Bus-Pedestrian Interaction in Courtney Place: on a Budget

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Abstract

Wellington City Council is expanding the city's network of bus lanes. Opus assessed opportunities for the introduction of bus lanes along Courtenay Place, Wellington’s unofficial party zone. Recent changes to provision for buses in Wellington have drawn substantial media coverage, much of which focused on the affect on pedestrians. Council therefore identified two main areas of focus for the study:

1. how will the introduction of bus lanes affect the level of service for pedestrians?

2. how can Council ensure the project is seen to deliver the forecast benefits?

The study team used a VISSIM micro-simulation model to model the interaction of buses, bus passengers, pedestrians and other motorised traffic. As well as information about traffic flow, this requires a huge amount of data relating to pedestrian behaviour and bus passenger travel patterns. The surveys originally planned exceeded the City Council’s budget. In order to progress, the study team applied innovations in pedestrian data collection methods and analysis. We also synthesized data from other sources to compliment that collected in the surveys thereby delivering more for less. These innovations have allowed us to progress the

assessment with limited effect on its quality. This paper presents the successes but also highlights the lessons the study team have learned.

INTRODUCTION

This paper summarises the challenges associated with collecting and analysing the data needed to simulate interaction between pedestrians, buses and general traffic in a busy urban environment. The paper documents a case study in which VISSIM micro-simulation modelling software was used to assess bus priority proposals in central Wellington.

On 22 September 2011, the Wellington City Council Strategy and Policy Committee approved the implementation of a package of bus priority measures along Courtenay Place between Taranaki Street and the Basin Reserve. The measures included:

- lengthening the existing westbound bus lane on Courtenay Place to extend between Cambridge Terrace and Taranaki Street;
- providing a new eastbound bus lane on Courtenay Place between Taranaki Street and Cambridge Terrace and removing peak hour parking;
- implementing traffic signal control at two zebra crossing locations on Courtenay Place; and
- bus pre-emption signals at selected locations.

Implementing bus lanes will change the road cross section from one to two lanes in each direction. In places this will be achieved by removing parking. Implementing the bus lanes without changes to the zebra crossing facilities could create a hazard. Buses stopped in the kerbside lane at a zebra could prevent motorists in the inside lane from seeing pedestrians stepping onto the crossing. The introduction of traffic signal controlled crossings was intended to accommodate the proposed bus lanes without introducing this unsafe situation; but what effect would this have on bus and traffic flows? How much additional delay would pedestrians experience?

Background

The measures were the latest element of the Wellington "Passenger Transport Spine" to be implemented. The Passenger Transport Spine extends through the city between Johnsonville and Wellington's southern and eastern suburbs. It is a concept that is integral to the City Council's plan for urban growth[1] in Wellington. Plans for strengthening the Passenger Transport Spine were investigated as part of a Strategy Study[2] and subsequently incorporated in the Ngauranga to Airport Corridor Plan[3].

In central Wellington the Passenger Transport Spine follows what is known as "The Golden Mile". Streets on the Golden Mile pass through Wellington's principal employment and retail area (see Figure 1). About 45 bus routes serve the Golden Mile at peak hours. This translates to just over 120 buses per hour in the peak direction in the morning and afternoon peak hours. The Golden Mile Capacity Assessment[4] estimated that the service capacity of

[1] Urban Development Strategy - Directing growth and delivering quality, Wellington City Council, July 2006
[2] Ngauranga to Airport Strategy Study, Opus International Consultants, May 2008
[3] Transit NZ, Greater Wellington Regional Council and Wellington City Council, October 2008
[4] Opus International Consultants, August 2006

the Golden Mile was currently between 75 and 130 buses per hour. The current bus service frequencies are therefore close to the upper end of the capacity range.

Courtenay Place, at the south-eastern end of the Golden Mile, is a popular route for travel between the suburb of Mount Victoria and the central business district (CBD). It is also Wellington's party zone and has a concentration of bars, restaurants, and cinemas. Throughout the day there is a lot of pedestrian activity across and along Wellington's Golden Mile.

Courtenay Place forms the last part of many commuters walk to work. In the morning peak hour, pedestrians walk along Courtenay Place from Cambridge Terrace towards Taranaki Street. There is notable demand at the four signal controlled crossing facilities and two zebra crossings on Courtenay Place.

Although current traffic flows on Courtenay Place are low and generally less than 400 vehicles per hour in each direction at any time of the day, the availability of peak hour on-street parking makes the interaction between buses and traffic more complex. For many motorists, Courtenay Place is a destination. They may drive more slowly looking for a place to park and interrupt traffic flows as they park their vehicles.

