diminishes.

The impact of the incident in the inter-peak model is more pronounced given that delay in the base network is at a lower level than experienced in the busier AM and PM peaks.

Table 1-6 Effects of Increasing Diversion Response to an Incident on A14 Westbound, J25 Hemingford Abbots (AM peak)

Percentage of Transfer from the A14	Total Travel Time		Total Travel Distance		Average Speed		Delay	
	(PCU hours)	% Change	(PCU kms)	% Change	(km/h)	% Change	(PCU hours)	% Change
A14_C2H_2011	76,219	-	4,314,535	-	57	-	4,016	-
20%	-	3.4%	-	0.2%	-	-3.0%	-	61.5%
25%	-	3.1%	-	0.2%	-	-2.8%	-	54.7%
30%	-	2.8%	-	0.3%	-	-2.5%	-	48.8%
35%	-	2.6%	-	0.3%	-	-2.3%	-	44.4%
40%	-	2.4%	-	0.3%	-	-1.9%	-	39.4%
45%	-	2.2%	-	0.3%	-	-1.9%	-	36.3%
50%	-	2.2%	-	0.3%	-	-1.8%	-	34.0%

Table 1-7 Effects of Increasing Diversion Response to an Incident on A14 Westbound, J25 Hemingford Abbots (Inter-peak)

Percentage of Transfer from the A14	Total Travel Time		Total Travel Distance		Average Speed		Delay	
	(PCU hours)	% Change	(PCU kms)	% Change	(km/h)	% Change	(PCU hours)	% Change
A14_C2H_2011	69,856	-	4,136,355	-	59	-	1,796	-
20%	-	4.0%	-	0.3%	-	-3.5%	-	149.1%
25%	-	3.6%	-	0.3%	-	-3.2%	-	130.1%
30%	-	3.1%	-	0.3%	-	-2.7%	-	110.0%
35%	-	2.7%	-	0.3%	-	-2.4%	-	91.9%
40%	-	2.6%	-	0.3%	-	-2.2%	-	86.0%
45%	-	2.1%	-	0.4%	-	-1.7%	-	67.1%
50%	-	1.9%	-	0.4%	-	-1.5%	-	54.7%

Table 1-8 Effects of Increasing Diversion Response to an Incident on A14 Westbound, J25 Hemingford Abbots (PM peak)

Percentage of Transfer from the A14	Total Travel Time		Total Travel Distance		Average Speed		Delay	
	(PCU hours)	% Change	(PCU kms)	% Change	(km/h)	% Change	(PCU hours)	% Change
A14_C2H_2011	80,543	-	4,576,993	-	57	-	3,759	-
20%	-	3.2%	-	0.2%	-	-2.8%	-	66.4%
25%	-	2.9%	-	0.2%	-	-2.5%	-	58.4%
30%	-	2.6%	-	0.2%	-	-2.3%	-	52.3%
35%	-	2.4%	-	0.3%	-	-2.1%	-	47.2%
40%	-	2.3%	-	0.3%	-	-1.9%	-	44.3%
45%	-	2.2%	-	0.3%	-	-1.8%	-	40.6%
50%	-	2.1%	-	0.3%	-	-1.8%	-	37.5%

1.6.2. Non Trunk Road Demand Rerouting Response

To assess the impact of varying the percentage of the main demand that can reroute, the percentage of the select link demand that can reroute from the A14 has been fixed at 20%. The percentage of the remaining demand that can reroute has then been set at 5% intervals in the range 5-20%.

Table 1-9 to Table 1-11 present the headline model outputs for an incident modelled in the eastbound direction on the A14 at junction 25. In the AM peak the impact of the incident can clearly be seen with total network delay increasing by 46.5% and average speed falling by -2.1% with 5% of the main demand able to reroute. As the percentage of main demand that has the option to reroute is increased, the impact of the incident on the network can be seen to gradually increase. The PM model gives similar results, demonstrating that as the percentage of the main demand that is allowed to reroute increases, the impact on the network increases.

The impact of the incident in the inter-peak model is more pronounced given that delay in the base network is at a lower level than experienced in the busier AM and PM peaks.

The suprising conclusion of these tests suggests the percentage gain of informing those not directly affected by the incident is limited. The more information given to those drivers may well lead to an overall disbenefit to the network as a whole (although it is likely the individual vehicles with better knowledge may well have benefit).

Table 1-9 Effects of Increasing Wider Diversion Response to an Incident on A14 Eastbound, J25 Hemingford Abbots (AM peak)

Percentage of Wider Traffic Diversion	Total Travel Time		Total Travel Distance		Average Speed		Delay	
	(PCU hours)	% Change	(PCU kms)	% Change	(km/h)	% Change	(PCU hours)	% Change
A14_C2H_2011	76,219	-	4,314,535	--	57	-	4,016	-
5%	-	2.4%	-	0.2%	-	-2.1%	-	46.5%
10%	-	2.8%	-	0.2%	-	-2.5%	-	53.4%
15%	-	2.9%	-	0.2%	-	-2.7%	-	56.9%
20%	-	3.1%	-	0.2%	-	-2.8%	-	60.4%

Table 1-10 Effects of Increasing Wider Diversion Response to an Incident on A14 Eastbound, J25 Hemingford Abbots (Inter-peak)

Percentage of Wider Traffic Diversion	Total Travel Time		Total Travel Distance		Average Speed		Delay	
	(PCU hours)	% Change	(PCU kms)	% Change	(km/h)	% Change	(PCU hours)	% Change
A14_C2H_2011	69,856	-	4,136,355	-	59	-	1,796	-
5%	-	3.0%	-	0.3%	-	-2.5%	-	118.6%
10%	-	3.0%	-	0.3%	-	-2.5%	-	118.7%
15%	-	3.0%	-	0.3%	-	-2.5%	-	118.8%
20%	-	3.2%	-	0.3%	-	-2.7%	-	125.9%

Table 1-11 Effects of Increasing Wider Diversion Response to an Incident on A14 Eastbound, J25 Hemingford Abbots (PM peak)

Percentage of Wider Traffic Diversion	Total Travel Time		Total Travel Distance		Average Speed		Delay	
	(PCU hours)	% Change	(PCU kms)	% Change	(km/h)	% Change	(PCU hours)	% Change
A14_C2H_2011	80,543	-	4,573,993	-	57	-	3,759	-
5%	-	2.9%	-	0.2%	-	-2.5%	-	64.4%
10%	-	3.0%	-	0.2%	-	-2.6%	-	68.5%
15%	-	3.1%	-	0.2%	-	-2.6%	-	69.1%
20%	-	3.2%	-	0.2%	-	-2.8%	-	71.8%

1.7. Variations in Incident Impact by Location

Section 1.4 compared the available observed data with the modelled outputs for a replicated incident. In this section, a more detailed look at how the network could react to differing incident locations is undertaken. For this analysis, 35% of select link demand and 10% of main demand has been given the option to reroute.

Incidents at two locations have been investigated: junction 25 at Hemingford Abbots; and a second location on the Cambridge northern bypass section of the A14 at the Milton interchange. Incidents have been investigated in both the eastbound and westbound directions. Tests were undertaken for all 3 time periods. The AM Peak results only are presented, since the patterns observed were consistent across each time period.

The following presents a comparison of the incident scenario minus the A14_C2H_2011 base model. Graphical map based (SATURN Plots) representation of the changes in hourly traffic flow and delay changes can be seen in Appendix E.

1.7.1. Incident on A14 Eastbound, J25 Hemingford Abbots

With the incident introduced, a drop in demand can clearly be seen on the A14 eastbound, starting from the A1198/A14 junction just downstream of the incident location. Vehicles with the option to reroute have predominantly elected to turn off onto A1198. Some of the demand has then rejoined the A14 using the B1040, avoiding the incident. Others have continued on the A1198, joining the A428 to continue eastwards towards Cambridge. A small amount of rerouting can also be seen further west, with vehicles electing to leave the A14 at Huntingdon to join the A141, bypassing the incident.

1.7.2. Incident on A14 Westbound, J25 Hemingford Abbots

With the incident introduced a drop in demand can clearly be seen on the A14 westbound. Vehicles with the option to reroute are electing to take an alternative route as far back as the M11 junction with the A1303, rejoining the A14 via the A428 and A1198 or B1040. Some vehicles are electing to leave the A14 at Fenstanton to rat-run through Hemingford Grey and Hemingford Abbots to avoid the incident and rejoin the A14.

1.7.3. Incident on A14 Eastbound, J33 Milton Interchange

With the incident introduced a drop in demand can clearly be seen on the Cambridge Northern Bypass section of the A14 eastbound. Vehicles with the option to reroute are mostly electing to leave the A14 at junction 32, Histon interchange to rat-run to the north through Impington or south via Kings Hedges Road to rejoin the A14 via Milton interchange.

1.7.4. Incident on A14 Westbound, J33 Milton Interchange

With the incident introduced a drop in demand can clearly be seen on the Cambridge Northern Bypass section of the A14 westbound. Vehicles with the option to reroute are electing to leave the A14 to travel through the centre of Cambridge to avoid the incident. Increased flows can be seen on Newmarket Road and Fulbourn Road. Some vehicles are then rejoining the A14 via Milton Road. Others are rejoining the A14 further west via Huntingdon Road, or the A428 via the A1303 Madingley Road.

1.8. Conclusions

A model has been developed to predict the impact on the highway network of an incident on the A14. The model has been developed to allow incidents to be modelled at all major junctions between the A1 and A11. This initial study has assessed the impact of incidents in both directions at J25 Hemingford Abbots and J33 Milton Interchange only.

The model is flexible in that it allows the percentage of select link and main demand that can reroute to be easily adjusted. The capacity reduction percentage resulting from an incident can also be adjusted.

Sensitivity tests have been carried out to understand the impact of varying the percentage of vehicles that have the option to reroute. The model predicts that as the percentage of demand that would normally pass through the incident site and is allowed to reroute is increased, the total network delay decreases. Conversely, increasing the percentage of the main matrix that has the option to reroute has the opposite effect with total network delay increasing.

The alternative routes taken by vehicles in the model in the event of an incident appear logical. Those vehicles that have the option to reroute make rational alternative route choices.

A westbound incident on the Cambridge Northern Bypass section of the A14 has the most significant impact on vehicle flows and delay in the centre of Cambridge. The main rerouting options are for vehicles to find alternative routes through the city centre.

2. Element 2 – Residual Capacity

The potential amount of additional traffic that the alternative routes may be able to accommodate has been analysed by assessing the level of capacity compared to the level of traffic flow as observed within the SATURN highway model. This analysis has yielded a graphical representation as to the level of additional traffic that key routes can accept along their length.

The level of residual capacity may also correlate to the journey time reliability along these routes, with higher residual capacity likely to be seen on a route where there is less susceptibility to delay. These routes therefore are likely to exhibit a more reliable journey time.

The following sections present the level of residual capacity along the key alternatives routes identified within Element 1. Graphical representations of the residual capacity trends along these routes can be found within Appendix F.

2.1. A1123 / B1050 – St Ives, Earith, Willingham Longstanton to A14 at Bar Hill

The route along the A1123 and B1050 can provide an alternative for incidents along the A14 for the majority of the distance between Huntingdon and Cambridge. The figures in Appendix E present the residual capacity along the route from the A141/A1123 junction to the west to the B1050/A14 junction at Bar Hill to the east. Representations are given for each of the three modelled time periods.

It can be seen that there is residual capacity along the route throughout both the AM and Inter peak periods, however there are two areas where there is little or no residual capacity in the PM peak. The area around the Ramsey Road junction in St Ives and through Earith towards the B1050 both exhibit capacity restraints without any diversion from the A14 due to an incident. It should be noted that these areas also have limited residual capacity in the other time periods as well.

It appears that this route would begin to suffer additional delays if traffic levels increased by around 200 PCUs in either the AM or PM peak, with St Ives and the B1050 section of the route likely to come under significant stress with this level of increased traffic.

The areas of the route in St Ives and close to Earith are also likely to display high variability in journey time, particularly in the PM peak period.

The westbound direction displays a similar picture to the eastbound data, with the area around Ramsey Road in St Ives once again being an area with limited residual capacity. The route as a whole would generally be able to accommodate less additional traffic in the PM peak, where additions of around 200 vehicles per hour would again push sections of the route over capacity.

Once again the areas of the route in St Ives and in Earith are likely to have weaker journey time reliability. It can be seen that the lower levels of residual capacity in the PM peak may also caused increased variability, particularly close to the A14.

2.2. A1123 East / A142 – Earith, Haddenham, Stretham, Fordham to A14 at Newmarket

The route along the A1123 and A142 from the B1050 to the A14 can provide a longer-distance alternative for incidents along the A14 as far east as Newmarket. The figures in Appendix E present the residual capacity along the route. Representations are given for each of the three modelled time periods.

This analysis shows that there are areas of capacity restraint in both the AM and PM peak periods. The AM peak has restraints both around the B1049 junction and on the approach to the A14. The PM peak has similar restraints, although not to such a great extent, but also has restrictions around the B1381/B1050 junction.

The journey time variability is likely to be high along this route, since there are several of areas of low residual capacity. This indicates that small changes in flow are likely to have increasing impacts on the delays experienced along the route.

The westbound direction displays a similar picture to the eastbound. The AM and PM peak periods both show areas of low residual capacity on the A142 close to the A14 and on the A1123 close to the B1050 junction. Both time periods also show there to be low residual capacity at the A1421 junction in Haddenham.

As with the eastbound direction, there is likely to be high journey time variability along the route, given that there are areas where there is very low or zero residual capacity.

2.3. A1198 Godmanchester to Caxton Gibbet and A428

This route provides a similar alternative to the south of the A14 for incidents between Cambridge and Godmanchester. The figures in Appendix E present the residual capacity along the length of this route in both an eastbound and westbound direction.

It can be seen that both the A1198 and A428 have greater residual capacity to accommodate additional traffic diverted off the A14 due to an incident than the A1123 or B1050. The reliability of the journey time is likely to be relatively high along this route, although the greatest variability is likely to be seen close to Caxton Gibbet where traffic is conflicted against the A428 St Neots to Cambridge through movements.

In the opposite westbound direction, there are similar levels of residual capacity along both the A1198 and A428. Increases in flow of greater than 400 PCUs will start to put pressure on the area around Caxton Gibbet on both the A1198 and A428, particularly in the PM peak. This PM peak is expected to have the lowest residual capacity due to the tidal nature of flow out of Cambridge at that time of day. PM journey time reliability is likely to be most variable close to Caxton Gibbet.

2.4. A1307 (Huntingdon Road)

Depending on the location of an incident on the A14, the pattern of movement into or out of Cambridge may also be influenced. One such road that may be influenced is Huntingdon Road, as a key access route to the A14.

It can be seen that the area of lowest capacity in both the northbound and southbound direction is at Girton Corner, where there is around 500 PCUs residual capacity. As expected, the lowest level of residual capacity is in-line with the tidal flow into Cambridge in the morning and back out in the evening.

2.5. A14, Cambridge Northern Bypass

The A14 Cambridge Northern Bypass is a key route passing to the north of Cambridge. It can be seen that the in the eastbound direction, the area between Girton and Histon in the AM peak period has very limited residual capacity. In the PM peak period, there is the lowest level of residual capacity around the Fen Ditton junction.

The westbound direction displays slightly more consistent levels of residual capacity throughout the day. The area around the Girton interchange shows little or no residual capacity throughout the day and would be an area unable to accommodate any further traffic flow increases.

The Cambridge Northern Bypass would generally have difficulty in absorbing any additional traffic, but the lack of residual capacity also indicates that it would be very sensitive to any reductions in capacity due to an incident.

The areas of low residual capacity are again likely to be indicative of areas where high journey time variability can be expected.

2.6. M11

The traffic flow along the M11 are susceptible to changes if there is an incident on the A14 itself, causing drivers to seek wider alternative routes. The figures in Appendix E present the residual capacity on the M11 from Girton Junction 14 through to Madingley Junction 13.

It can be seen that in both the northbound and southbound directions, the area around Madingley Junction 13 has the lowest levels of residual capacity. The tidal nature of the flow on this section is evident once again, with the southbound direction having less residual capacity in the AM and the northbound carriageway having the lowest residual capacity in the PM.

3. Element 3 – Alternative Arrangements

3.1. Initial Investigation

Initial investigations have been conducted to establish the main areas where additional delay may be present due to increased traffic arising from vehicles diverting to avoid an incident. This analysis has been undertaken individually for each of the incidents replicated in Section 1.4.

3.2. A14 Westbound Accident at Hemingford Grey

The following analysis is based on the AM Peak model, however very similar patterns can also be seen in the inter-peak and PM Peak models.

The model shows that traffic is likely to divert onto the A428 westbound to avoid the A14. Approximately two-thirds of these vehicles join the A428 at the Madingley Mulch roundabout having come from Madingley Road with the remaining joining from the A14 northern bypass. Traffic is then forecast to turn right onto the A1198 and are split evenly between the Papworth bypass and the local road through Papworth itself. A second stream of traffic is forecast to join the A1198 northbound at Hilton having diverted from the A14 at St Ives. The majority of traffic then joins the A14 westbound downstream of the accident, with the remainder heading through Godmanchester.

The model also identifies some traffic that leaves the A14 westbound at Fenstanton, upstream of the accident and divert through Fenstanton and use Low Road to travel through Hemingford Grey and Hemingford Abbots where they re-join the A14 westbound just downstream of the accident.

3.2.1. Caxton Gibbet

It can be seen that the extra traffic travelling on the A428 westbound and turning right at Caxton Gibbet increases the delay on this junction approach. Due to the extra vehicles right turning from east to north, the southern and western arms have fewer opportunities to enter the roundabout and the delays also increase here.

3.2.2. A14 J24, Godmanchester

The traffic diverting along the A1198 which re-joins the A14 at Godmanchester increases the delay on the southern arm of the roundabout.

3.2.3. A1198 / Graveley Road (Hilton)

The traffic leaving the A14 westbound at St Ives are predicted by the model to use Graveley Way to access the A1198 northbound and therefore must turn right when they reach the A1198. In reality, it is our opinion that the majority of vehicles would remain on the B1040 (the turning to Graveley Way is small and the road itself is narrow) and access the A1198 at the B1040/A1198 roundabout.

If this were the case then there would be an increase in traffic turning right at this roundabout, forcing the diverted traffic coming from the A428 to give way to them, possibly causing congestion on the south-western arm.

3.2.4. A14 J27, Fenstanton

The traffic leaving the A14 westbound at Fenstanton to avoid the accident increase the delay on their diversion route quite significantly, given that only a small number of vehicles would normally use this route.

The delay on Low Road leaving Fenstanton increases, although vehicles could leave the A14 one junction later at St Ives if queues have not blocked back beyond this point. Due to the increased demand at the A1096 / Hemingford Road roundabout either on the Low Road (south-eastern) or A1096 (south-western) arm, congestion here is likely.

To divert through Hemingford Grey, traffic must turn right from Braggs Lane onto Manor Road. The model then predicts that diverted traffic will use New Road to re-join the A14 at J25 (Hemingford Abbots), however it is our opinion that vehicles are more likely to remain on Hemingford Abbots High Street and access J25 from Rideaway as New Road is not sign-posted. For this reason the delay on Rideaway is likely to increase rather than on New Road. The delay at J25 is forecast to marginally increase. Therefore, although no significant issues are predicted at J25, the rural route between junctions 27 and 25 is likely to become congested if an accident occurs on this stretch of the A14.

3.2.5. Potential Congestion Reducing Measures During a Westbound Accident on the A14

The following are potential measures that could be investigated to help mitigate against potential increased delay as a result of diverting traffic.

- Ensure symbol signed diversion routes are unambiguous to aid efficient diversion. Consider reviewing diversion routes to avoid congestion on one single diversion route;
- Consider the use of mobile variable messaging signs to inform drivers where to avoid / where to divert; and
- Traffic management at Caxton Gibbet to help traffic clear more efficiently. This is particularly important on the eastern and western arms where demand is high.

In practise, there is limited scope for potential mitigation, since the key junctions do not already have traffic signals in place and Police would be unable to provide manual junction control on a national speed limit section of carriageway.

3.3. A14 Eastbound Accident at Hemingford Abbots:

The following analysis is based on the AM Peak model, however very similar patterns can also be seen in the inter-peak and PM peak models.

The model shows that a significant proportion of traffic diverts from the A14 onto the A1198 at Godmanchester to avoid the A14 eastbound. Around half of these vehicles leave the A1198 at Hilton and use Potton Road (B1040) to access J26 (St Ives) to rejoin the A14 eastbound downstream of the accident, while there is a small proportion that use Fenstanton Road / Hilton Road to rejoin the A14 eastbound at J27 (Fenstanton) or use the A1198 to travel through Elsworth and Boxworth to rejoin the A14 eastbound at J28 (Swavesey). The other half continue on the A1198 to join the A428 eastbound. This traffic stream then splits at the Madingley junction, with half continuing eastbound on the A14 northern bypass and half heading eastbound on Madingley Road.

The model also identifies a further small proportion that leave the A14 at Huntingdon to use the A141 to reach the A1123 and rejoin the A14 eastbound at St Ives.

3.3.1. Caxton Gibbet

It can be seen that the extra traffic approaching from the A1198 southbound and turning left at Caxton Gibbet increase the delay on the A1198 southbound significantly.

3.3.2. A14 J24, Godmanchester

The level of traffic that diverts away from the A14 eastbound at junction 24 (Godmanchester), increases the amount of traffic using this junction significantly. This increases the delay on the eastbound off-slip and the A1198 southbound. It can also be seen that there are significant increases in delay on the A14 eastbound due to the accident.

3.3.3. A14 J26, St Ives

Half of the traffic diverts around the accident by heading south on the A1198 and then accesses the A14 eastbound at junction 26 (St Ives). This increases the delay on the B1040 northbound.

3.3.4. A1123, St Ives

The small proportion of traffic that diverts around the accident by diverting on the A1123 and then accessing the A14 eastbound at junction 26 (St Ives) increases the delay on the A1123 eastbound in St Ives (near Ramsey Road) quite significantly, since this junction is already operating near capacity.

3.3.5. Potential Congestion Reducing Measures During an Eastbound Accident on the A14

The following are potential measures that could be investigated to help mitigate against potential increased delay as a result of diverting traffic.

- Ensure symbol signed diversion routes are unambiguous to aid efficient diversion. Consider reviewing diversion routes to avoid congestion on one single diversion route.
- Consider the use of mobile variable messaging signs to inform drivers where to avoid / where to divert.
- Traffic management at Caxton Gibbet to help traffic clear more efficiently. This is particularly important on the northern arm as the heavy west-east flows will prevent this traffic from pulling out.

Once more, there is limited scope for potential mitigation, since the key junctions do not already have traffic signals in place and Police would be unable to provide manual junction control on a national speed limit section of carriageway.

4. Element 4 – Roadwork Data Analysis

Atkins has been provided with the following two Excel files from the CCC Streetworks team containing records of road works on County Council roads:

- FX372-Works_details-20140314-101820.xls. (1,726 records covering the months of October and November 2011).
- FX372-Works_details-20140314-101956.xls. (1,624 records covering the months of November and December 2011; February, March, April and July 2012; and January, March and June 2013).

The following approach has been taken to filter the data to identify only those records significant to the study area:

- All records classified as immediate (emergency and urgent), minor and standard have been discarded. Only records classified as major have been considered.
- All records of type "None/Signing Only" have been discarded as these will not impact the highway network.
- Records that do not fall inside or within close proximity of the study area formed by the triangle of the A14, A1 and A428 have been discarded.
- Any records that only impact footpaths have been discarded.
- All records of works with duration of less than one week have been discarded.

The table in Appendix G presents the remaining records which have been considered significant to the study area. These records have been investigated further to determine the potential impact on rerouting in the event of an incident on the A14. Comments have been provided against each record.

5. Element 5 – Future Model Enhancement Strategy

Having established an outline assignment methodology, and developed the assignment model such that it can be automatic and flexible in its ability to replicate incidents, further development could focus upon the way in which the model reports results and is able to capture data from new incidents to feed back into the assumptions that govern the reassignment of traffic due to an incident on the A14. The following outlines the areas for further development of the modelling process.

5.1. Identification of Use of Output Data

Consideration needs to be given to understand the data that can be made available for the enhanced model and how it can be utilised to facilitate wider knowledge and awareness of the impacts of incidents on the road network. It is important to consider the final use of this data, since this may govern the development path that the modelling process may take. The following points outline current suggestions to develop the methodology into a flexible platform that can be best manipulated in the future.

5.2. Capturing Feedback

Algorithms can be developed that capture the nature of an incident and the impact that has on the network, and combine these with the duration of an incident to predict the level of capacity reduction that would occur. This factor can be then fed into the model to replicate the incident. The modelled outputs can then be correlated to observed data as it becomes available to ascertain if the level of diversion and the impacts seen from the model are representative of the actual impacts. The algorithms that define the inputs can then be adjusted to help calibrate the model to become more accurate and take on board information from incidents in the future.

Scenarios can then be tested with differing levels of diverting traffic to establish the impacts should a greater or lesser number of drivers have information about the incident and be able to adjust or re-plan their route accordingly.

6. Conclusions

There are a number of rich data sources that can be utilised to undertake analysis of the performance of the road network when an incident takes place.

Long term traffic count data from the Highways agency's TRADS database is able to show the level of traffic reduction on the A14 (or other trunk road) due to an incident in 15 minute segments, which allows a clear understanding of the level of restriction caused. This data can also be used to analyse the traffic level increases on adjacent trunk roads as a result of traffic diverting to avoid the incident.

TrafficMaster journey time data also hold valuable information for capturing the scale of disruption that is caused by an incident, giving an indication of the queue emanating from the incident location as well as the speed changes on other areas of the road network as a result of traffic diversion.

There is also the ability to analyse the nature and location of roadworks on the network at that time to understand the potential impact that each may have on any diversion that may occur. By correlating this data to the diversionary effects seen, it would be possible to infer the impact of any future roadworks on a diversion route, and therefore help to guide any information that may be passed to drivers.

Element One of this study has demonstrated that it is possible to create a model that is able to provide a broad replication of the level of diversion and other impacts that are caused during an incident. It can be seen that by enabling different parameters to be altered within the model, there is the potential to replicate a number of different incident scenarios.

The run-time of the model is such that it is unlikely to be suitable for real-time use during an incident. Therefore an implementation for the modelling process could be to pre-run a series of assignments covering different incident locations and parameters to produce a data-bank of results from which to draw upon during an incident. This would allow instant access to the data at the onset of an incident to enable the fastest response possible to be implemented.

Element Two demonstrated that it was possible to use modelled results to identify areas of high or low residual capacity on the road network, and that this could then be interpreted to indicate areas that are likely to have a greater impact should any incident occur that would result in increased traffic levels on these sections.

These first two sections combined demonstrate that it is possible to undertake a wealth of analysis in to how an incident would impact upon the road network. This analysis has also shown that the greatest benefits can be seen by allowing road users who would be directly impacted by an incident (the incident would take place along their normal route) to have the greatest levels of diversion. Greatest effort should therefore be targeted towards providing better information in the event of an incident to those travelling, or intending to travel, along the route on which the incident occurs.

Element Three has demonstrated that the model is able to predict pinch-point areas that are likely to suffer adverse effects due to an incident. Analysis of these areas can then be undertaken to attempt to ascertain if there are any mitigation measures (either temporary or permanent) that can be put in place to help reduce the negative impact of any incident that may occur. The results shown in this report indicate that it would not always be possible to put in place mitigation measures. In a semi-rural area where diversion is likely to occur, there are unlikely to be any significant number of traffic signals at key locations whose timings could be altered to help ease congestion arising from an incident. Speed limits on these rural roads are also likely to be high, therefore precluding the utilisation of manual Police control at junctions.

Element Four has shown that data is available to cross-reference against recorded impacts of incidents to attempt to establish if other factors, such as long term roadworks which may also impact upon the routing of traffic during an incident. In the incidents analysed, it was found that there was no evidence to suggest that the roadworks in place at the time of these incidents would have had a material impact upon the reassignment of traffic observed.

Element Five has outlined further work which could also be undertaken to determine the data that is collected during an incident and understand how best to optimise or define a long term data collection strategy to best monitor the impact of incidents along the A14 corridor.

