IMPROVING PEDESTRIAN ACCESS ACROSS ARTERIAL ROADS

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INTRODUCTION

A critical building block of a functional successful city is the presence of vibrant streets; streets that encourage walking. The level of pedestrian activity is an indicator of a great street as well as economic viability and is often used in determining rental values for retail premises. Walking creates a healthy population and is reflective of a liveable city. Walking is also critical to the overall effectiveness of a transport system, supporting every public transport trip and a lot of private vehicle trips.

For decades traffic engineering and planning in Australian cities has focused on and invested in improvements to roadways, with the singular objective of moving vehicle traffic. An incremental shift towards the implementation of broader integrated transport objectives has started to occur. This shift is partly in recognition that building roads can not solve traffic congestion and that roads have a large influence on the overall fabric and function of cities. The complex challenge of balancing the needs of different road users will become more complicated as Australia continues to become more urbanised (Vallyon, et al 2009).

Even with policy beginning to shift in support of walking, it is still under-represented in transport projects and designs are still leading to poor outcomes for pedestrians (Hess, 2009). While this is partly due to the size of the task to assess and modify roads to support all modes, there is more that can be done to provide good effective examples of interventions to support walking to help this process. These ideas are not new in terms of urban design and town planning (Jacobs J., 1961 and Utermann R, 1984) but more comprehensive change could be achieved if they were incorporated into traffic engineering practices.

This challenge has started to be reflected in the changing terminology in traffic engineering practice. Recognition of the wider role of streets is evidenced in the UK *Manual for Street* (DFT, 2007) and locally in *SmartRoads* (VicRoads, 2010). Frameworks such as level of service have started to evolve and expand into ideas around streets providing a dual role as a *Link* for through movement and a *Place* as a destination in its own right (Jones et al, 2007), or broader provision for all users in *Complete Streets* (http://www.completestreets.org/). The link between transport and land use has also been recognised and is a major input into Network Operating Plans under the VicRoads *SmartRoads* framework.

Creating direct and connected local walking network is the basic building block to start to increase walking. Physical barriers such as rivers, freeways and even railway lines are well recognised as impeding levels of walking activity. However, walking levels are more likely to be constrained by the 'barrier effect' resulting from "the delays and reduced access that vehicle traffic imposes on pedestrians' (PWC, 2011). It is often caused by arterial roads which are prevalent in urban areas.

PAPER STRUCTURE AND METHODS

The barrier effect is the focus of this paper. This paper starts with a short discussion of the lessons learnt from project interventions that sought to improve access across arterial roads through grade separation (underpasses) and the provision of wide raised traffic medians. Following this discussion the paper considers how signalised intersections (segregation of pedestrian and vehicles in time to provide safe crossing) can be improved to increase access. A range of metropolitan Melbourne projects are examined to contribute to the understanding of the effectiveness of these three interventions to encourage walking by improving safety and comfort.

This paper builds on literature through the review of project experiences in metropolitan Melbourne delivered as part of the Victorian Department of Transport's Local Area Access Program (LAAP). As part of the LAAP grants, successful applicants' were required to complete pre and post evaluation. This evaluation was often a mixture of quantitative and qualitative activities that were focused on project outcomes. Table 1 presents the evaluation undertaken for each of the projects discussed in the body of the paper.

As each of the individual projects was evaluated separately the results are difficult to compare. While some projects were evaluated rigorously, including the use of statistical techniques, other evaluation data can only provide an indication of outcomes that are likely to have been achieved. The small size of these projects and their isolated nature these indicative results are helpful in validating some conventional wisdom and provide evidence that these treatments can make a difference to walking levels. Lessons learnt from the evaluation of these projects are included in the section "Summary of Results from Local Experiences".