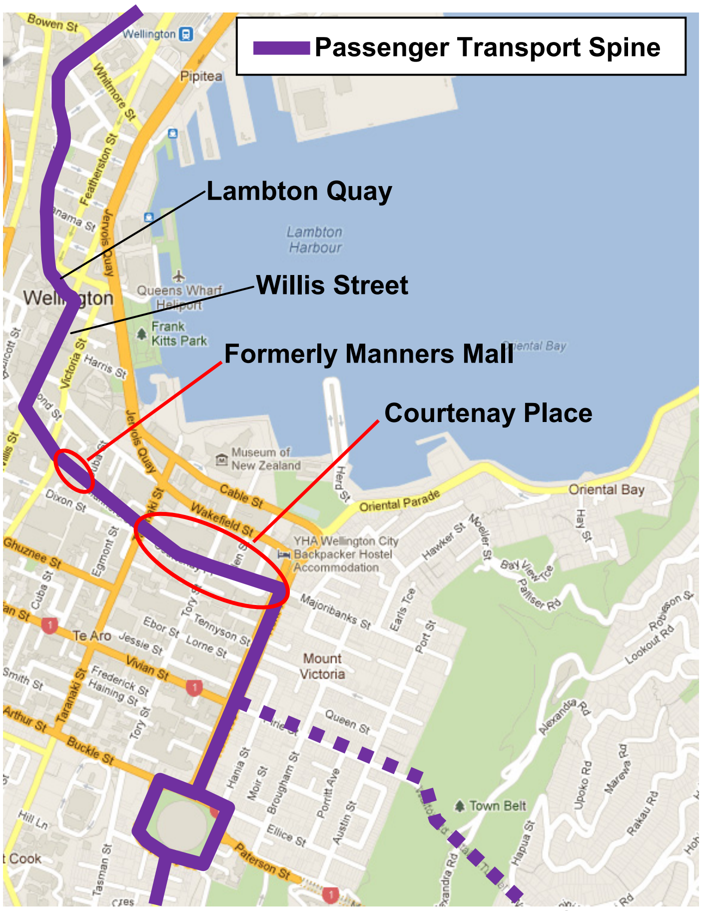

Figure 1: Wellington Passenger Transport Spine

In November 2011, the city council re-opened Manners Mall for buses only. The new route, which since 1978 had been a pedestrian only shopping precinct, reduced the travel distance and improved bus route legibility by providing for in and outbound journeys on the same roads. The transportation assessment for this scheme relied on analysis of outputs from the Wellington Traffic Model, built using SATURN modelling software. Whilst this approach is sufficiently robust to compare alternative options and to highlight the affect on the wider traffic network, SATURN software is not well suited for simulating the effect of traffic signal co-ordination, bus pre-emption at traffic signals and the interaction between pedestrians and traffic.

The Manners Mall busway scheme attracted high levels of media attention. Protesters that valued the amenity of Manners Mall and felt that bus traffic would detract from this, lodged an unsuccessful appeal to the environment court. In anticipation of similar levels of opposition to the Courtenay Place bus priority proposals, council officers wanted more detailed information to be available. Given the complexity of the interaction between buses, pedestrians and other traffic, council officers decided that it would be appropriate to use a micro-simulation model to assist in the assessment and design of bus priority for Courtenay Place.

Micro-simulation software models the movements of individual vehicles. They enable realistic representations of driver behaviour such as lane changing and overtaking. In this regard they are distinct from the deterministic models (such as SATURN) which use an aggregate representation of traffic where all vehicles exhibit uniform behaviour. When compared to deterministic models the finer resolution and stochastic approach of micro-simulation software allows better representation of driver and therefore network behaviour.

The main questions the technical assessment sought to answer were:

a. to what extent could bus travel time savings be achieved through bus priority?

b. what were the implications of introducing signal control at existing zebra crossings for pedestrians, motorists, and bus passengers?

c. how would this scheme work on the ground?

OVERALL APPROACH

Once it had been decided to build a micro-simulation model, VISSIM was identified as the most appropriate software package. VISSIM is one of the leading microscopic simulation programmes for multi-modal traffic modelling. One of the key advantages of VISSIM over other micro-simulation software is its ability to simulate pedestrian interaction with general traffic. VISSIM is also able to simulate interaction between public transport passengers and public transport vehicles. The study team would use this capability to model buses moving through the network, passengers boarding and alighting and pedestrians crossing. To do this well, observed data was needed including:

- number of passengers boarding and alighting;
- time per passenger for boarding and alighting;
- bus dwell times; and
- pedestrian counts.