Appendices

Appendix A. Modelled Capacity Graphs

Figure A-1 A14 WB Modelled Capacity

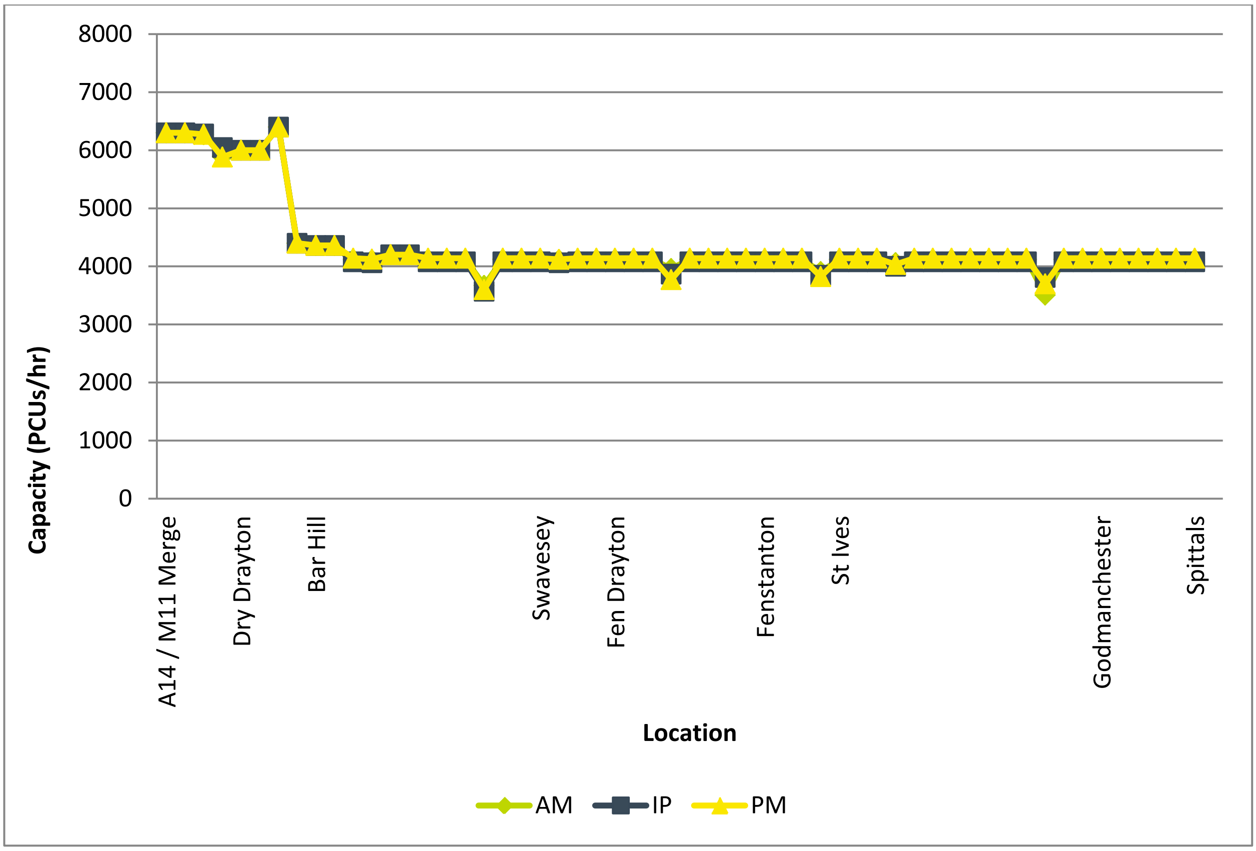


Figure A-2 A14 EB Modelled Capacity

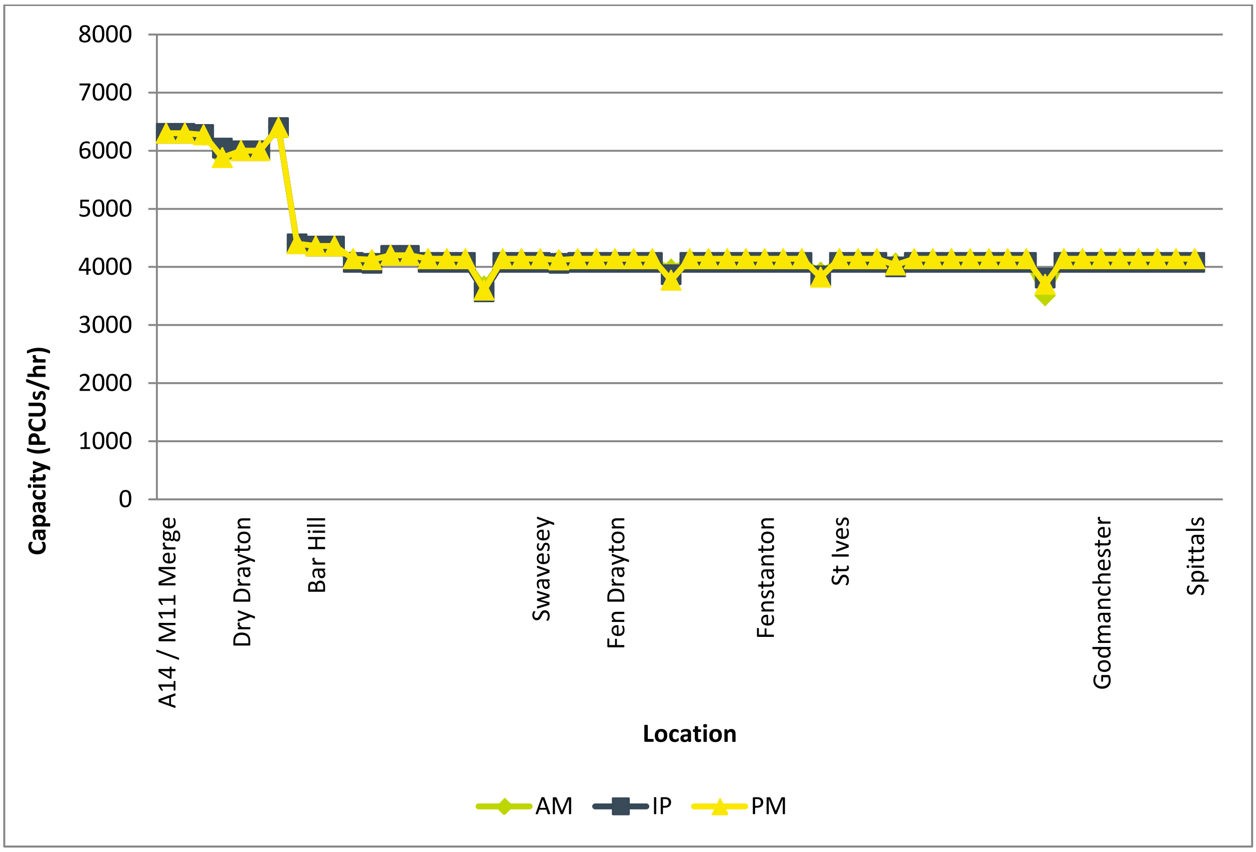


Figure A-3 A428 EB Modelled Capacity

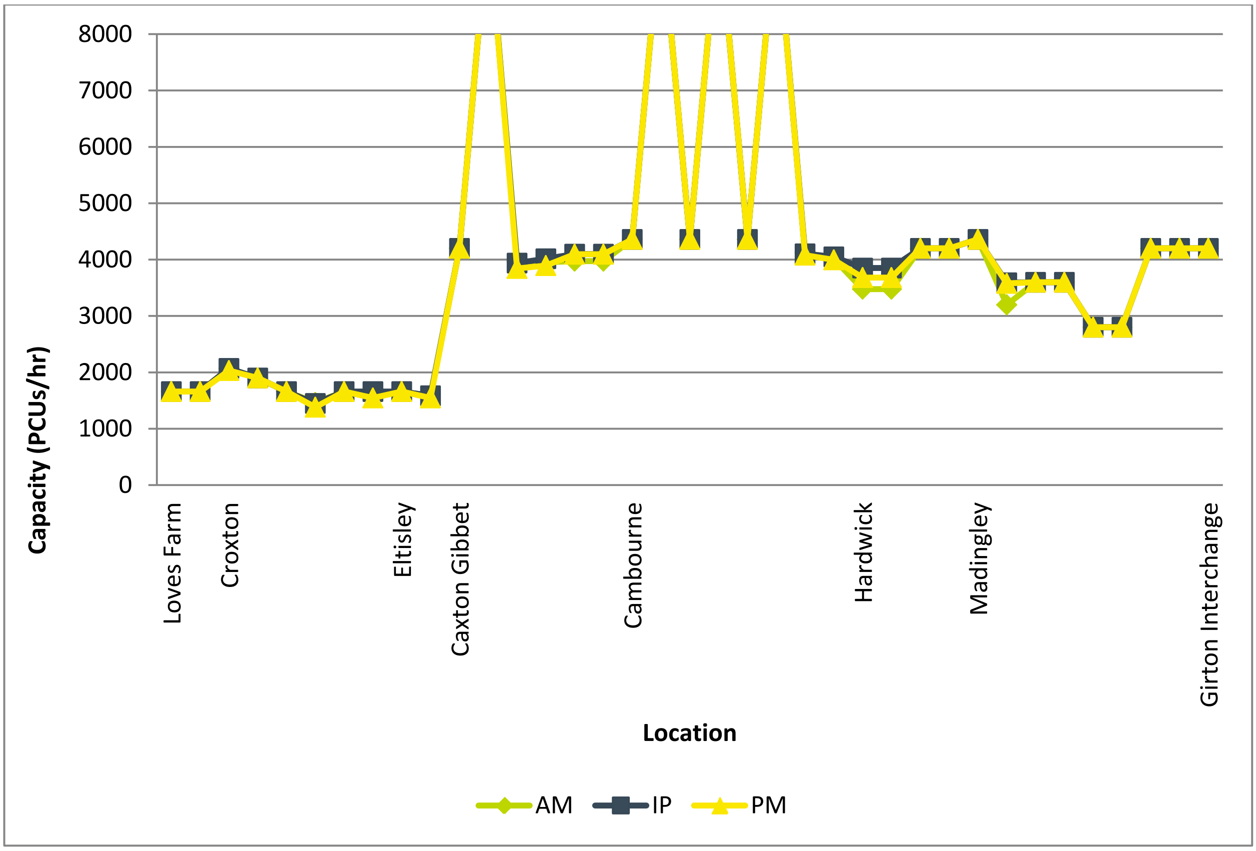


Figure A-4 A428 WB Modelled Capacity

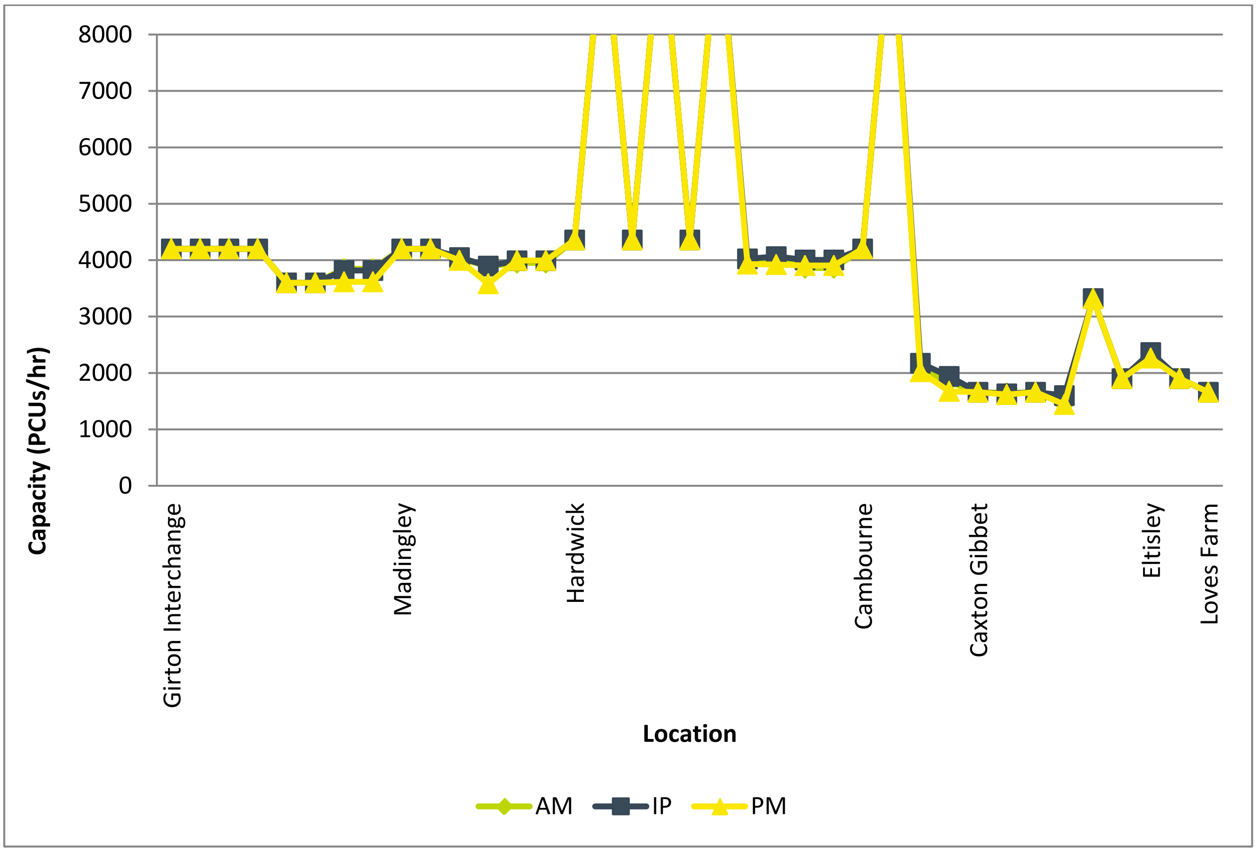


Figure A-5 A1123 and B1050 EB Modelled Capacity

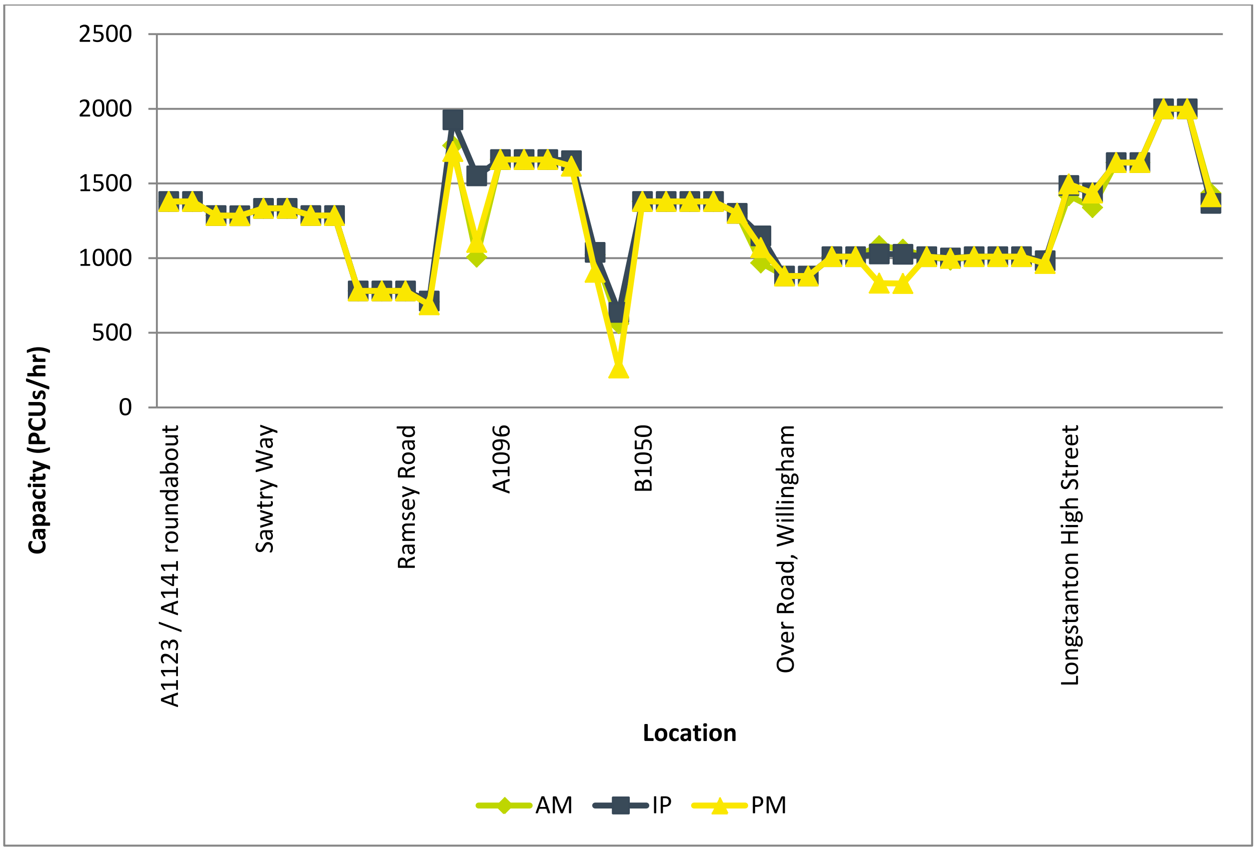


Figure A-6 A1123 and B1050 WB Modelled Capacity

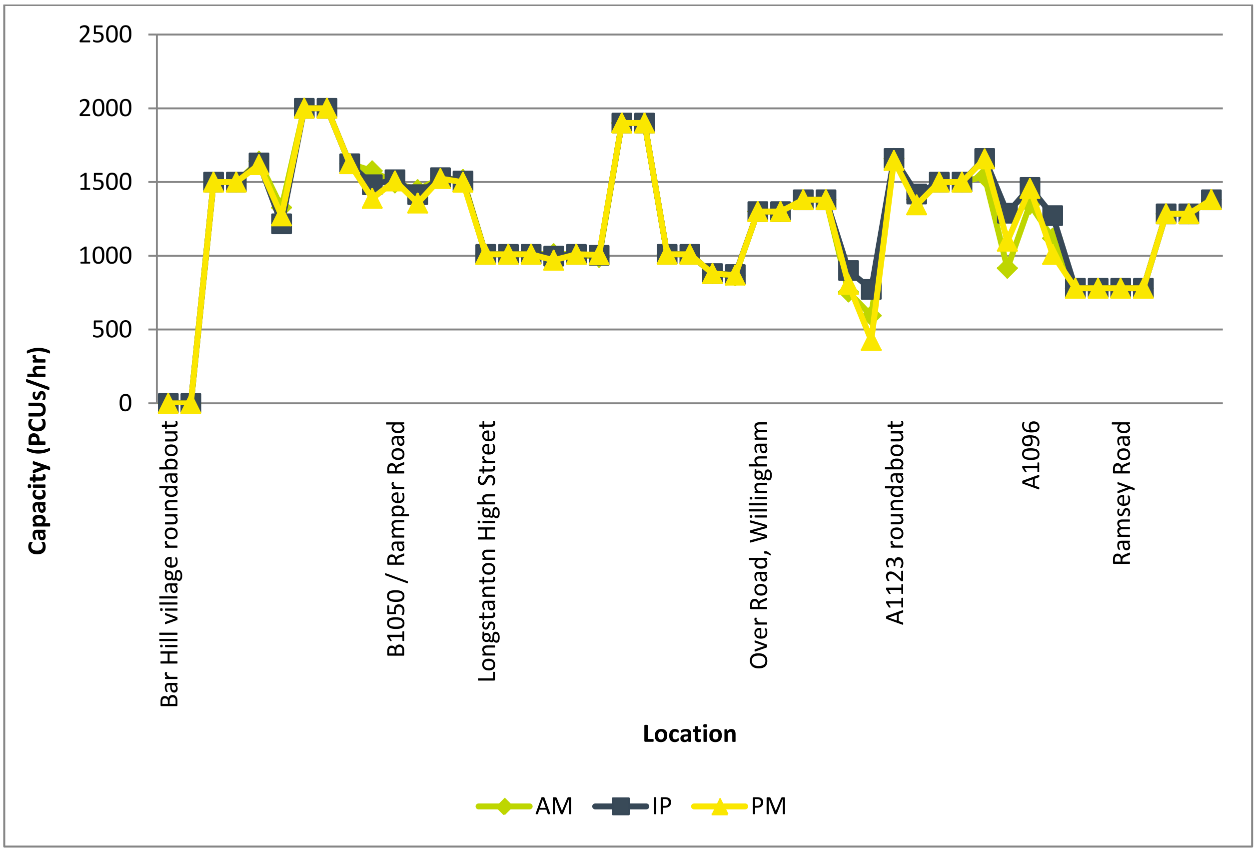


Figure A-7 A1123 and A142 EB Modelled Capacity

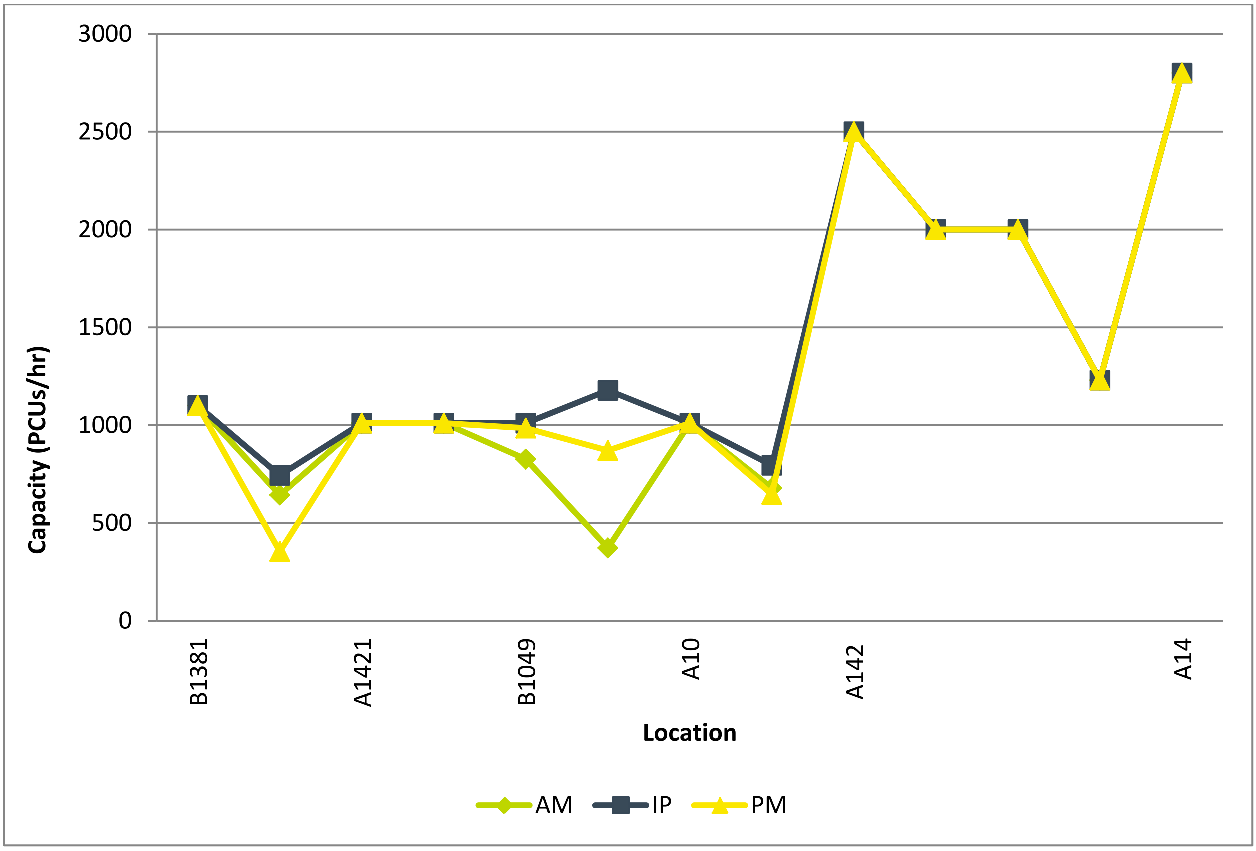


Figure A-8 A1123 and A142 WB Modelled Capacity

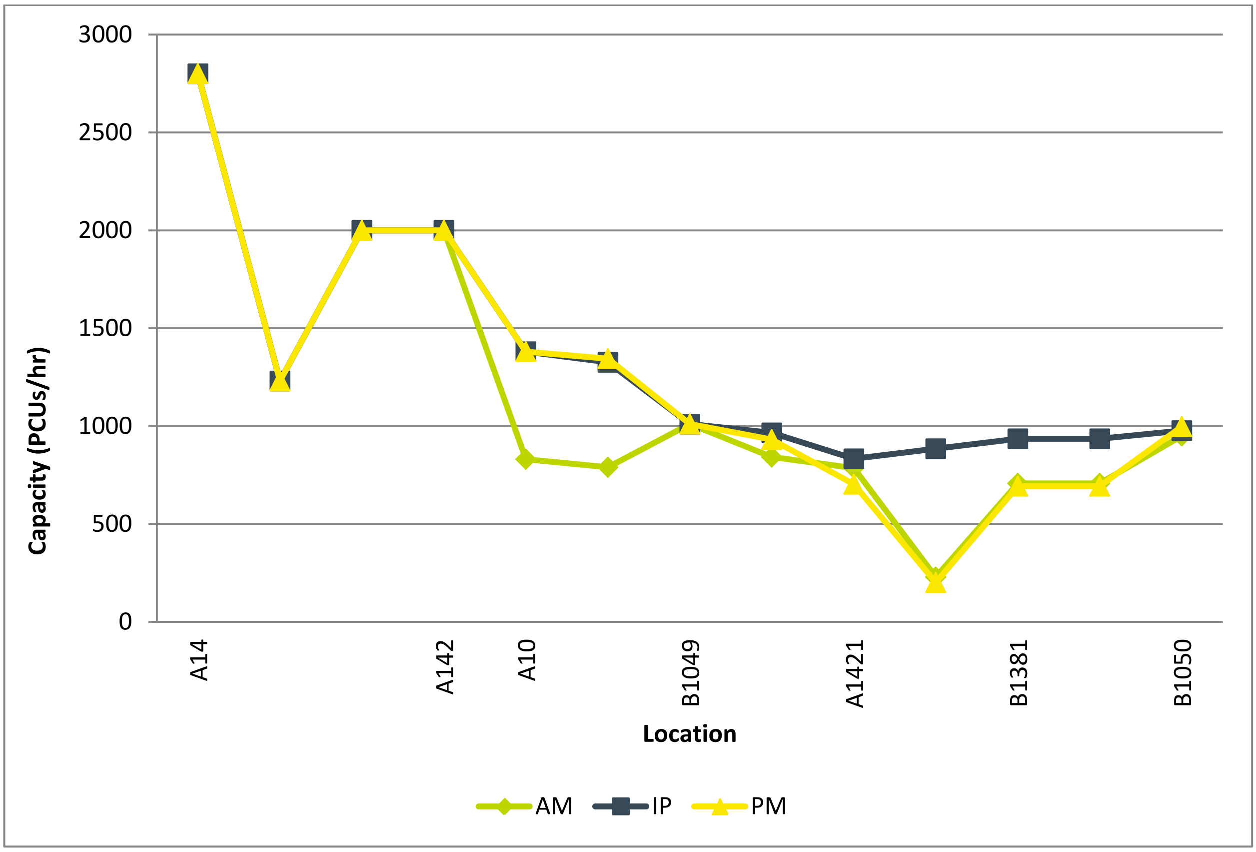


Figure A-9 A14 Cambridge Northern Bypass EB Modelled Capacity

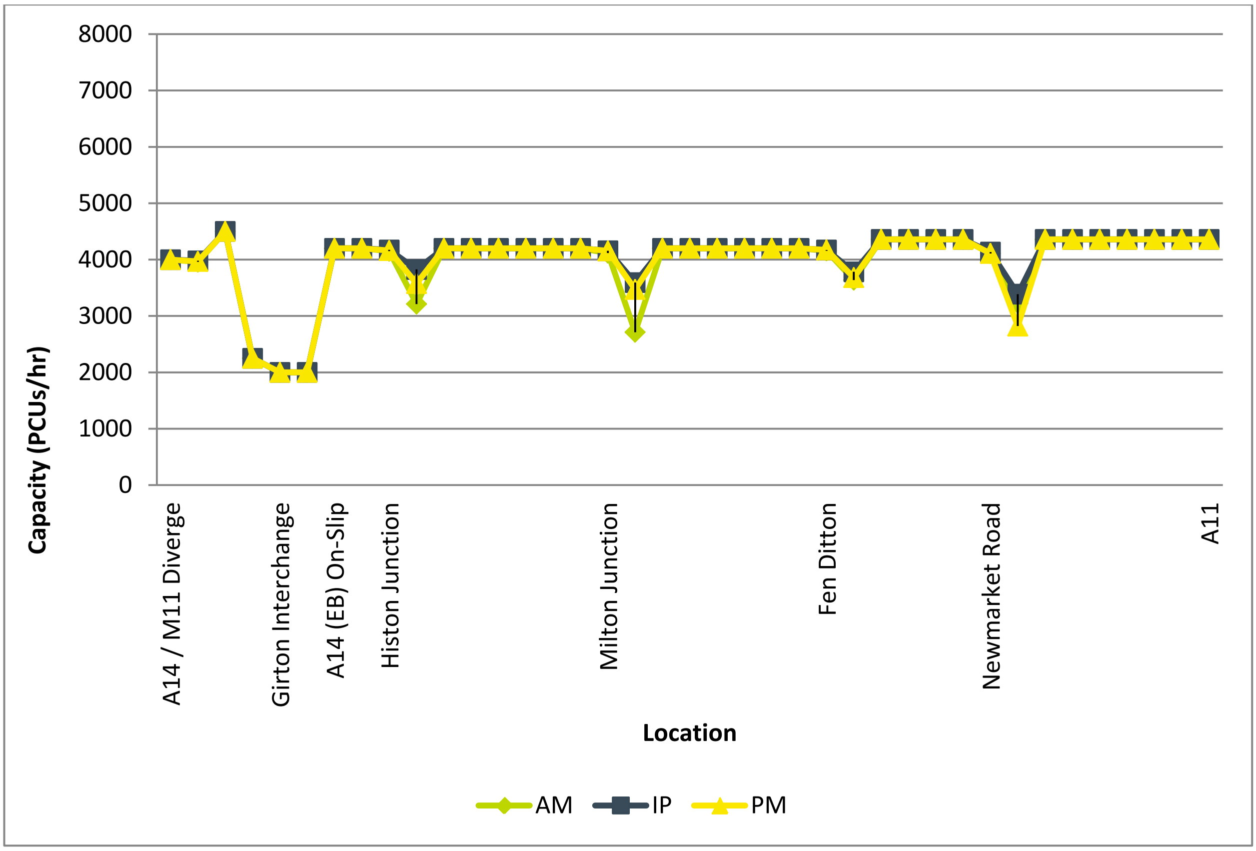


Figure A-10 A14 Cambridge Northern Bypass WB Modelled Capacity

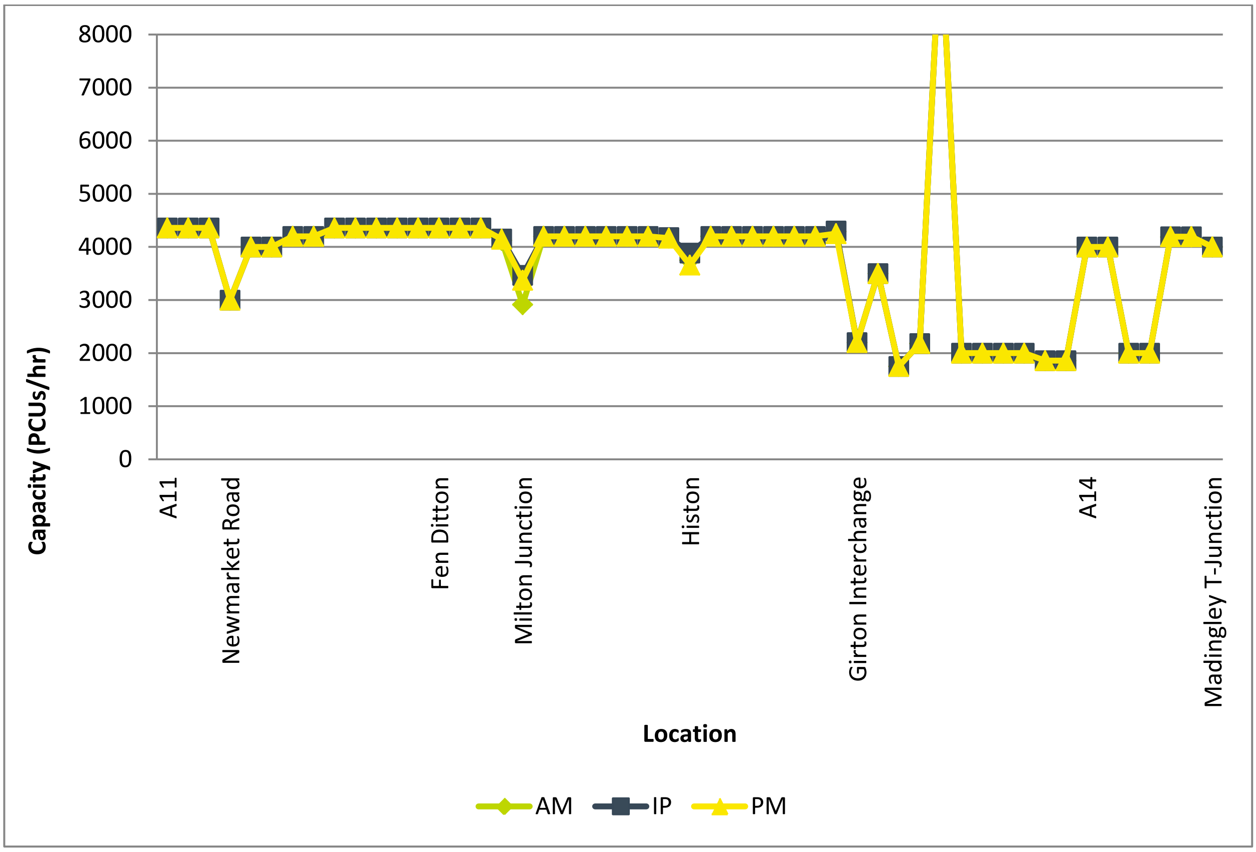


Figure A-11 A1307 Huntingdon Road EB Modelled Capacity

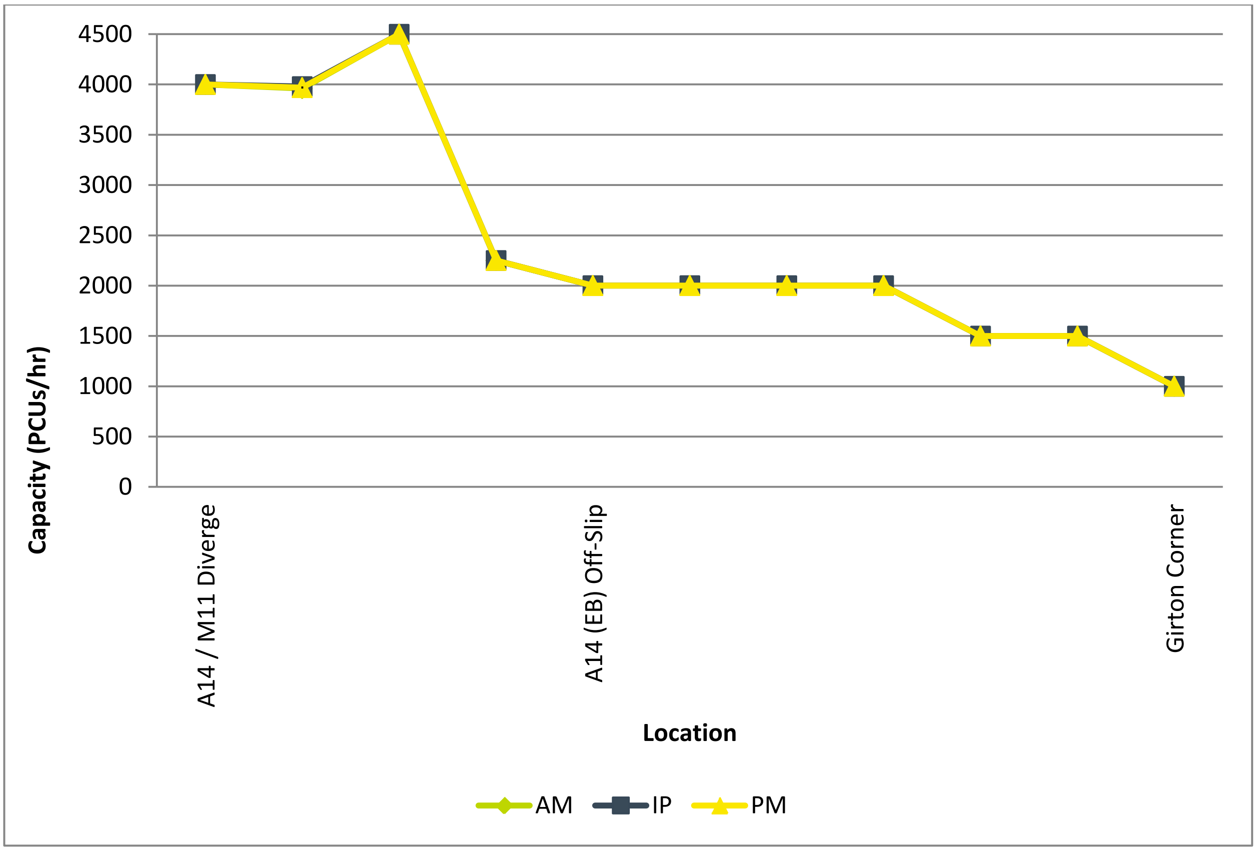
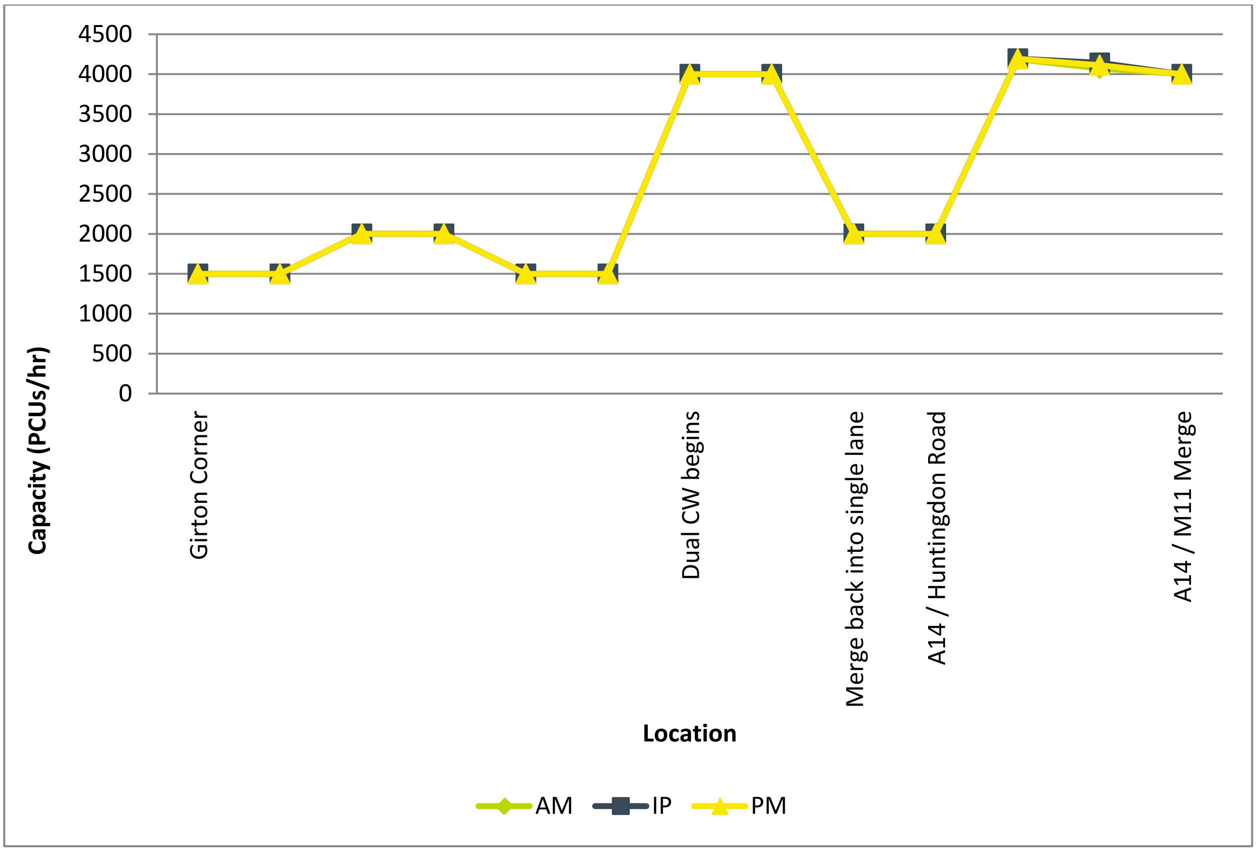


Figure A-12 A1307 Huntingdon Road EB Modelled Capacity



Appendix B. Journey Time Variability Graphs

Figure B-1 A14 Cambridge Northern Bypass Eastbound Journey Time Variability – AM Peak Hour

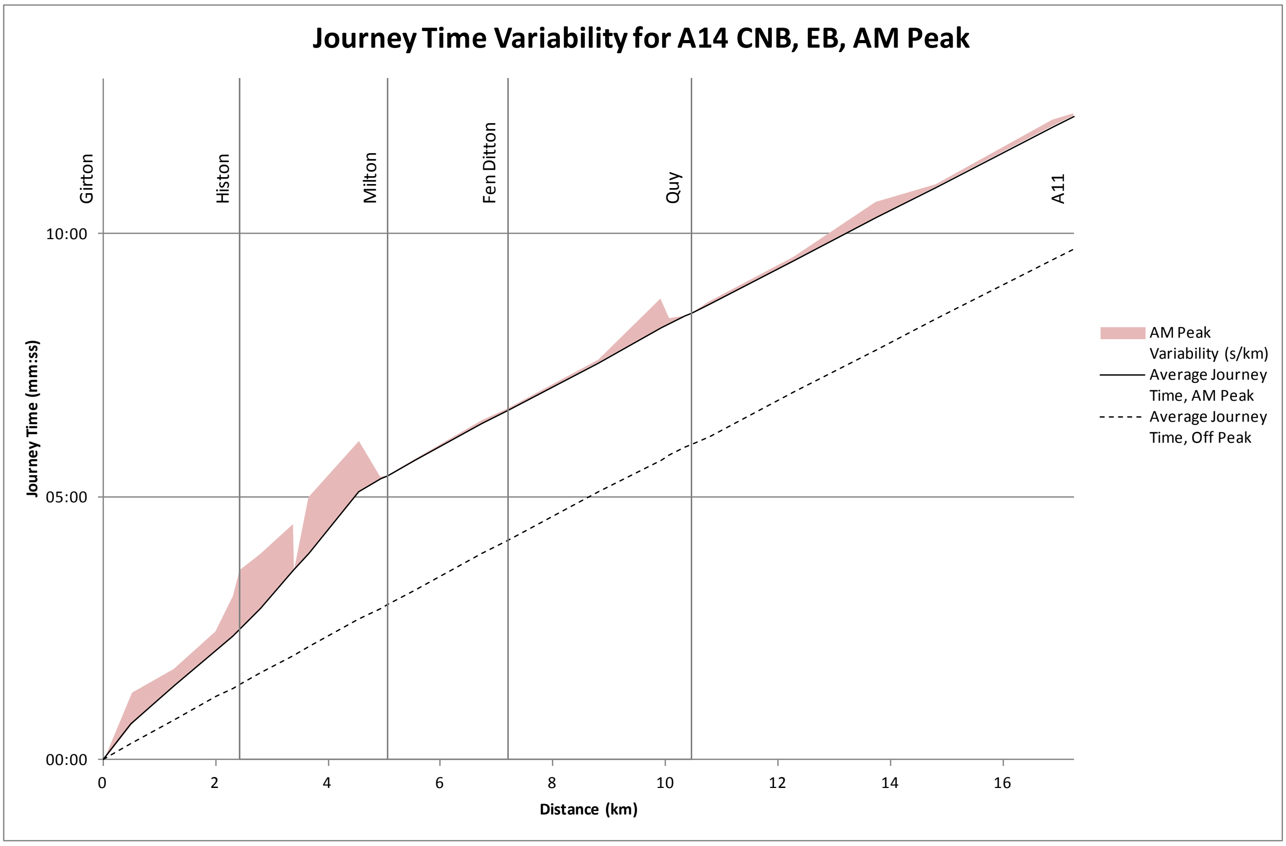


Figure B-2 A14 Cambridge Northern Bypass Eastbound Journey Time Variability – Inter Peak Hour

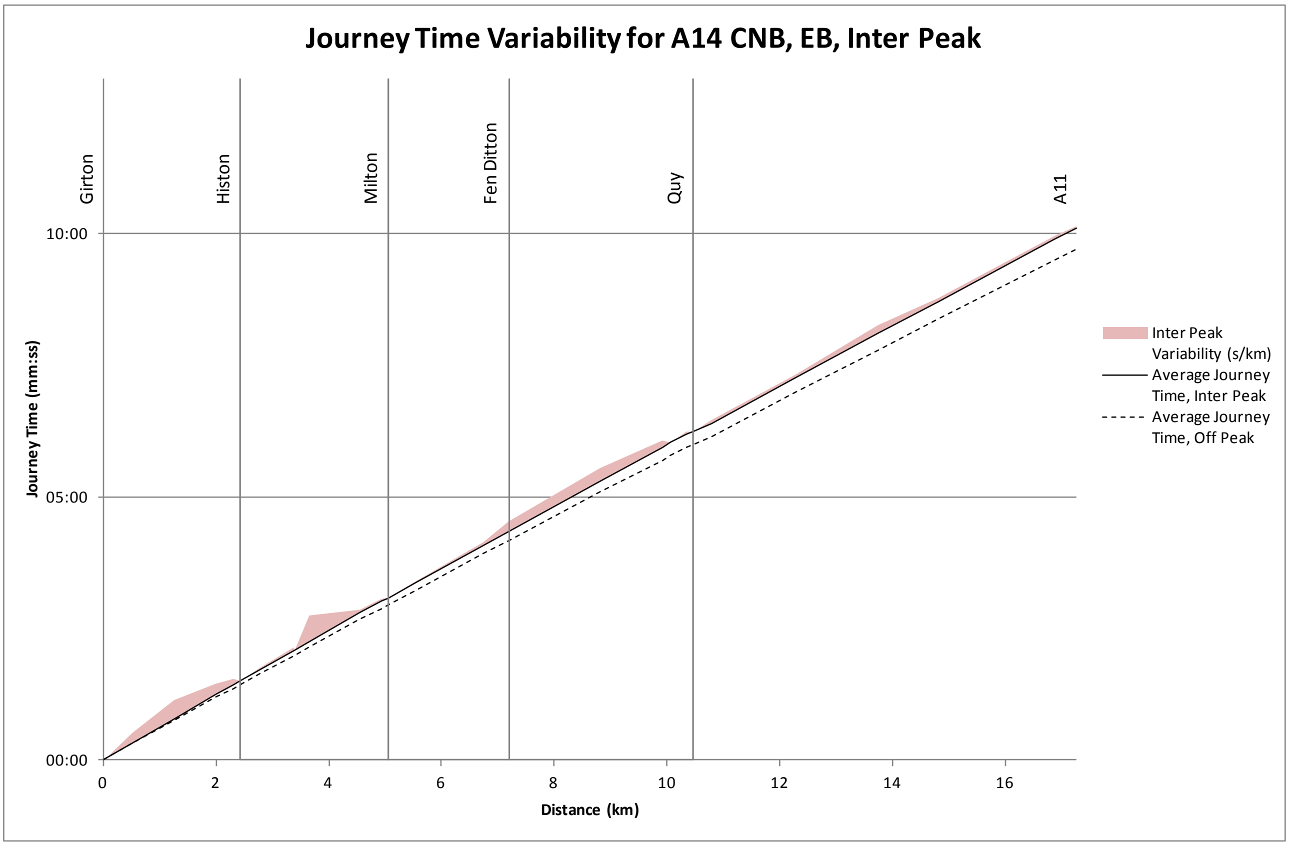


Figure B-3 A14 Cambridge Northern Bypass Eastbound Journey Time Variability – PM Peak Hour

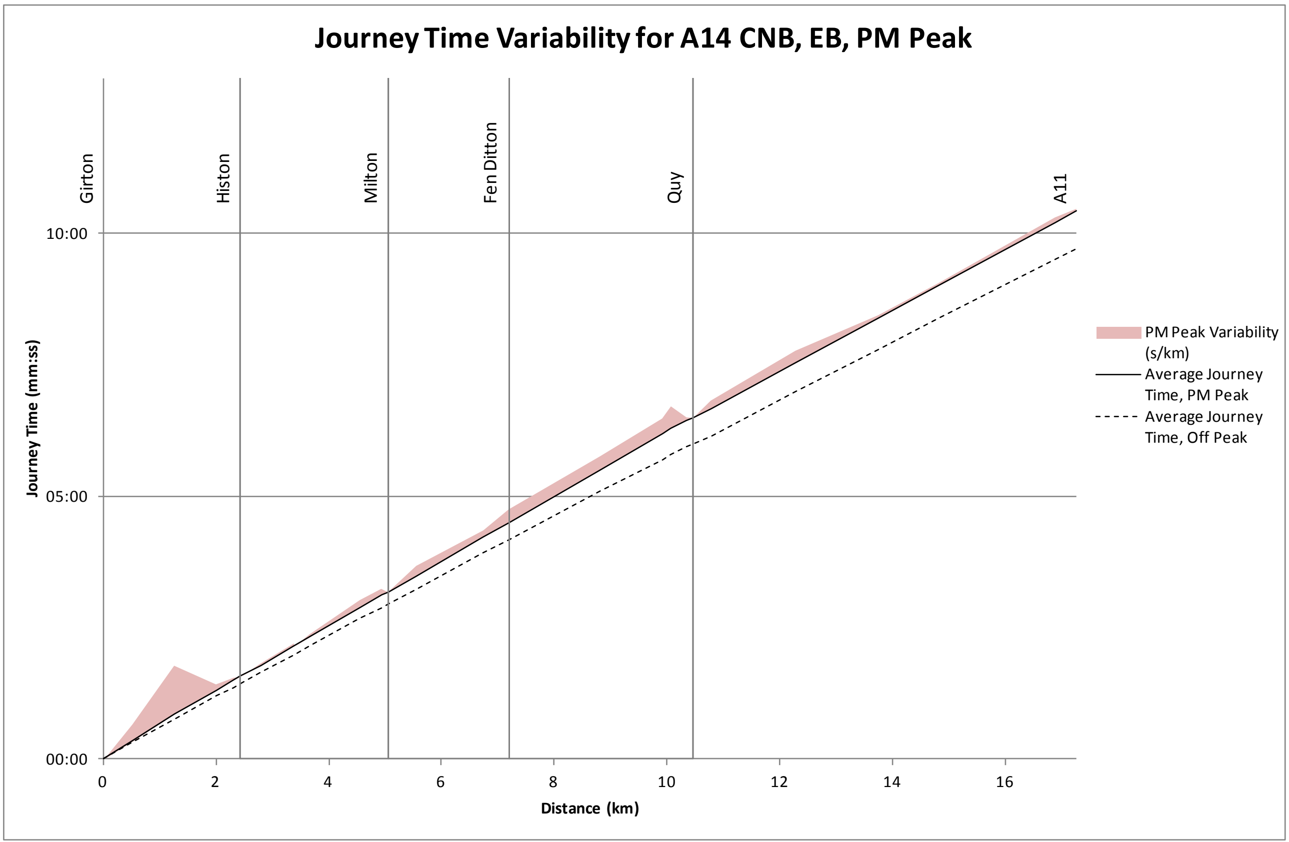


Figure B-4 A14 Cambridge Northern Bypass Westbound Journey Time Variability – AM Peak Hour

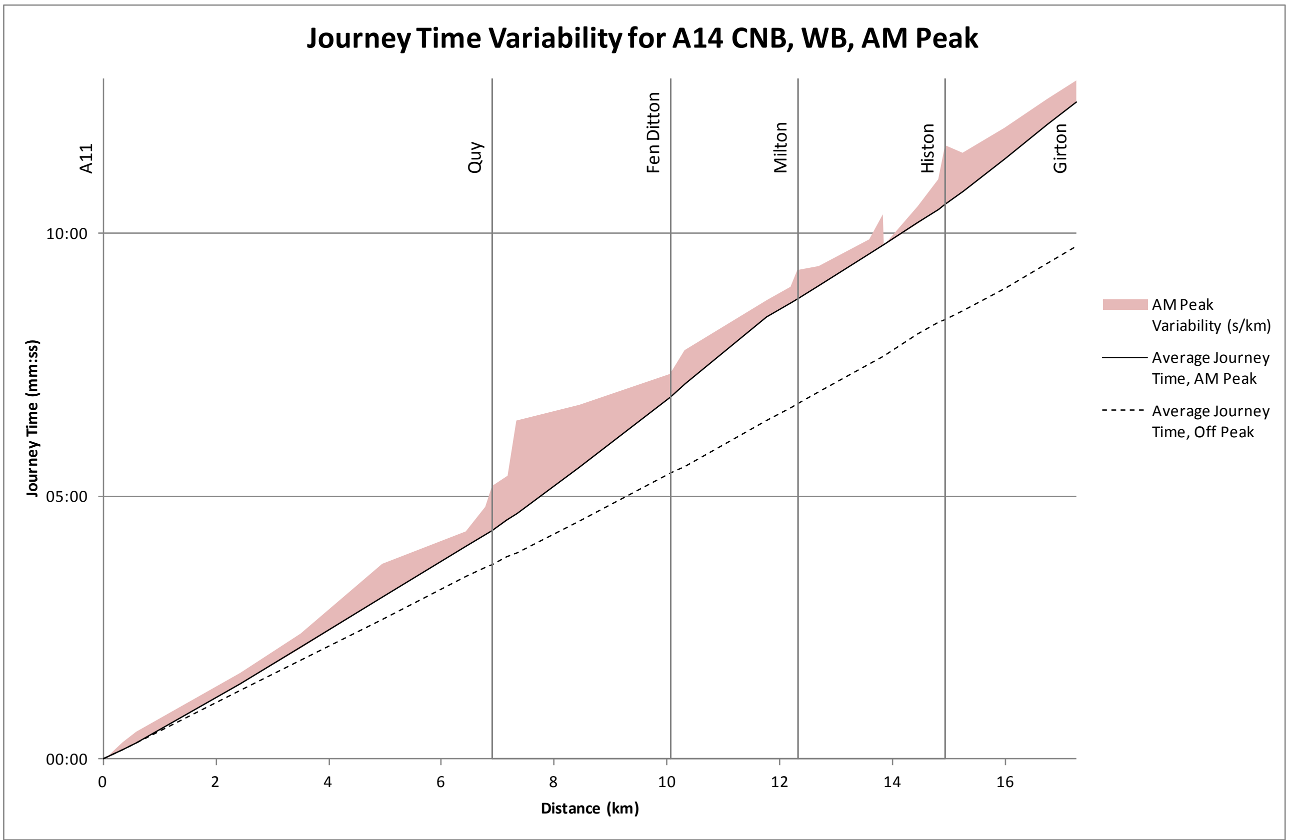


Figure B-5 A14 Cambridge Northern Bypass Westbound Journey Time Variability – Inter Peak Hour

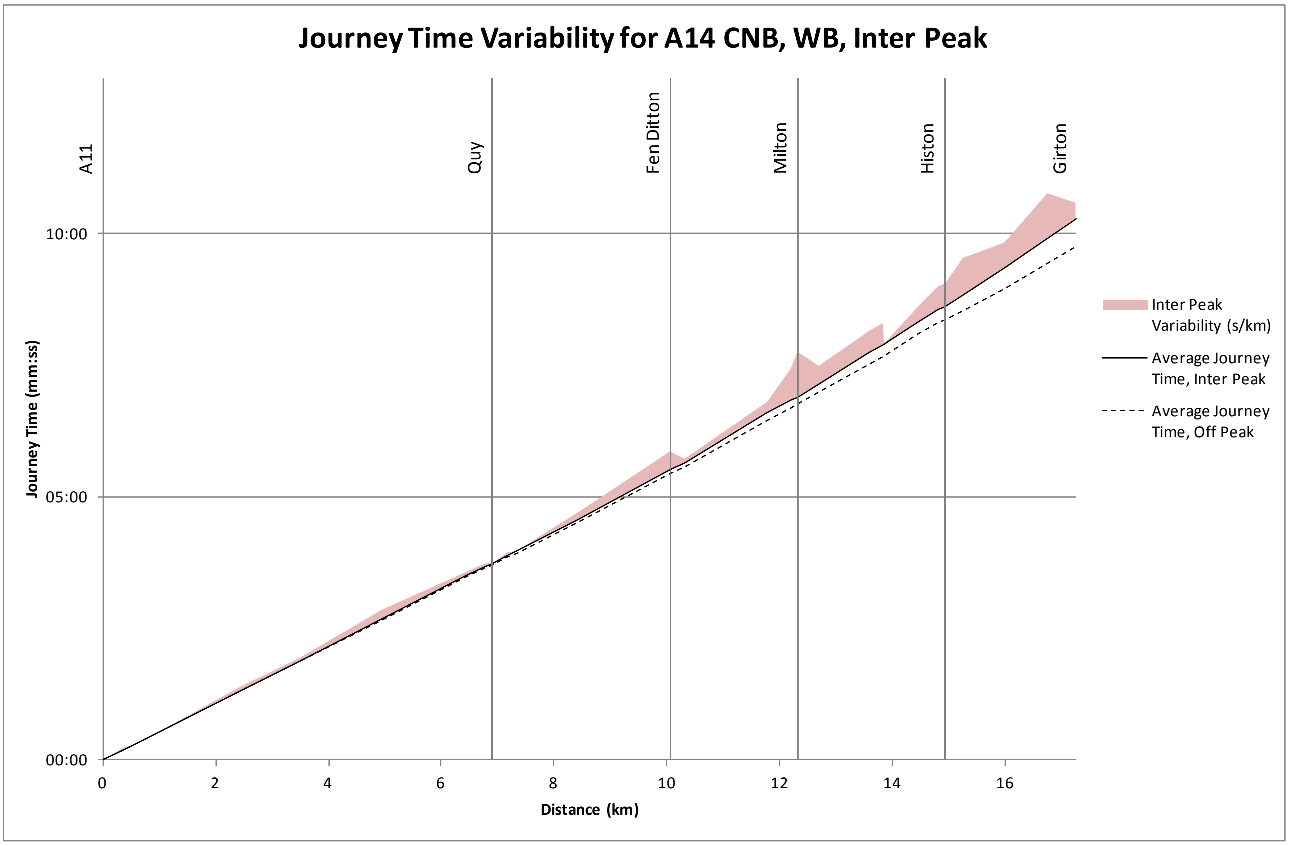


Figure B-6 A14 Cambridge Northern Bypass Westbound Journey Time Variability – PM Peak Hour

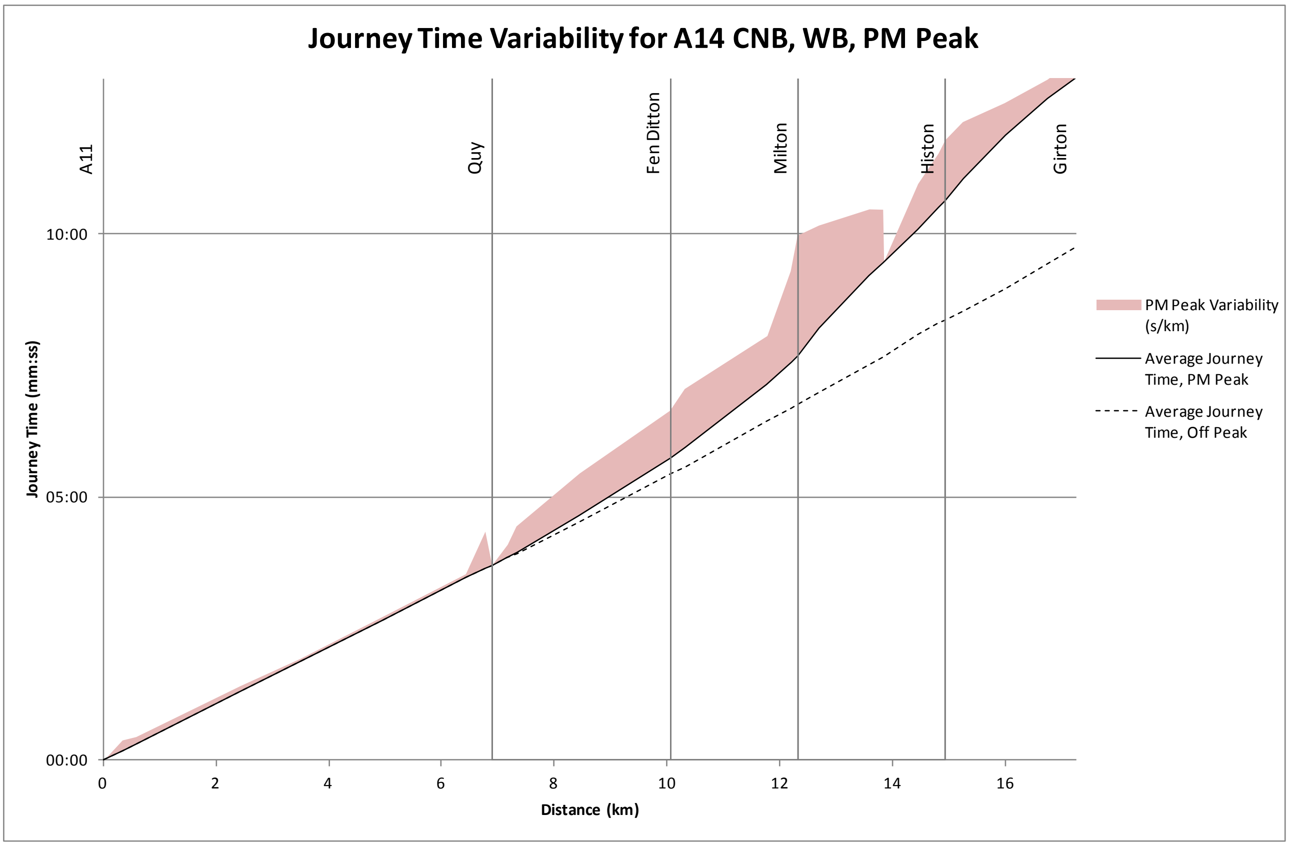


Figure B-7 A14 Cambridge to Huntingdon Eastbound Journey Time Variability – AM Peak Hour

