Big Data in Capturing Travel Time

A quick snapshot of the applications in Auckland Transport

Author/Presenter: Bill Qu, B.E.(hons), M.E.(hons)
Principal Traffic Engineer, Auckland Transport
Email: bill.qu@aucklandtransport.govt.nz

Co-Author: Miguel Menezes, B.Sc. (Civil Engineering)
Team Leader Operational Planning and Performance, Auckland Transport
Email: Miguel.Menezes@aucklandtransport.govt.nz

ABSTRACT

Time is money! The ability to quantify journey time reliability in terms of travel time is becoming increasingly possible in the modern age. For transportation practitioners, this too is becoming valuable information that enables better optimisation of the transport network to be made. What not so long ago started as floating vehicle surveys, has quickly become BIG DATA.

So how do we capture the data? How we can use this data? What can we learn from this? And how helpful is it really?

What new thinking is being applied to journey information gathering - how we are making the most of the technological advances in this field to inform planners, engineers, decision makers and ultimately our customers.

This practical paper will provide examples from the Auckland context and the variety of uses from network performance monitoring, network operations planning, and temporary traffic management (including major new projects). How we are telling the true story in amidst the squeaky wheels!

1.0 Introduction

Understanding the traffic performance on our network has always been an integral part of responsivities for transport practitioners. The information can be used in various areas, including:

- Strategy and Transport planning
- Operating Performance Reporting
- Operational Deficiency Analysis
- BCR assessment for project post-implementation
- Providing customers with better and more accurate information

Technology is rapidly growing, so are our ways of capturing the travel time information. What was considered "the only reliable way" a few years back may deemed redundant nowadays.

This paper aims to provide a snapshot of popular technologies and methodologies available currently to capture the travel time information. It then described a few case studies and applications in Auckland Transport, in terms of how we are making use of the data.

The BIG DATA concept we referred in this paper is not the traditional IT terminology. In this report, the "BIG DATA" is to truly reflect the huge amount of data available to us as transport practitioners. It probably is the golden age for traffic data mining, and it may keep growing for the next many years.

2.0 Capturing the Information

Traditionally, back five to seven years ago**, floating vehicle surveys** were still the predominant method of capturing travel time information. This method involves having dedicated drivers travelling along selected routes and corridors on the network, back and forth, to mimic a snapshot of the typical travel times. It is considered highly accurate for the time period and routes covered, in fact until now, many times the transportation practitioners have been using the result of floating vehicle surveys to calibrate other different technologies.

However, to have a wider and better understanding of travel performance from a network perspective, a few inevitable drawbacks were present:

- Data sample size is small on selected routes only, especially if the routes were too long, or not too many drivers were deployed for the survey – typically between five and ten drivers were used.
- The survey is limited to a daily (or a very few days) snapshot. It may not be the typical performance of the corridors, and would not be able to track monthly and seasonal variation.
- Inflexibility during accident or unexpected event. Once survey is committed, there is no way going back. If the weather conditions changes, or accident happens on the

network, the survey results would not be reflecting a typical day, and hence normally considered “not accurate”.

- Not value for money, or even very costly. The amount of manual work involved, from planning and organising the survey, checking the condition on the survey day (weather and accident etc.), processing the data, all rely heavily on people, hence normally manual surveys have high labour cost.

Nowadays, with the rapid advancement of technology, different applications and methods were developed to better capture the travel time information. In general, technology can be divided into two ways: **Matching or Tracking**:

- Matching typically involves at predefined locations (normally major intersections), certain unique identifications, either from the vehicles or devices in the vehicle, were captured and matched, technologies includes:
  - ANPR (Automatic Number Place Recognition): matching the number place of vehicles. Typically the kerbside lane is used for easy setup the camera.
  - Bluetooth or Wi-Fi: matching the MAC (media access control) address from any communication device in the car.
  - Normally the Matching technology requires permanent or temporary infrastructure installation.
  - It is considered that higher data sample size is observed using the Matching technology
  - The disadvantage is the transportation practitioners could not be able to tell what happened between the two matching points, including start/stops, or the actual routes taken to arrive between the two marching points (rat running) – however this may be less significant if the data sample size is large enough.