The Courtenay Place Micro-simulation Model (CPMM) was developed to a base year of 2011 for the morning, inter and evening peak periods using VISSIM. The traffic matrix was estimated from a prior matrix extracted from the Wellington Traffic Model (SATURN) and calibrated to observed turning counts. Future bus passenger demand was estimated using forecasts made using the Wellington Transport Strategy Model (WTSM). It should be noted that traffic demands in the Wellington Traffic model are also derived from WTSM.

The rest of this paper describes how the data needed to build the VISSIM model was collected and explains how this differed from the approach initially conceived. The paper highlights the challenges faced during the data collection process and model-build and how the study team overcame them.

DATA COLLECTION

Surveys were conducted during winter term time (July 2011) so as to reflect traffic conditions for a representative weekday. The model represents the area shown in Figure 2. The following surveys were undertaken:

- observed classified turning counts;
- travel times through the study area corridor;
- bus stop dwell times;
- pedestrian counts at signalised intersections; and
- pedestrian counts at mid-block pedestrian crossings and uncontrolled locations on Courtenay Place.

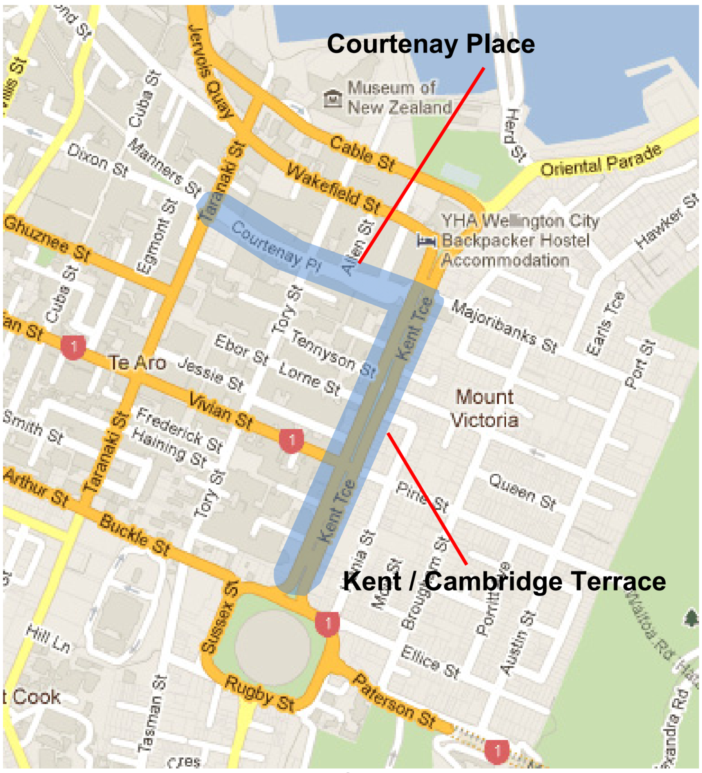

Figure 2: Study Area

In addition, the following secondary data was collated from various sources to enable the calibration and validation of the model:

- bus routes and frequencies;
- intersection layout and operational information;

- signal controlled intersection phasing and timings; and
- speed limits.

Traffic Data Collection

Classified vehicle turning counts were recorded at the ten main intersections within the study area in the morning, inter and evening peaks. Each survey lasted two hours. The data was collected in five minute increments using high mast video cameras recording at each intersection. This data was used to calibrate the model.

Vehicle travel time surveys were undertaken on the same day as the turning counts using the ‘floating car’ technique. The ‘floating car’ technique involves one or more survey cars driving along designated routes within the modelled area. Traditionally there will be a driver and a second surveyor manually recording the time at pre-defined and easily identifiable points. These points are typically, though not exclusively, signalised stop-lines or give-way road markings. Two routes were identified. The first was along the study corridor from north to south, the second in the reverse direction. This data was used to validate the base model.

Our survey used three vehicles to collect between 35 and 50 travel time surveys in each direction in each two-hour survey period. Using manual methods would have required at least 36 man-hours (three vehicles, each with two staff for two hours on three occasions on the day of the survey). Instead global positioning equipment was used in each of the survey vehicles allowing the time to be recorded automatically when each timing point was reached. Use of global positioning equipment allowed the study team to extract the journey time data easily after the survey. This method provided more accurate data and required half the manpower associated with manual methods.