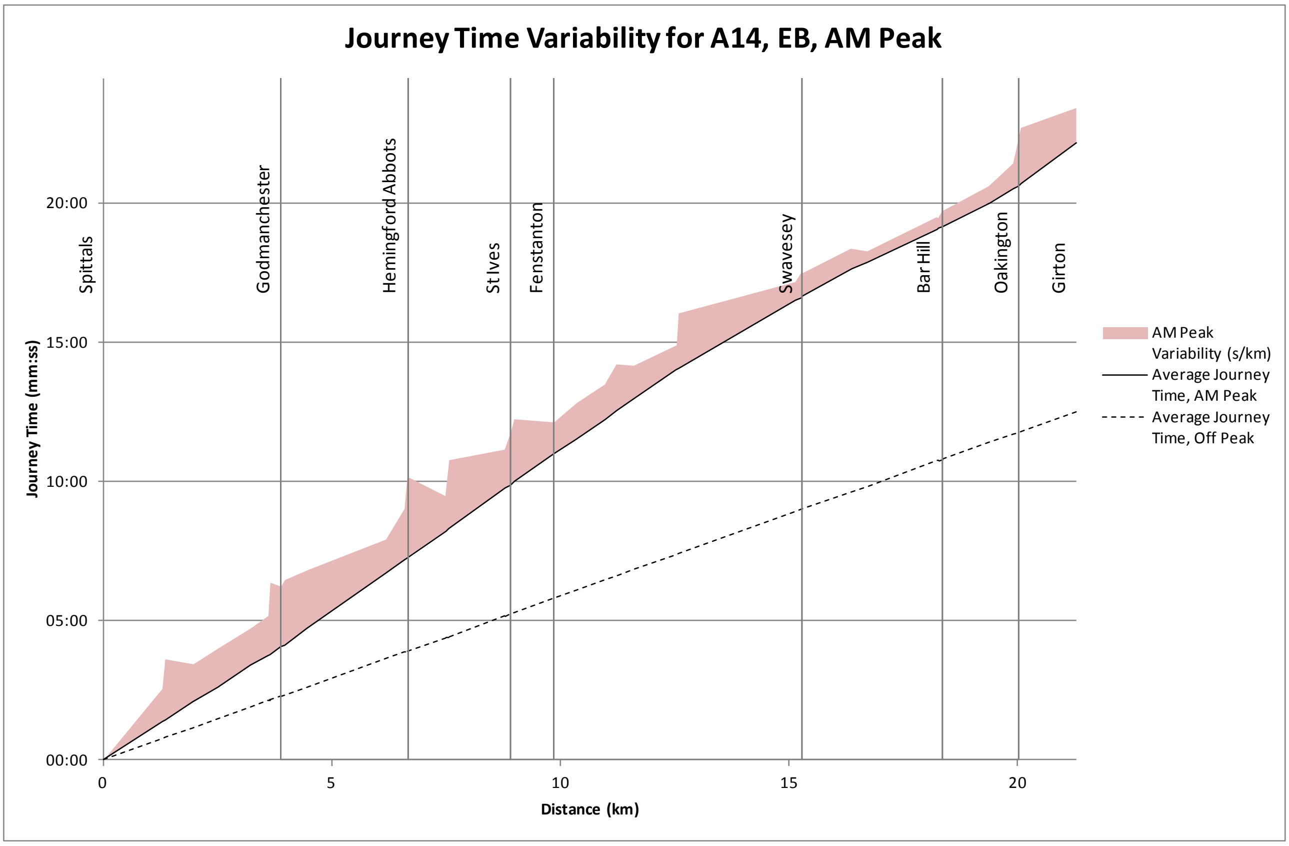


Figure B-8 A14 Cambridge to Huntingdon Eastbound Journey Time Variability – Inter Peak Hour

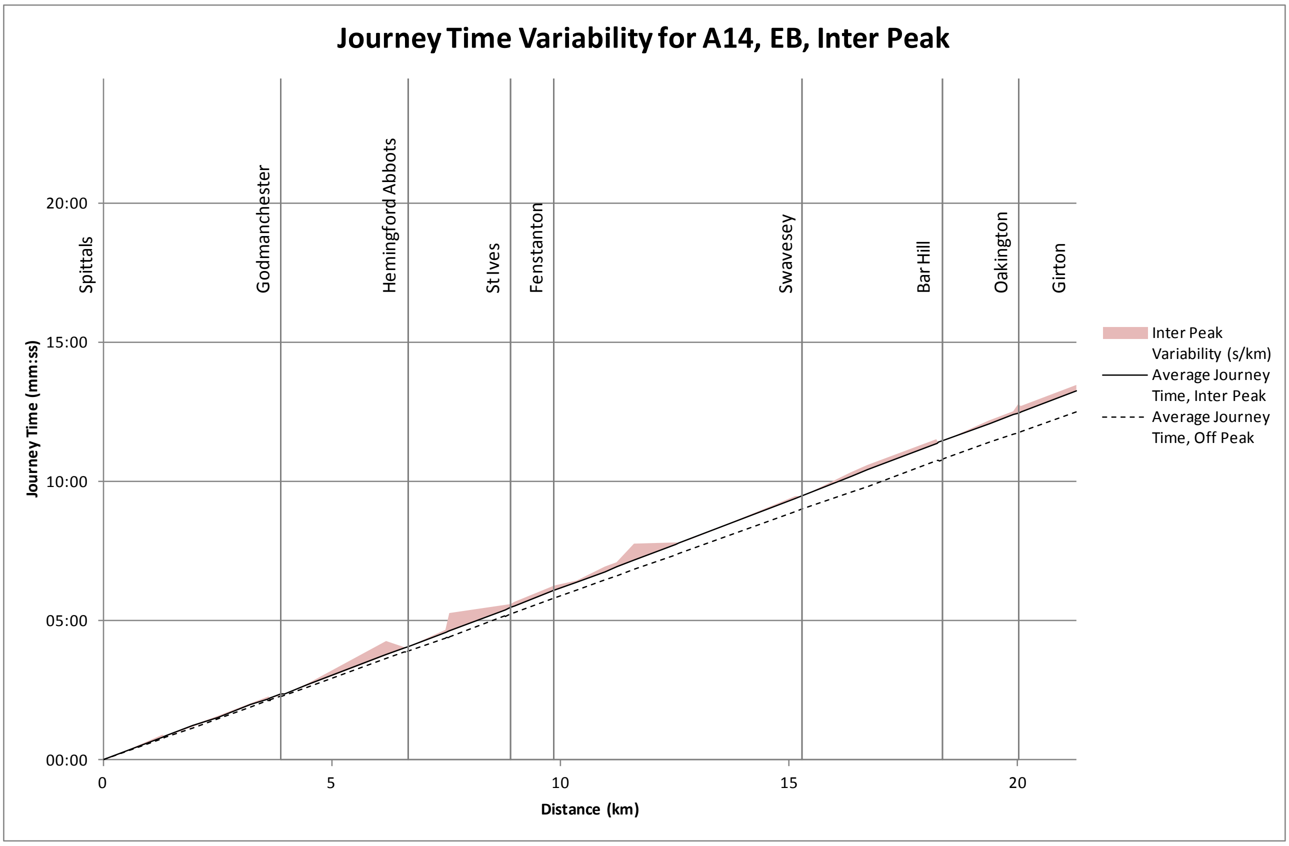


Figure B-9 A14 Cambridge to Huntingdon Eastbound Journey Time Variability – PM Peak Hour

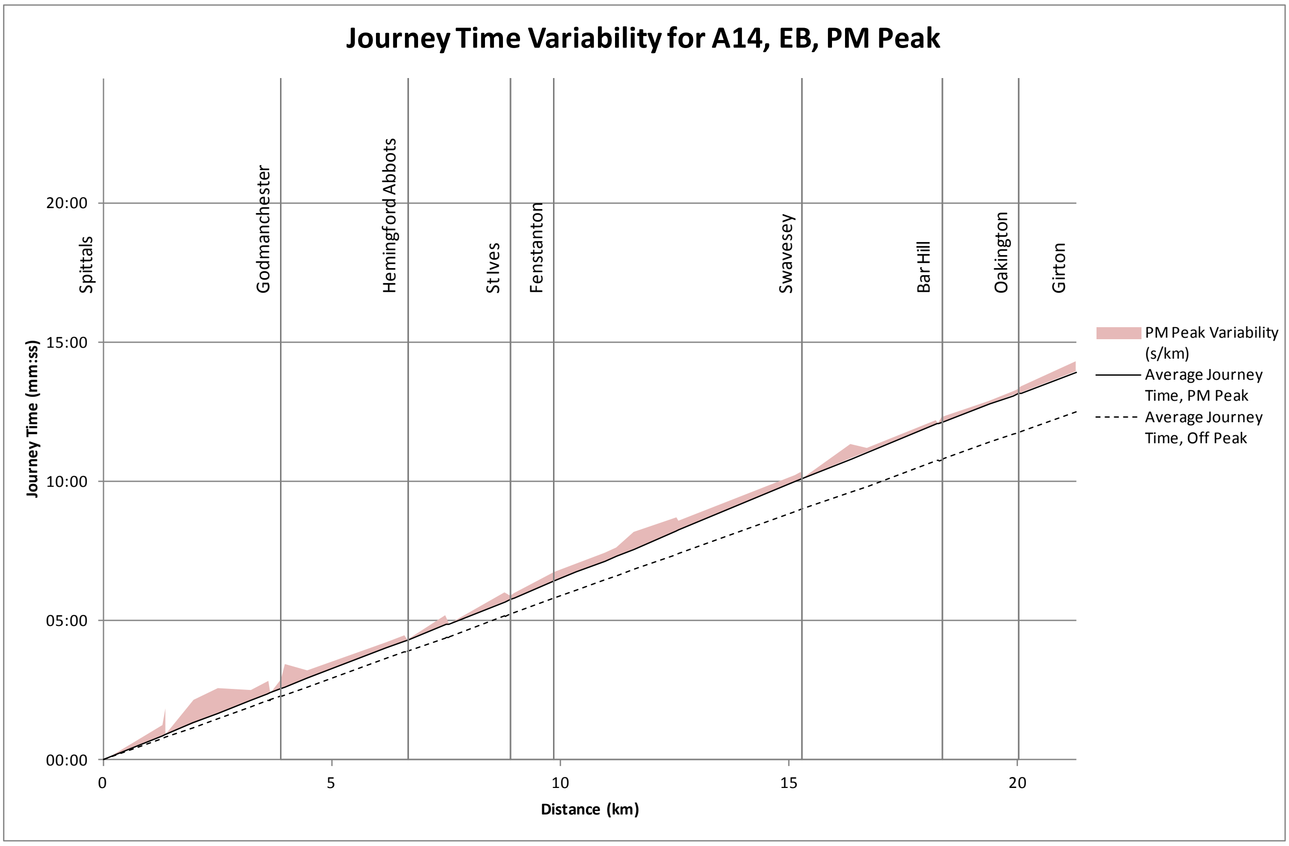


Figure B-10 A14 Cambridge to Huntingdon Westbound Journey Time Variability – AM Peak Hour

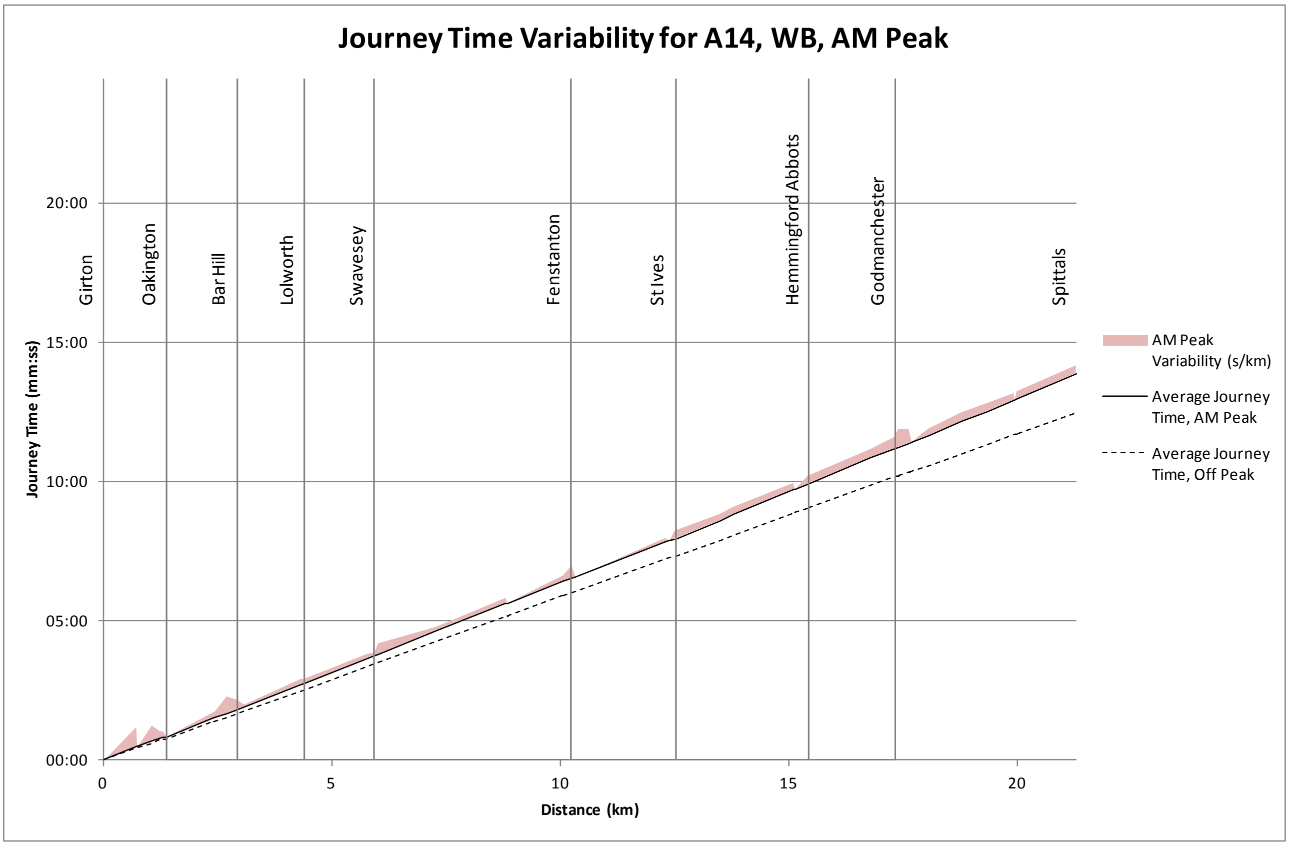


Figure B-11 A14 Cambridge to Huntingdon Westbound Journey Time Variability – Inter Peak Hour

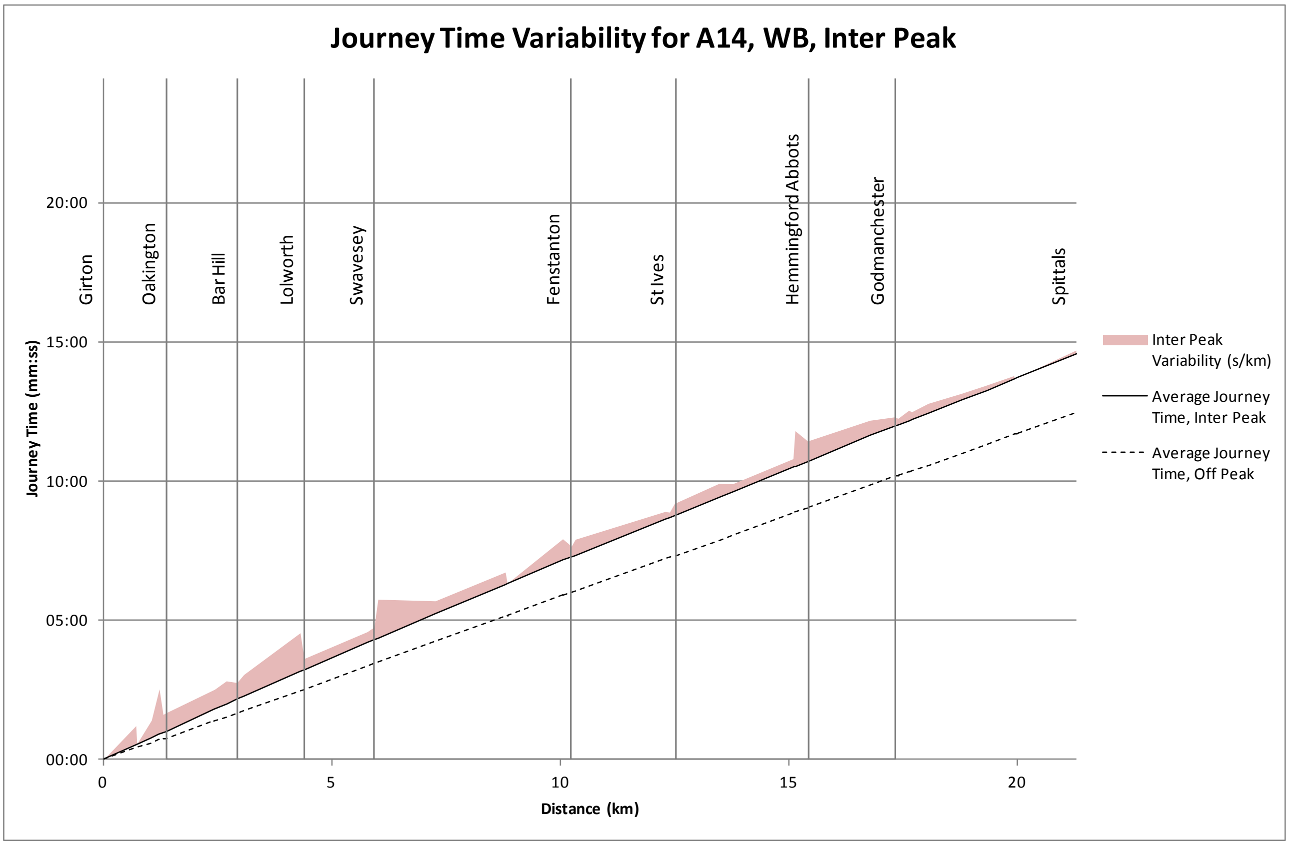


Figure B-12 A14 Cambridge to Huntingdon Westbound Journey Time Variability – PM Peak Hour