- Tracking technology means constantly tracking the vehicle or devices in the vehicles. The frequency of tracking various depends on the technology, and the individual device settings:
  - GPS tracking: everything can be tracked these days – people, pets, your mobile phone. And vehicle is no exception. Originally used for fleet management, this technology has been deployed widely and commonly to assist capturing travel time information. If appropriate GPS tracking devices are installed in the vehicles, the devices will report back constantly (in seconds) the vehicle’s location and driving data back to the satellite, sometimes in real time.
  - Mobile phone data tracking – remember the times when your app. on your smartphone ask you to share your location data? Well, that information may have contributed to generate the congestion information. Very similar to GPS tracking, the mobile phones are constantly sharing the location data back to the satellite.
  - Tracking technology could hopefully give transportation practitioners more confident about data accuracy as they can apply filtering algorithm to take out “outliers”.
  - However, two potential problems of using tracking technology:
    - In general, relatively low data sample size comparing to matching technology, especially after “filtering”

- "Canyon effect" with high rise surroundings. The signal sent to the satellites may be bounced around, reflecting low accurate location information. This also applies in tunnels.

There are other technologies exist in the market, including algorithms to use loops and/or radars. These are well tested and utilised along the motorway network, however the true application on the arterial network is still unclear, hence this paper will not discuss these in detail.

The table below summarised the above paragraphs:

Type	Technology	Notes
Traditional	• Floating Vehicle Surveys	• Deemed highly accurately • Small data sample size • "Typicality" highly relies on weather, network condition during the survey period • Can't track monthly/seasonal variation • High operational cost • More used as a validation method
Matching	• ANPR (number plate) • Bluetooth or Wi-Fi (MAC address)	• Typically, larger data sample size than Tracking • Normally requires permanent or temporary infrastructure installation. Upfront cost for setup and on-going maintenance. • Not be able to tell what happened in between matching points – however less significant if data sample size is large enough
Tracking	• GPS • Mobile phone data	• Could apply filtering algorithm to easily take out outliers, data accuracy higher • Normally purchase services from third party. • May struggle with data sample size • Canyon effect in high rise surroundings, also tunnels
Others	Loops//radar + calculation algorithms	• Not discussed in this paper

3.0 Making use of the information – Case Studies

First and foremost, it is important to note that except floating vehicle survey, we are obligated to receive and process the aggregated data only – all the technology and algorithms applied need to make sure they satisfy the Privacy Act 1993.

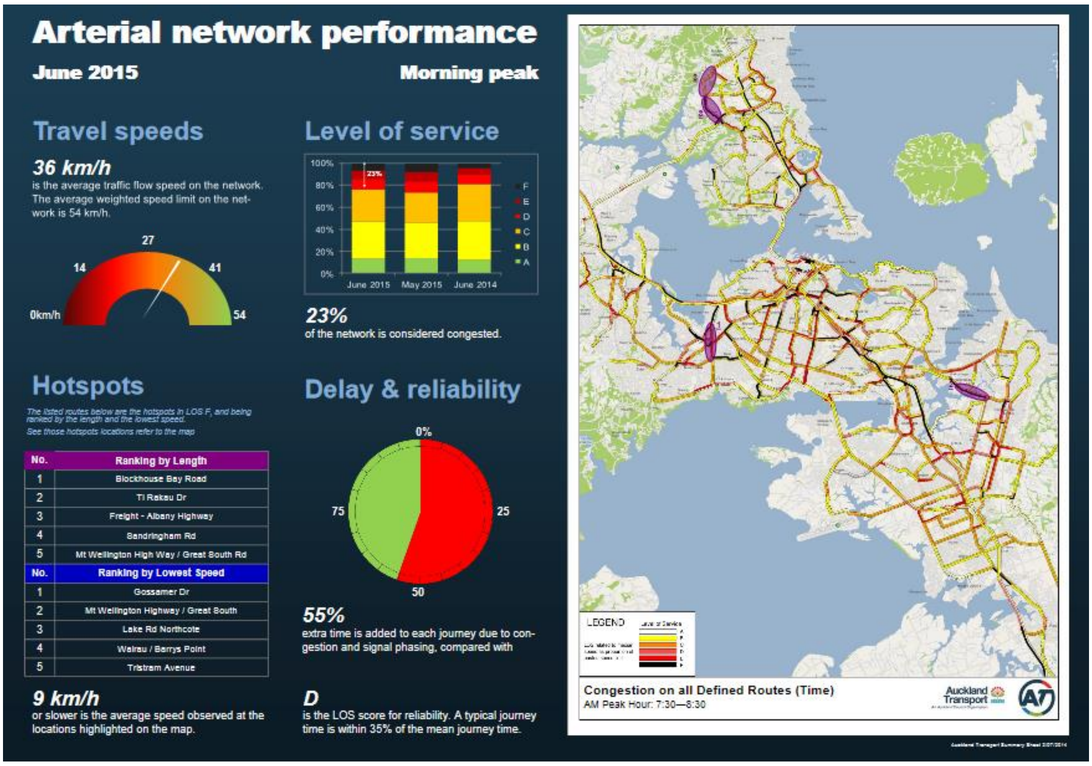
After information gathering, filtering, processing and analysing, it can then be used in many areas, including network performance monitoring, network operations planning, and temporary traffic management (including major road works) monitoring. In this chapter, we will be presenting a few case studies of how Auckland Transport has been making use of the data from multiple sources, for various projects.