Bus Stop Surveys

Like all motorised traffic, the movement of buses is affected by link and intersection capacity. In addition, bus travel times are influenced by the following factors:

- the time it takes to get to the bus stop;
- the time it takes for passengers to board and alight; and
- the number of other buses in the stop.

Dwell times are influenced by the time it takes for passengers to board and alight and this in turn is influenced by the number of passengers already travelling on each bus. A large amount of bus related data was therefore required including bus frequency, bus dwell time, bus journey time, numbers of passengers boarding and alighting as well as the number of passengers on the bus.

Bus-bunching is a major issue for bus operations along the Golden Mile. It is not uncommon for platoons of five or six buses to arrive and depart from bus stops at the same time. On many occasions, passengers were observed boarding and alighting from buses that were queuing to reach the bus stop. Sometimes the drivers of these buses would allow boarding and alighting again when the queuing bus finally reached the bus stop.

The study team determined through survey trials that the widely used methods where buses were tracked through the stops and boarding / alighting numbers were unworkable because it was not possible for surveyors to see both ends of the bus stopping areas without walking up and down the footway. This would be too much for surveyors to record accurately. Using several surveyors at each stop would be costly and introduce human errors.

The study team concluded that they would not be able to resource surveys where all this data was collected on a single day and considered spreading the various aspects of the bus data collection over several days. This would however have limited the suitability of the bus data for model validation. Instead the study team decided to reduce the scope of the data collection. The number of boarding and alighting passengers would be gathered from other sources instead of asking surveyors to collect this data as well as bus dwell times.

Further in order to keep the survey costs at manageable levels, the information about bus frequencies was derived from timetables available on-line, rather than observed information. Route frequencies were extracted from the regional passenger transport website: Metlink[5]. Using published timetables to code the bus routes was a good check for the bus data collected during the surveys. There were several different approaches to the study area (as shown in Figure 3), however on average, 45 bus routes passed along Courtenay Place in each peak period.

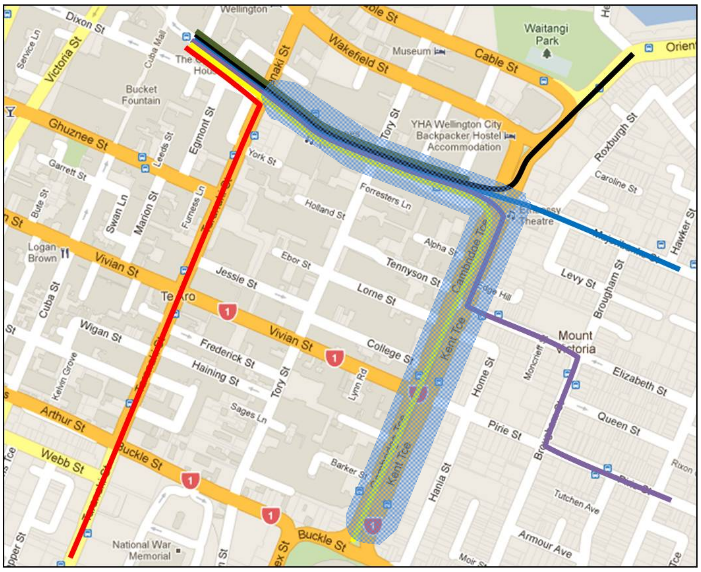

Figure 3 : Bus Route Paths within the Core Study Area

To collect the bus dwell time data, the study team devised a "Bus Stop Zone" methodology. Surveys were undertaken at ten bus stops at the same times as the traffic surveys. Each bus stop was converted into a zone as shown in Figure 4. Two surveyors were assigned to each bus stop zone. One surveyor recorded entry time for each bus and the other recorded exit time of each bus. As well as these times, surveyors recorded identifying information (see Figure 5) such as:

- bus type (diesel powered or trolley bus);
- route number;
- fleet (vehicle) number; and
- bus operator.

Surveyors were also asked to record unusual incidents such as break downs in the bus stop.