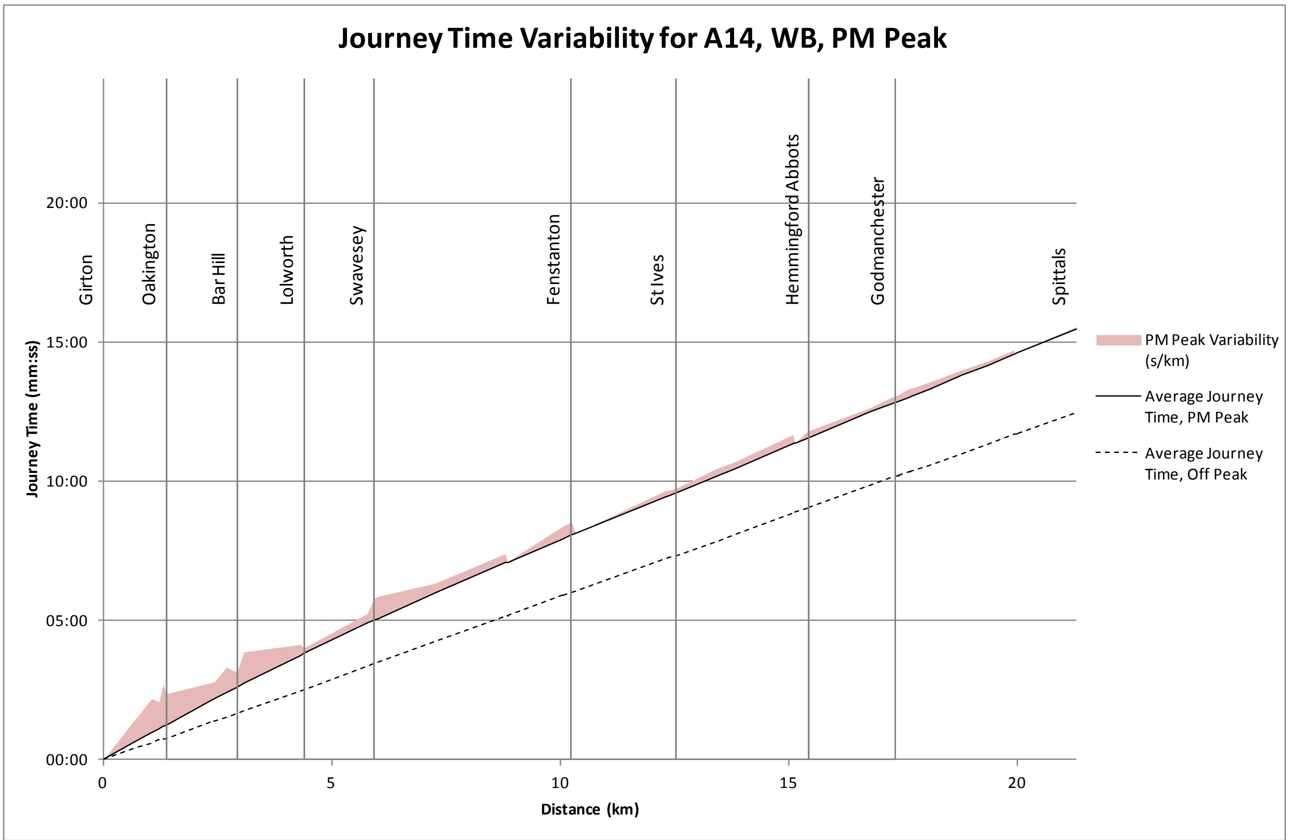


Figure B-13 A428 West Eastbound Journey Time Variability – AM Peak Hour

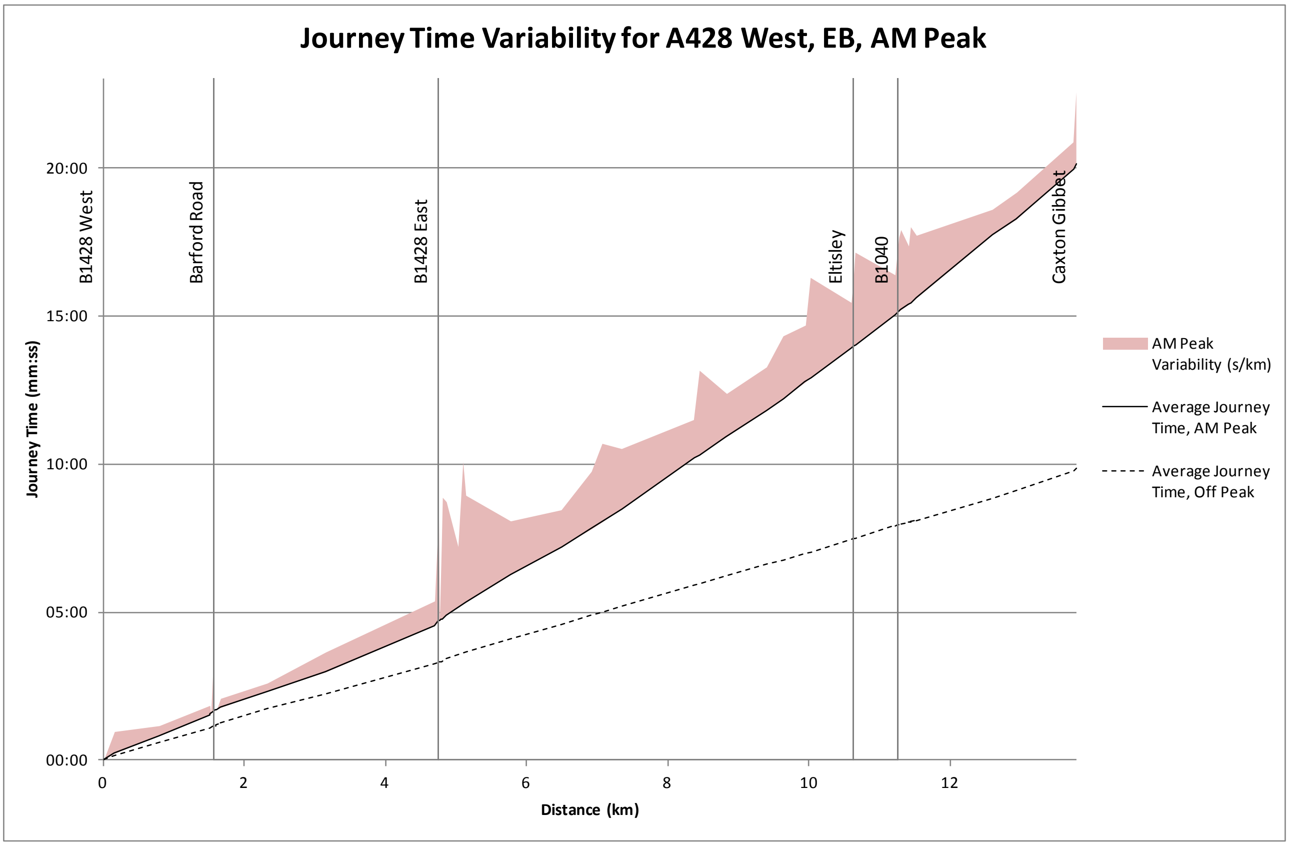


Figure B-14 A428 West Eastbound Journey Time Variability – Inter Peak Hour

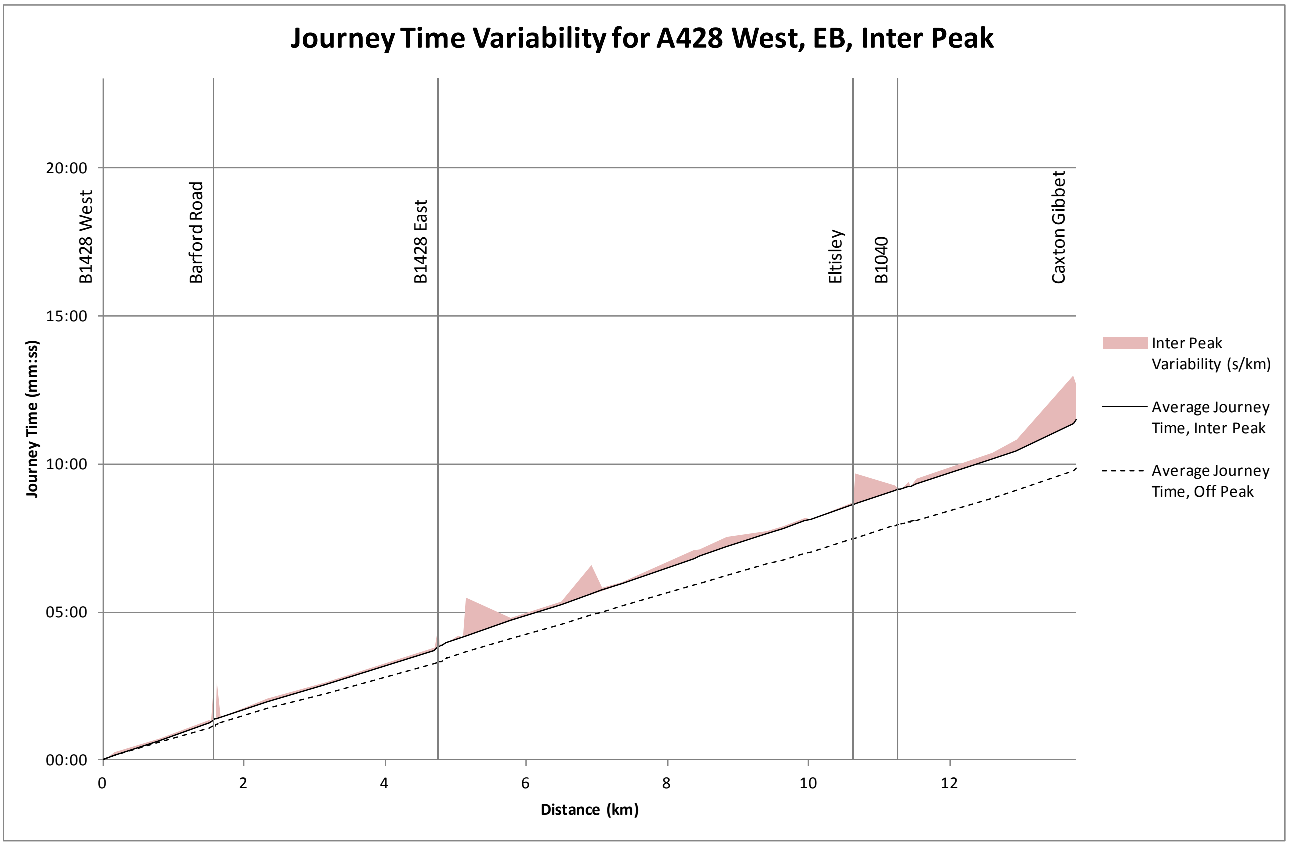


Figure B-15 A428 West Eastbound Journey Time Variability – PM Peak Hour

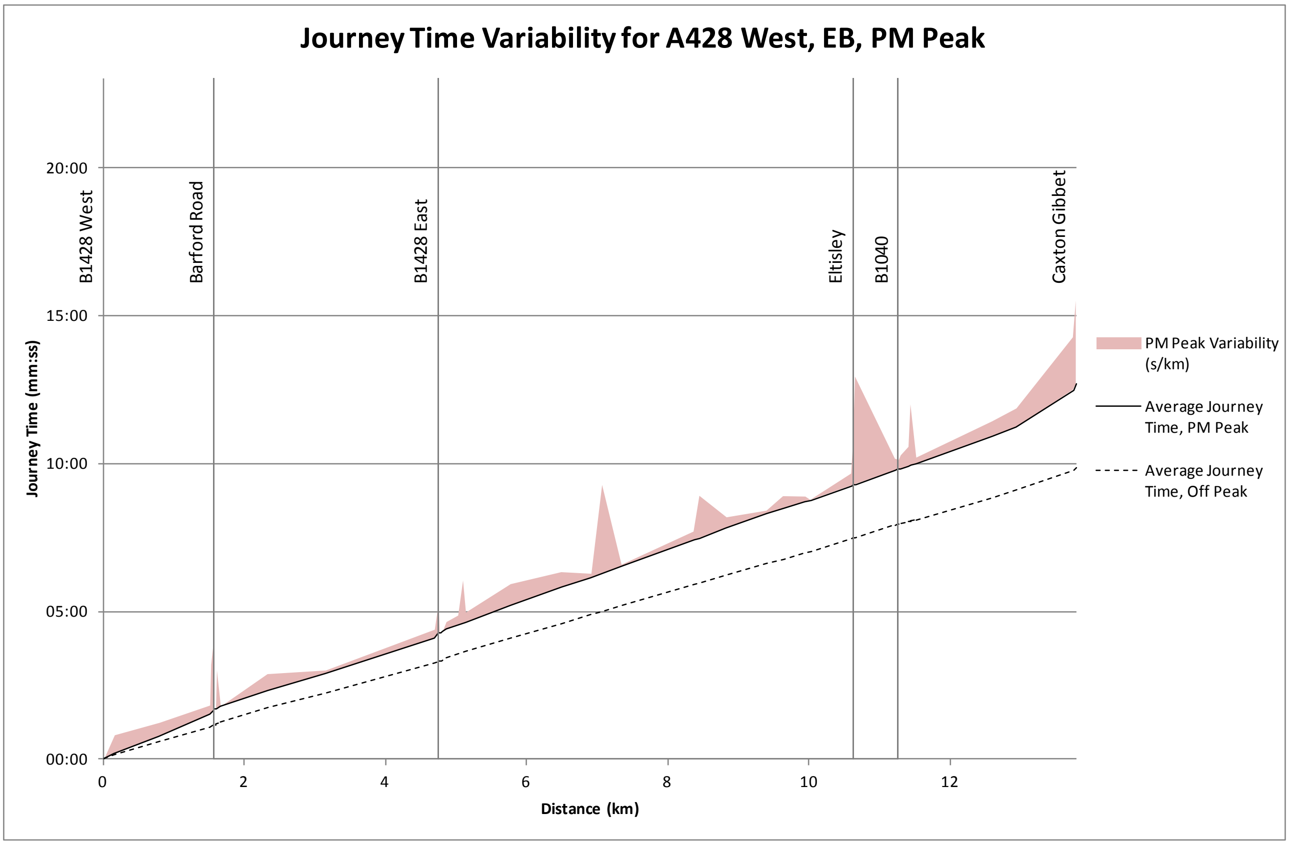


Figure B-16 A428 West Westbound Journey Time Variability – AM Peak Hour

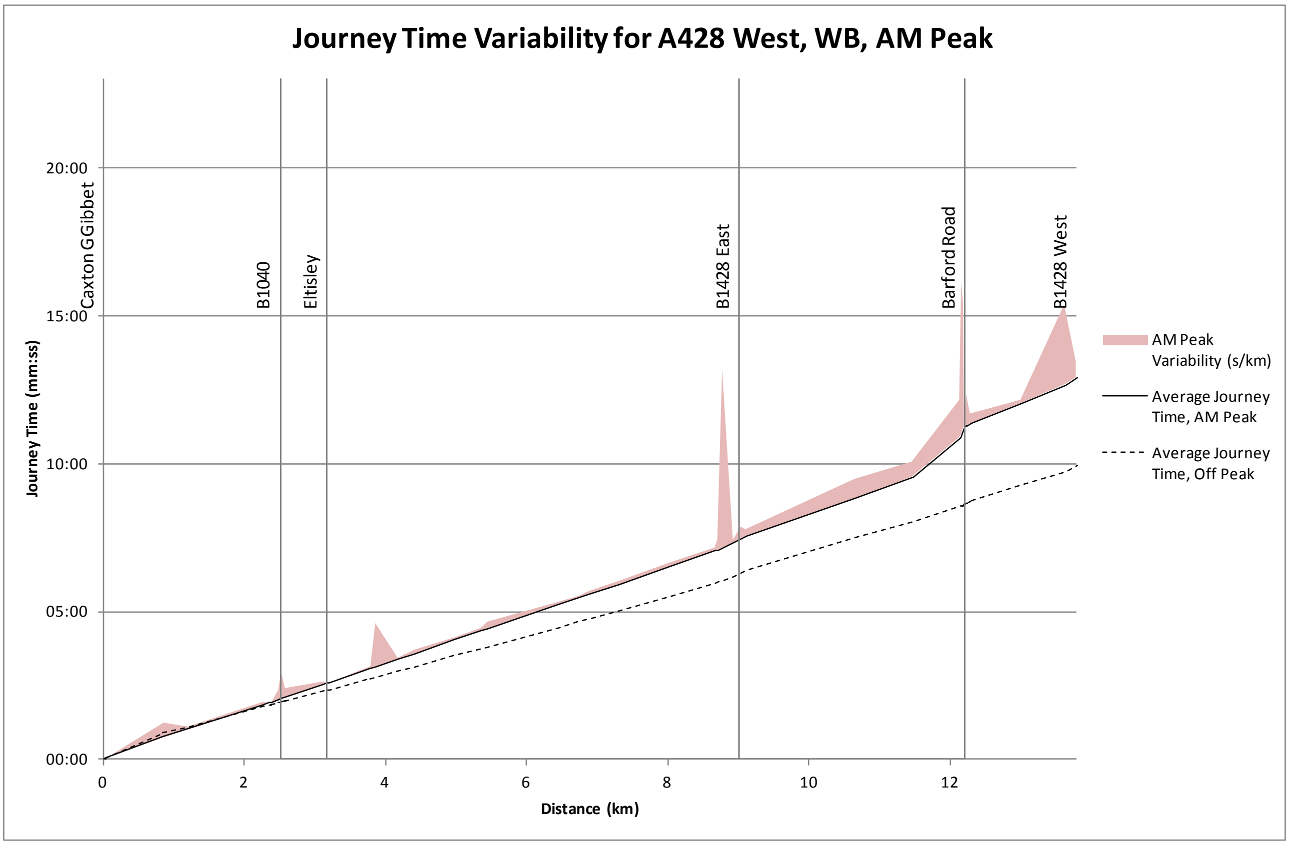


Figure B-17 A428 West Westbound Journey Time Variability – Inter Peak Hour

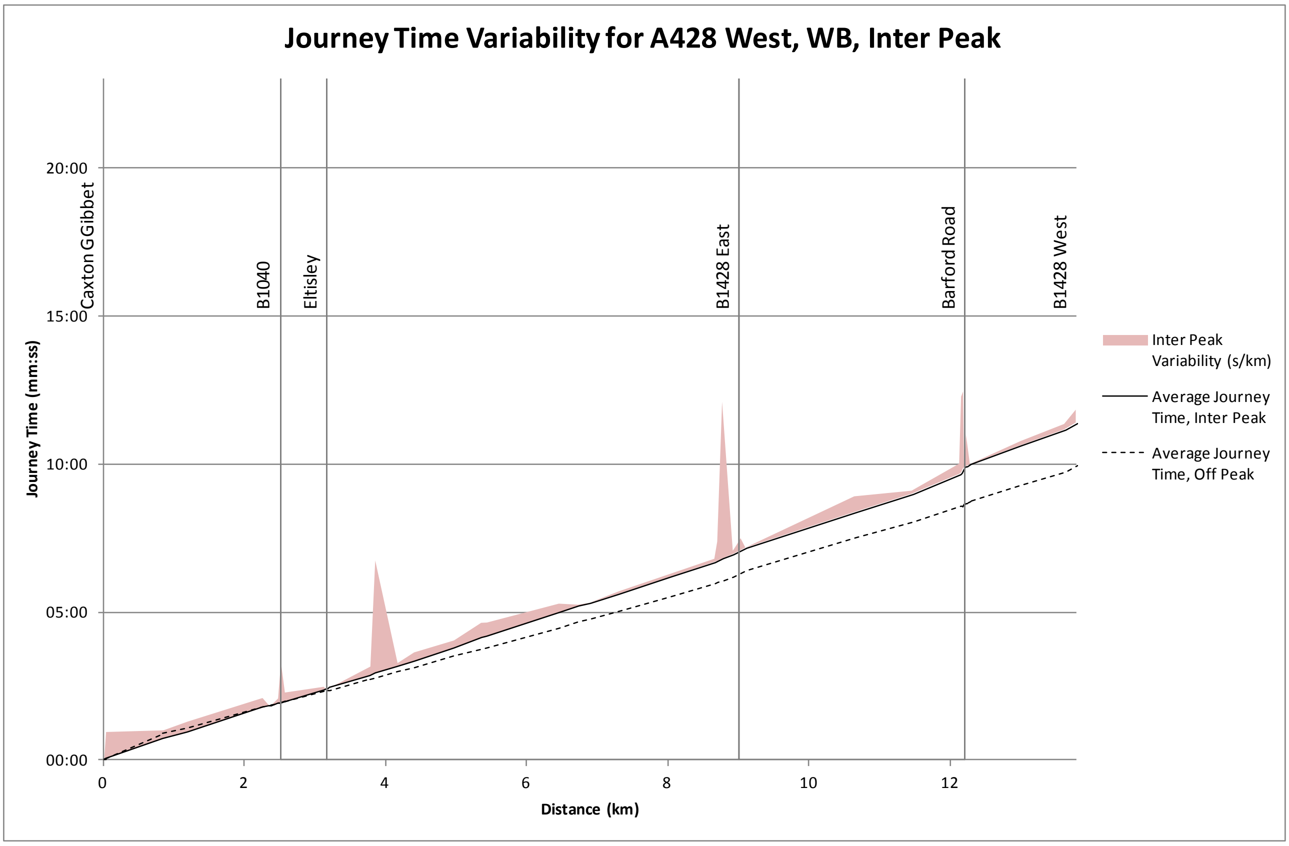


Figure B-18 A428 West Westbound Journey Time Variability – PM Peak Hour

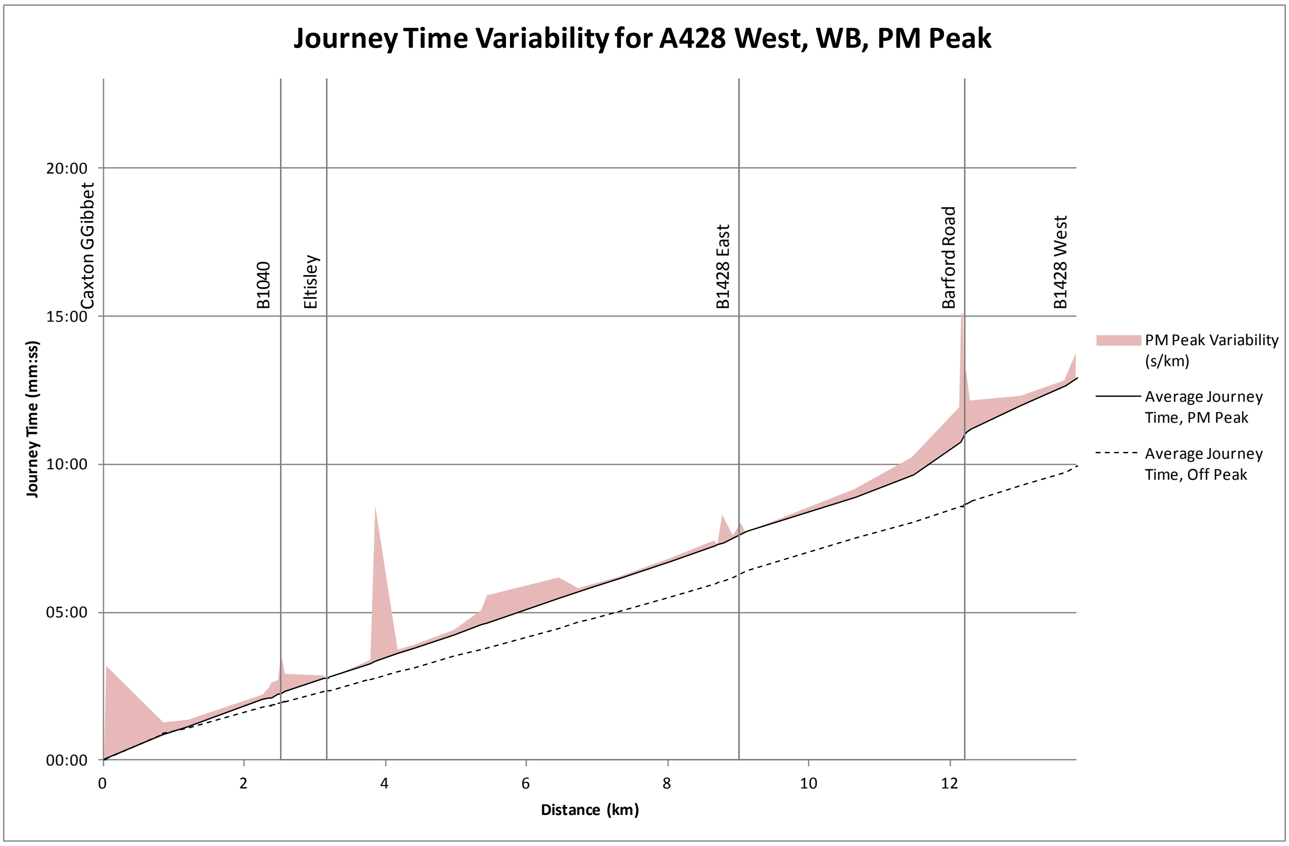


Figure B-19 A428 East Eastbound Journey Time Variability – AM Peak Hour

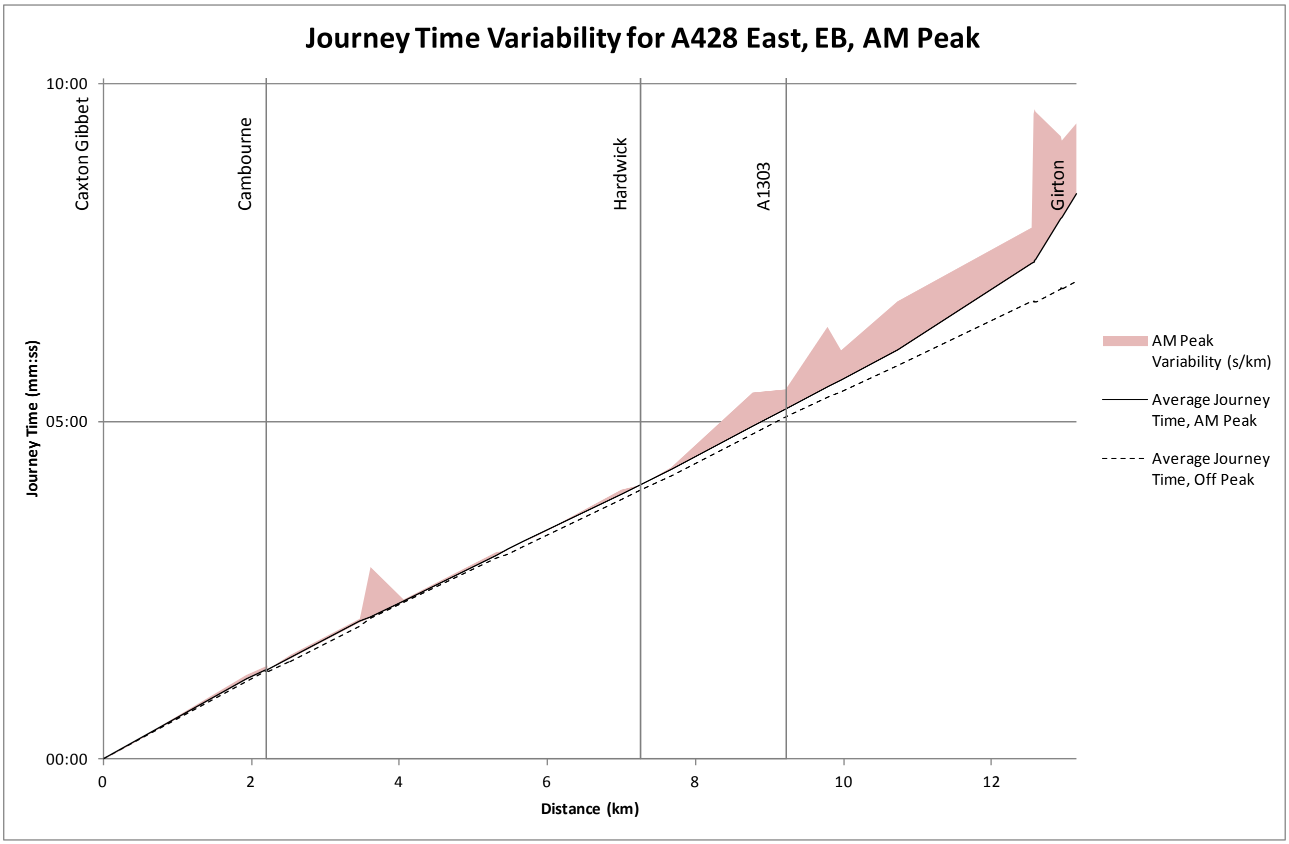


Figure B-20 A428 East Eastbound Journey Time Variability – Inter Peak Hour

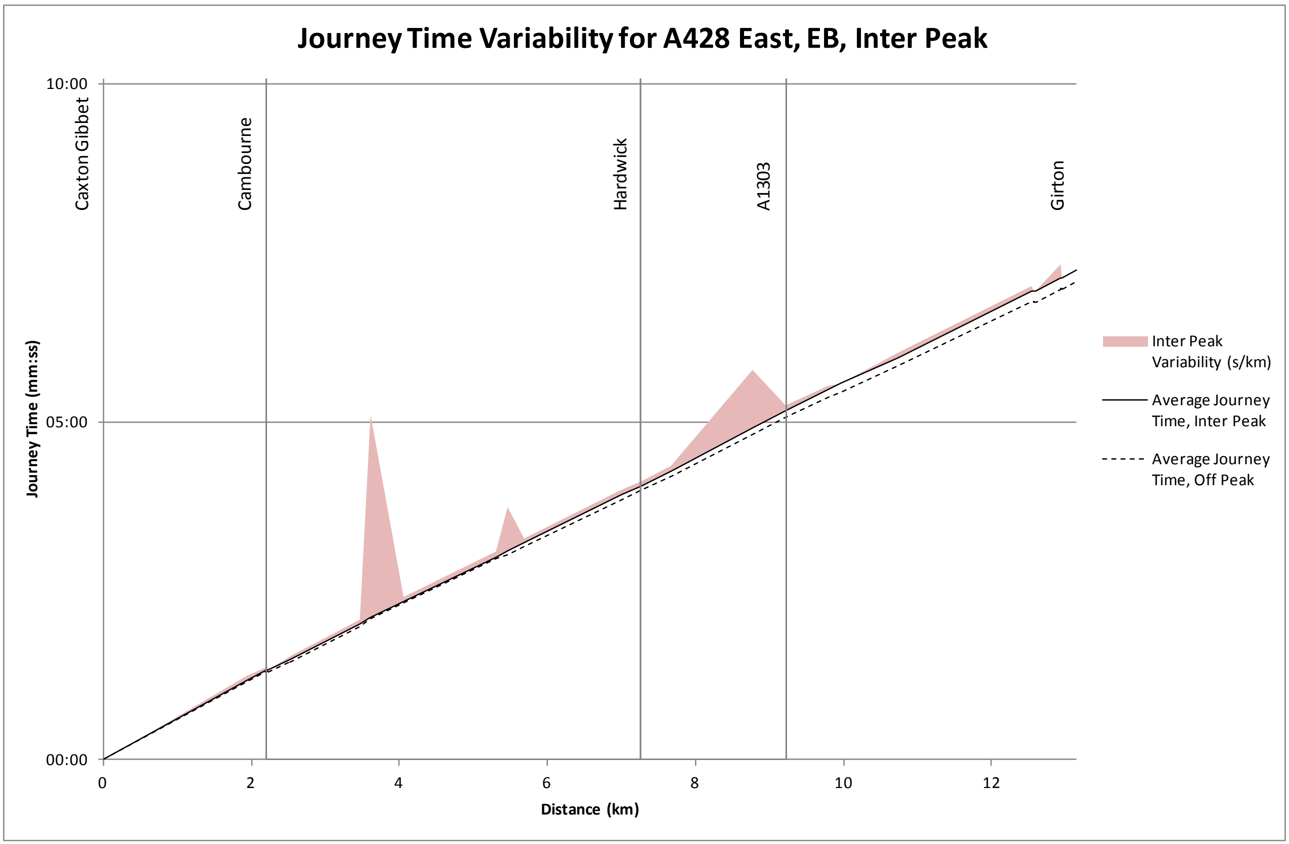


Figure B-21 A428 East Eastbound Journey Time Variability – PM Peak Hour

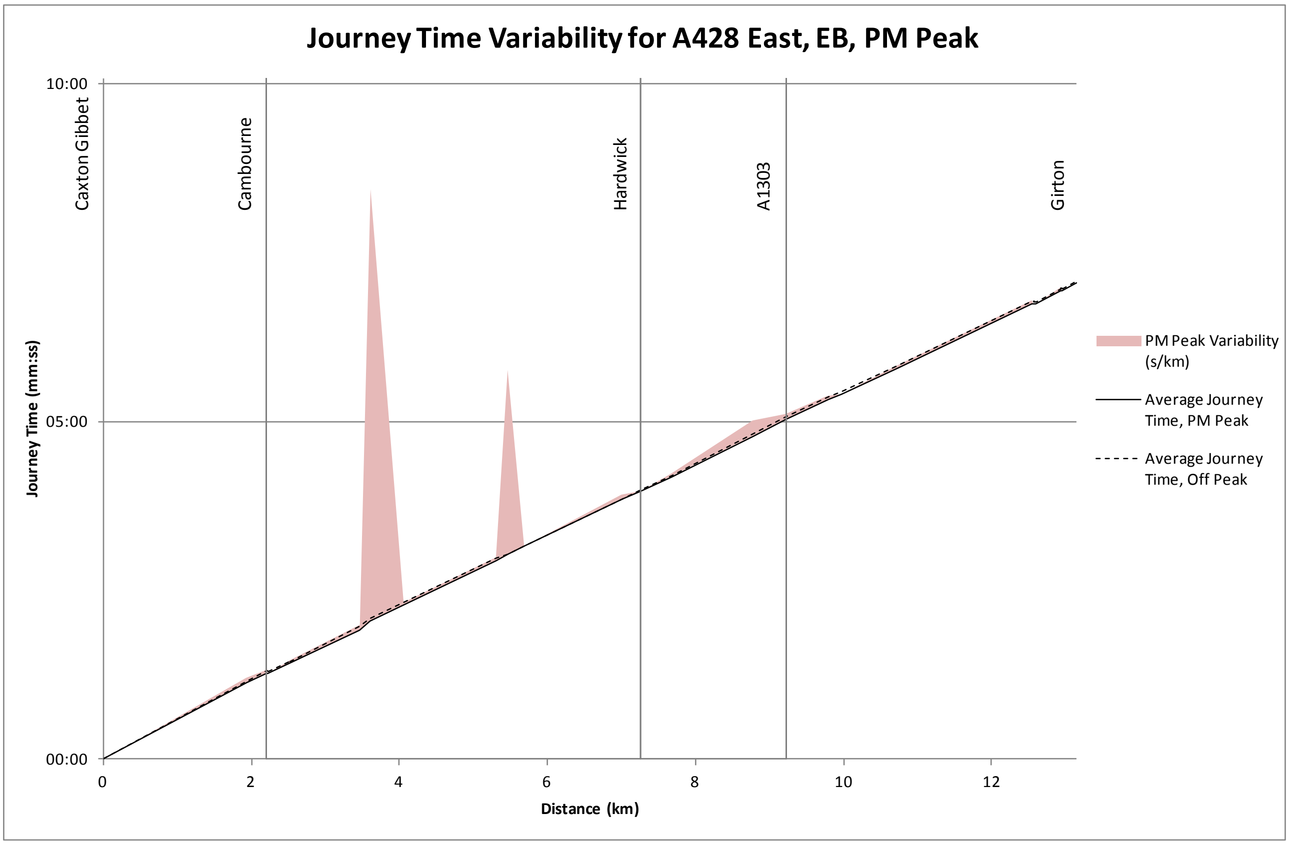


Figure B-22 A428 East Westbound Journey Time Variability – AM Peak Hour

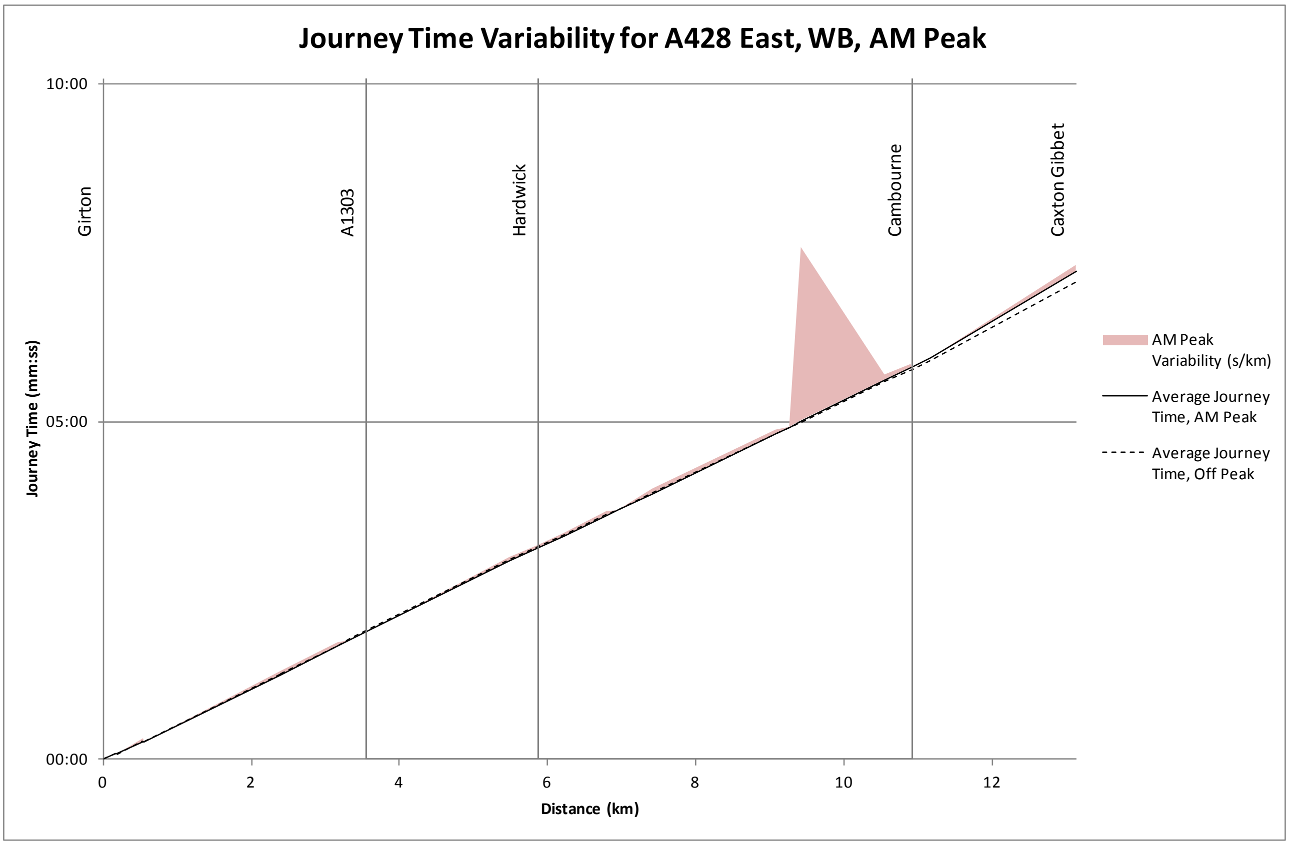


Figure B-23 A428 East Westbound Journey Time Variability – Inter Peak Hour

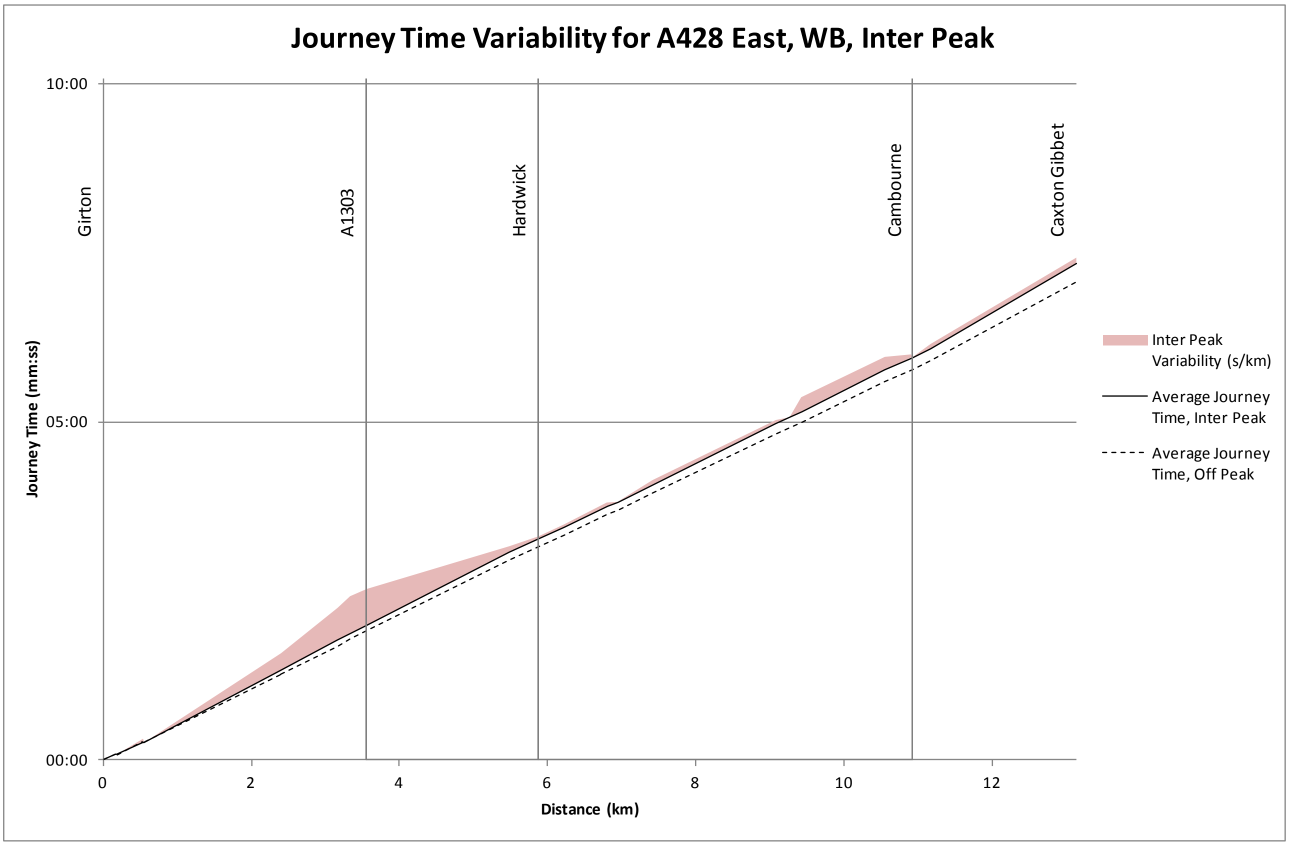


Figure B-24 A428 East Westbound Journey Time Variability – PM Peak Hour

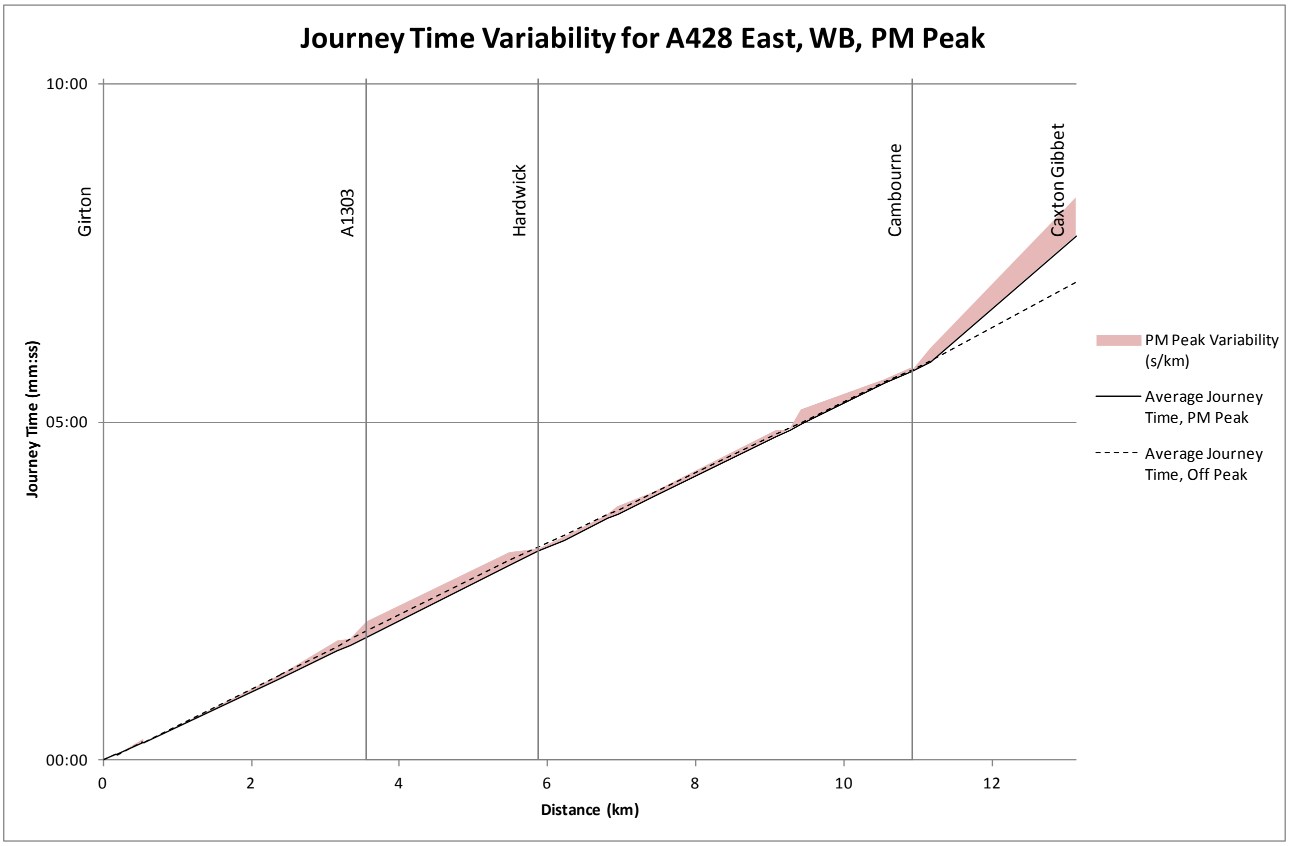


Figure B-25 A1123 West Eastbound Journey Time Variability – AM Peak Hour

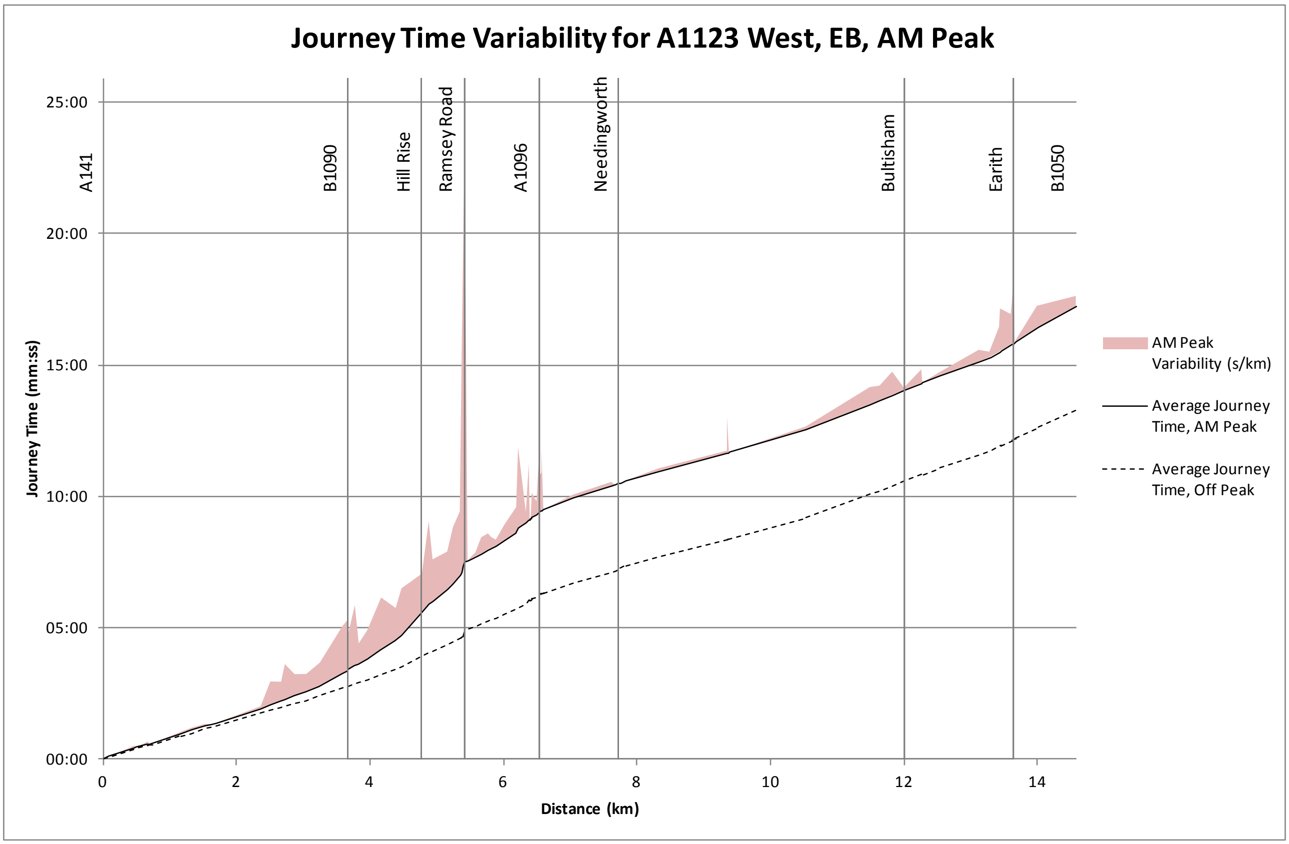


Figure B-26 A1123 West Eastbound Journey Time Variability – Inter Peak Hour

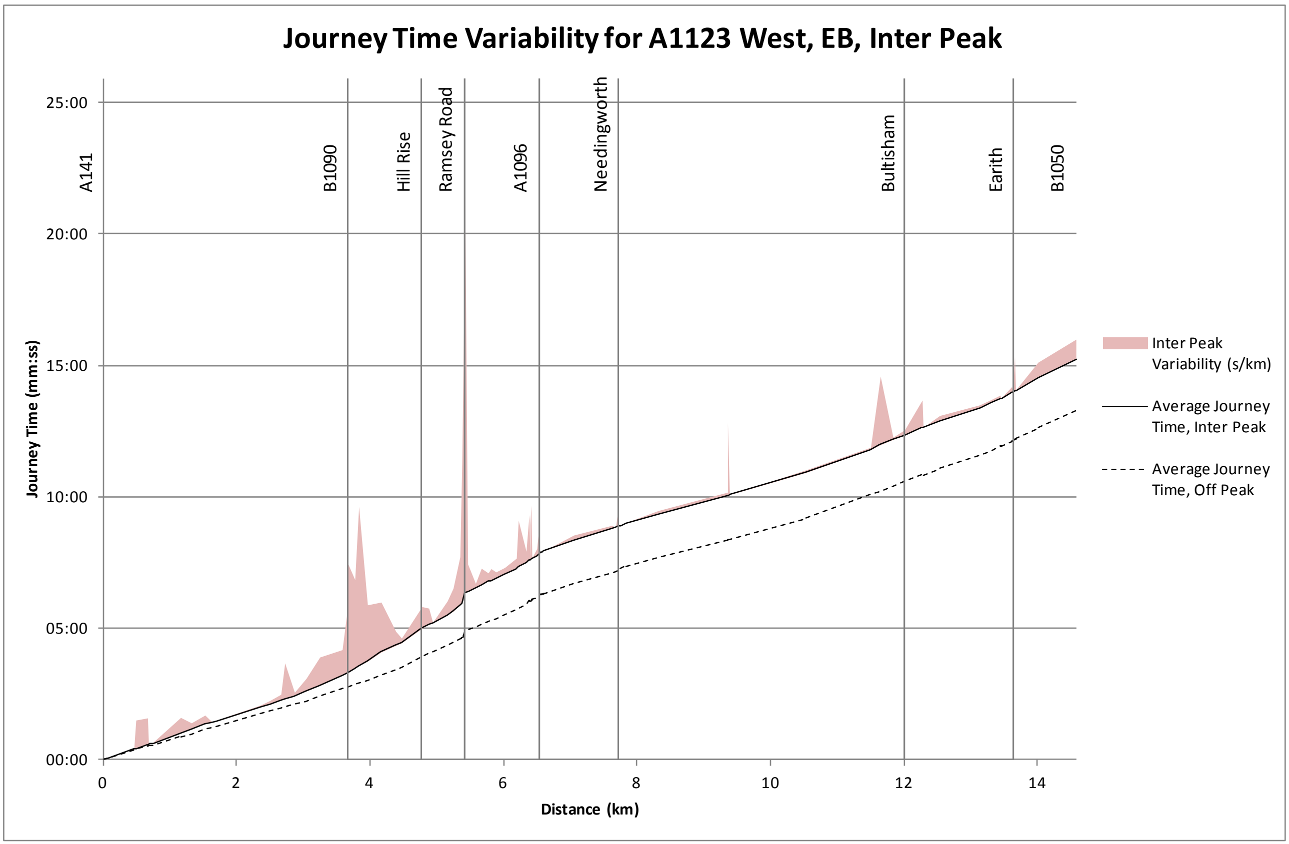


Figure B-27 A1123 West Eastbound Journey Time Variability – PM Peak Hour