3.1 Network Performance Monitoring

Auckland Transport has been leading on reporting network performance using technology – we started six years ago using GPS tracking. By working closely with a local fleet management company, together we have developed a robust algorithm, processed information validated using floating vehicle surveys, to provide regular network performance snapshot, as well as ad-hoc requests for detailed studies and projects.

We have managed to cover all of the primary arterial networks, as well as most of the secondary arterials including collectors. The network coverage could also be expanded if required on an ad-hoc basis.

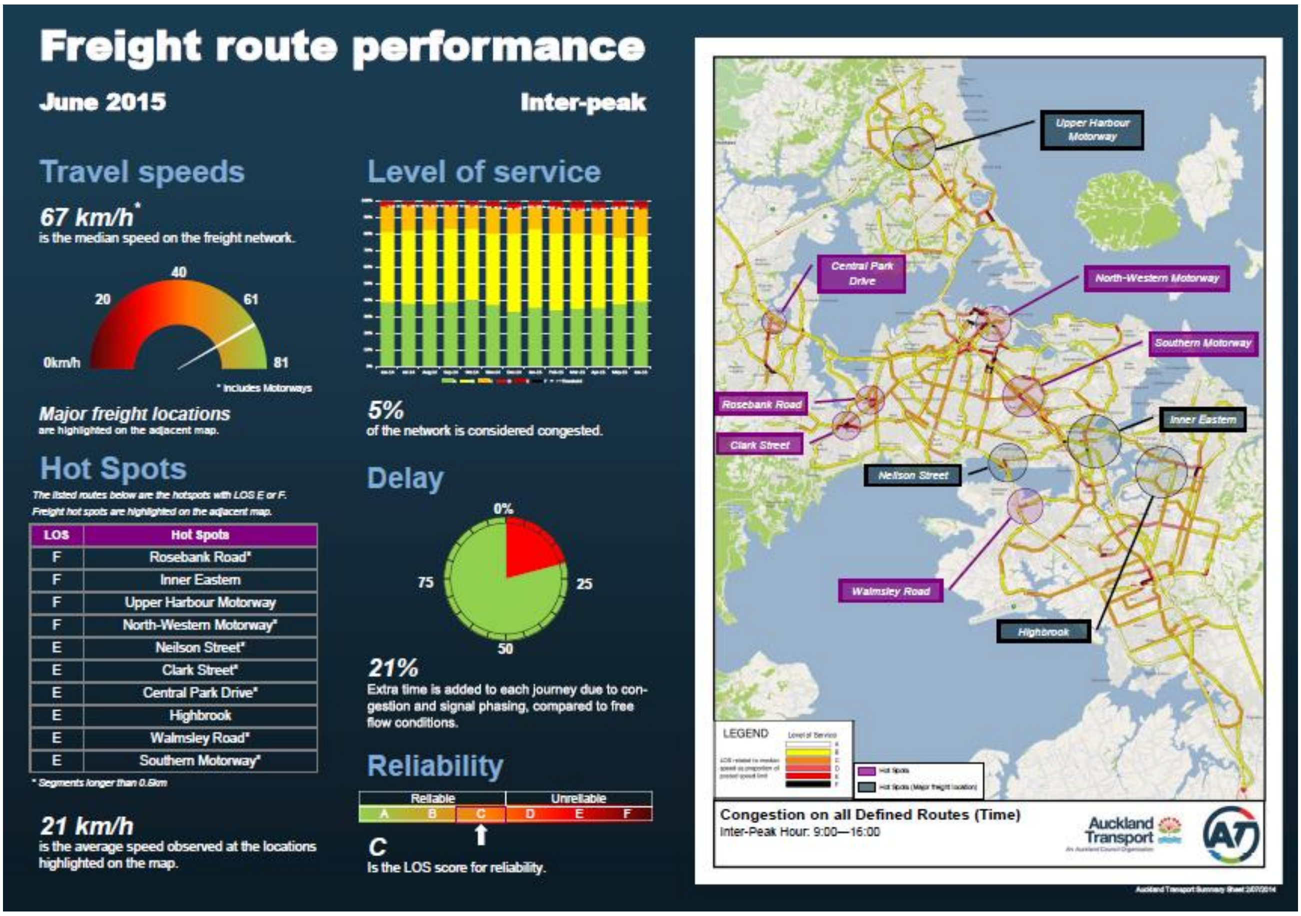
By processing the travel time information, we have produced the congestion maps, as well Auckland Transport defined KPIs relating to the network performance monitoring:



Through processing the aggregated data, Auckland Transport has developed a robust and sophisticated system, to report on the pre-defined Key Performance Indicators (KPIs), including:

- Average network speed
- Hotspot (similar to the "blackspot" concept in road safety)
- Level of Service (LOS) table, horizontal comparisons across different months
- Traffic Delays
- Journey Reliability

Similarly, we have produced similar network performance scorecard for freight, buses and pedestrians:

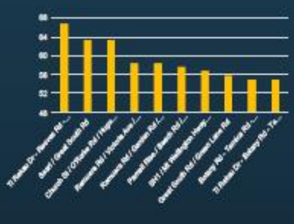


Pedestrian crossing performance

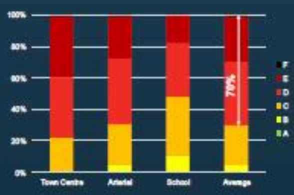
June 2015 **Inter-peak**

Worst Intersection

Ti Rakau / Reeves Rd
is the worst intersection for Pedestrians on the network.



Level of service



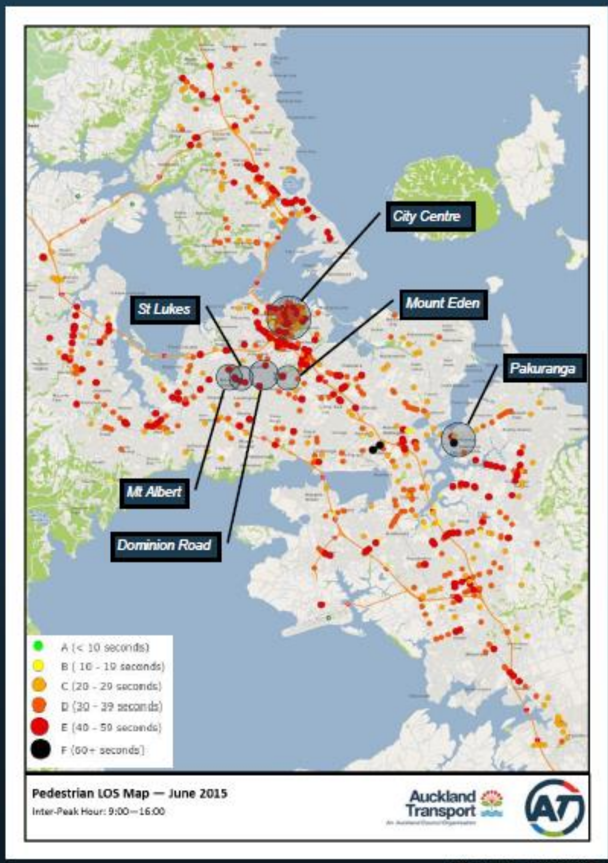
70%
of the network is operating below desired LOS for pedestrians.