[5] http://www.metlink.org.nz/

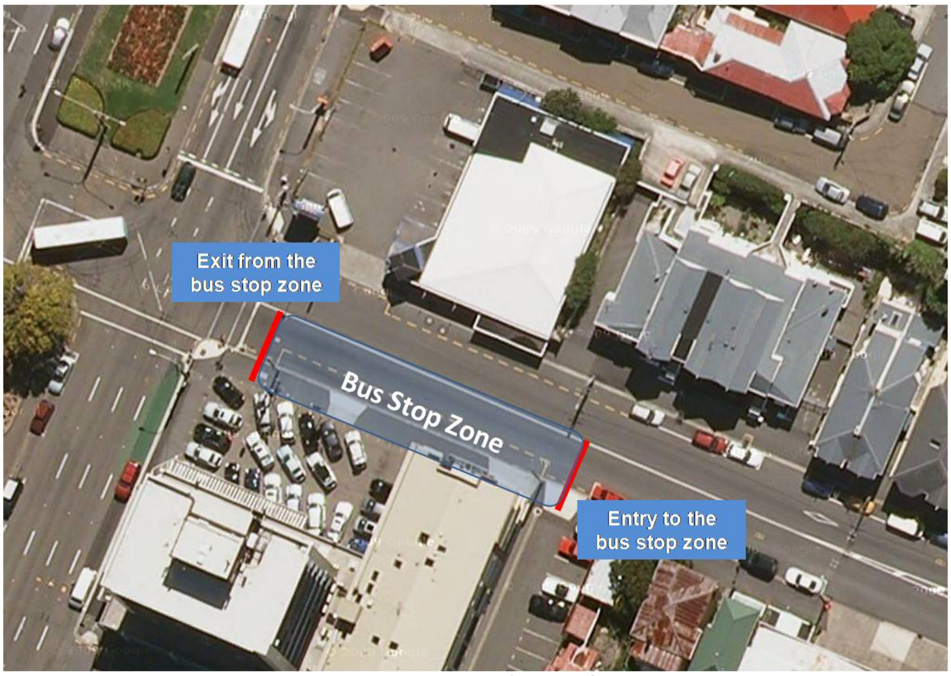

Figure 4 : An Example of "Bus Stop Zone"

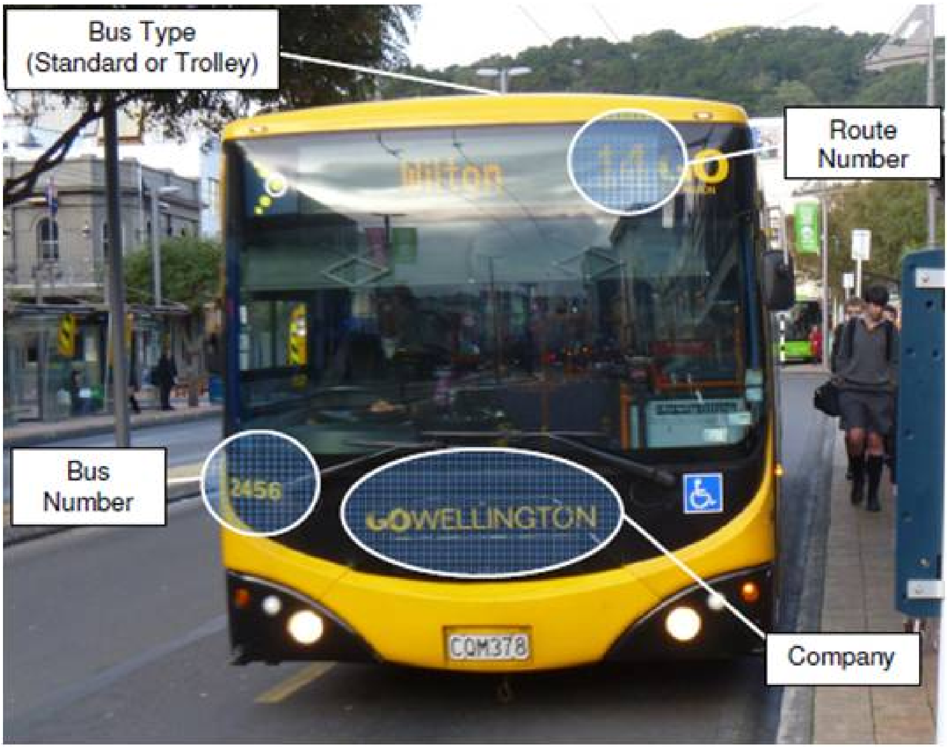

Figure 5: Additional Bus related Information

Pedestrian Data Survey

Courtenay Place is one of the busiest pedestrian routes in Wellington CBD. During the surveys 1000 to 1500 pedestrians per hour were counted walking along Courtenay Place. Between 3500 and 6000 pedestrians per hour were recorded crossing Courtenay Place in each of the peak hours. Around 42% of pedestrian crossing movements recorded in all three periods occurred in the PM peak hour survey. The level of service for pedestrians was therefore an extremely important consideration and a factor affecting the flow of buses and other traffic through the study area.