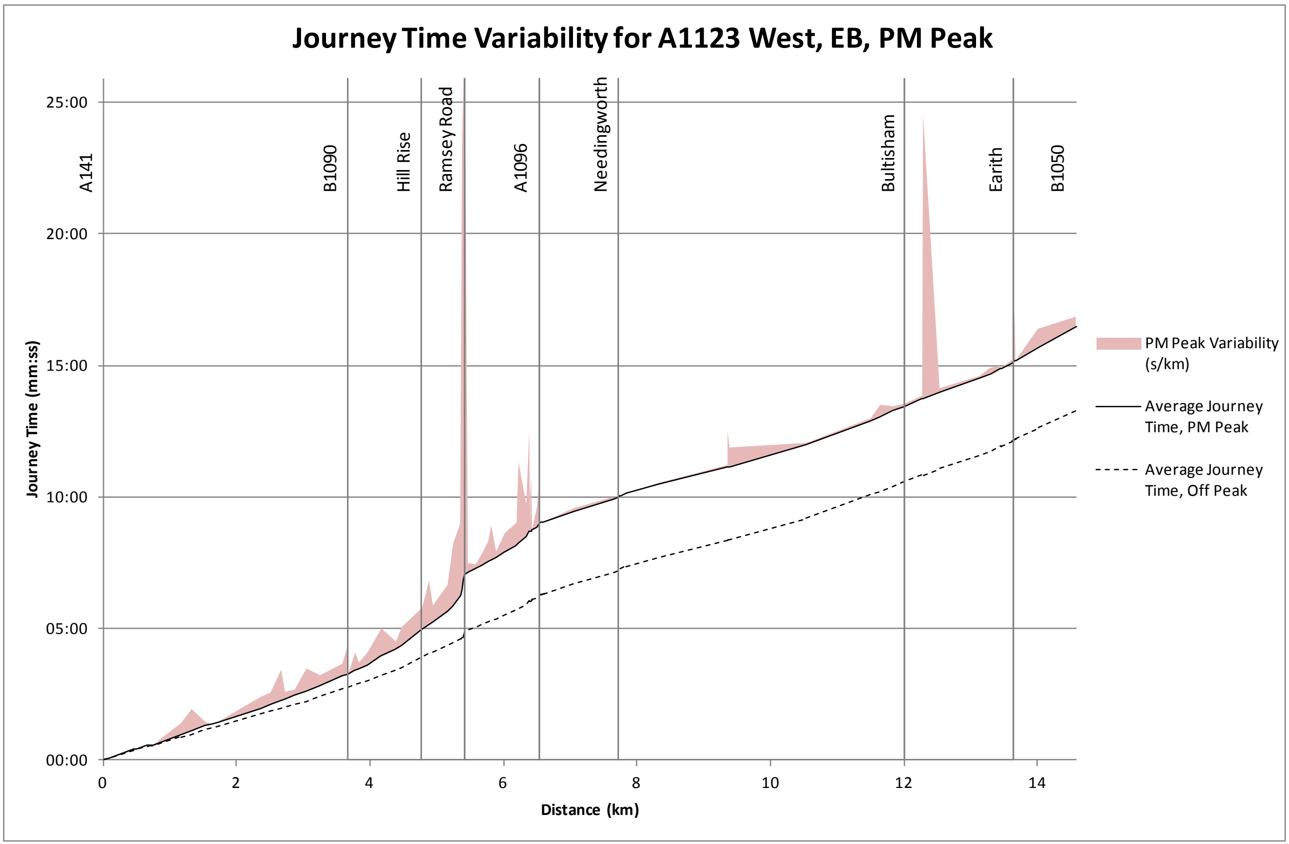


Figure B-28 A1123 West Westbound Journey Time Variability – AM Peak Hour

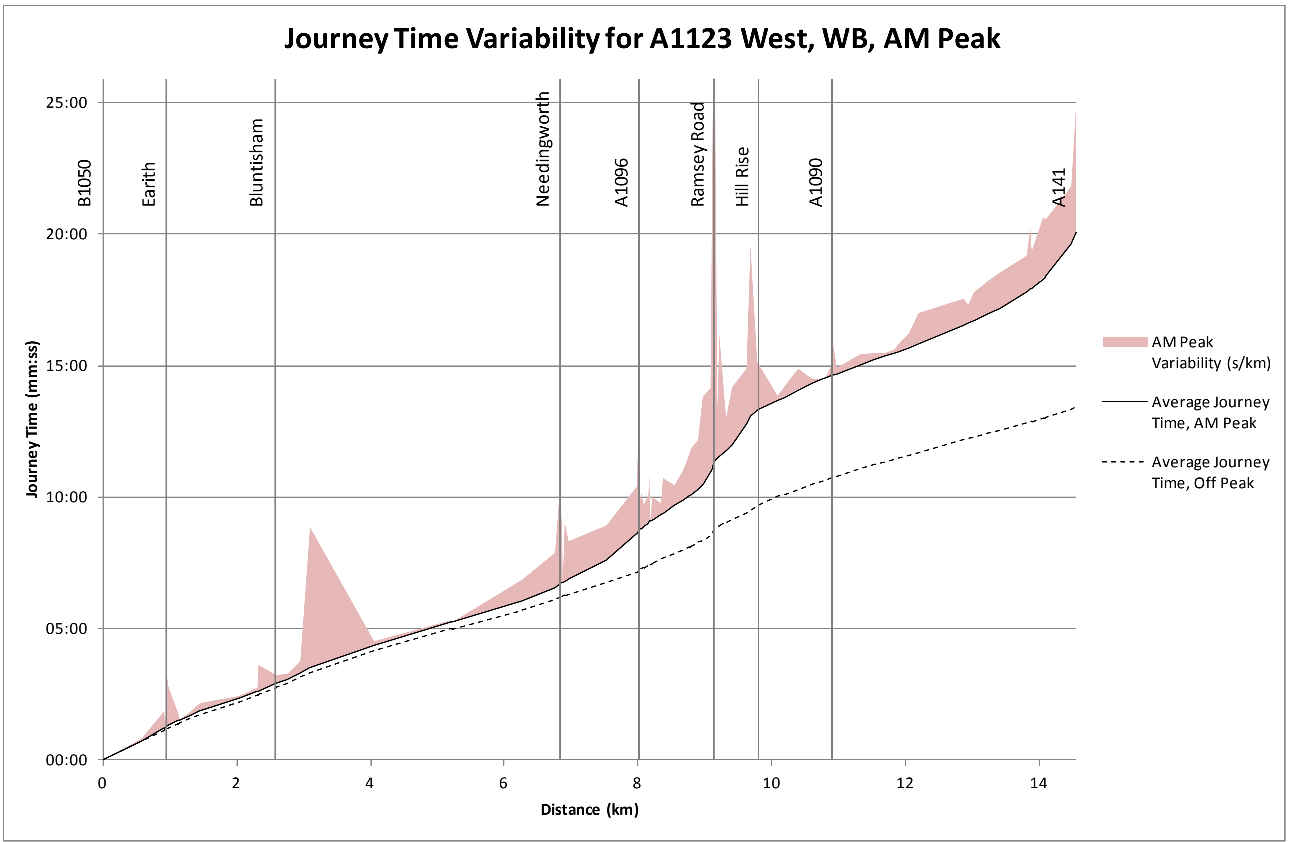


Figure B-29 A1123 West Westbound Journey Time Variability – Inter Peak Hour

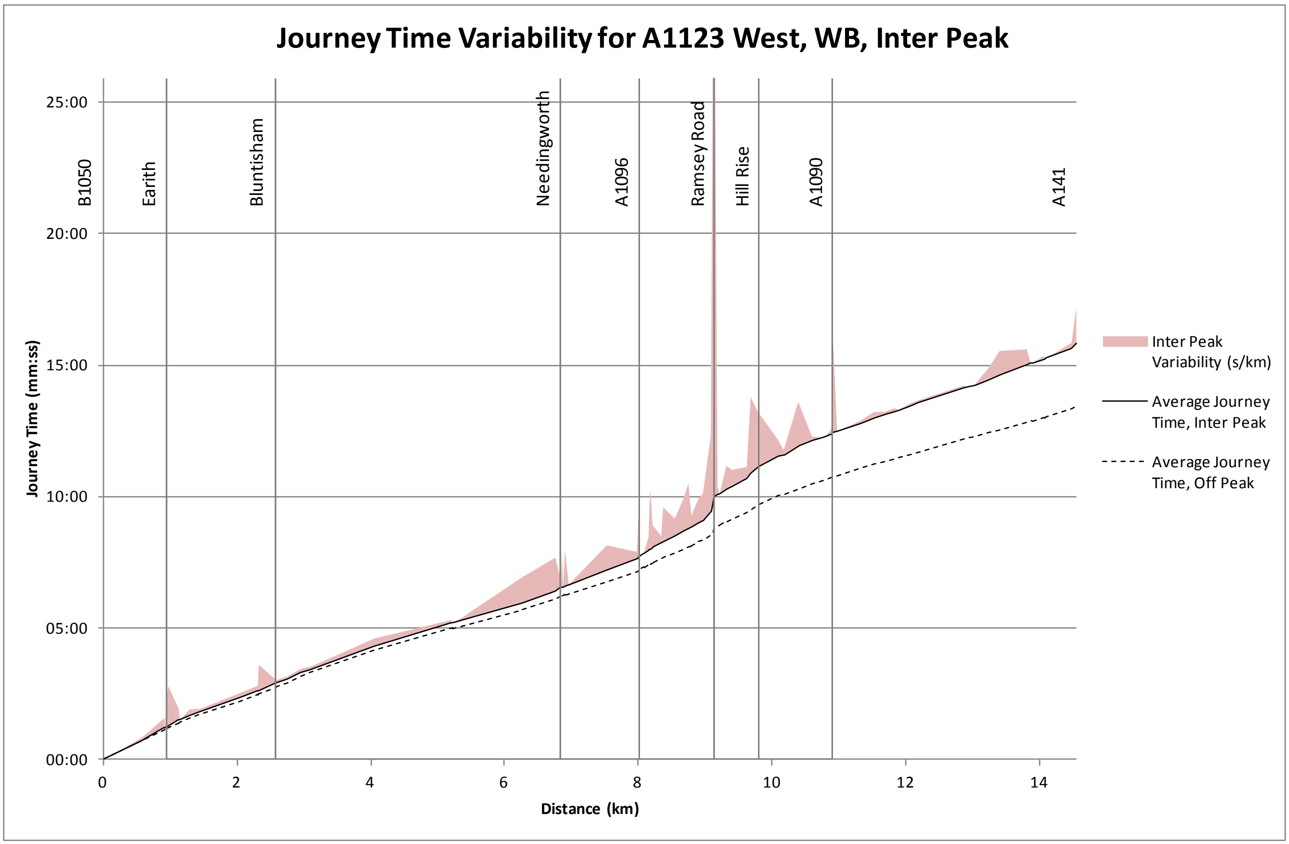


Figure B-30 A1123 West Westbound Journey Time Variability – PM Peak Hour

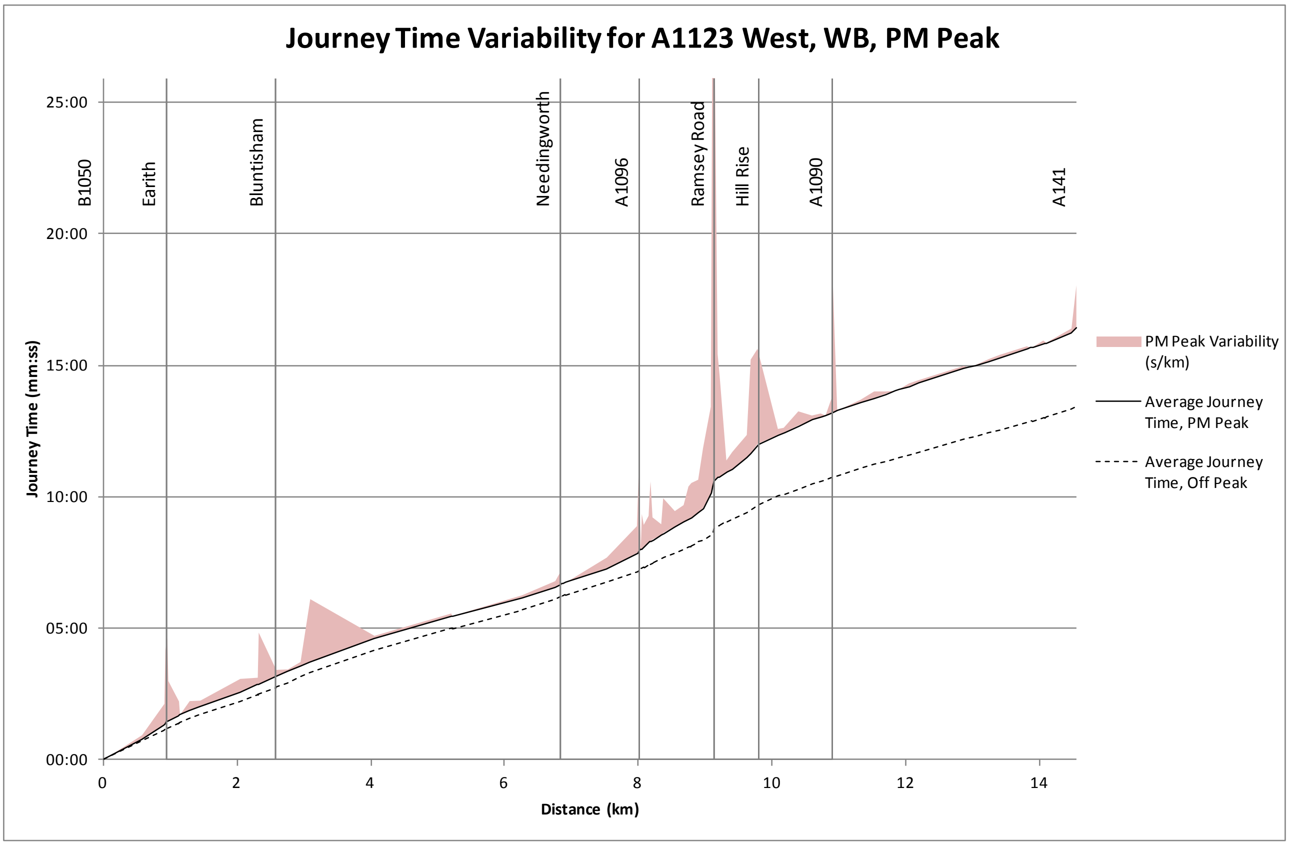


Figure B-31 A1123 East Eastbound Journey Time Variability – AM Peak Hour

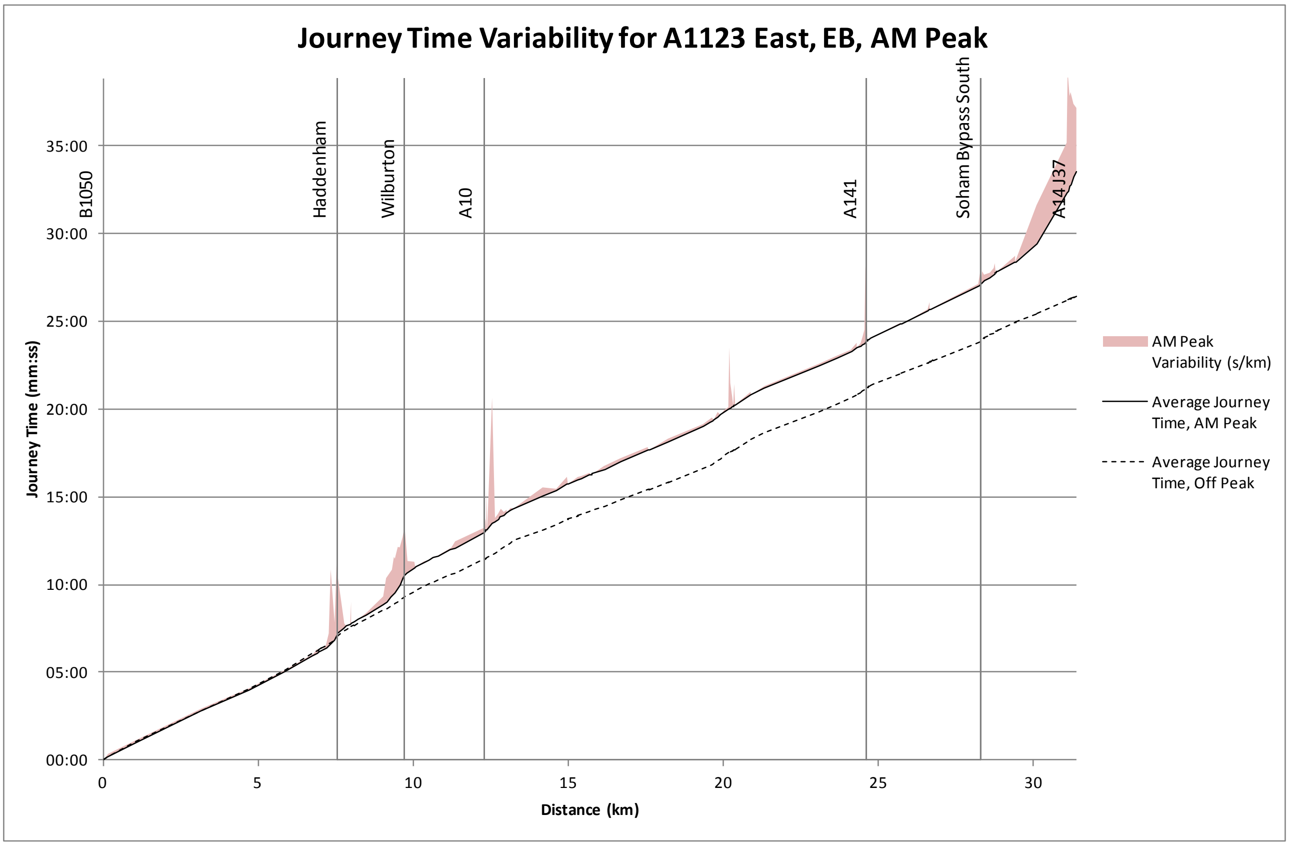


Figure B-32 A1123 East Eastbound Journey Time Variability – Inter Peak Hour

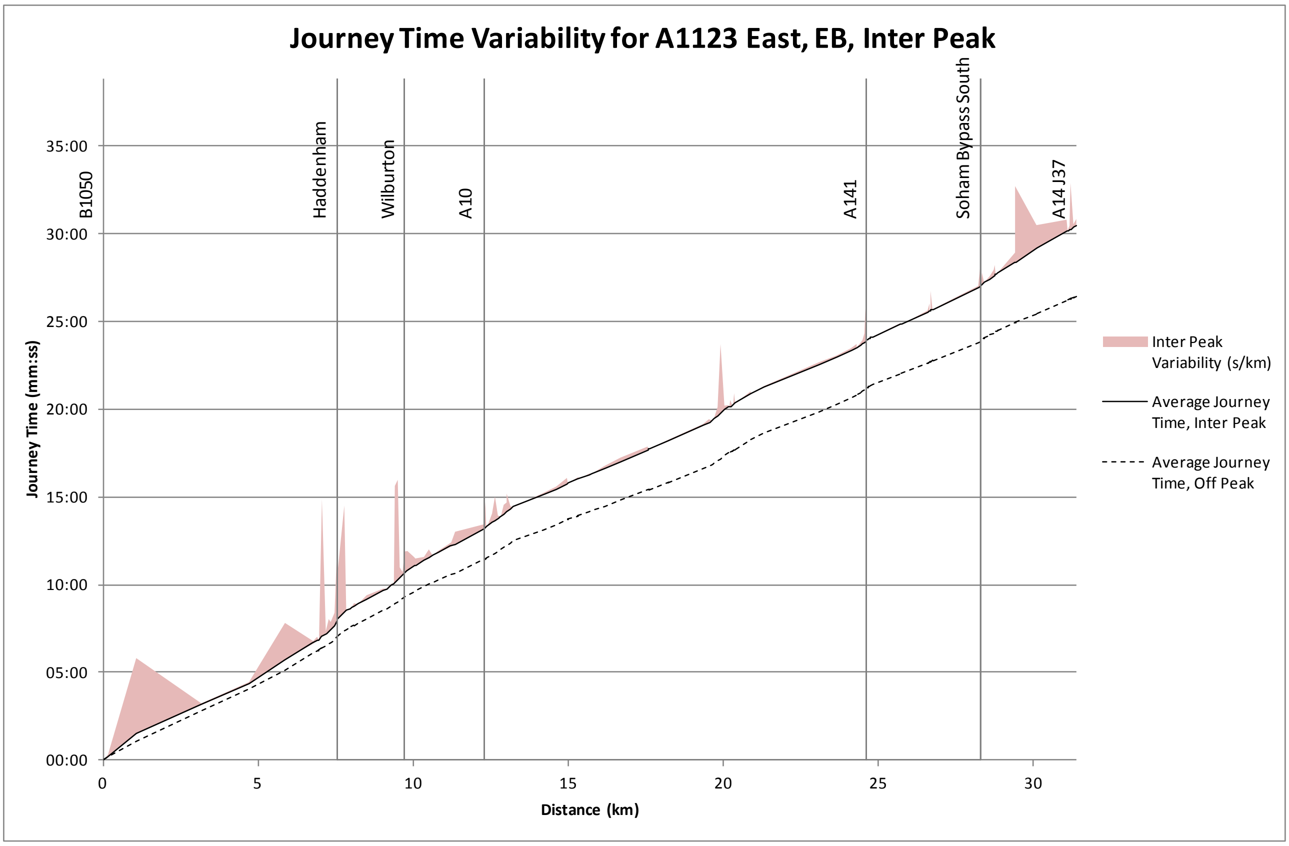


Figure B-33 A1123 East Eastbound Journey Time Variability – PM Peak Hour

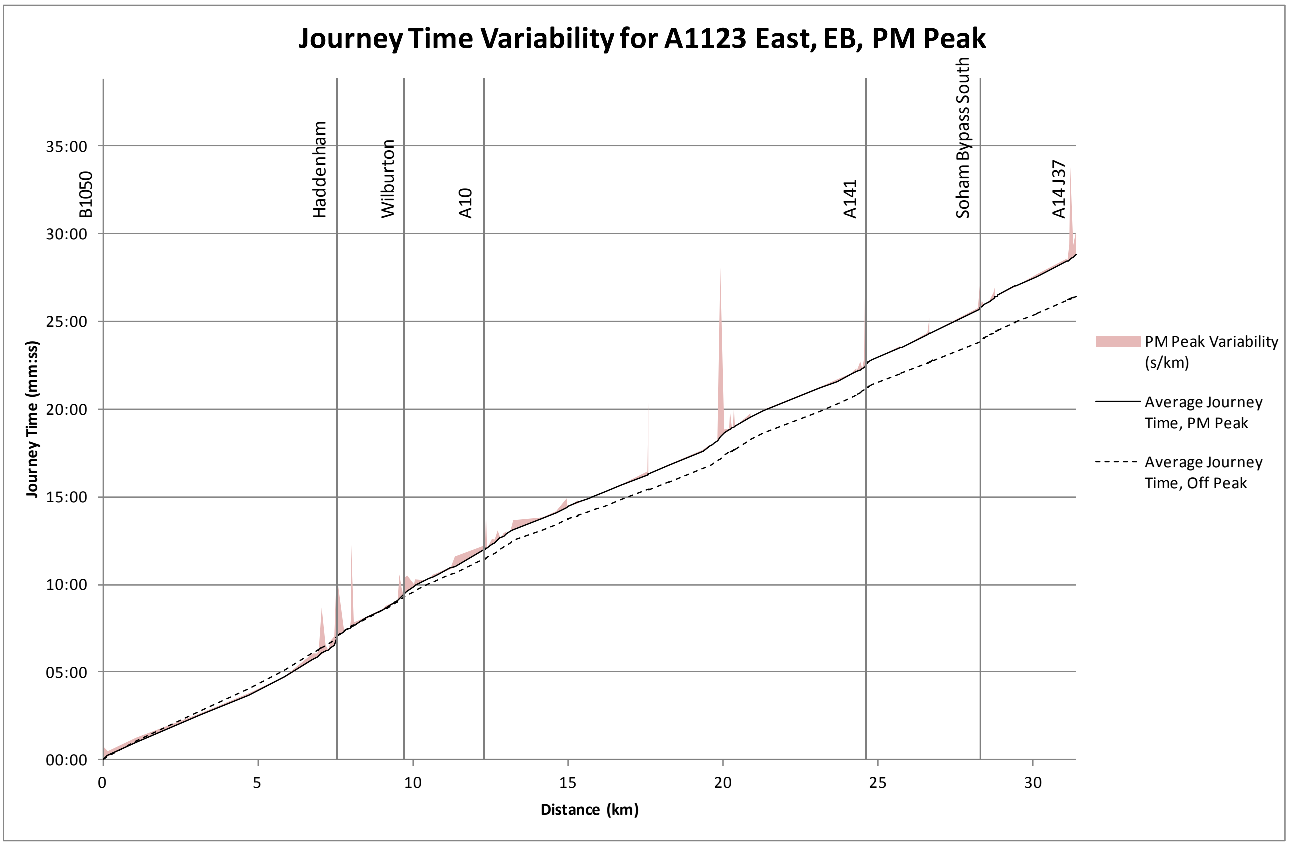


Figure B-34 A1123 East Westbound Journey Time Variability – AM Peak Hour

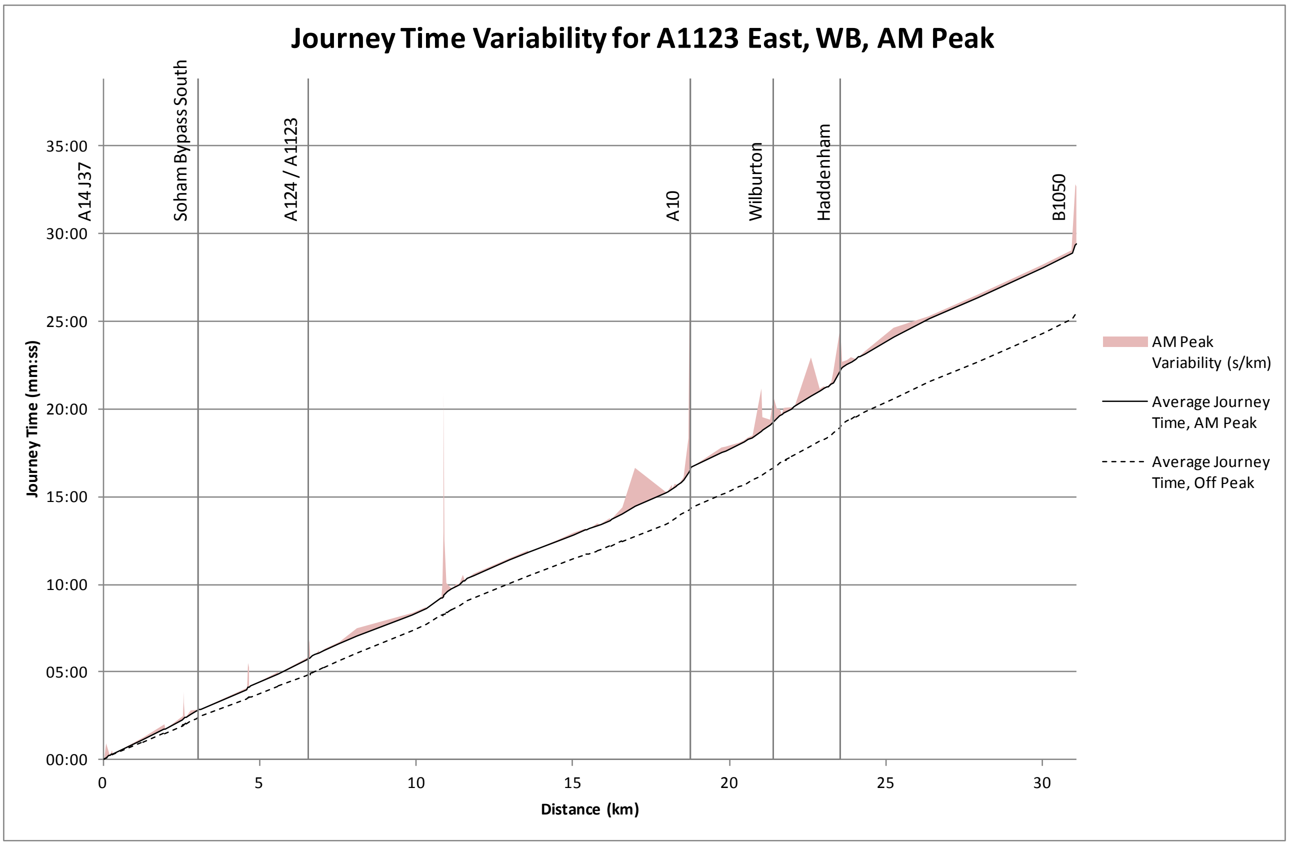


Figure B-35 A1123 East Westbound Journey Time Variability – Inter Peak Hour

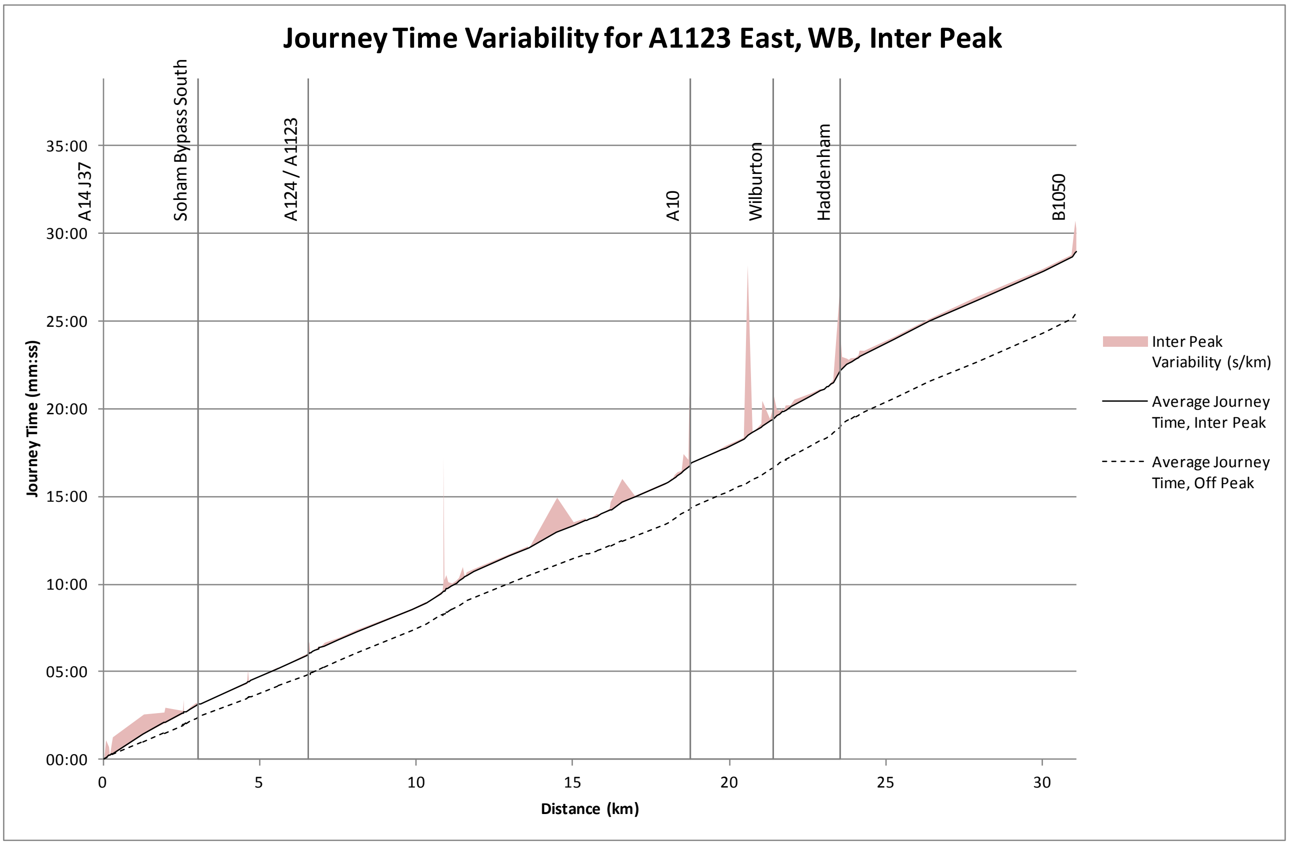


Figure B-36 A1123 East Westbound Journey Time Variability – PM Peak Hour

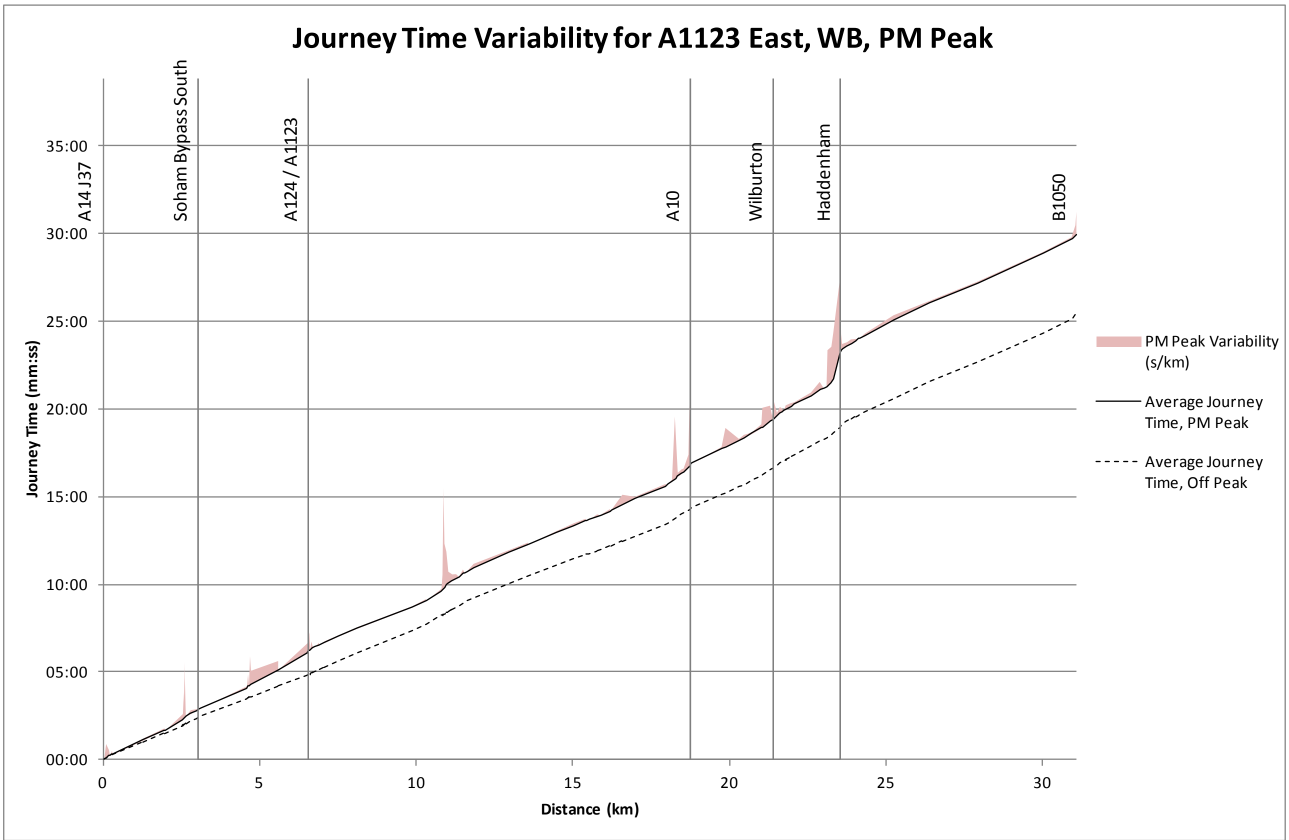


Figure B-37 A1198 Northbound Journey Time Variability – AM Peak Hour

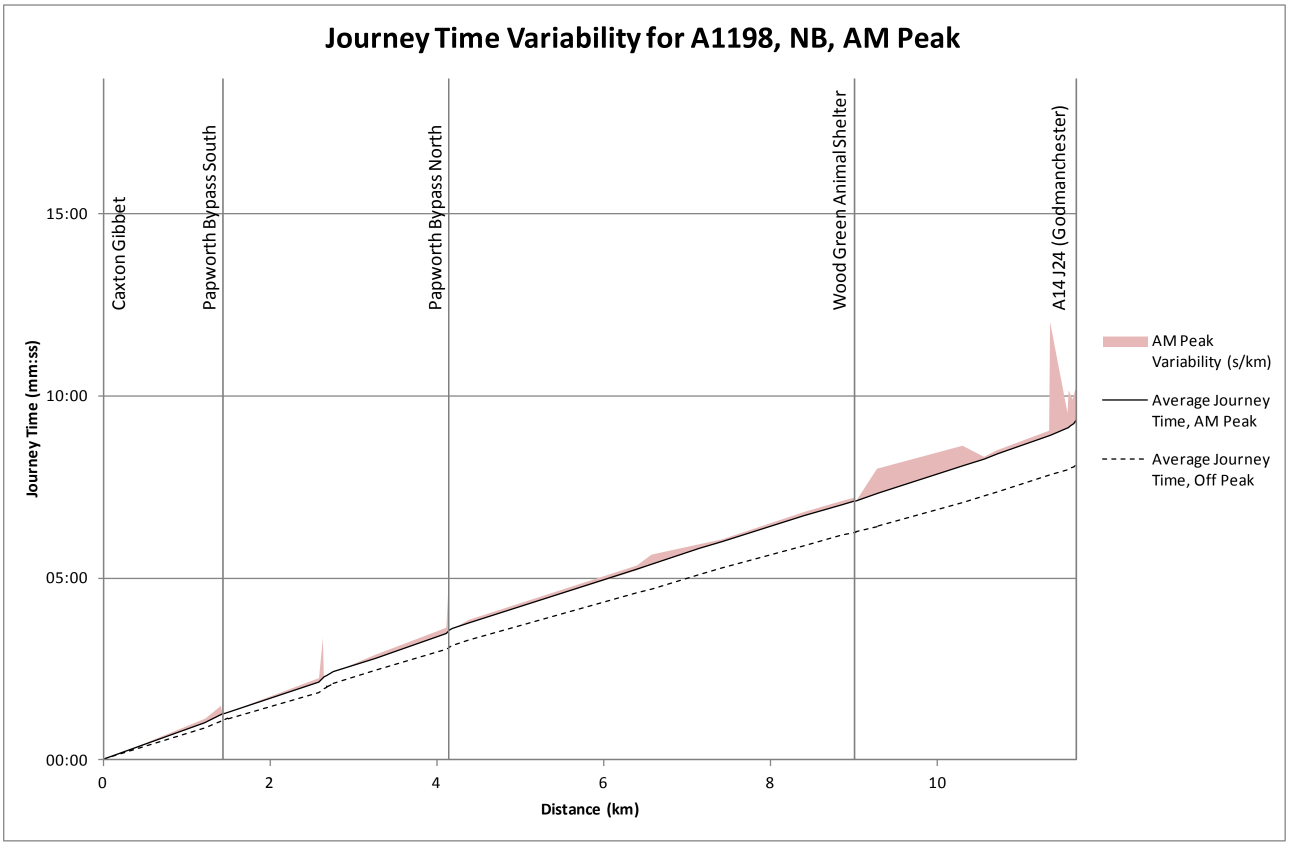


Figure B-38 A1198 Northbound Journey Time Variability – Inter Peak Hour

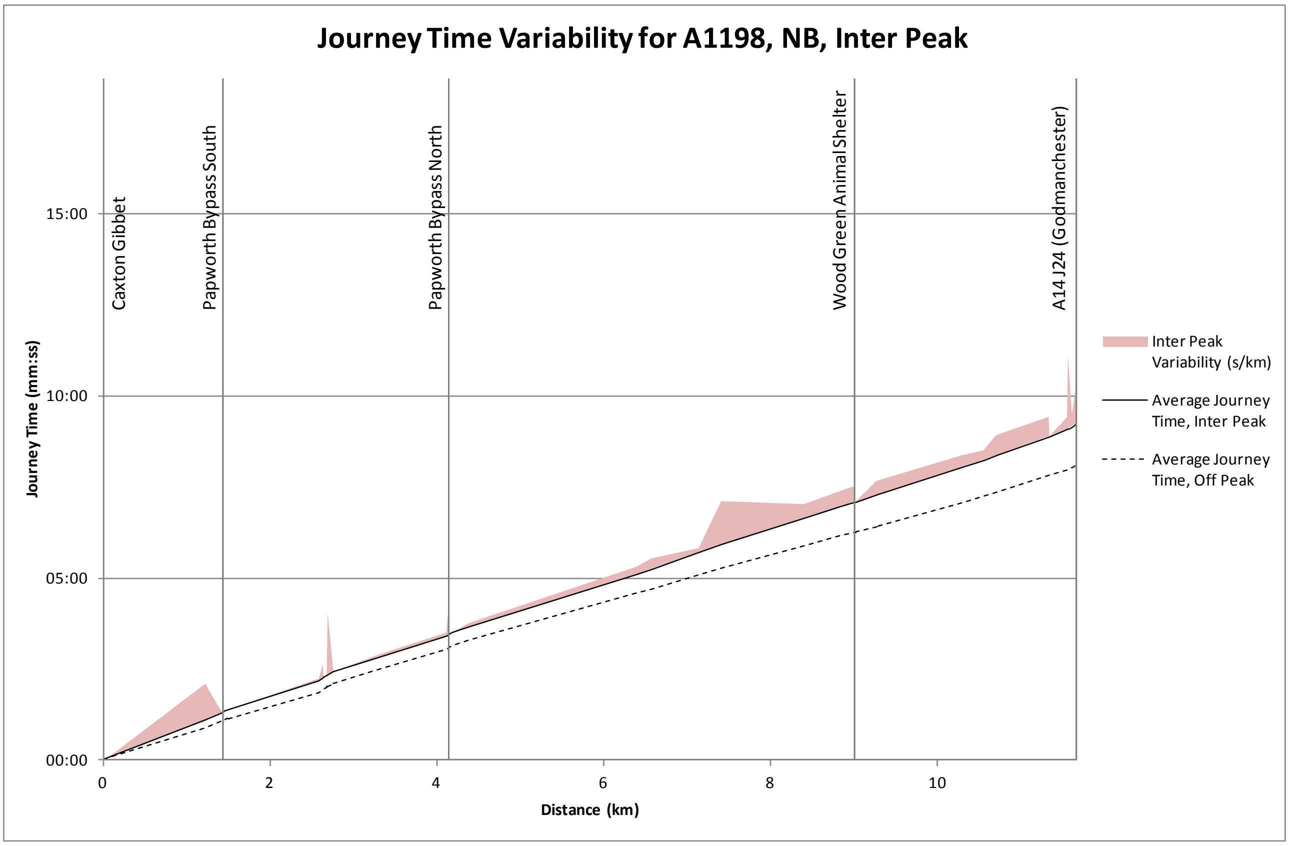


Figure B-39 A1198 Northbound Journey Time Variability – PM Peak Hour

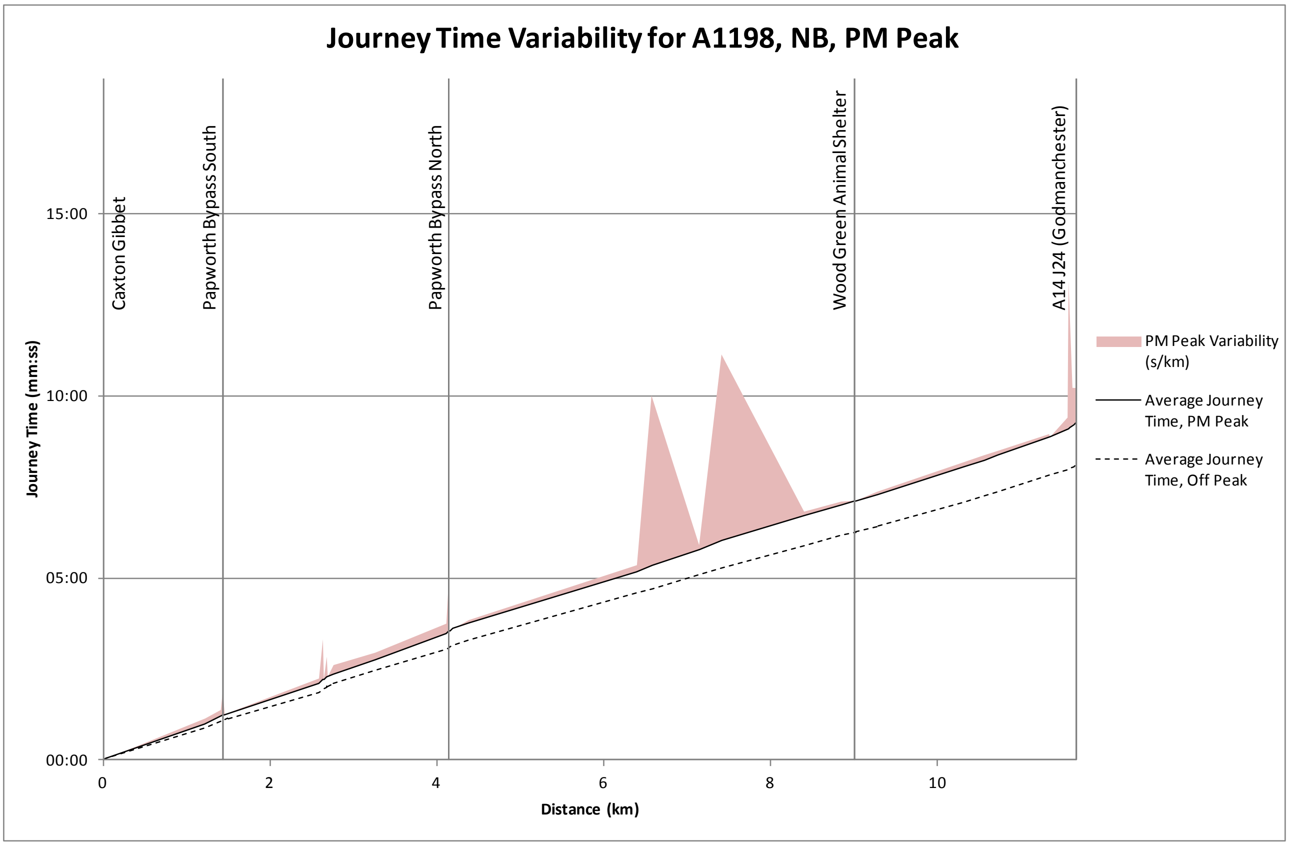


Figure B-40 A1198 Southbound Journey Time Variability – AM Peak Hour

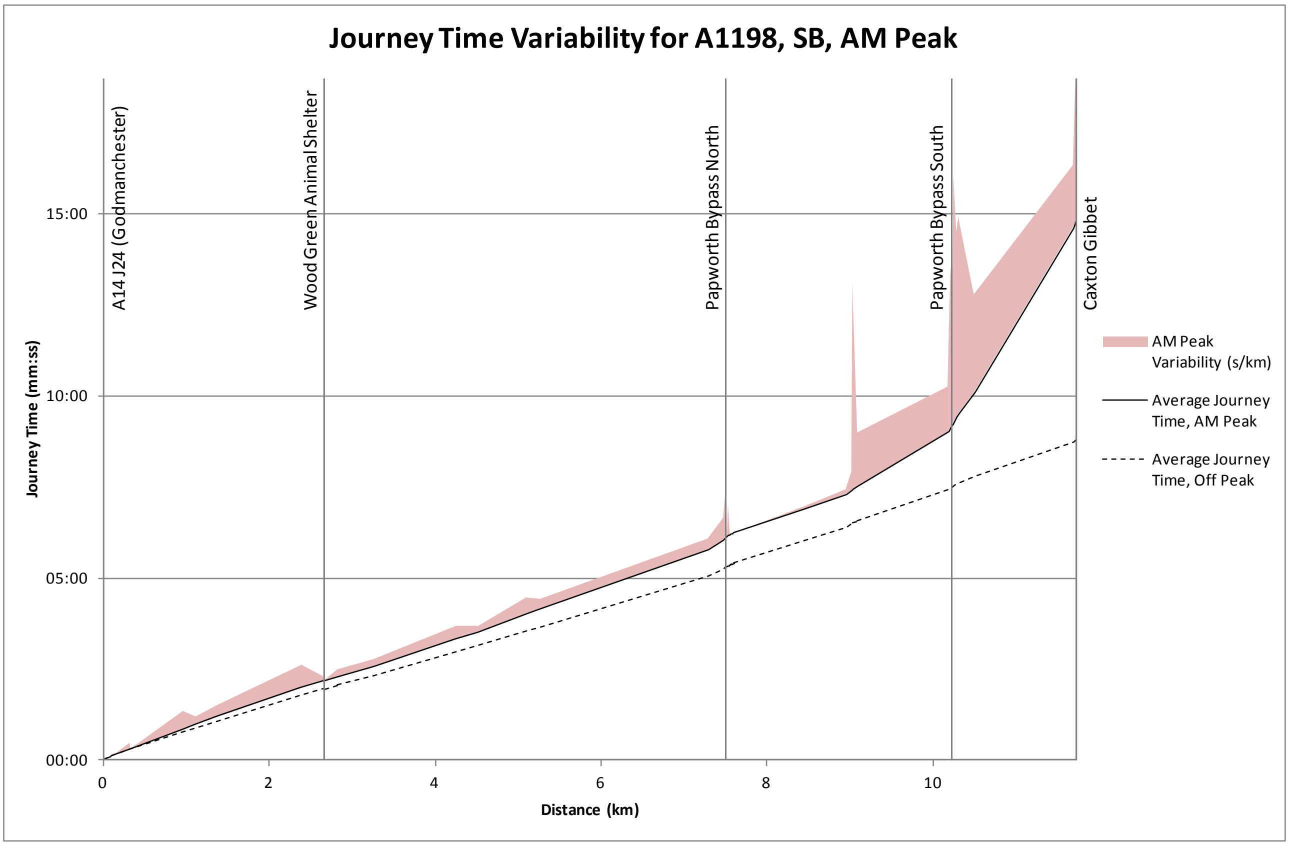


Figure B-41 A1198 Southbound Journey Time Variability – Inter Peak Hour

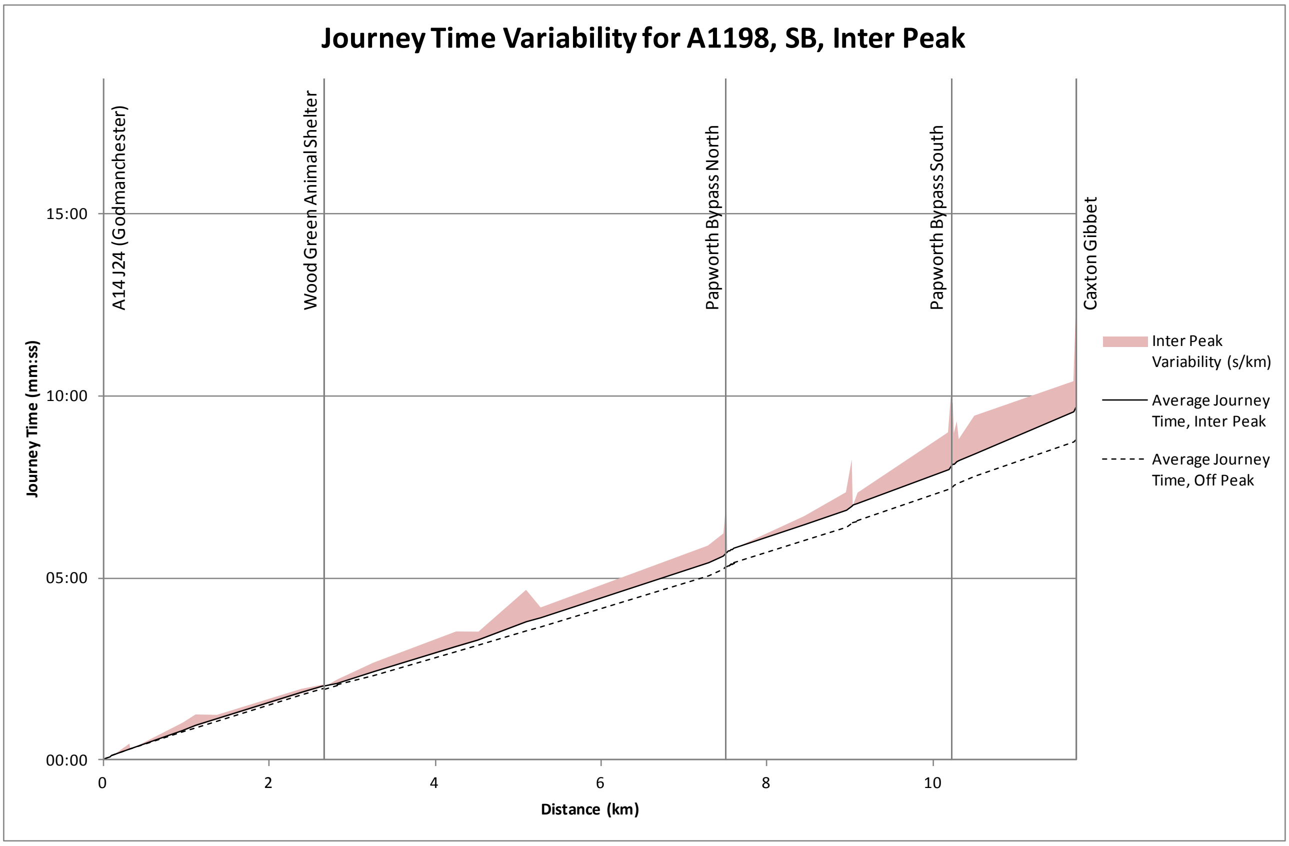


Figure B-42 A1198 Southbound Journey Time Variability – PM Peak Hour

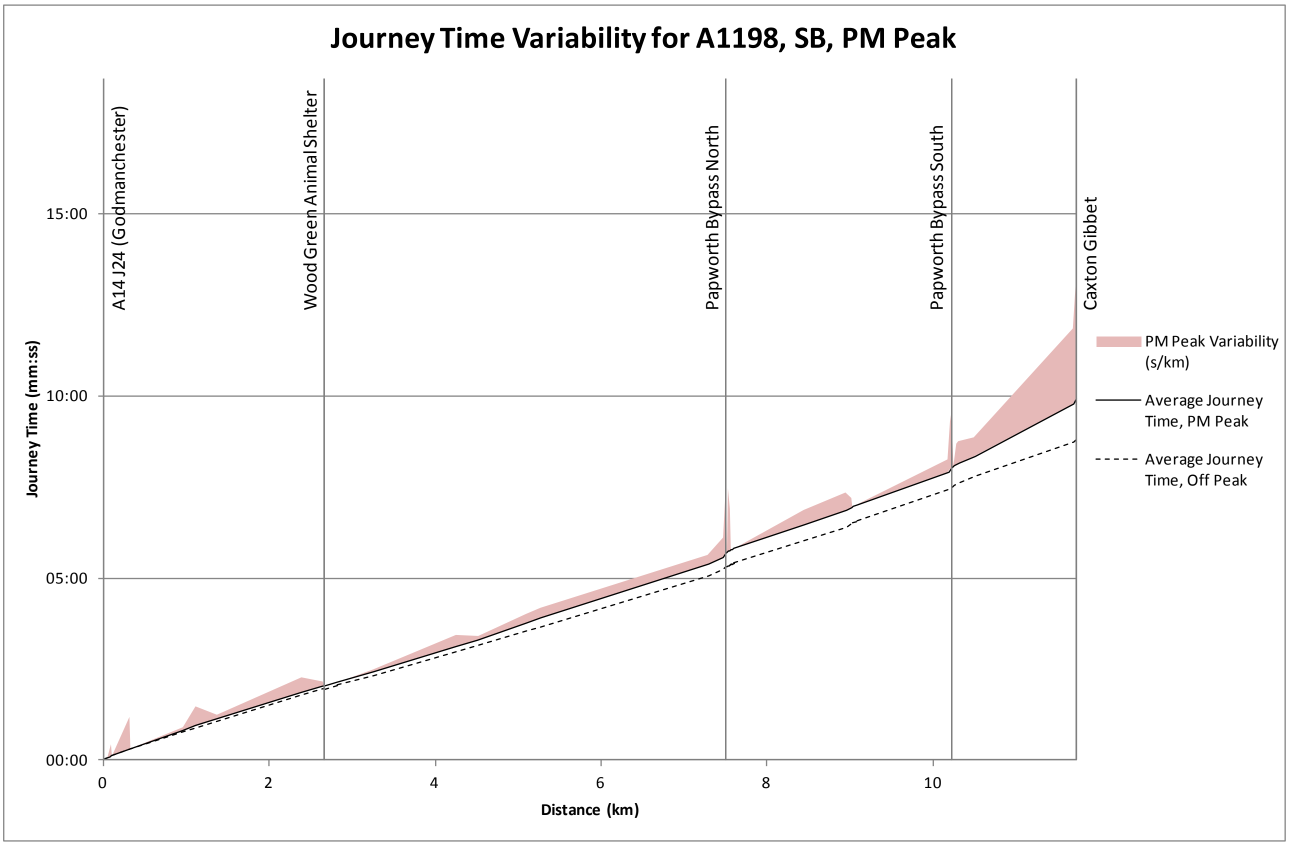