Town Centre Performance

67 seconds
is the average pedestrian delay on Pakuranga town centre, the worst performing town centre in Auckland.

Pedestrian Delay

35.4 seconds
of average delay is added to each pedestrian journey due to congestion and signal phasing at the intersection, compared with free flow conditions.



Morning Peak Bus Performance

March 2015

Morning peak

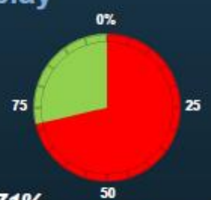
Travel speeds

28 km/h
is the average bus travel speed on the arterial network. The weighted average speed limit on the network is 52 km/h

Level of Service

53%
of the network is considered congested.

Delay



71%
extra time is added to each journey due to congestion and boarding time, compared with free flow conditions.

Hotspots

The listed segments below are the hotspots in LOS F, with the lowest travel speed.
See those hotspot locations refer to the map

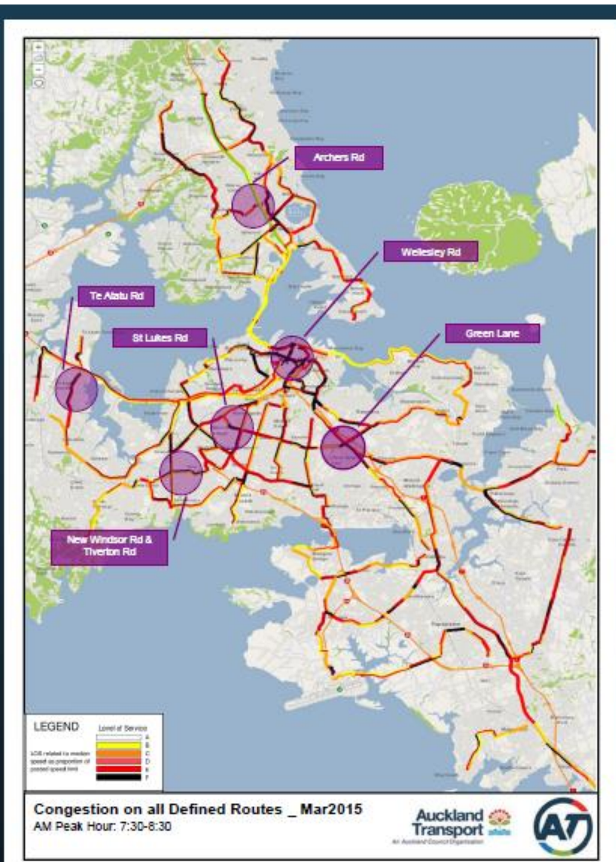
No.	Hot Spots
1	Te Atatu Rd (Edmonton - Jaemont)
2	New Windsor Rd (Tiverton - Maioro)
3	Tiverton Rd (Whitney—New Windsor)
4	Wellesley Rd (Hobson-Albert)
5	Green Lane (Wheturangi—Great South)
6	Te Atatu Rd (Mcleod-Edmonton) ♦
7	Te Atatu Rd (Jaemont-SH16)
8	St Lukes Rd (Morning Star-Kingsway)
9	Archers Rd (Poland-Wairau)
10	Wellesley Rd (Queen-Princes)

♦ segment length longer than 500m

5 km/h
or slower is the average speed observed at the locations highlighted on the map.

Reliability

40%
is the difference in travel time between a typically bad journey and the average.



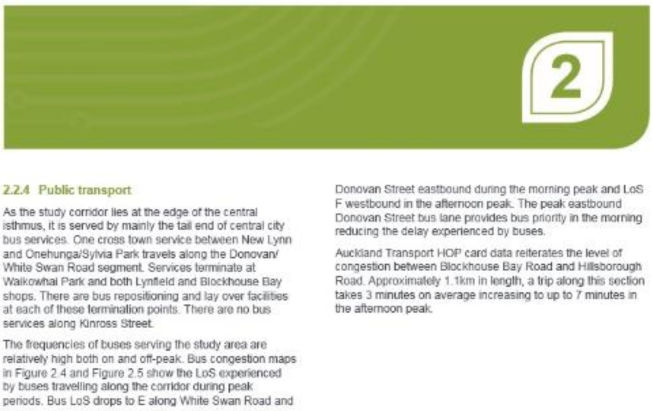
3.2 Network Operations Planning

With all the performance KPIs defined and captured regularly for various modes, we have been able to greatly contribute towards various projects, including:

- Strategy and Planning Corridor Management Plan (e.g. Hillsborough Road CMP)
- Routine Traffic Signal Optimisation (e.g. New North Road Optimisation)
- Multi-modal Deficiency Assessment for buses and vehicles (e.g. Parnell Road Bus Lane Study)
- Better understanding and hence responding to the customers for congestion related enquiries
- Performance tracking and reporting post project implementation (e.g. Fanshawe Street Bus Lane)
- Data feed to Network Operating Plans and SmartRoads software for GAP assessment

3.2.1 Corridor Management Plans

The multi-modal network performance monitoring information was a key part of the corridor management plan projects. It identifies the key multi modal deficiencies from an operational level. Below is a snapshot from the Hillsborough Corridor Management Plan.



2

2.2.4 Public transport

As the study corridor lies at the edge of the central isthmus, it is served by mainly the tail end of central city bus services. One cross town service between New Lynn and Onehunga/Sylvia Park travels along the Donovan/ White Swan Road segment. Services terminate at Waikowhai Park and both Lynfield and Blockhouse Bay shops. There are bus repositioning and lay over facilities at each of these termination points. There are no bus services along Kinross Street.

The frequencies of buses serving the study area are relatively high both on and off-peak. Bus congestion maps in Figure 2.4 and Figure 2.5 show the LoS experienced by buses travelling along the corridor during peak periods. Bus LoS drops to E along White Swan Road and Donovan Street eastbound during the morning peak and LoS F westbound in the afternoon peak. The peak eastbound Donovan Street bus lane provides bus priority in the morning reducing the delay experienced by buses.

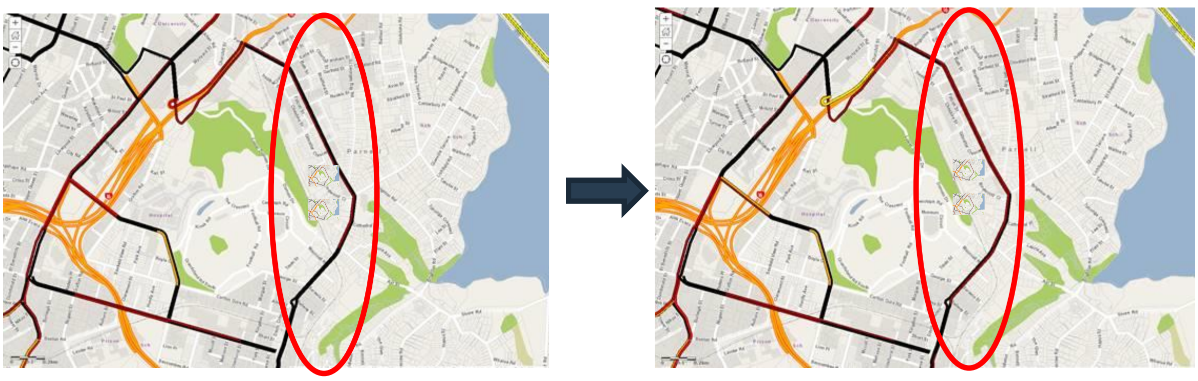
Auckland Transport HOP card data reiterates the level of congestion between Blockhouse Bay Road and Hillsborough Road. Approximately 1.1km in length, a trip along this section takes 3 minutes on average increasing to up to 7 minutes in the afternoon peak.

3.2.2 Traffic Signal Routine Optimisation

We have started to introduce and include the multi-modal congestion information into the traffic signal routine optimisation. To assist the ATOC signal engineers where the potential hotspots are on the routes being optimised. Below is a screenshot of example for New North Road traffic signal routine optimisation.

3.2.3 Multi-modal Deficiency Assessment for buses and vehicles

Through our business as usual network performance reporting, we are able to identify projects through deficiency assessment. Parnell Road bus lane is an example. The monthly bus congestion monitoring indicates severe congestion along Parnell Road southbound in the afternoon peak. Through our investigation, we have introduced a quick win projects to convert the kerbside parking into an afternoon peak bus lane. The improvement is easily visible (the darker the colour, the worse the LOS, hence the more severe congestion is).