As well as recording pedestrian flows at specific locations the surveys were designed to record information regarding pedestrian behaviour. Detailed information was needed to allow the micro-simulation model to realistically simulate pedestrian-traffic interaction. The surveys therefore recorded:

- pedestrian desire lines;
- the number of pedestrians crossing at uncontrolled midblock locations; and
- the number of pedestrians crossing against a red man pedestrian signal.

Courtenay Place was nominally subdivided into nine sections. The study team used high mast video cameras to record pedestrian activity in each section. The video footage was reviewed after the survey in a comfortable office environment. Data analysts reviewing the footage drew a line on a tablet-style computer screen representing the path of each pedestrian observed. An example of the visual outputs from this survey method is shown in Figure 6, below.

Figure 6: Pedestrian Desire Lines across Courtenay Place between Blair and Allen Streets

The data collected in this way was processed using data analysis software developed by the traffic surveying division of Traffic Engineering & Management Ltd (TEAM). This project was the first time the software had been used on a project in New Zealand. The software allows analysis of the space-time details of objects drawn on the tablets. In the case of this pedestrian survey the software made it very easy to identify desire lines, tabulate the data and manipulate it to better identify trends. The data was analysed to determine crossing demands by direction, time and location.

Although not used for this survey the software allows analysis of additional attributes such as pedestrian gender. It can also be used to generate time slice videos showing how pedestrian behaviour varies with time.

CHALLENGES

Future Growth in Passenger Transport Demand

The demand matrices in the CPMM are all derived from higher level transportation models of Wellington. Future bus passenger demand was estimated from forecasts made using the Wellington Transport Strategy Model (WTSM). Passenger flows on links within the study area were extracted for the 2006 and 2026 WTSM do minimum scenarios for the AM, inter and PM peaks. Using these passenger flows, the percentage growth between 2006 and 2026 was calculated for each time period WTSM currently contains the following growth forecasts between 2006 and 2026:

- 1.48% growth per annum in passenger demand for northbound bus journeys (all peak periods); and
- 1.93% growth per annum in passenger demand for southbound bus journey for all peak periods.

Surveys undertaken for the Central Area Bus Operational Review found that at peak times some buses had no un-occupied seats and no standing room as they enter or leave Courtenay Place. Our initial approach was therefore to proportionally increase the number of buses on busy routes according to the forecast growth in passengers. Preliminary runs of the models found that this had an acute effect on bus and traffic congestion in the study area. Essentially the study team found that there were too many buses to fit on the roads. This was unsurprising and validated previous conclusions that the Golden Mile was operating at the upper end of the capacity range.

Following consultation with public transport officers from Greater Wellington Regional Council (GWRC) the study team decided to assume that service patterns in 2026 would be broadly similar to the present day. The justifications for this assumption were:

- that although the Central Area Bus Operational Review found that some buses are full, there is spare capacity other buses operating along the Golden Mile (even during the AM, IP and PM peak periods); and
- given that the Golden Mile would struggle to accommodate more buses, additional passenger demand could be accommodated by peak spreading.

Forecasting Future Year Bus Travel Times

The CPMM was validated to observed general traffic travel times. The purpose was to identify the extent to which the model reflected the current conditions indicators such as average speed and delay were compared to assess the validity of the model.

Considering the focus of the study, it was also important to validate the modelled bus travel times. The observed entry and exit times from surveyed bus stops were used to calculate the average bus travel times between stops. These were then compared against the modelled bus travel times to confirm that the CPMM adequately represents current bus operations.

The movement of buses is affected by link and intersection capacity. It is also affected by what happens at bus stops. Future year models included passenger growth forecasts derived from the Wellington Transport Strategy Model. If current forms of ticketing and smart card technologies are continued, future dwell times will increase because there will be more passengers boarding and alighting buses on the Golden Mile. To forecast future bus travel times, the study team needed a robust base for forecasting how these dwell times would change as bus patronage increased. The lack of passenger boarding and alighting numbers made this a challenge.

The study team decided to use bus stop data collected for the Central Area Bus Operational Review[6] an earlier study completed for Greater Wellington Regional Council in 2009. For this earlier study a larger data sample was collected including bus dwell times and the corresponding number of passengers boarding and alighting and at bus stops. The data could be disaggregated by service number (route) or according to the way in which the buses approached the study area (see Figure 3).