Figure B-43 B1050 Northbound Journey Time Variability – AM Peak Hour

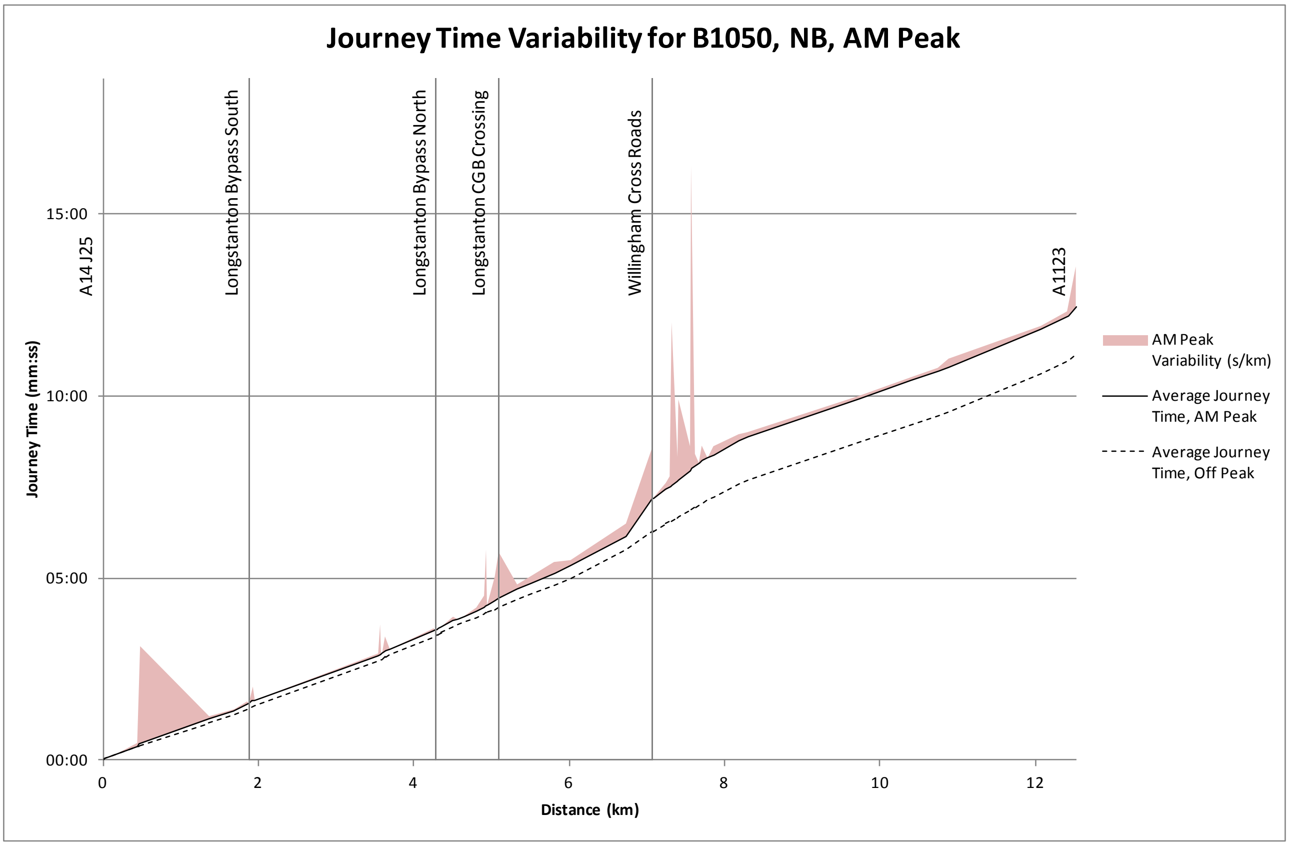


Figure B-44 B1050 Northbound Journey Time Variability – Inter Peak Hour

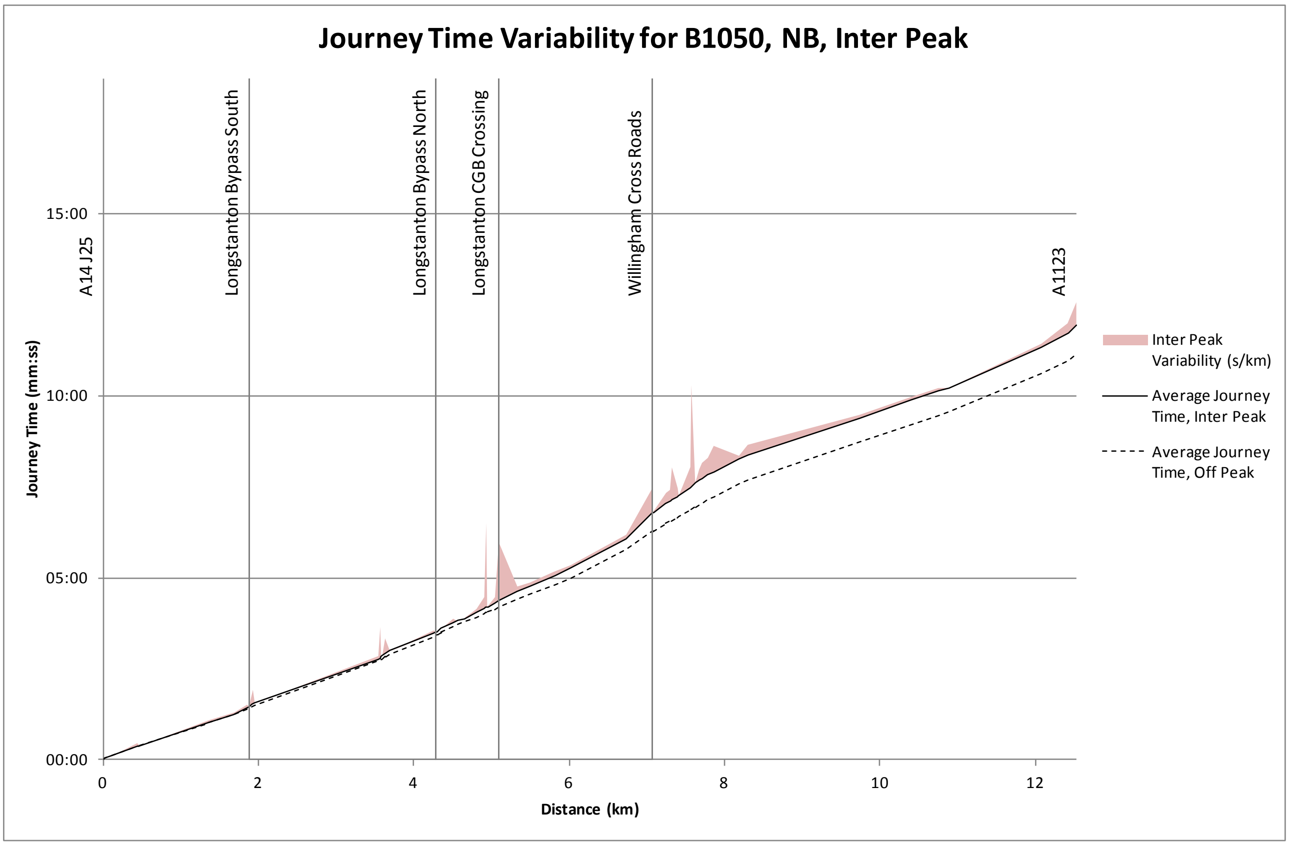


Figure B-45 B1050 Northbound Journey Time Variability – PM Peak Hour

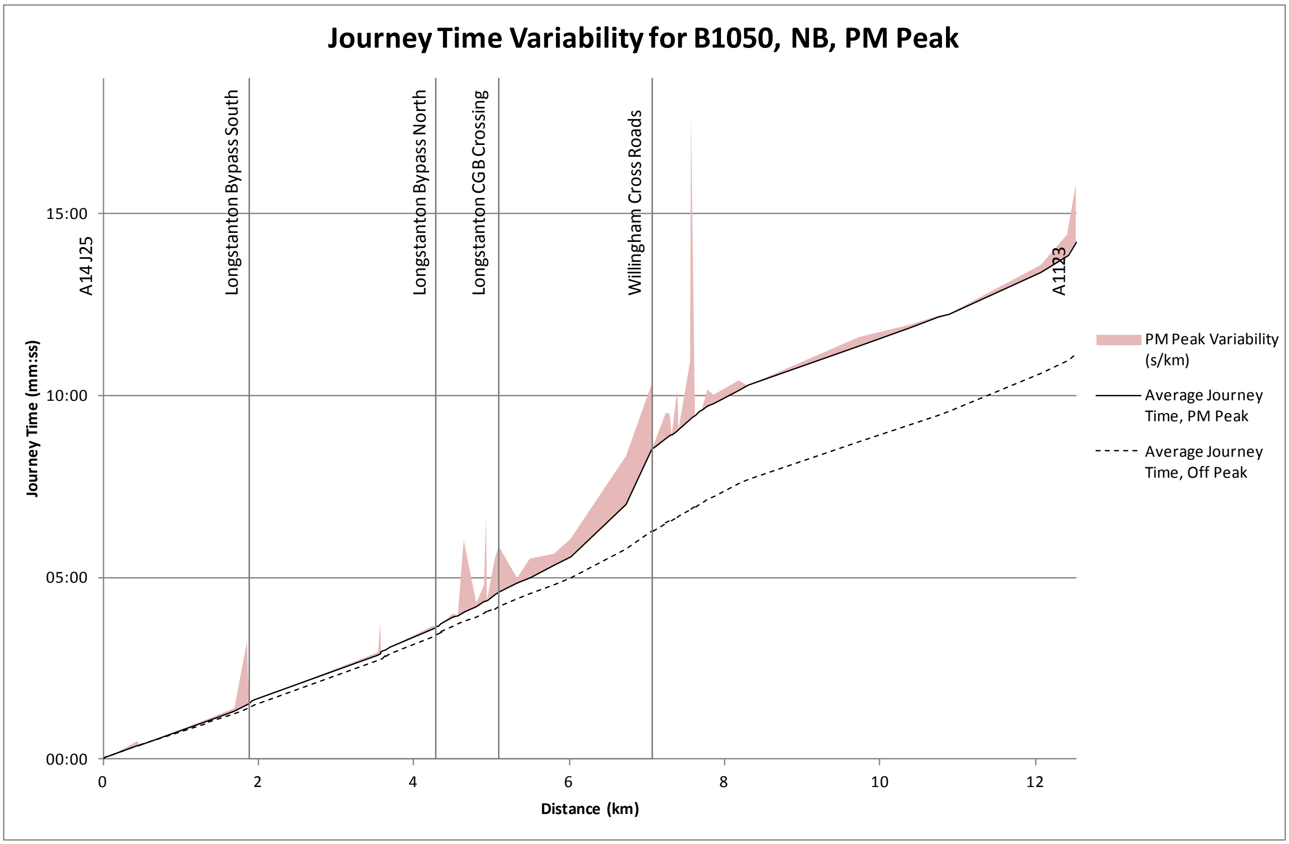


Figure B-46 B1050 Southbound Journey Time Variability – AM Peak Hour

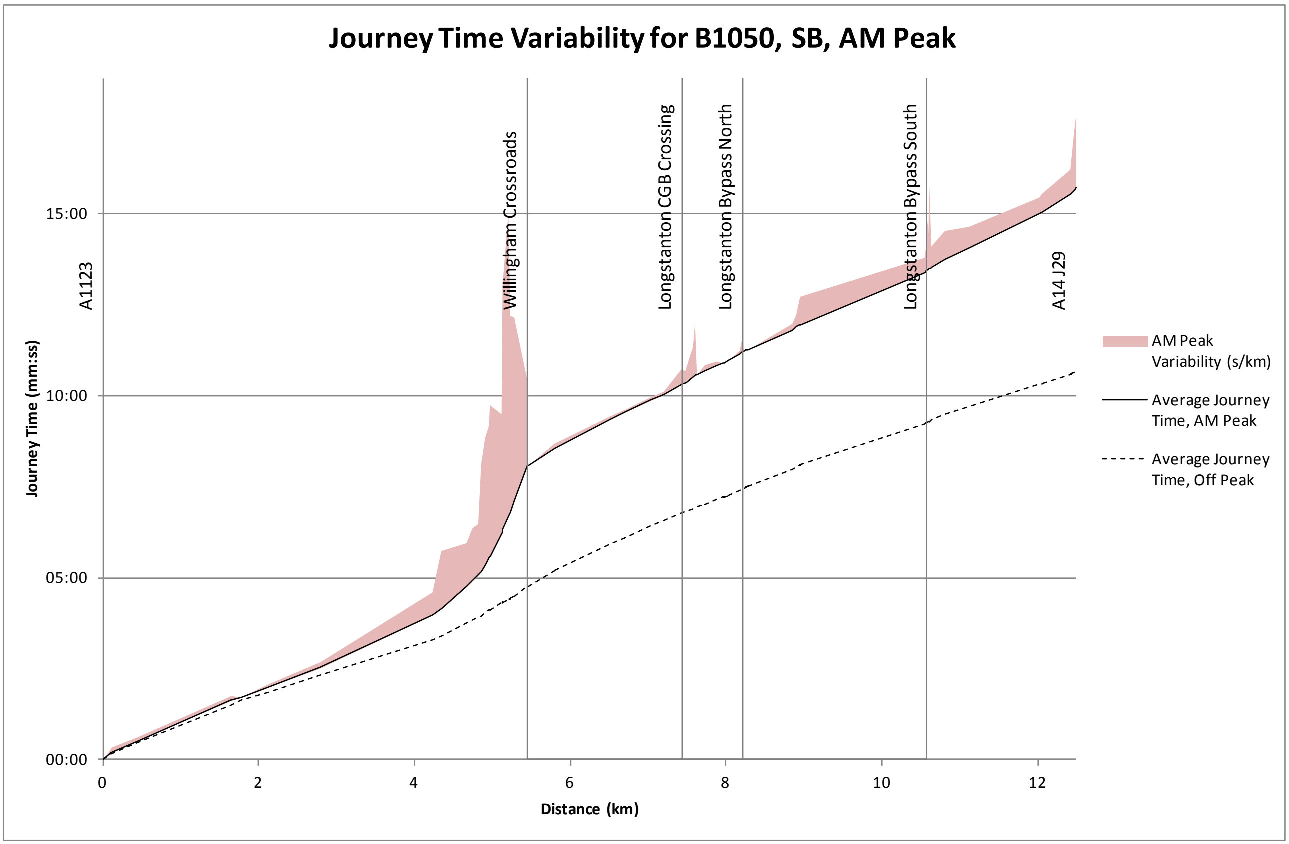


Figure B-47 B1050 Southbound Journey Time Variability – Inter Peak Hour

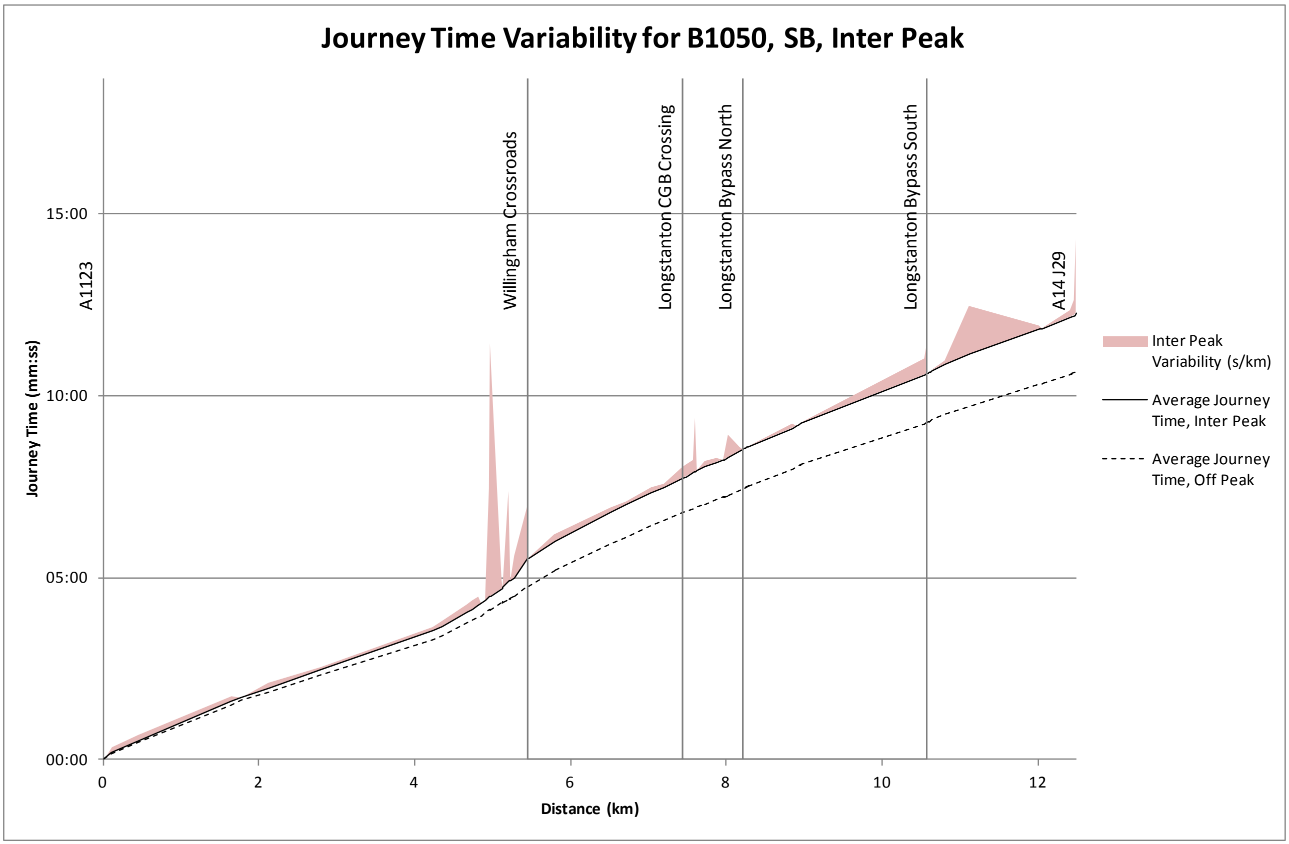


Figure B-48 B1050 Southbound Journey Time Variability – PM Peak Hour

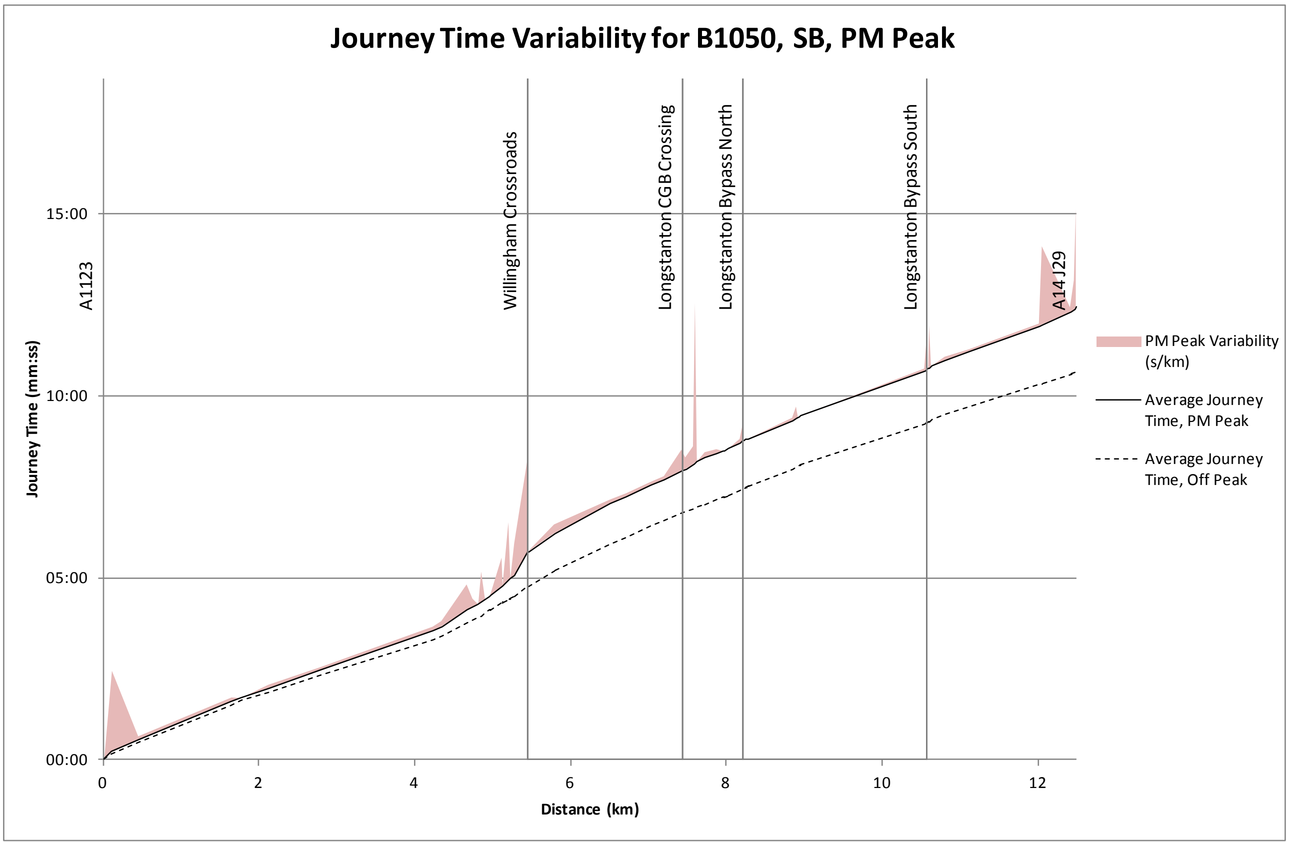


Figure B-49 M11 Northbound Journey Time Variability – AM Peak Hour

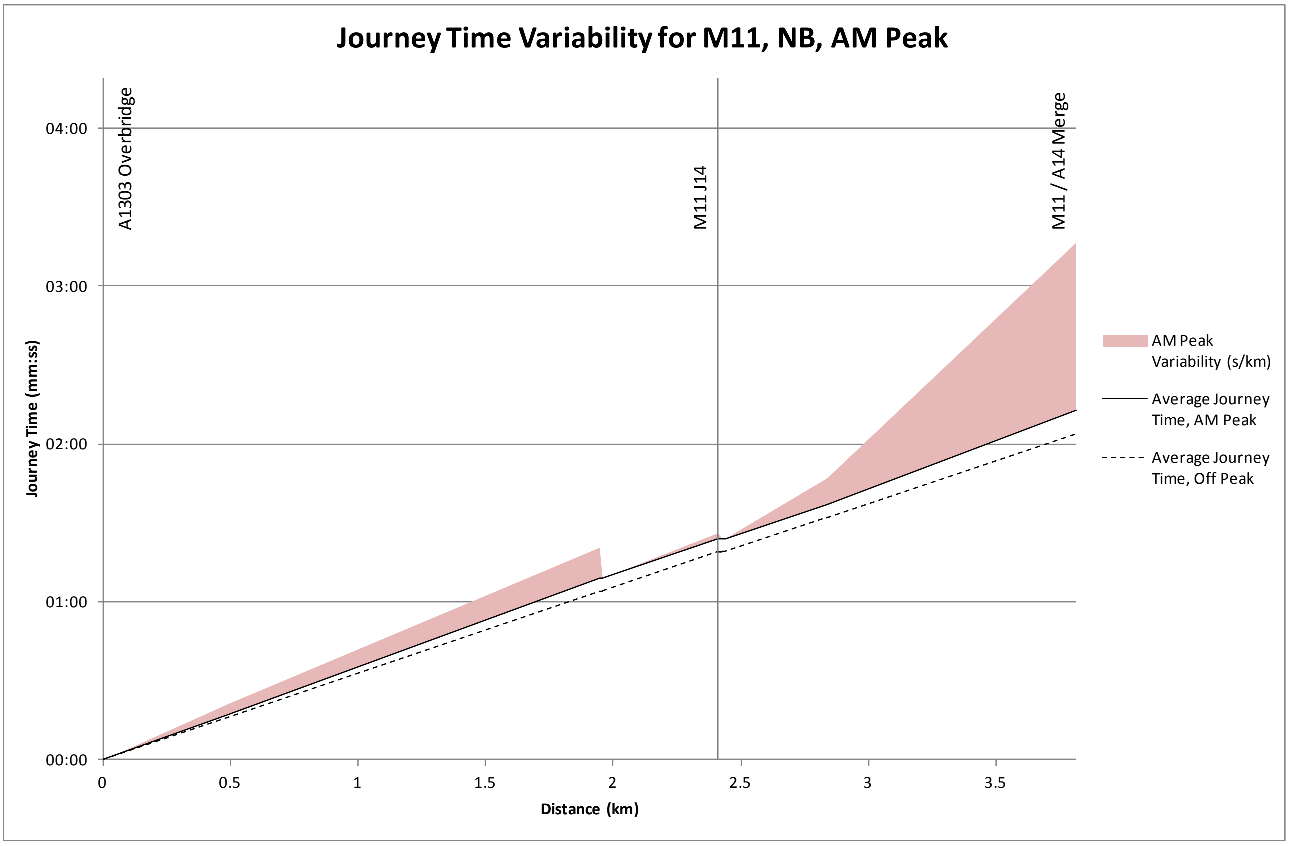


Figure B-50 M11 Northbound Journey Time Variability – Inter Peak Hour

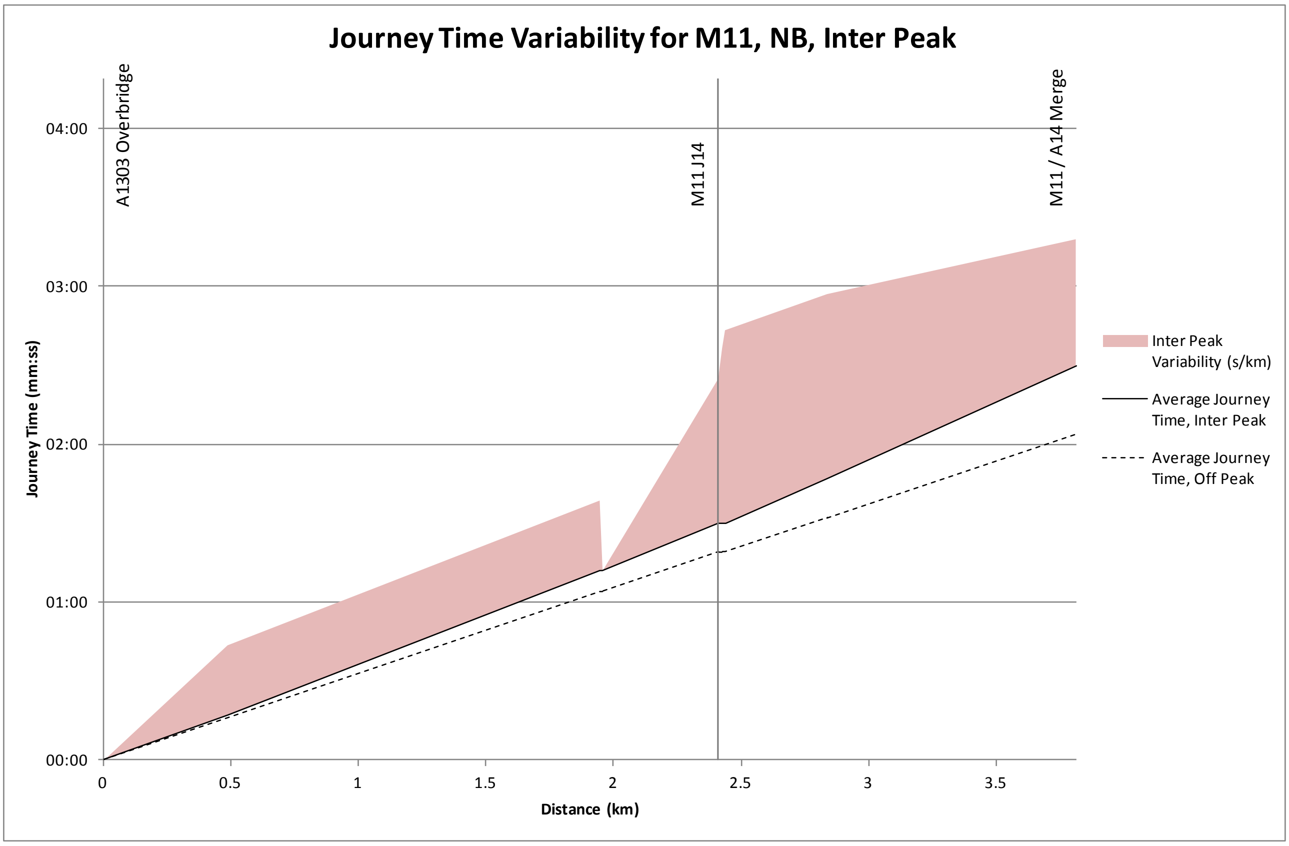


Figure B-51 M11 Northbound Journey Time Variability – PM Peak Hour

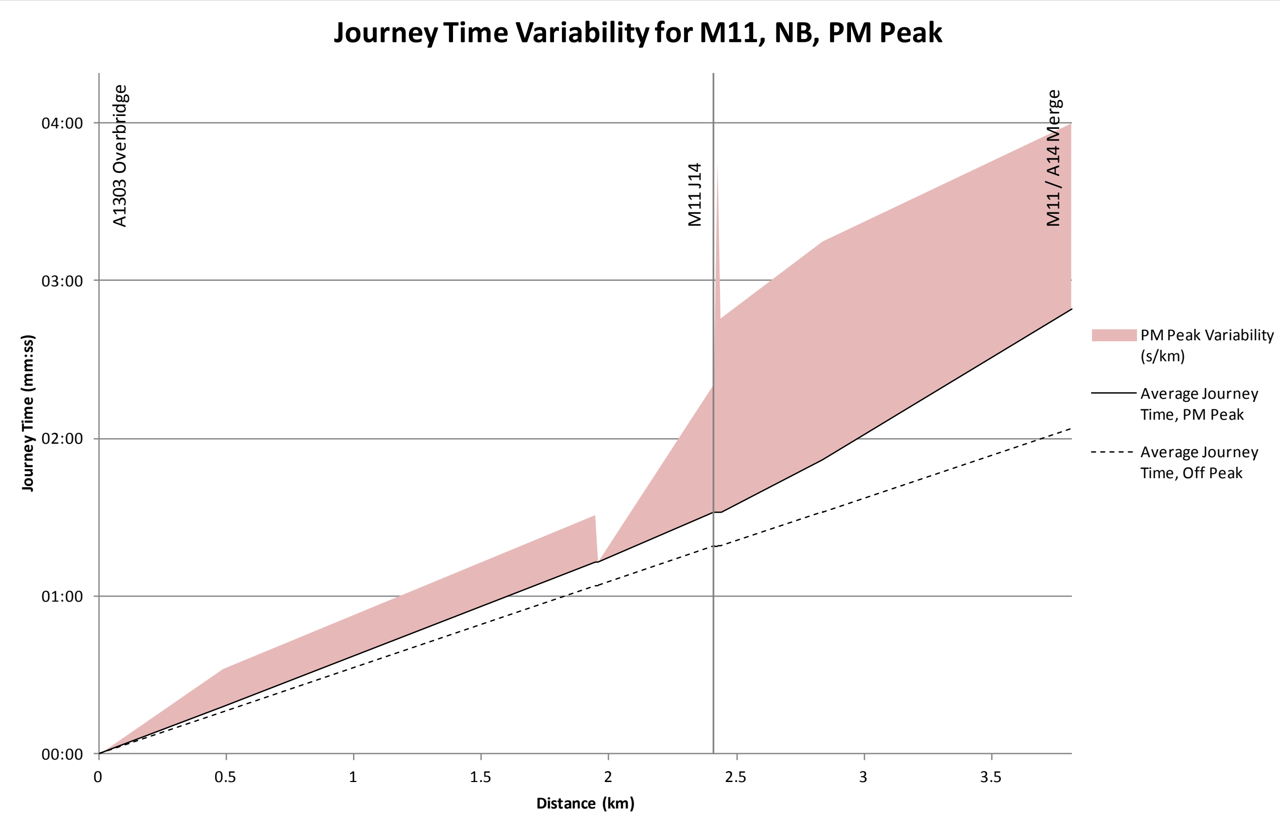


Figure B-52 M11 Southbound Journey Time Variability – AM Peak Hour

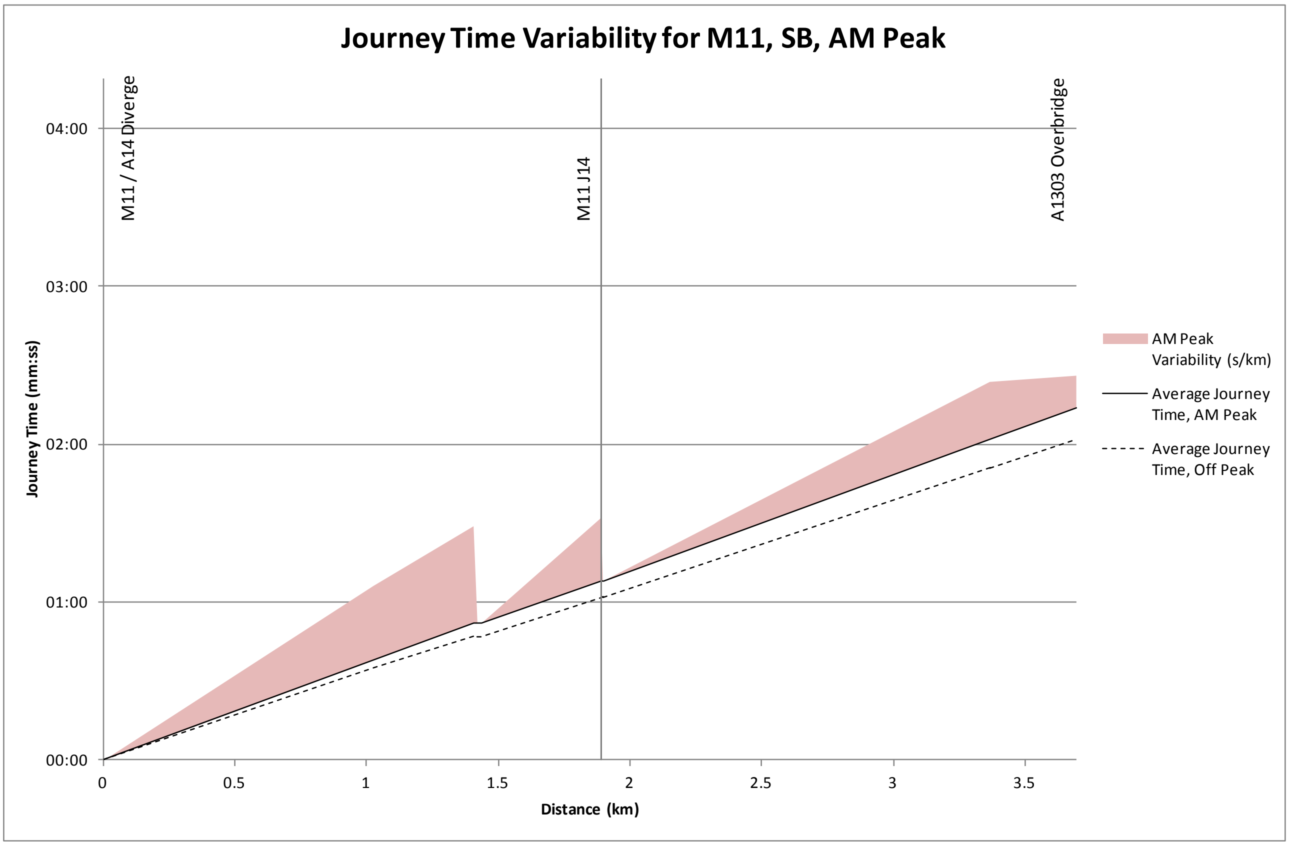


Figure B-53 M11 Southbound Journey Time Variability – Inter Peak Hour

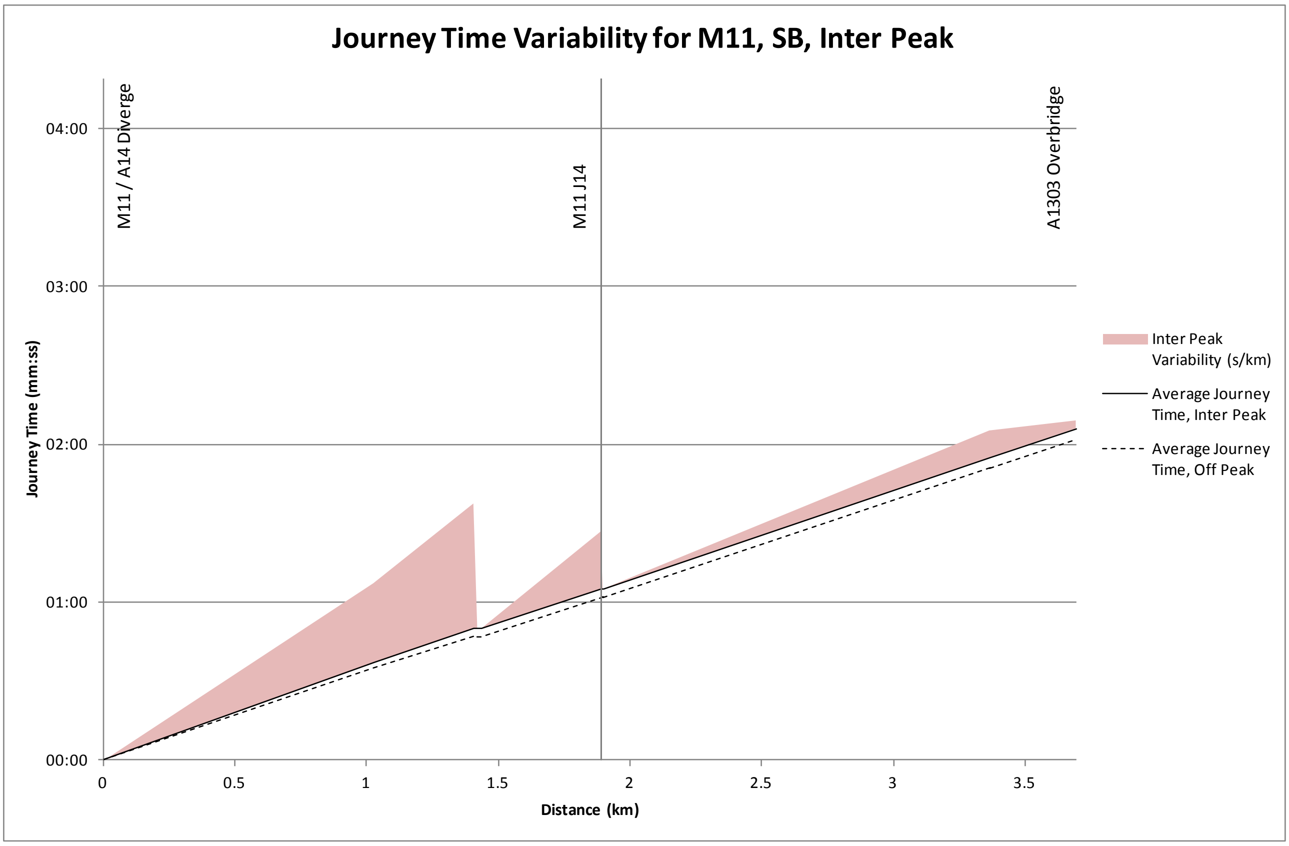
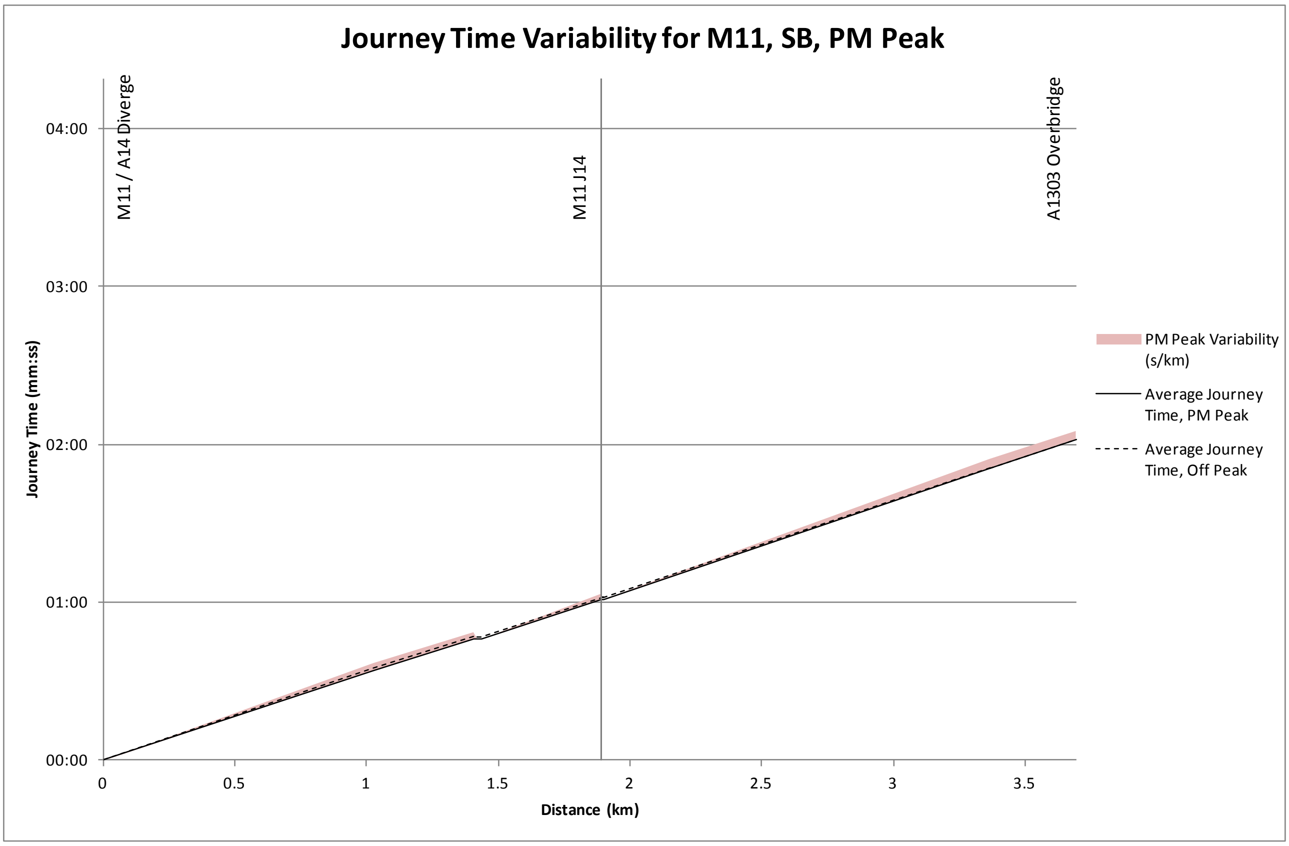


Figure B-54 M11 Southbound Journey Time Variability – PM Peak Hour



Appendix C. Eastbound Modelled Incident Additional Graphs

Figure C-1 A1198 SB V/C Ratio, Modelled Incident EB at Hemingford Abbots, Inter Peak Period

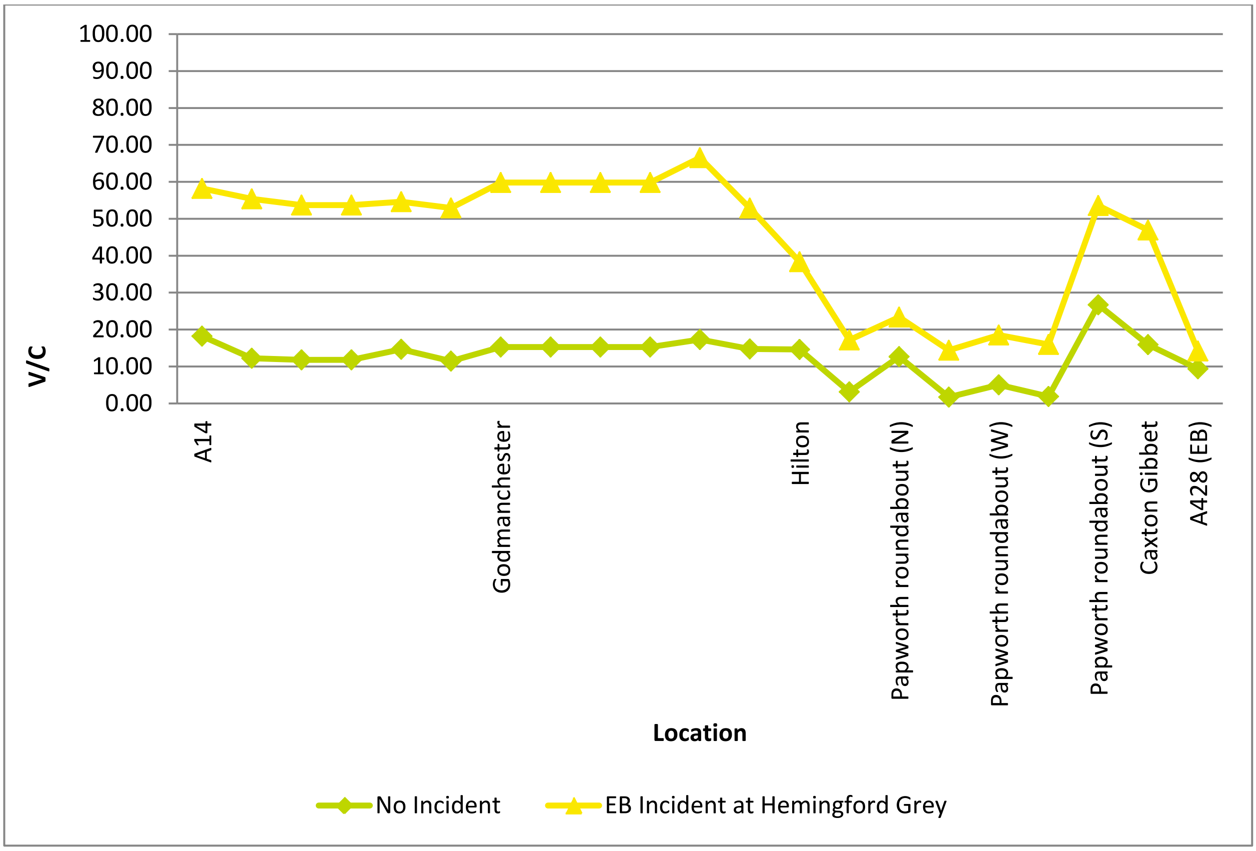


Figure C-2 A428 EB V/C Ratio, Modelled Incident EB at Hemingford Abbots, Inter Peak Period

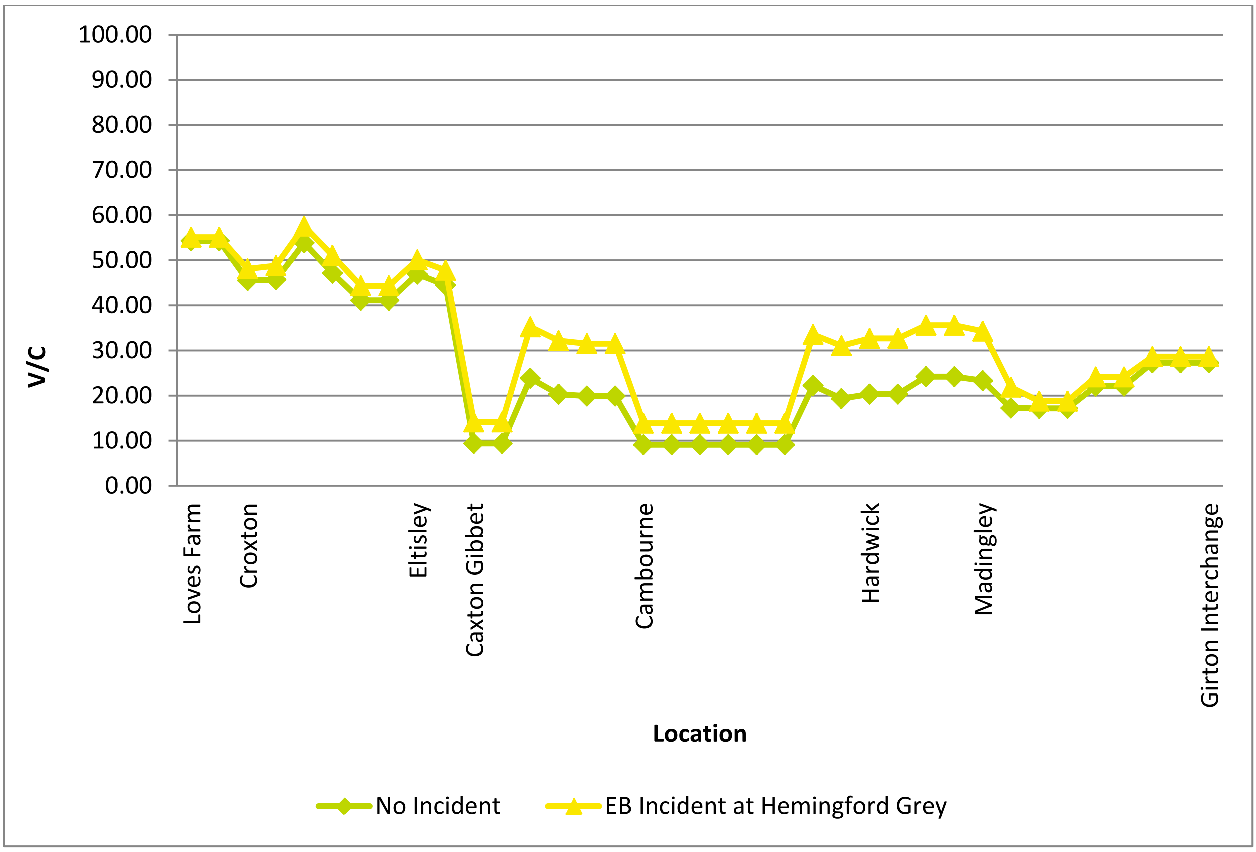


Figure C-3 A1123 SB V/C Ratio, Modelled Incident EB at Hemingford Abbots, Inter Peak Period