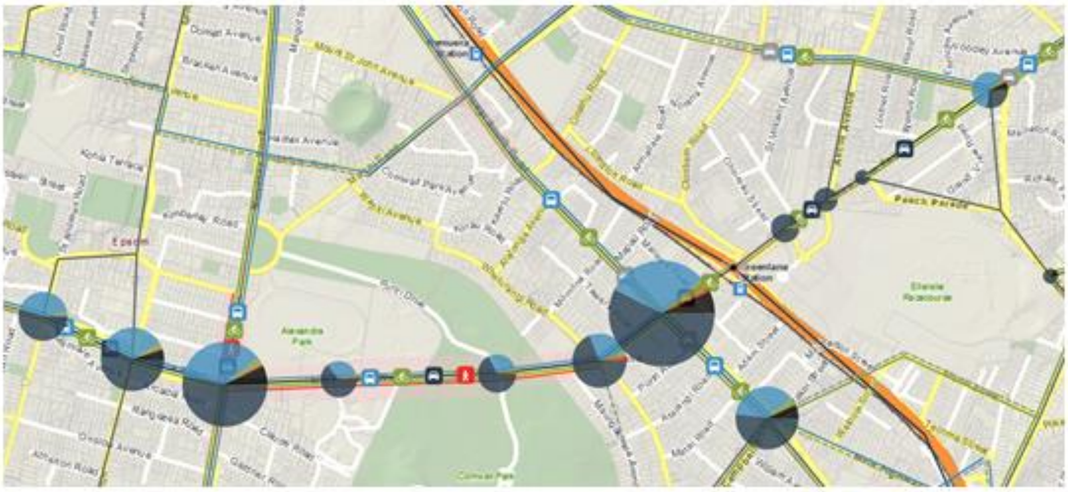


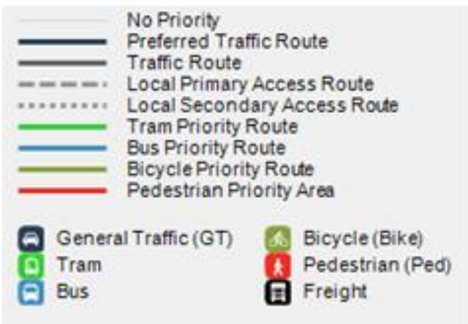
Data feed to Network Operations Planning (NOP) tool (SmartRoads)

The multi-modal network performance information can be directly fed into the Network Operations Planning tool (SmartRoads software) as well. It has been well used for various projects planning including traffic signal routine optimisation. Below is an example of NOP produced for Greenlane corridor traffic signal optimisation, based on the operational multi-modal performance we have been reporting.