The study team found that in Wellington number of boarding passengers has a much larger impact on the dwell time than alighting passengers. To board the bus only the front door can be used and the driver must accept cash and give change for any passengers without a smart (Snapper) card. Boarding passengers may also have to wait for alighting passengers to get off the bus first. When alighting, passengers are able to use both doors and the process is much faster. Keeping this behaviour in mind, the observed data was used to derive a simple relationship between dwell times, boarding numbers, and alighting numbers.

The study team applied this pragmatic relationship to the dwell times observed in the 2011 survey. This allowed a good approximation of the numbers of passengers boarding and alighting on the day of the survey to be derived. The expected future growth in passengers was then applied to these boarding and alighting numbers so that future dwell times could be forecast.

Uncontrolled Pedestrian Midblock Crossings

6% – 8% of pedestrian crossing movements recorded during the survey were at uncontrolled midblock locations. For much of Courtenay Place, pedestrians can wait on a narrow central median if they are unable to cross the road in one movement. VISSIM is able to simulate such crossing behaviour using a pedestrian module.

From preliminary experiments with the pedestrian module the study team identified that a significant amount of time and computing power would be required if the mid-block crossing behaviour was not simplified.

In order to minimise model run time without compromising the actual operation of the network, the key pedestrian desire lines were identified using TEAM Traffic tracking software and used to simplify the coding in the VISSIM Model. An example of such coding is illustrated in Figure 7.

[6] Opus International Consultants, November 2009

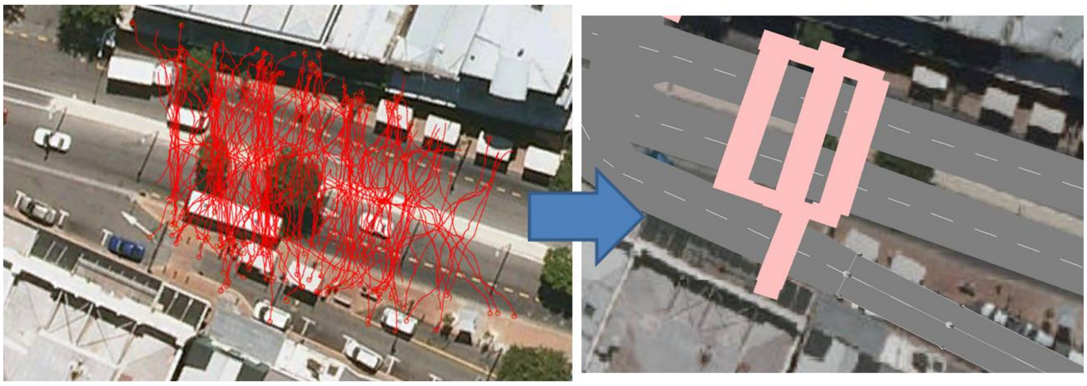

Figure 7 : Example of Uncontrolled Midblock Pedestrian Coding

It was disappointing that the detailed data, the study team had collected, needed to be simplified in order to make the model run. Ultimately it would be desirable to simulate the numbers of pedestrians using every possible route. Fortunately the data collection technique and analysis adopted did not require more resource than would have otherwise been required. Since completing the project the study team has been working with PTV, the suppliers of VISSIM, who have since identified ways to overcome this issue.

Pedestrian Response to Signal Controlled Crossings

If bus lanes were to be introduced along Courtenay Place it would be necessary to introduce signal control at the existing zebra crossings for safety reasons. Currently pedestrians have priority at zebra crossings. How would they respond to signal control?

Ideally the study team would have liked to have modelled the pedestrian response to changes in crossing delay. This would have had significant implications for the pedestrian survey methodology. It would also been at the limits of the functionality of the VISSIM modelling software. To model this behaviour in VISSIM the study team would have needed to create a full pedestrian origin-destination matrix for each peak hour. The model would then have simulated pedestrian choices on whether to wait for a green man, cross against a red man cross at an uncontrolled mid-block location or walk to the next signal controlled crossing facility.

To reduce costs the pedestrian survey only recorded crossing acts. Pedestrian paths before and after crossing Courtenay Place were not recorded. So, pedestrian response needed to be assessed in another way.

As well as noting the numbers of pedestrians using existing signal controlled pedestrian crossings, the surveys also noted the number that crossed against a red man. Table 1 shows the proportion crossing Courtenay Place against a red man at the three intersections that are currently signal controlled. Unfortunately the same data was not collected at the signal controlled mid-block crossing outside Reading cinema.