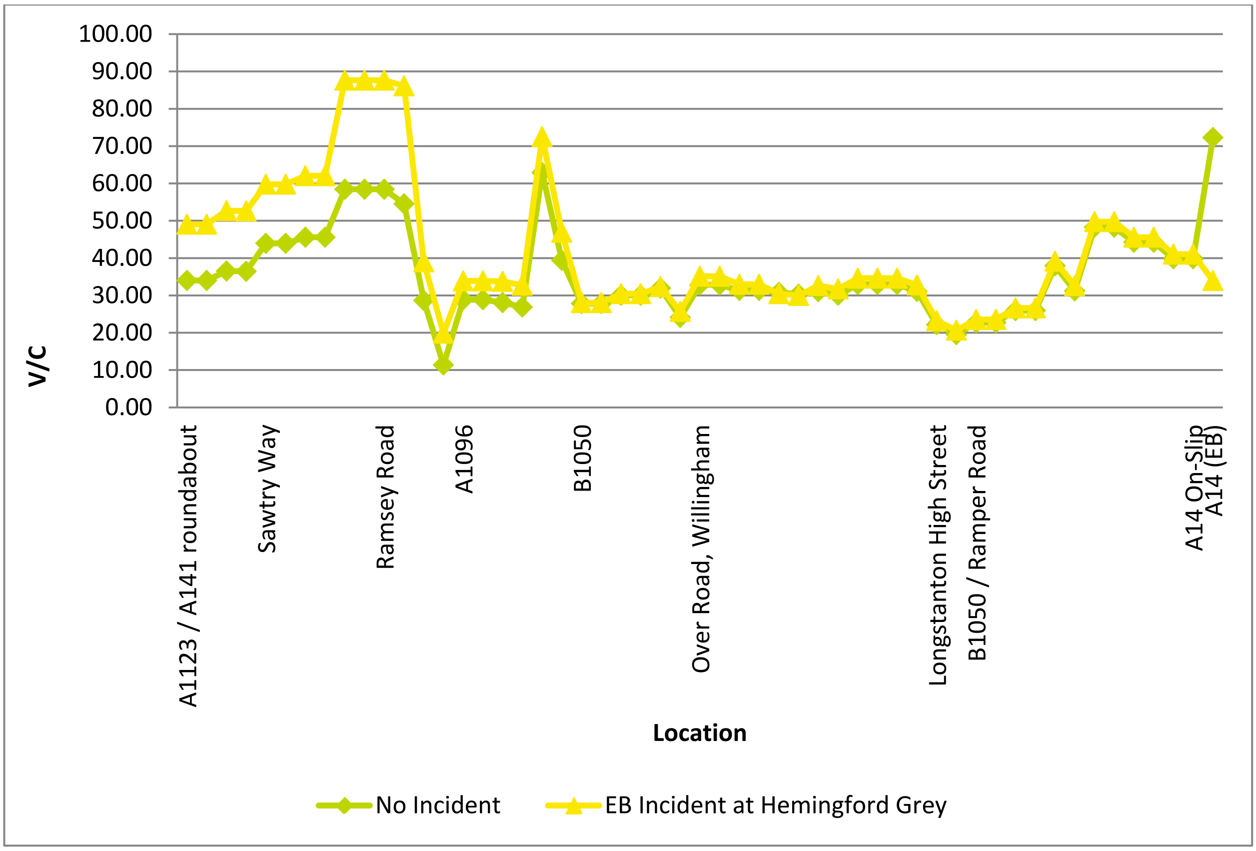


Figure C-4 A14 EB V/C Ratio, Modelled Incident EB at Hemingford Abbots, Inter Peak Period

Appendix D. Westbound Modelled Incident Additional Graphs

Figure D-1 A1198 NB V/C Ratio, Modelled Incident EB at Hemingford Grey, Inter Peak Period

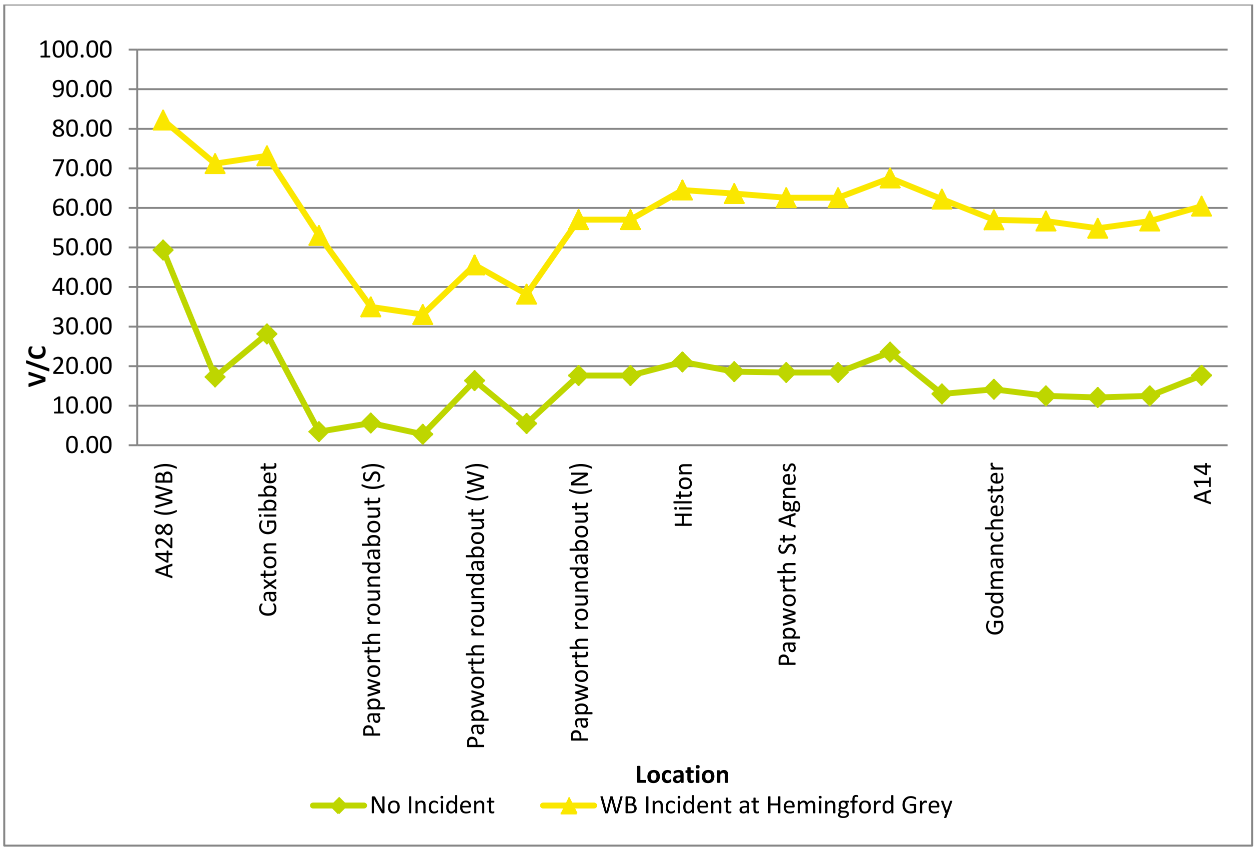


Figure D-2 A428 WB V/C Ratio, Modelled Incident EB at Hemingford Grey, Inter Peak Period

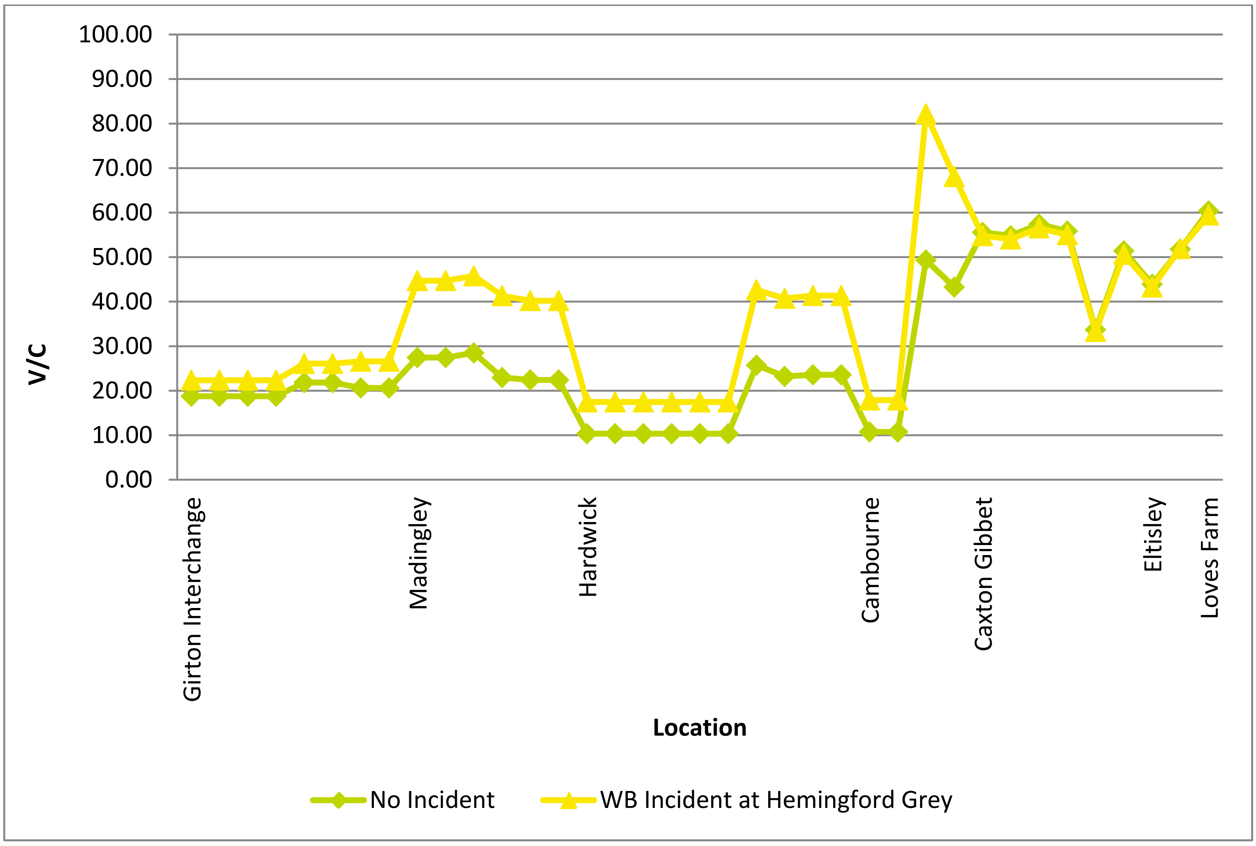


Figure D-3 A1123 NB V/C Ratio, Modelled Incident EB at Hemingford Grey, Inter Peak Period

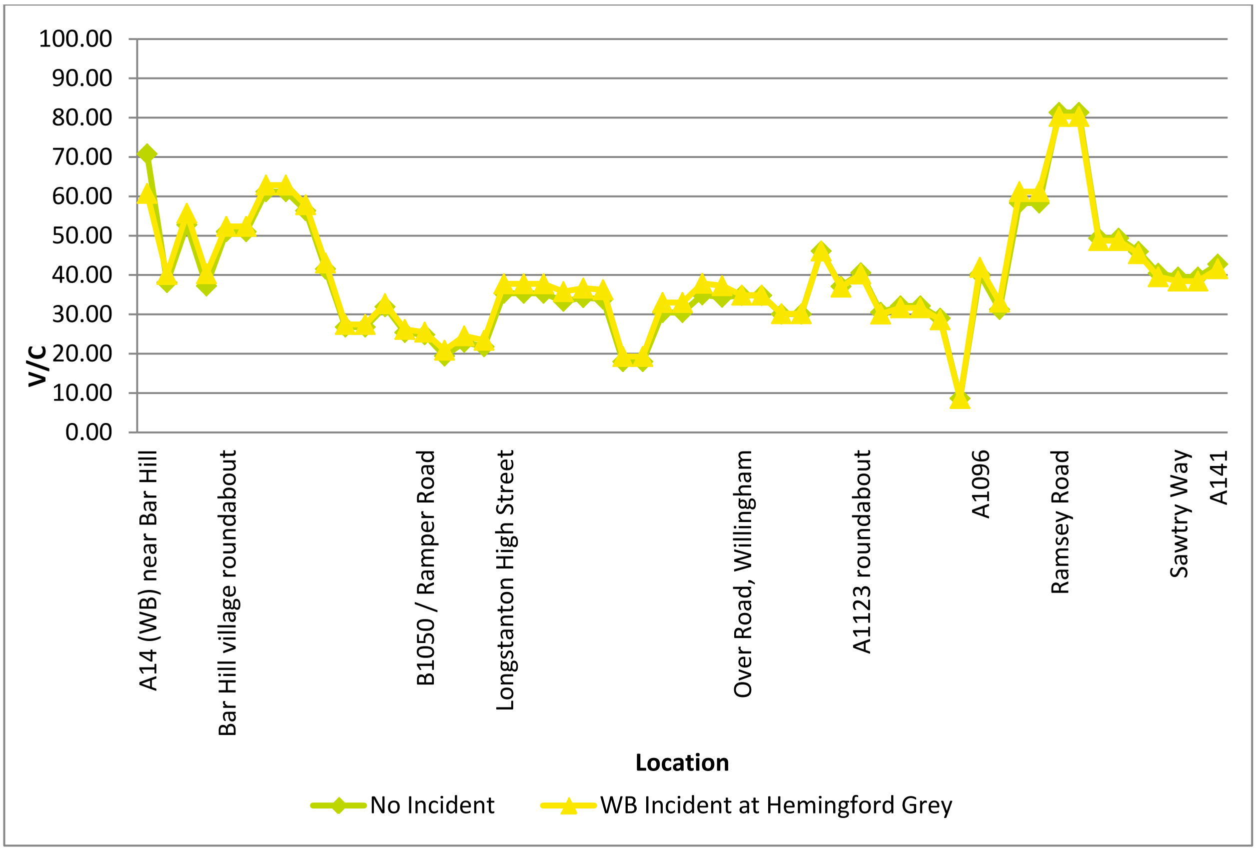
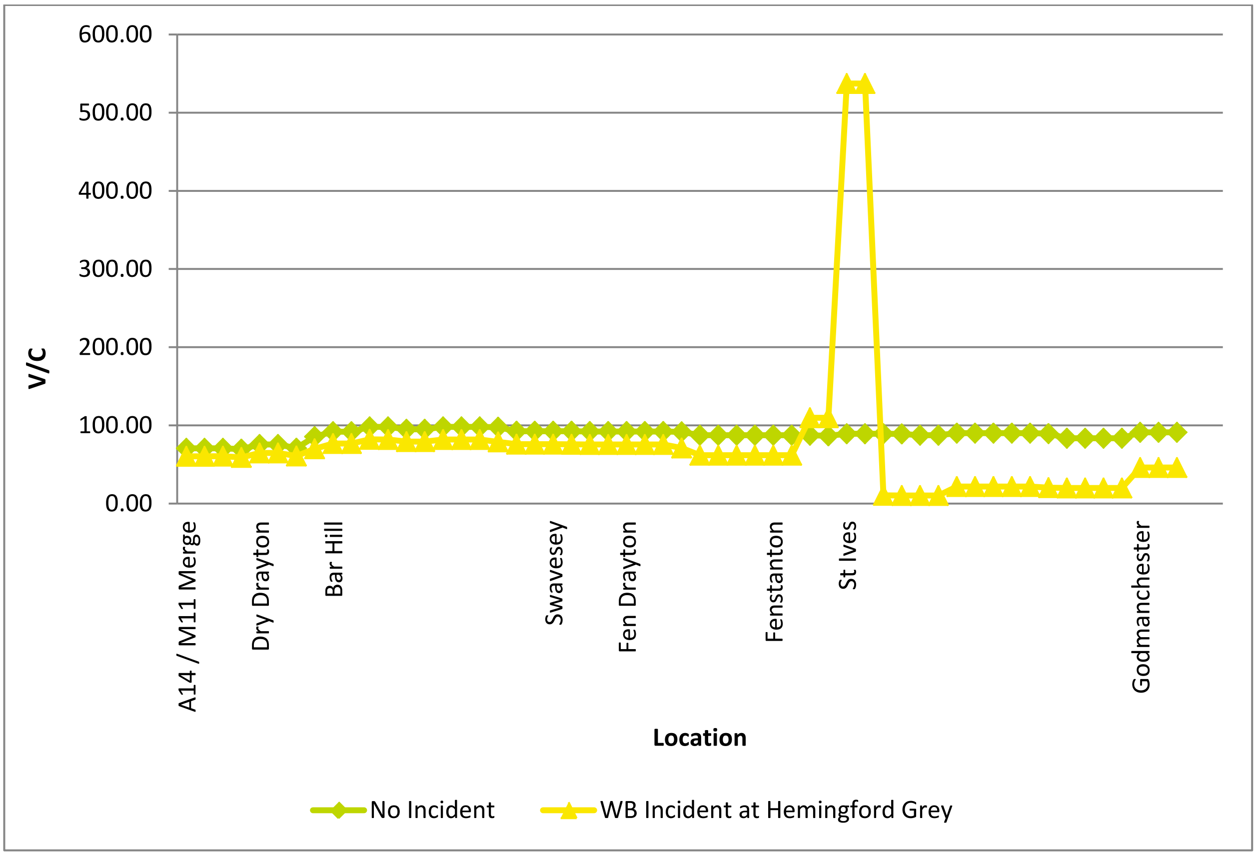


Figure D-4 A14 WB V/C Ratio, Modelled Incident EB at Hemingford Grey, Inter Peak Period



Appendix E. Detailed Incident Analysis

Figure E-1 Actual Flow Comparison (Incident – Base). Incident on A14 Eastbound, J25 Hemingford Abbots (AM peak)

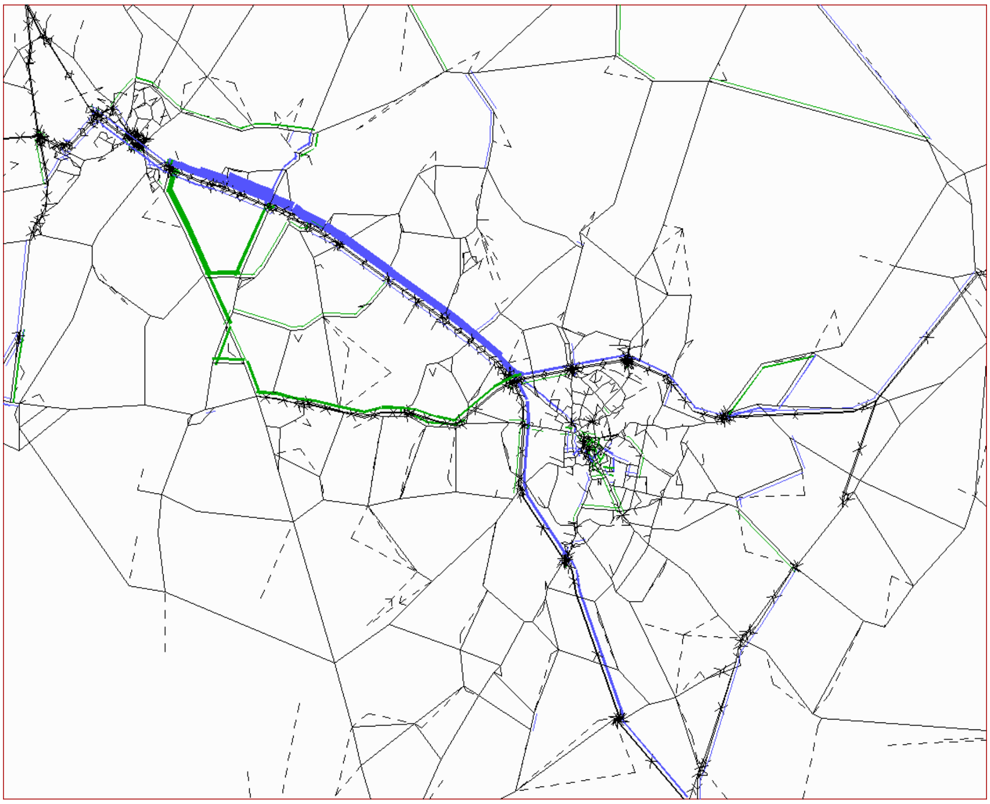


Figure E-2 Actual Flow Comparison (Incident – Base). Incident on A14 Westbound, J25 Hemingford Abbots (AM peak)

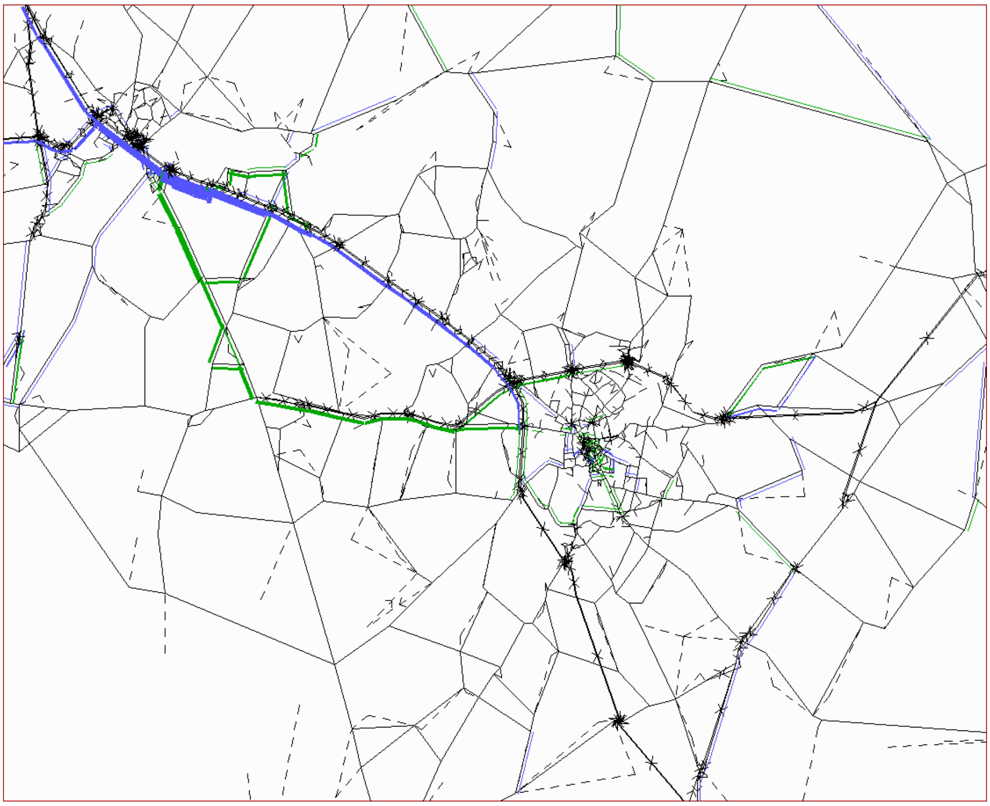


Figure E-3 Figure E-4 Actual Flow Comparison (Incident – Base). Incident on A14 Eastbound, J33 Milton Interchange (AM peak)

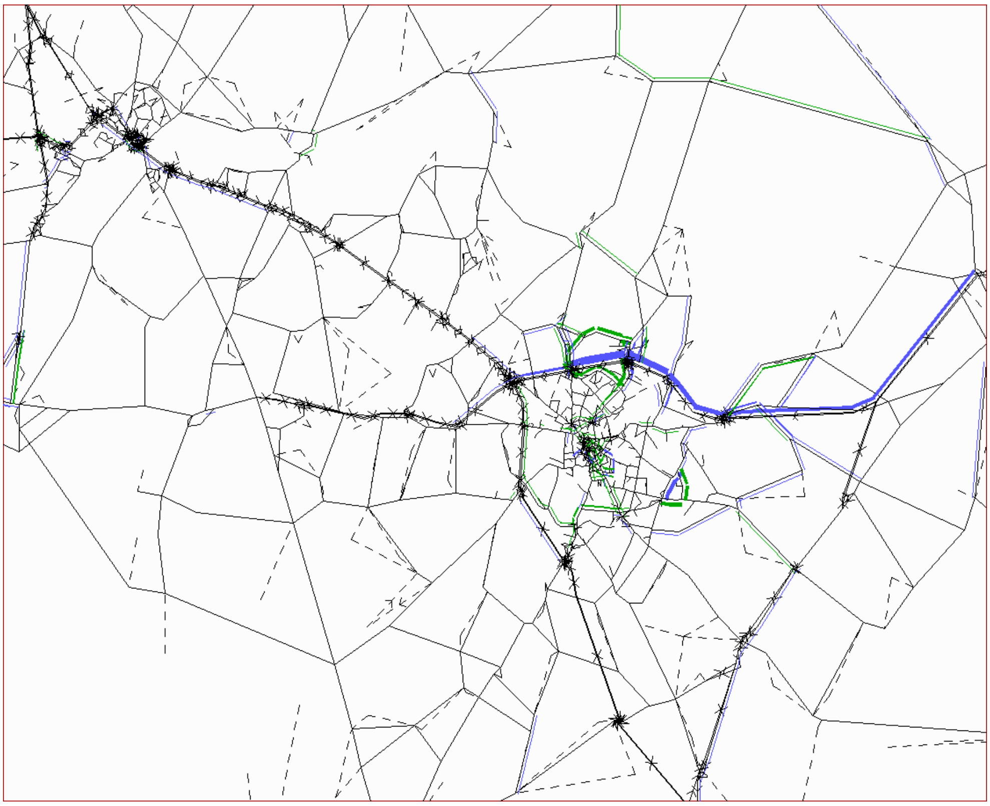
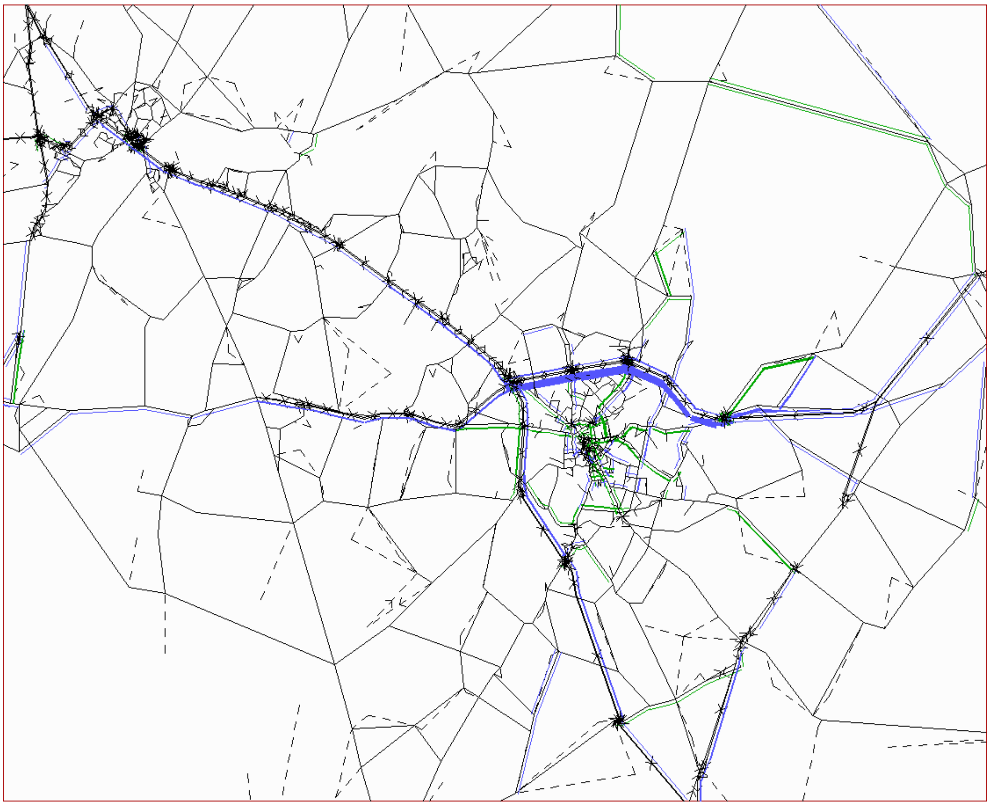


Figure E-5 Actual Flow Comparison (Incident – Base). Incident on A14 Westbound, J33 Milton Interchange (AM peak)