AM Peak

PM Peak



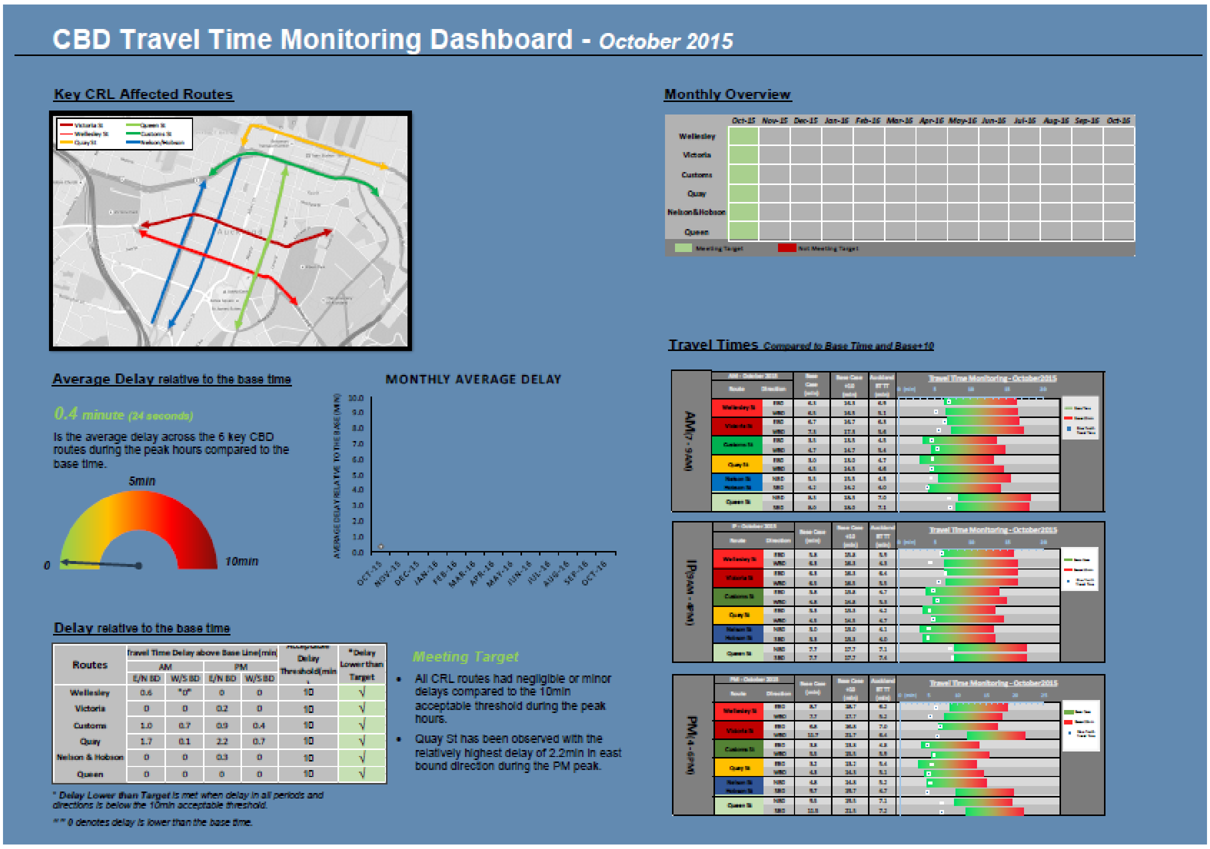


Temporary Performance Tracking on Major Projects - CRL

Travel time tracking has also been applied to major projects, the City Rail Link is one of the examples. Apart from the high level Notice Of Requirement conditions set up for the resource consent application, Auckland Transport has been working with AraFlow, to setup Bluetooth travel time tracking on the key corridors in the CBD. Alarm systems were also setup when the travel time experienced went over certain pre-defined benchmarks.

This has given Auckland Transport the opportunity to access near real time travel time information, action quickly if needed to deal with the (unexpected) traffic conditions.

Since October 2015, Auckland Transport has been reporting on the network performance snapshot, normally on a monthly basis, but also on ad-hoc checks when necessary.



Routes	Travel Time Delay above Base Line(min)				Acceptable Delay Threshold(min)	*Delay Lower than Target
	AM		PM			
	E/N BD	W/S BD	E/N BD	W/S BD		
Wellesley	0.6	"0"	0	0	10	√
Victoria	0	0	0.2	0	10	√
Customs	1.0	0.7	0.9	0.4	10	√
Quay	1.7	0.1	2.2	0.7	10	√
Nelson & Hobson	0	0	0.3	0	10	√
Queen	0	0	0	0	10	√

* Delay Lower than Target is met when delay in all periods and directions is below the 10min acceptable threshold.

"" 0 denotes delay is lower than the base time.

Conclusion

With the fast explosion of technology, there are definitely more, and potentially better ways of capturing travel time information than the traditional floating vehicle surveys. With this rapid development, we need to be aware of the pros. and cons. of various technologies, and choose the most appropriate one according to our requirement.

Auckland Transport has been testing and adopting new technology since five to six years ago. We have procured, validated various technologies, and applied them for different uses.

There is a growing demands for accurate data, it is important that all transportation practitioners share their relevant experience. There is no right or wrong technologies, it all depends on how we use it.

Technology wise, we could never really be able to predict what would happen in the next few years. Face recognition may become popular, or we will all be planted with chips to our bodies. Who knows.

The best we can do is to understand the new technology, adapt to it, make good use of it, and make sense out it.