Table 1: Proportion of Pedestrians Crossing Courtenay Place against a Red Man

	% Crossing Against a Red Man			
Intersection	*AM*	*IP*	*PM*	*All*
Taranaki Street	9%	5%	3%	5%
Tory Street Intersection	4%	23%	14%	16%
Kent / Cambridge Terrace	1%	2%	2%	2%

The table shows that there was better traffic control compliance at the larger, higher traffic capacity intersections at either end of Courtenay Place. More pedestrians crossed against a red man at the smaller, Tory Street intersection.

It was therefore assumed that pedestrians would treat the proposed signal controlled pedestrian crossings on Courtenay place in the same way as the crossing facilities at the Tory Street intersection and that 4% and 14% would cross against a red man in the morning and evening peaks respectively.

It would have been interesting to model the effect of introducing signal control on the numbers or proportion of pedestrians crossing at uncontrolled midblock locations. Would more pedestrians cross mid-block delay were introduced at crossing points? To simulate this effect it would have been necessary to create a full pedestrian origin-destination matrix for each peak hour. Instead it was assumed that there would be no change this behaviour and that 6% – 8% of pedestrian crossing movements would be at uncontrolled midblock locations as was recorded during the survey.

CONCLUSIONS

The focus of the project was to assess the effect of the proposed bus priority measures on bus journeys, pedestrian movements and traffic flows on Courtenay Place. The study team found that micro-simulation modelling helped them analyse the problem and the performance of the options, but that this came at a cost.

A substantial amount of data was required as inputs to the model, particularly for the pedestrian and passenger transport elements. This required a very large survey team and increased the resource needed to process the data. Cost savings were made by using the latest video and pedestrian analysis software. This new approach to large pedestrian surveys has proven very beneficial. It has led to:

- more accuracy than could have been achieved though traditional methods;
- reduction in the survey response required;
- greater ability to manipulate and analyse the survey data to identify trends; and
- the ability to simplify the VISSIM coding for midblock uncontrolled pedestrian crossing movements.

The survey methodology and software application has significant potential for application to other similar projects. As well as identifying desire lines the method can be used to visualise pedestrian crossing behaviour by time segment.

VISSIM’s advanced pedestrian module was used to model pedestrian behaviour. The study team was required to simplify the way in which uncontrolled pedestrian crossing movements were simulated in the model and to make assumptions regarding the pedestrian response to the introduction of signal controlled crossings.

Use of the new module was a challenging learning curve, but one which will be helpful for future projects. Despite simplifying the coding for the midblock uncontrolled pedestrian crossing movements the study team still found that the models took a long time to run. The main reason for this was the size of the study area and the number of pedestrian movements recorded in each period (i.e. 35,000 crossing movements in six hours). The current pedestrian module is better suited to a smaller, more focused study area. The study team have provided feedback to PTV, the suppliers of VISSIM who have subsequently identified ways that would allow this issue to be avoided in future. Lessons learned from this project will make future use of this micro-simulation modelling software more streamlined.

The scope of the bus stop surveys was pulled back to make them more manageable, but also to minimise the cost to the client. This required the study team to use secondary data as the basis for forecasting future boarding and alighting numbers and resulting dwell times. If the secondary data had not been available the future year forecasts would have been far less robust.

At the outset of the study, the team sought to answer three main questions:

a. to what extent could bus travel time savings be achieved through bus priority?

b. what were the implications of introducing signal control at existing zebra crossings for pedestrians, motorists, and bus passengers?

c. how would this scheme work on the ground?

Despite the challenges associated with simultaneous collection of the traffic, pedestrian and bus data needed for micro simulation modelling the team were able to address these questions. VISSIM proved to be an appropriate tool for assessing the bus priority proposals for Courtenay Place. The software enabled the team to answer the main questions and to provide sufficient confidence in the forecasts. The study team's assessment of the bus priority package concluded that:

- it would result in a reduction in bus travel times in the order of 10% - 20%;
- much of this saving was attributable to the introduction of signal control at existing zebra crossing locations;
- it would result in less variability in bus travel times;
- mean pedestrian delay associated with the proposed signal controlled crossings would be 15 second which pedestrians will perceive a level of service B[7];
- private motorists would also experience travel time savings as a result of signal control at existing zebra crossing locations;

[7] Refer to Exhibits 18-9 and 18-13 from the Highway Capacity Manual 2000

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ACKNOWLEDGEMENTS

The authors would like to acknowledge Traffic Engineering & Management Ltd (TEAM) for their survey services for this project. The authors highlight the contribution the pedestrian video surveys and subsequent data processing towards the success of this project.