Appendix F. Residual Capacity Graphs

Figure F-1 A1123 – B1050 Eastbound Residual Capacity

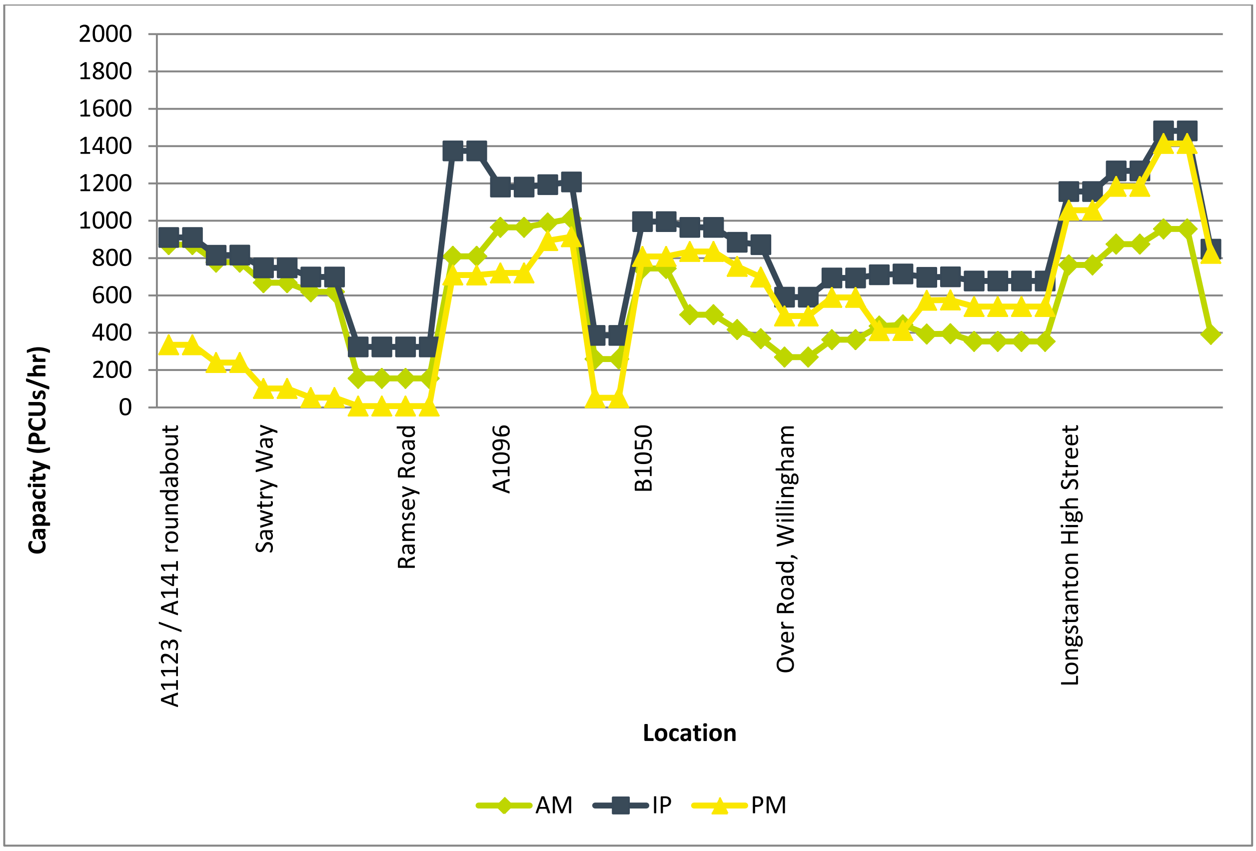


Figure F-2 A1123 – B1050 Westbound Residual Capacity

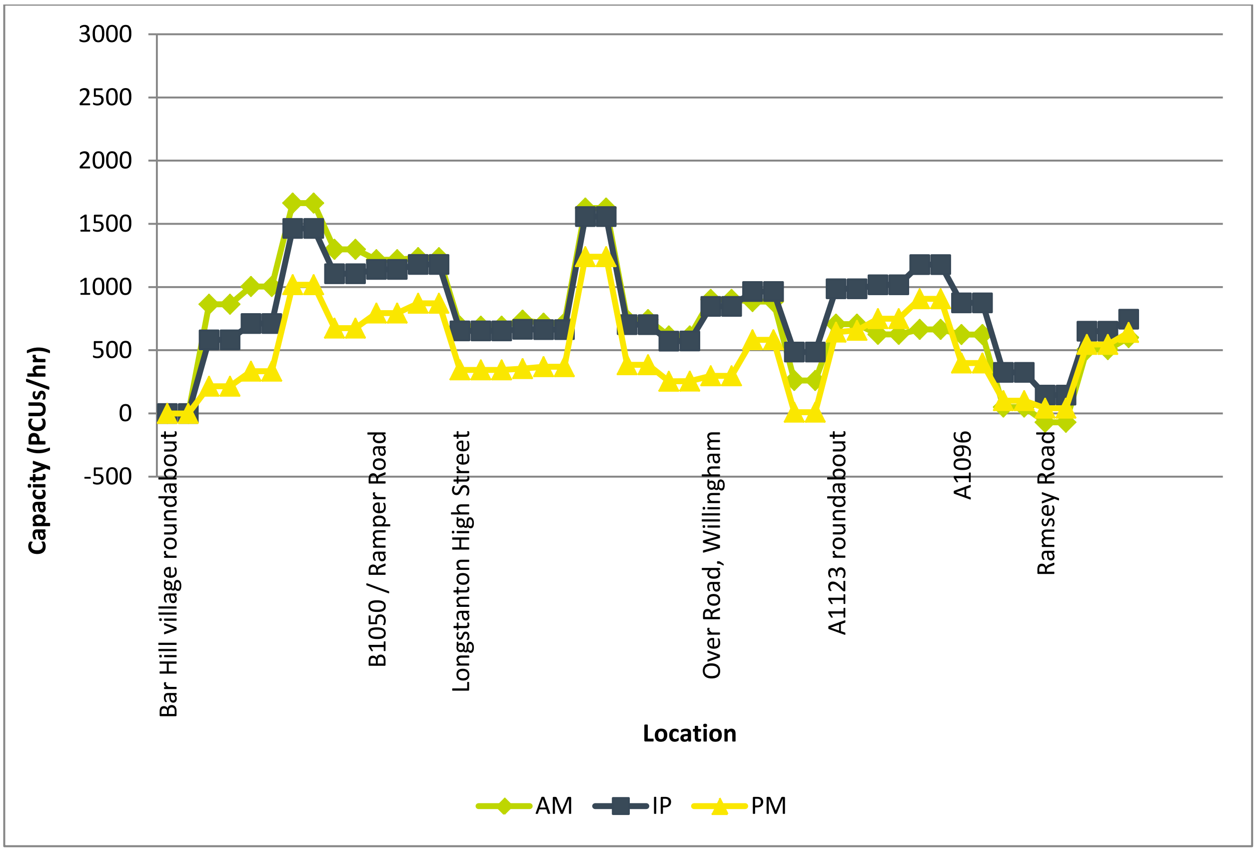


Figure F-3 A1123 – A142 Eastbound Residual Capacity

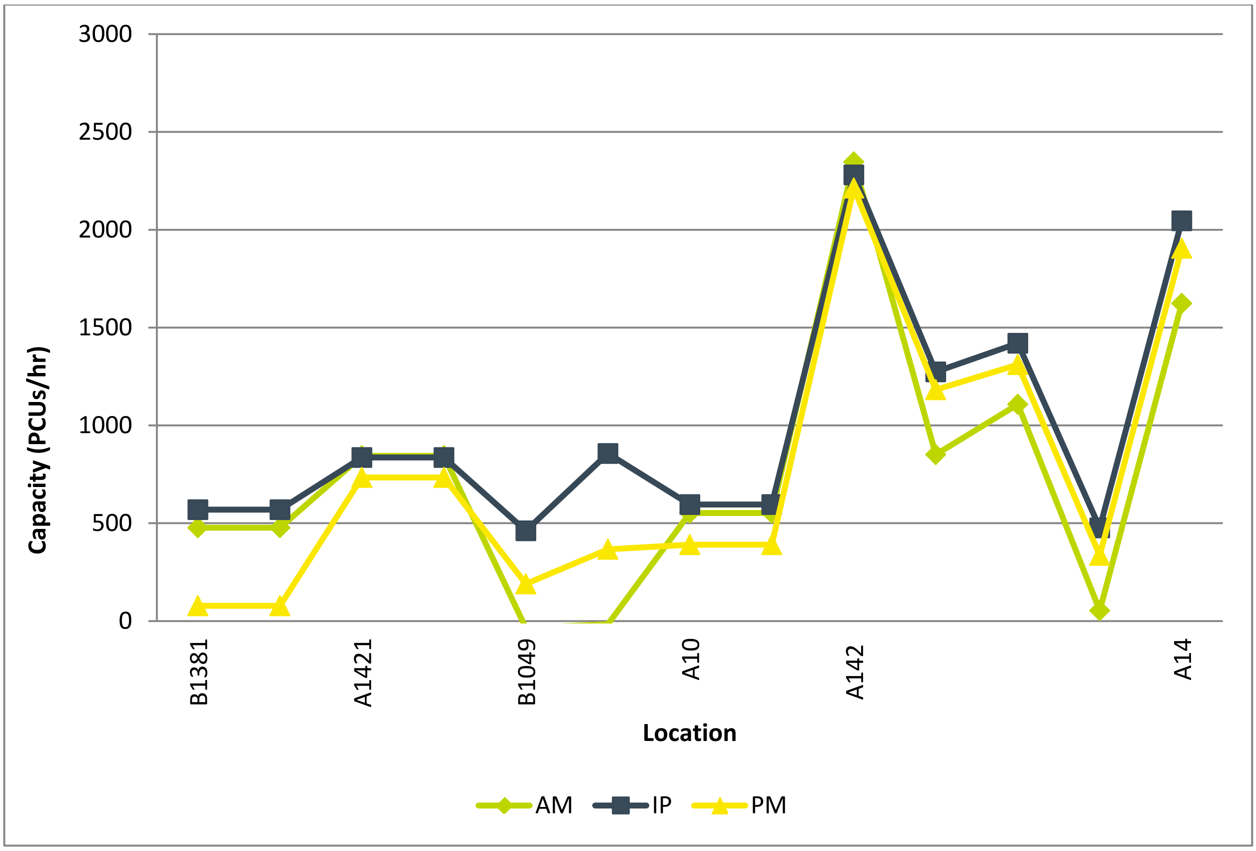


Figure F-4 A1123 – A142 Westbound Residual Capacity

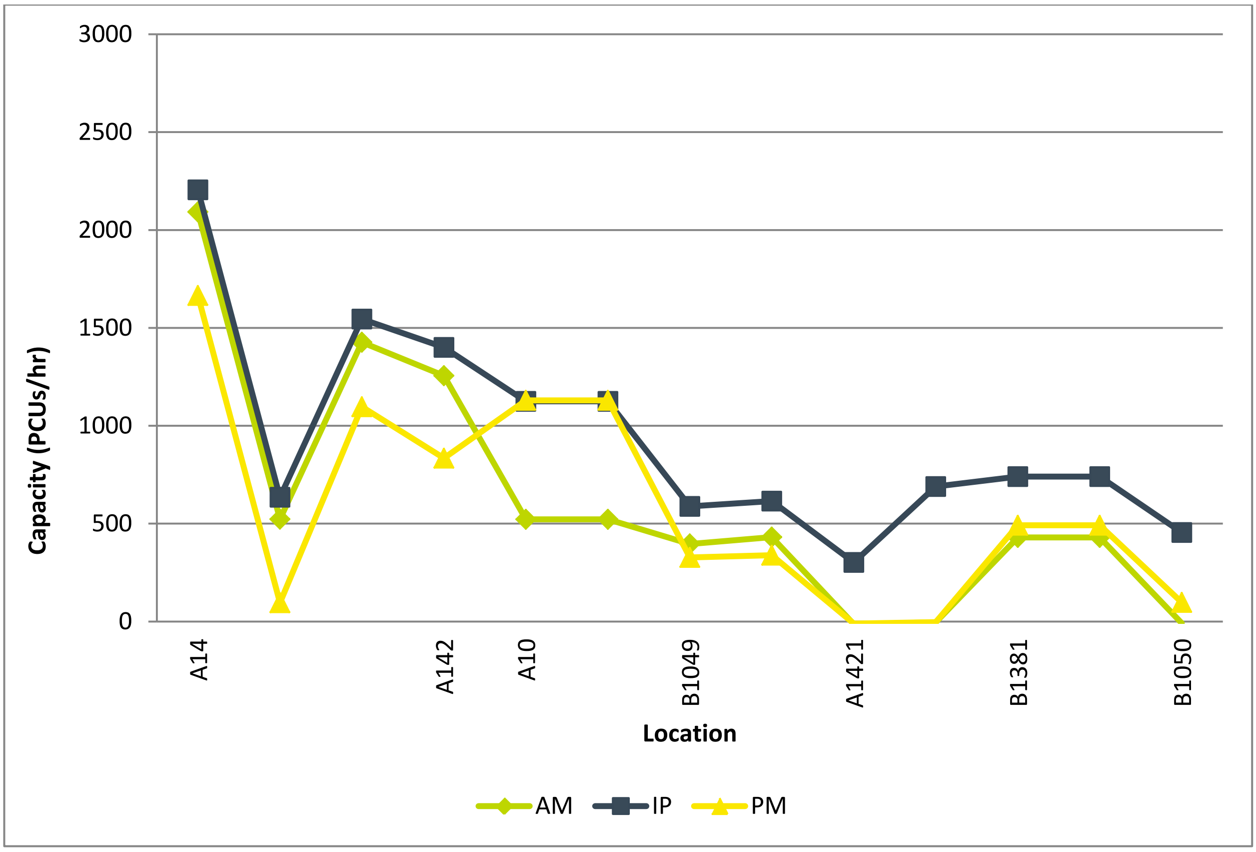


Figure F-5 A1198 Southbound Residual Capacity

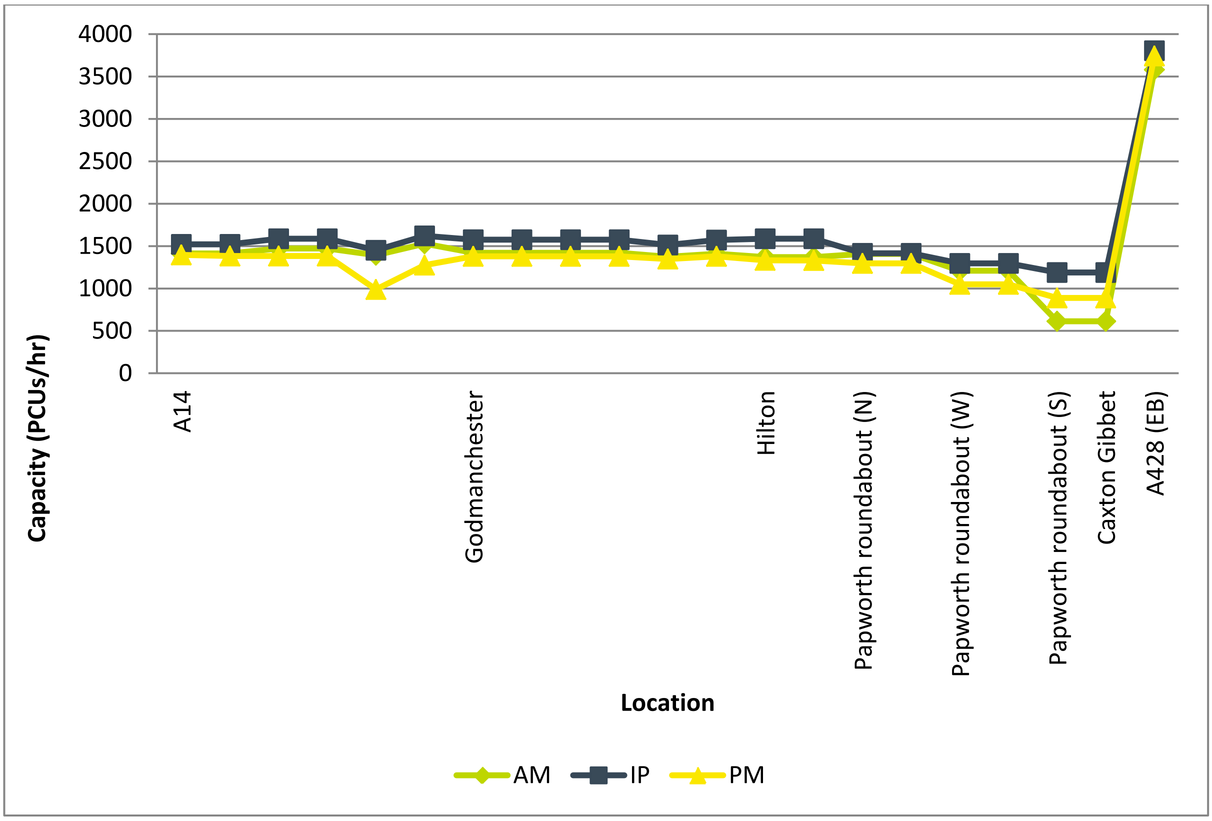


Figure F-6 A428 Eastbound Residual Capacity

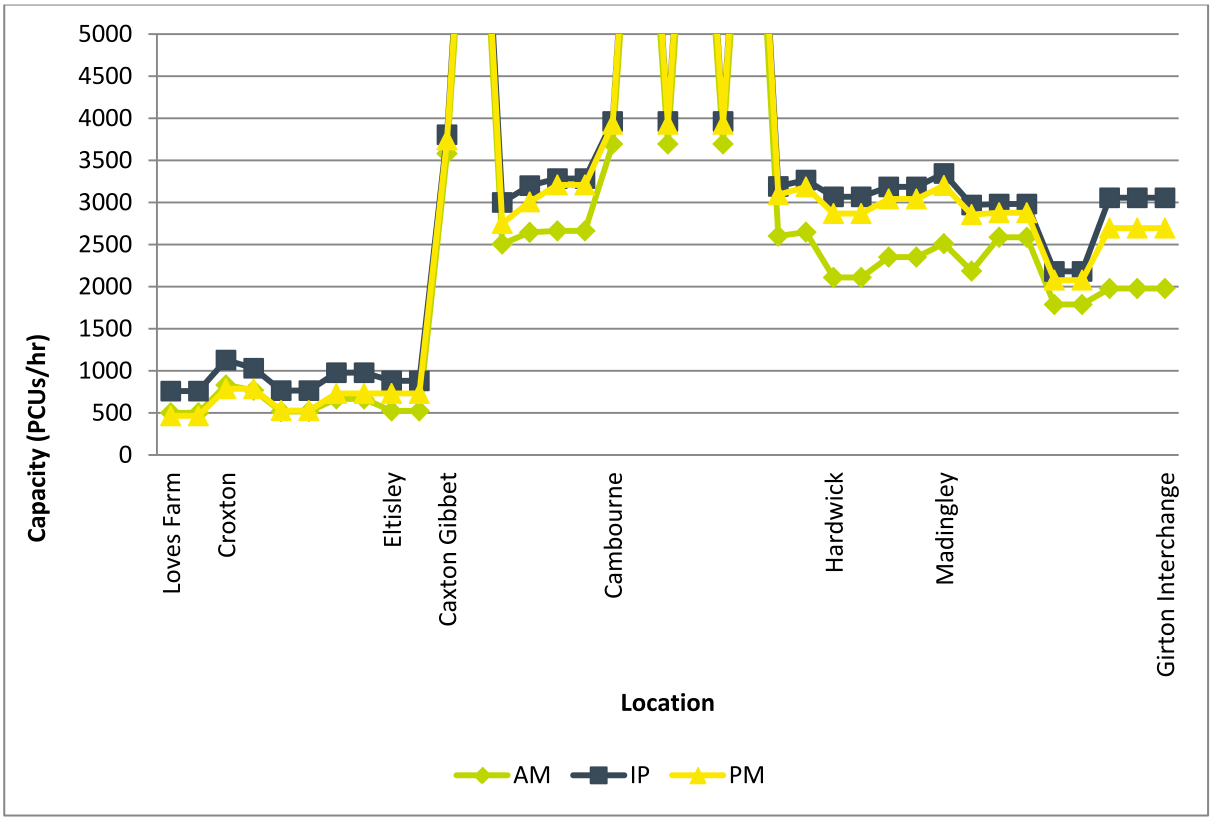


Figure F-7 A428 Westbound Residual Capacity

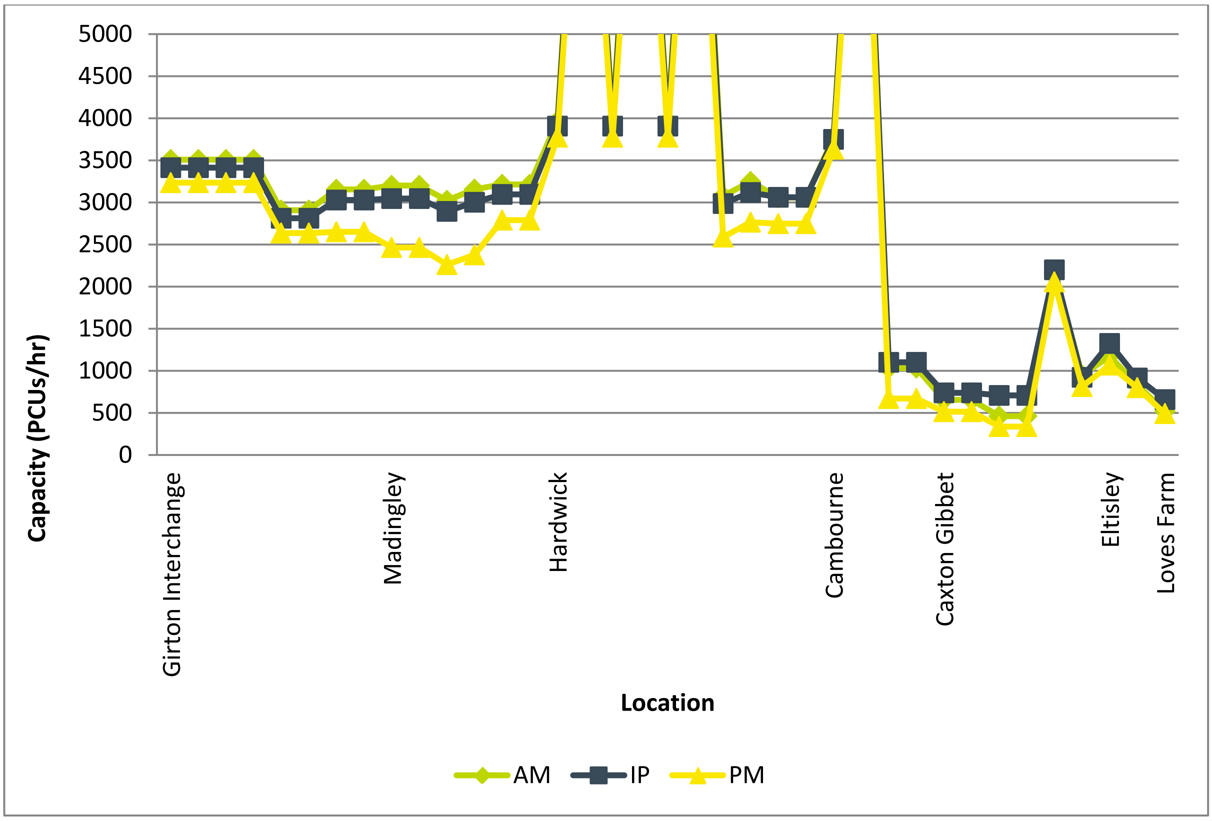


Figure F-8 A1198 Northbound Residual Capacity

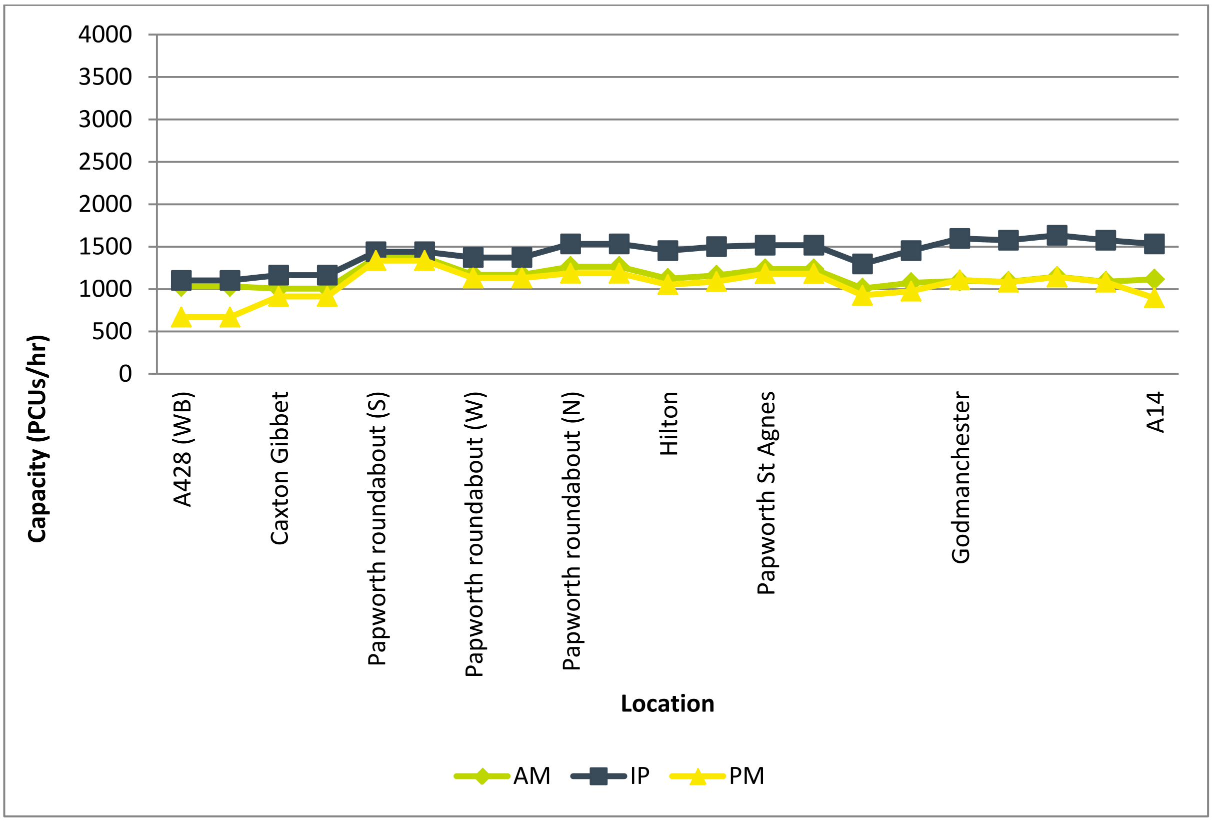


Figure F-9 A1307 Huntingdon Road, Cambridge Eastbound Residual Capacity

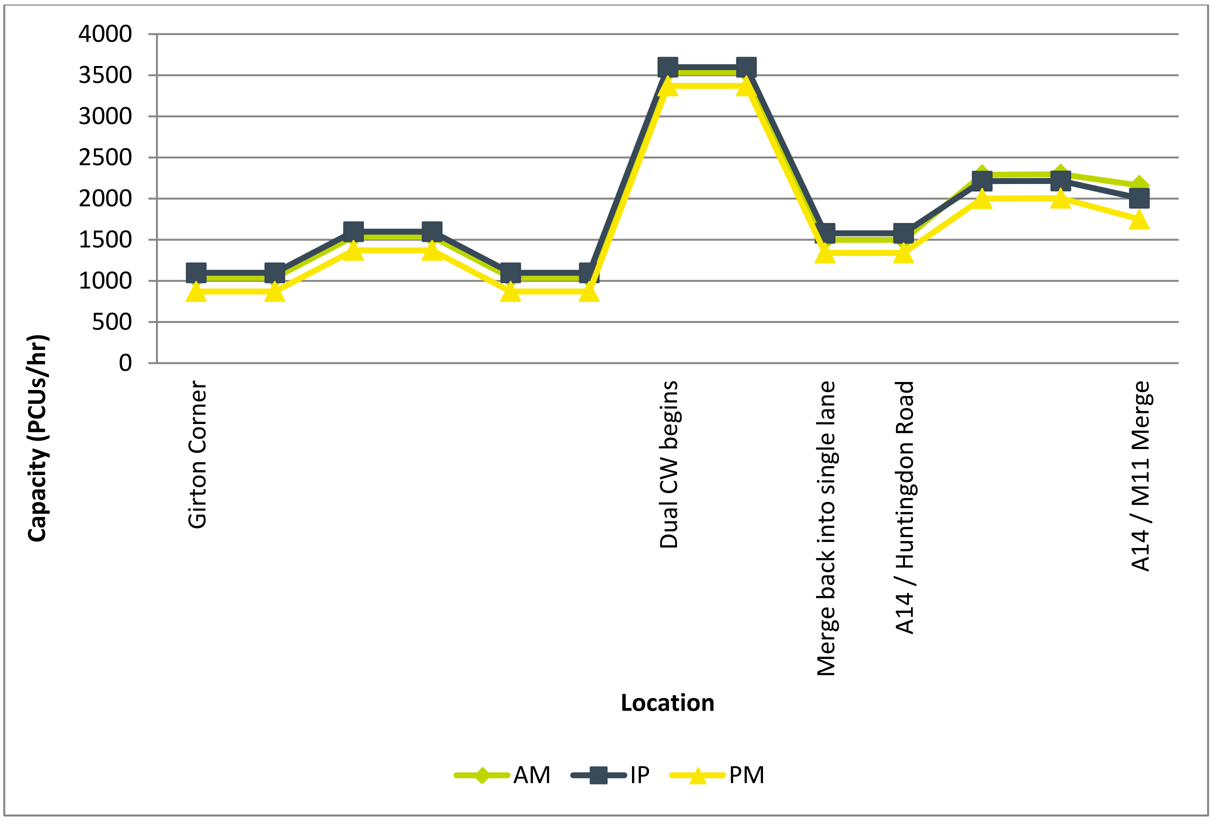


Figure F-10 A1307 Huntingdon Road, Cambridge Westbound Residual Capacity

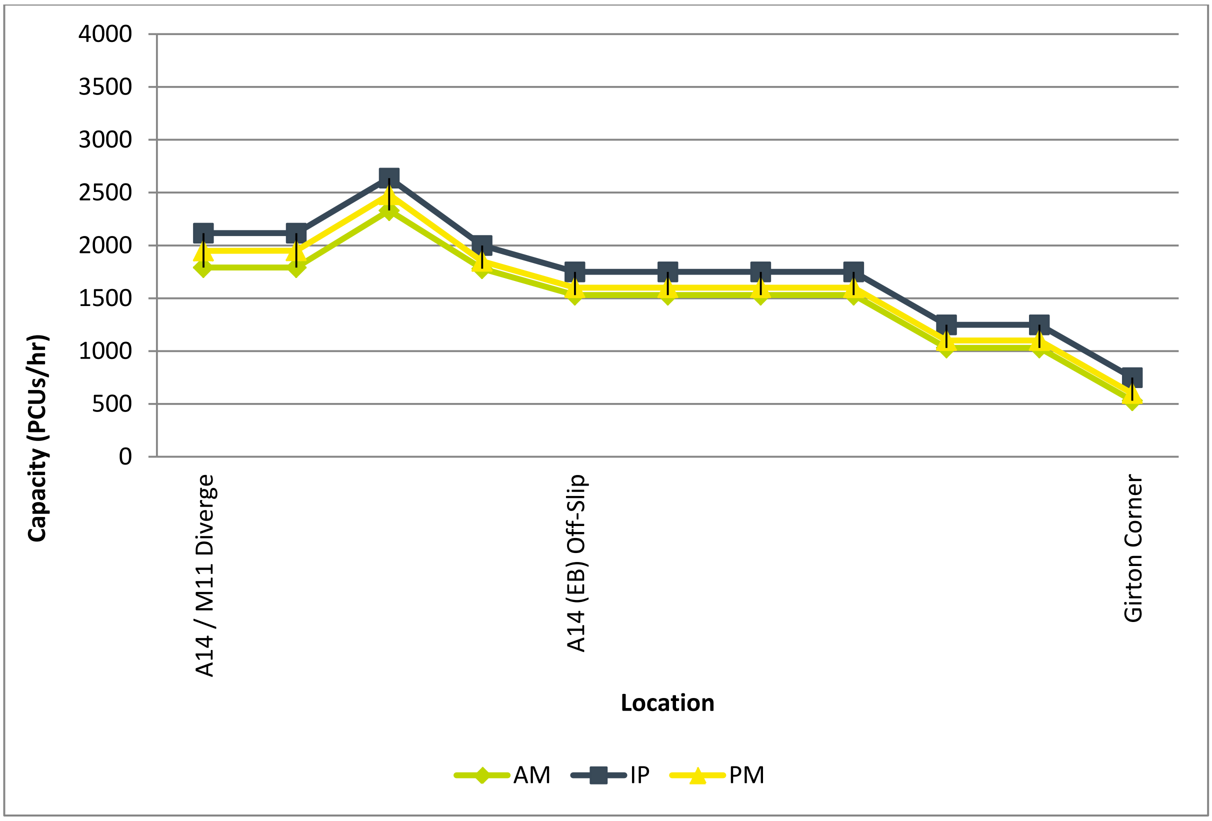


Figure F-11 A14 Cambridge Northern Bypass Eastbound Residual Capacity

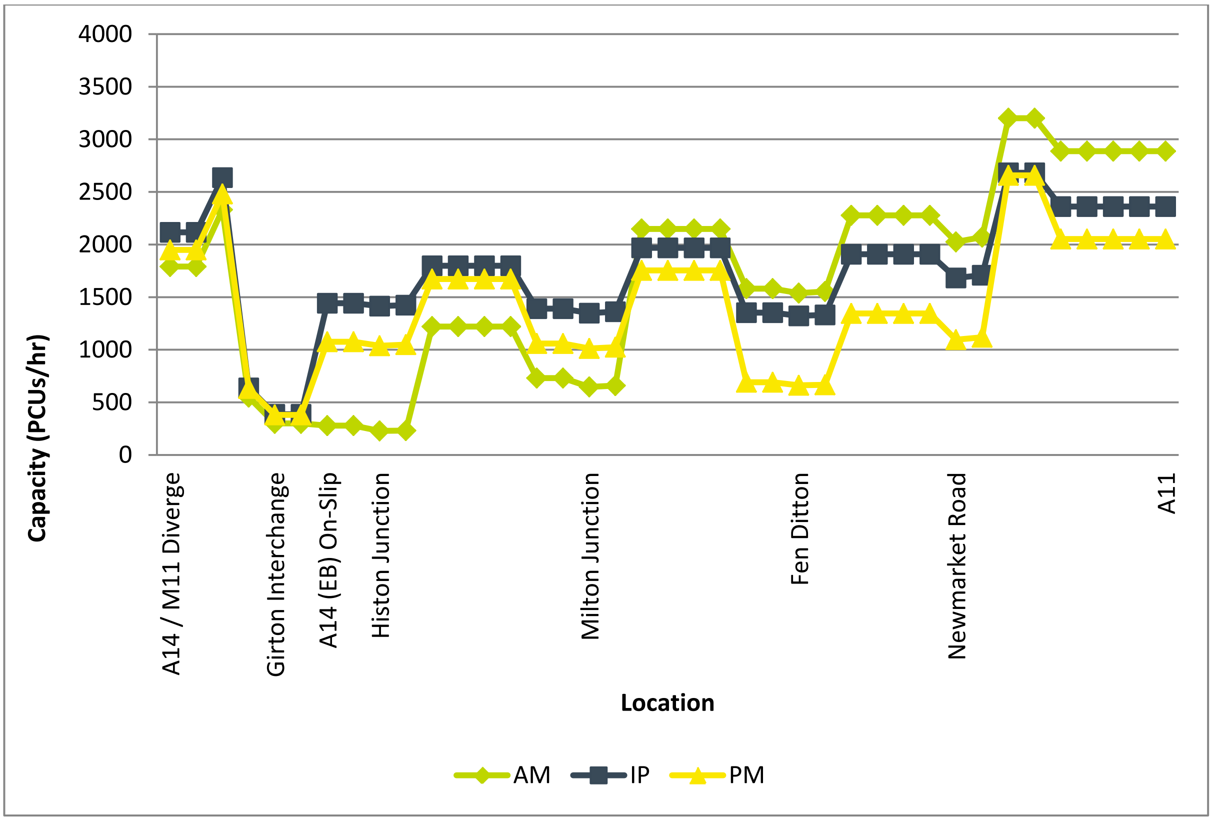


Figure F-12 A14 Cambridge Northern Bypass Westbound Residual Capacity

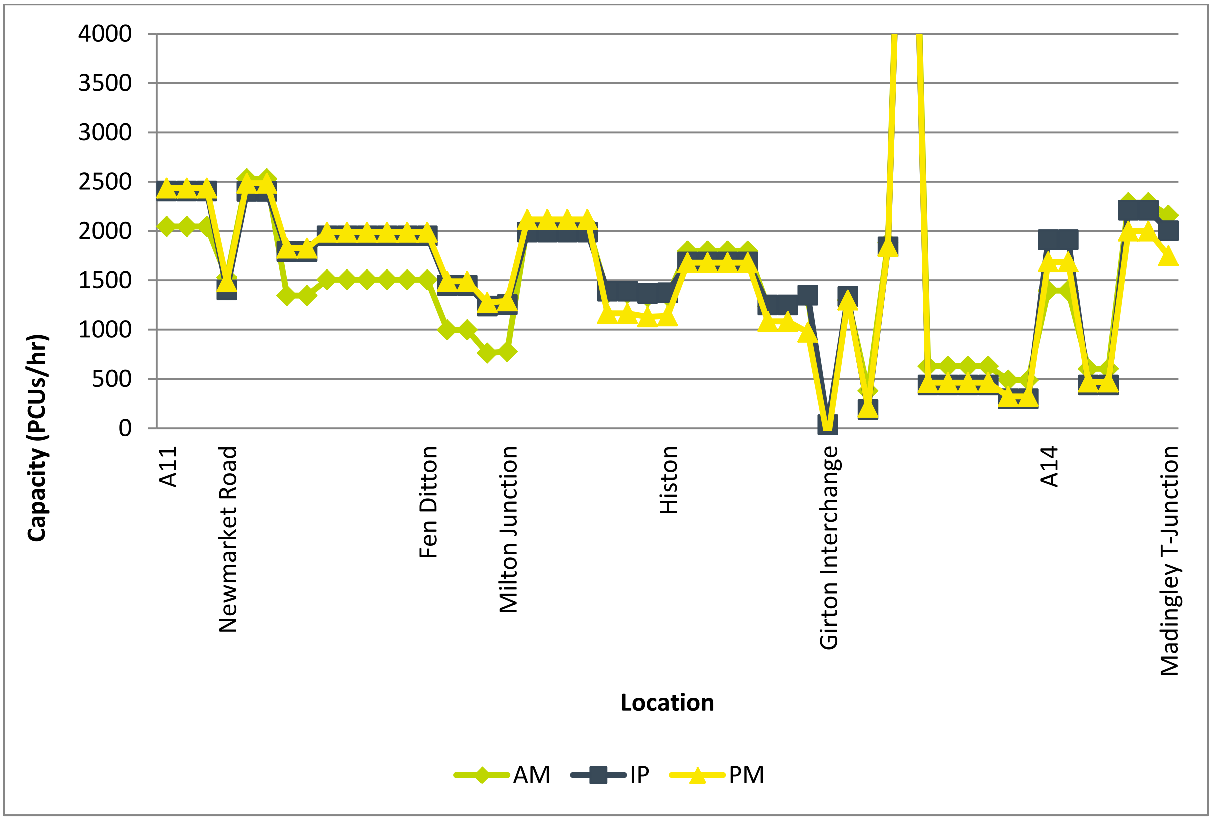


Figure F-13 M11 Southbound Residual Capacity

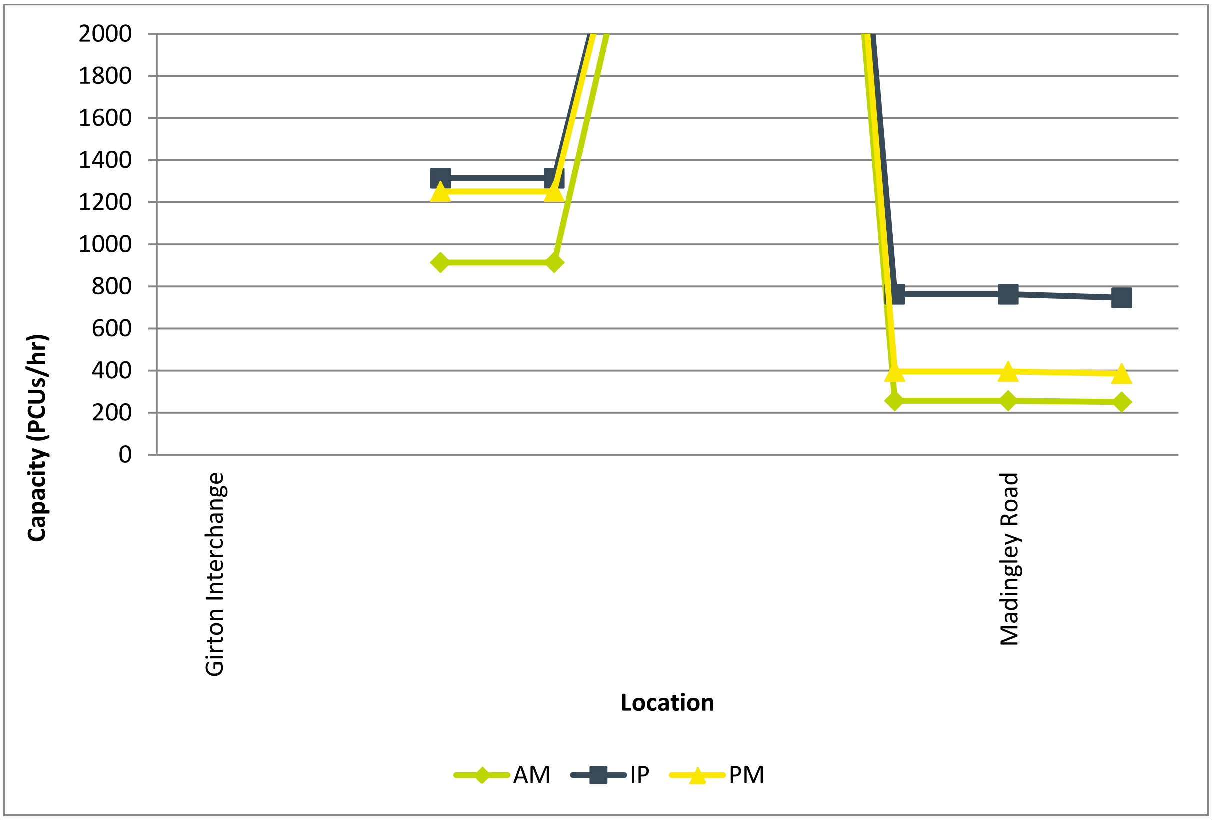
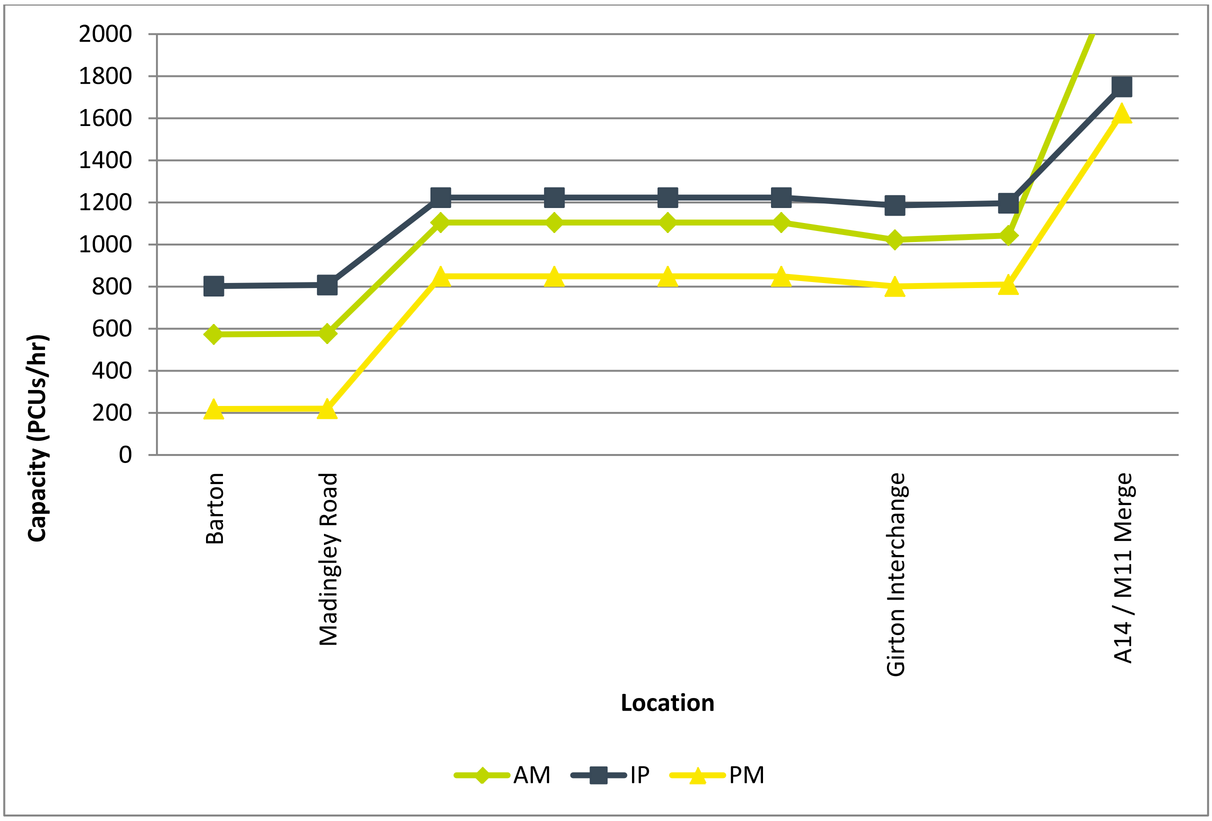


Figure F-14 M11 Northbound Residual Capacity



Appendix G. Roadworks Data Summary

Table G-1 Roadwork Data Summary

ID	Road	Location	Road Number	Notice	Start	Finish	Description	Atkins Comments
342082	FENSIDE ROAD	WARBOYS	C116	21-Dec-2011	29-Oct-2011	29-Oct-2011	Emergency Closure - Carriageway resurfacing works - CCC West Highways	Single day only.
342345	CAXTON ROAD	BOURN	C177	06-Dec-2011	07-Nov-2011	07-Nov-2011	Install 507m of 1 way poly duct in Carriageway	Single day only.
337637	HIGH STREET	COTTENHAM	C187	21-Dec-2011	31-Oct-2011	31-Oct-2011	Road Closure - Speed Limit- Essential carriageway resurfacing	Single day only.
331851	HARRISON WAY	ST IVES	A1096	04-Aug-2011	28-Oct-2011	02-Aug-2011	L.A. Code: 326663 - Plane and resurface carriageway over bridge deck using HRA& Chips - Site W10	Work likely done during the night so no impact to target time period.
326594	NEW ROAD (C208)	IMPINGTON	C208	19-Dec-2011	06-Nov-2011	06-Nov-2011	Event - Bonfire Burn 10K - Times 10:00hrs to 10:45hrs	Single day only.
355577	REDWONGS WAY	HUNTINGDON		06-Mar-2012	06-Mar-2012	06-Mar-2012	L.A. Code: 338756 - ******* arranged for the 6th March 2012************ 15m2 patching with road closer as agreed with street works and depot manager	Single day only.
352819	BRIDGE STREET	ST IVES		05-Mar-2012	02-Mar-2012	04-Mar-2012	ROAD CLOSURE - Anti Skid reinstatement -	Two days only.

ID	Road	Location	Road Number	Notice	Start	Finish	Description	Atkins Comments
348307	COOTES LANE	FEN DRAYTON	C185	03-Jul-2012	01-Mar-2012	22-Jun-2012	Capital Programmes: PROJECT:; Undergrounging scheme of HV and Lv ,Verge ,Carriageway	~4 months of works. Stop/go boards on a minor road in Fen Drayton on a potential rat run to avoid A14.
347093	THE FOOTPATH (C200)	COTON	C200	28-Mar-2012	12-Mar-2012	23-Mar-2012	Road Closure - To lay 20 mts of 125mm replacement water main and connect to the existing network - H2O Water	~1.5 weeks of works. Appears to be works on footpath, but road closure specified. Coton potential ratrun between M11 and A428.
347226	OAKINGTON ROAD	DRY DRAYTON	C193	21-Mar-2012	05-Mar-2012	21-Mar-2012	Road Closure - Carriageway resurfacing work on entry and exit slip roads at A14 - Carillion WSP Dates 05/03/12 to 07/03/12 21/03/12	~2 weeks of works. Resurfacing on A14 slips. Work likely done during the night so no impact on target time period.
345331	SAXON WAY	BAR HILL		10-Jul-2012	09-Mar-2012	06-Jun-2012	CIP WORKS Installation of 119 New Street Lights & Removal of 119 non DTC Street Lights,(incl' Signs). Including excavations in Footways/Verge for PL/DNO supply connections/Disconnections & Reinstating of excavations. Latern Upgrades required for 20 Street Lights.	~3 months of works. "GIVE & TAKE" so no road closure or stop/go boards. Assume this has no impact on highway network.

ID	Road	Location	Road Number	Notice	Start	Finish	Description	Atkins Comments
347092	THE FOOTPATH	COTON		28-Mar-2012	12-Mar-2012	23-Mar-2012	Road Closure - To lay 20 mts of 125mm replacement water main and connect to the existing network - H2O Water	~1.5 weeks of works. Appears to be works on footpath, but road closure specified. Coton potential ratrun between M11 and A428.
353826	REDWONGS WAY	HUNTINGDON		06-Mar-2012	06-Mar-2012	06-Mar-2012	Road Closure - Patching works	Single day only.
347087	CAXTON ROAD	BOURN	C177	16-Mar-2012	06-Mar-2012	16-Mar-2012	Road Closure - Laying duct in carriageway	~1.5 weeks of works. Road closure. Potential ratrun to avoid section of A428.
347257	DRY DRAYTON ROAD	OAKINGTON	C197	28-Mar-2012	08-Mar-2012	22-Mar-2012	Road Closure - Carriageway resurfacing work on entry and exit slip roads at A14 - Carillion WSP Times 08/03/12 to 11/03/12 22/03/12	~2 weeks of works. Resurfacing on A14 slips. Work likely done during the night so no impact on target time period.
346695	CAXTON ROAD	BOURN	C177	27-Mar-2012	08-Mar-2012	21-Mar-2012	Install 507m of 1 way poly duct in Carriageway	~2 weeks of works. Road closure. Potential ratrun to avoid section of A428.

Atkins
5 Wellbrook Court
Girton Road
Cambridge
CB3 0NA
United Kingdom

Telephone: 01223 276002
Fax: 01223 277529

Appendix G: future technology

This appendix includes notes of workshops on 26 March 2014 and 30 May 2014. The main focus of the first was on the road system of the Highways Agency, and of the second on that of the local authorities.

Workshop on 26 March 2014

Notes by Jonathan Shewell-Cooper and Chris Gibbard

Attendance:

Nick Illsley	DfT (Chair)
Liz Brandt	Ctrl-Shift
Andy Fisher	Cambridgeshire County Counci
Chris Gibbard ``	DfT
Noelle Godfrey	Cambridgeshire County Council
Prof Peter Landshoff	Cambridge University
Ian Leslie	Cambridge University
Phil Proctor	HA
Antony Rix	TTP
Jonathan Shewell-Cooper	Atos
Chris Smith	BT
Tim Whitley	BT

1. Motorways are well serviced, but not 'A' roads. How to improve without large capital investment?
2. Manage congestion tactically. Private sector provides information fairly well to those with in-vehicle equipment.
3. Mobile phones can detect many things with their sensors, potentially removing the need to instrument roads. The challenge is to get data into large-scale use.
4. What would roads look like if technology was deployed and works? HA answer is an optimised road network, max traffic flow through existing width of road. Key to this is smoothing the flow, faster response to incidents. 'A' roads have a lower business case for implementation of technology than motorways. Too expensive to make A14 like a smart motorway.
5. HA wish is to improve service to all road users, especially on roads without significant kit.
6. Issues to tackle – congestion at pinch points, incident management, better information to the driver (the happy driver) – anything else?
7. In-vehicle equipment should give information to driver <u>and</u> encourage adjustment to driving to make better use of road space.
8. Technology enablers are: digital identity assurance (pilots sponsored by govt), personal data store/ cloud (forming now in market place), personal information management services (new one each week). These services have the potential to

break data out of silos. Sharing data has value and gives opportunity to create services. Why pay TomTom Live?

9. Transition period with partial vehicle/ driver communications coverage. Fragmentation is a challenge. Cannot rely on people having latest smartphones. Coverage of mobile in vehicles is enough to get data but not to remove VMS or stop installing new VMS yet.
10. Put wireless infrastructure on to roads? How much bandwidth does one need? What is the smallest useful data package to transmit into vehicles? Also to get data back to road managers?
11. Does work on “Stride” provide a potential in-car sensor?
12. How do we manage personal data and identity assurance in the context of data from individuals / vehicles used as probes? Do we put analytics in the hands of the individual whose data it is or with the operator of the road or …. Look for a market in “insight as a service” (I can take your data and tell you something valuable in return). Could this be an upsell to a paid-for service? Hyper-personalisation of services turns people off.
13. Is ‘White space’ the right communications technology to use in road management? What about GSM being switched off? Will wireless coverage then be everywhere? What about digital radio? What is the M2M network of the future? Do we have a missing technology e.g. low cost, low data rate, low power radio that could be attached to every lamp post & telegraph pole? What can be done soon and cheaply that will make a big difference?
14. Monitoring by detecting Bluetooth radio passing waypoints. Bluetooth is used sufficiently to give flow information.
15. Not just comms to the vehicle but to the person (who may not be the driver or may not be in a vehicle).
16. Can floating vehicle data replace loops to control signals? Information largely exists, the problem is communication and business case.
17. Need policy framework / governance framework for sharing of data to prevent silos of data being created – perhaps a data market is needed? GSMA working on governance models which may be relevant – trust frameworks for data exchange. Perhaps develop an equivalent of the Creative Commons licence for my personal data. Trust networks e.g. Synergetics exchanging data based on trust (like an eBay user rating).
18. Privacy is not black-and-white. Balances benefits to the individual with risk to the individual.
19. What about autonomous vehicles? Car-to-car information standards now exist but will not be used unless forced by regulation.
20. Road-trains. Fragmentation is an issue, and who has the responsibility and carries the risk?
21. Need to take account of liability and risk issues.
22. Must also instrument parking spaces and inform people about public transport options with the same technology. 3G and 4G are not good enough.

23. Use availability of parking spaces to change driver behaviour. Beware of damage to high street.
24. Better use of data to allow car sharing to get from A to B. Provide probabilities of reliability of journey by different modes.
25. Technologies to avoid falling asleep. No business case to improve safety.
26. Task omniscience for the person, e.g. driver knows why queue exists and what action is appropriate.
27. BT sees telecoms sector as a purveyor of insight.
28. Network modelling moving from use only in planning to real-time – dynamic network modelling. Take data in real-time for management intervention and M2M communications. Problem that it takes time to get data and analyse. How to demonstrate that it would make a difference?
29. What is the best information model? Is Hypercat the right model to use for Internet of Things?
30. Cambridge has a good road model – done by Atkins (Saturn), but this is built for looking at impact of planning applications not for managing a road network in near real time
31. Is model that infrastructure will detect car and talk to the network which will communicate with vehicles or should cars be intelligent?
32. What % of vehicles do you need information from and communication with to influence driver behaviour? E.g. could BT van fleet be used as probes? And could one instrument all 8m BT telegraph poles?
33. Potential use case – not do dynamic modelling, but use data to review success or otherwise of yesterday's decisions.
34. How can technology be applied to the 'outside' of the infrastructure or vehicle rather than integral? Need an IT tech equivalent to the vinyl 'paintwork' now applied to trains and buses, because of the much shorter life-cycle.
35. Phone is best delivery mechanism today but cannot rely on its continued availability in present form. Wearables market is about to explode. Devices will continue to be ephemeral, though not the infrastructure.
36. Need pilots to demonstrate value at TRL 7 or 8.
37. Need to get paper together for June.
38. Next session: focus on LTA roads, cities and rural separately?

Workshop on 30 May 2014

Notes by Jonathan Shewell-Cooper

Attendance:

Sam Appleton (Atkins)
Steve Baker (TTP)
Liz Burr (Essex County Council)
Dan Clarke (Cambridgeshire County Council)
Andy Fisher (Cambridgeshire County Council)
Paul Garner (BT)
Noelle Godfrey (Cambridgeshire County Council)
Peter Grimm (Suffolk County Council)
James Harris (Elgin)
Nick Illsley (DfT)
Peter Landshoff (EETI)
Ian Leslie (Cambridge University)
James Lindsay (Atkins)
Phillip Proctor (Highways Agency)
Jonathan Shewell-Cooper (Atos)
Neil Taylor (ITP)
Alan Ward (BT)

Nick Illsley set a task of looking at a five year time frame, within the context of the National Infrastructure Plan. Key changes on the horizon are the 2015 election and the proposed five year funding arrangements for the Highways Agency.

What big factors might we need to take into account?

No seismic shift, but a continuation of current trends

Impact of privacy

Wider engagement with individuals for the sharing data, potential of new funding models

Data as a service – expect price to be driven down as more data is available.

Arrival of eCall: will be pressure to move this from a cost on OEMs to a value added service

Reduction in revenue budgets for local authorities.

Lots of existing data are available

For example Thales is performing analysis on origin-destination data from TomTom

DfT has an existing contract with TrafficMaster available for use by Local authorities

Herts Integrated Transport Control Centre already uses Google maps to see congestion

Do we need a more formal market place / directory for UK transport and mobility data as has been implemented in Germany1

Need to understand data coverage – lots of interest in London data e.g. CityMapper

UTMC generates too much data to analyse and process

- TomTom already consumes Vodafone data
- Connected car will potentially generate lots more data.
- Elgin compiling of national data set of road works is nearly complete – but this has taken nearly 10 years.
- Lots of missing digitised data sets e.g. LA preferred freight routes, LA traffic orders, diversionary routes

Need to understand the role of LA Traffic Managers

- Will their responsibilities change when connected car is rolled out?
- Key: they need to understand how traffic is flowing
- This is required to be able to influence traffic flow
- This involves both long term and short term measures
- Inform broadcasters
- Adjust signal timing
- Adjust traffic flow
- Advertise diversionary routes
- Liaise with emergency services
- Each local authority will have their own set of routes that are important to manage along with their urban centres
- Recognise that on-going cost of many existing traffic detection systems is too high
- Too many local authorities for traffic data users / creators to deal with, just becomes too difficult
- Need to promote national data standards and expectations that they will be fully used
- Need to make it simple to find out what data is available on what terms
- Need new models of cross boundary co-operation to simply the selling and buying processes
- Work should be done to uncover and overcome the obstacles to sharing best practice governance, intellectual property protection etc.
- Business models should be created to help different organisations work together.
- Is there a role for DfT in facilitating co-operation and co-ordination?
- Is there a role for DfT in sponsoring shared systems and open standards?

Current diversion must allow all vehicle types – Ford fiesta vs HGV vs learner driver

- Use of data would give us the opportunity to separate them, so that most vehicles could take shorter routes
- Need to publish the impacts of diversions on road expected congestion and on adjacent roads
- Not possible to “force” information providers to publish official diversion routes

Too many data comms implementation in urban areas are scheme specific

Need to look at ways of raising coverage in general

Need to allow different schemes to share data comms – e.g. street lighting, bins and quality monitoring

Sensor points should be set up where a variety of devices can be plugged in