Table 1 Projects discussed in this paper, outcomes and measurement

Project	Outcomes	Measurement undertaken (before & after)
Doncaster Hill Pedestrian Underpass Project	Increased use of existing underpass	Pedestrian counts and observations, multiple days covering peak and lunch time periods
	Decreased road crossing away from signalised intersections	Pedestrian counts and observations, multiple days covering peak and lunch time periods
Preston Connect – Street improvements (including raised traffic median)	Increased in safe crossing practice	Pedestrian counts and observations (100 hours), supported by video evidence (1 hour)
	Improved perceptions of safety	Intercept survey of pedestrians (sample of 100)
	Increased number of people walking in the area	Pedestrian counts (100 hours)
Fitzroy Street Foreshore Connections	Facilitate pedestrian connection between the foreshore park and Fitzroy St.	Pedestrian wait times and frequency of pedestrian phases. Distance travelled & travel times between attractions
	Provide for a safe environment for pedestrian	Improved compliance – observations (from video) and counts on Friday and Saturday at pedestrian peak periods Vehicle counts & speeds
IMAP Greenlight signals Project (Inner Melbourne Action Plan)	Increased pedestrian safety and comfort.	Video data, pedestrian categories, crossing speed and non-compliant crossings
		Intercept survey on perceptions (before and after, sample 600)
		Traffic data and signal operations data
Pedestrian Priority At Signals – City of Darebin	Increased pedestrian priority	Information on pedestrian phases (frequency, length and wait times) from traffic signal controller
	Improved pedestrian safety & perceptions of safety	Observations and user intercept survey
	Increased level of walking	Pedestrian counts & signal SCATS Data
Napier and Johnston Street Intersection Improvements	Increased priority, safety & perception of safety for pedestrians	Cyclist delay, as a proxy for pedestrians as data on pedestrian delays were not collected Pedestrian, cyclist and driver interactions (video)
	Increased levels of walking in the study area	Walking volumes, average over three days and different periods of the day
Hoppers Crossing Pedestrian Access Project	Safe pedestrian access points that are used by pedestrians to cross Old Geelong Road	Percentage of people crossing at signals compared to other areas along the road way Percentage of people complying with traffic signals Percentage of people crossing within the railway tracks
	Links between the current pedestrian / cycle network and the station precinct	Measurement from the plans

KEY TO EFFECTIVE GRADE SEPARATION (UNDERPASSES)

At one end of the spectrum of providing for pedestrians is the complete segregation of vehicles from pedestrians. This is commonly experienced and applied in freeway design to provide environments that allow for high vehicle speeds. Segregation has also been applied to provide for pedestrians in places such as the Barbican Centre in London, the PATH network in Toronto (www.toronto.ca/path/index.htm) and underground network in Dallas (Terranova, 2009), with varying levels of success. Shorter single pedestrian underpasses are a more common approach to providing for pedestrians in the Australian road network. While most people can identify an example of a bad underpass there are some guiding design principles that can create more successful underpasses. Van Der Voor et al (1983) outlines some principles and user requirements for good walking and cycling underpasses.

In 2007 Manningham City Council received funding from the Victorian Department of Transport (DOT) to redesign an underpass in Doncaster Hill. The project followed the design principles of light, activity, amenity, clearer access lines, and visibility. The project changed the layout of the entrance on the northern side and added canopies to highlight the underpass's existence. Within the underpass an art-based lighting project was installed to improve the amenity and visibility (Fig. 1).

Figure 1 Inside the Doncaster Hill underpass before and after photos

Council reported that the post implementation counts indicated an overall increase in the number of people using the underpass, particularly primary school children, mostly accompanied by parents, in the morning and afternoons. However, counts also recorded an increase in the number of pedestrians crossing at ground level outside of the signalised pedestrian crossings throughout the days. Much of this increase was attributed to workers' 'coffee-runs'. Council concluded that it will be necessary to look at landscaping (or other) barrier treatments along the centre median in this location, to encourage greater use of the underpass and the signalised pedestrian crossing.

This example illustrates that in an urban arterial road environment there are often many local destinations and many opportunities to cross (created by down stream traffic signals) for an underpass to be extensively used. An underpass option should therefore only be considered in urban arterial road environments where;

- traffic volumes are very high and flow is continuous
- its presence is supported by topography
- there are large numbers of young children
- there is only a singular destination or path
- there are existing street level barriers to reinforce the underpasses use.

RAISED TRAFFIC MEDIANS AS A SAFE CROSSING

Raised traffic medians are often provided to support traffic flow (through the removal of U turns) and provide increased safety through segregation of oncoming traffic (Leong, 1970). Traffic medians can also provide better access for pedestrians by making crossing easier. This is because traffic medians allow people to break their crossing into two parts and therefore focus on one direction of traffic at a time. This increases their ability identify safe breaks in traffic and shortens crossing distances.

DOT funded the Preston Connect Project to provide 3.8 wide raised traffic medians to facilitate improved access for pedestrians. These wide medians were installed in combination with wider bike lanes and dedicated turning lanes on Cramer Street, Preston. These treatments were intended to increase safety for pedestrians and cyclist while increasing access to the many local destinations, including the Preston Market. Post-implementation observations showed that on average 63% of pedestrians crossing Cramer Street used the medians. The rate of use varied significantly from location to location and was lower than desired. On the other hand, on a sliding scale of 0 to 10, where 10 is very unsafe, pedestrians rated Cramer Street an average of 6.7 prior to improvements and 4.9 after improvements. Fig 2 shows the range of the responses to this question before and after the works. This distribution of respondents highlights the significant achievement of this project in terms of perceived improvements to the pedestrian safety, even if not all pedestrians used the medians. Perceived improvements are also supported by an increase in pedestrian activity along Cramer Street of 288 people or 10% over a year. Not all of this increase can be attributed to the raised traffic medians as other works were completed at the same time.

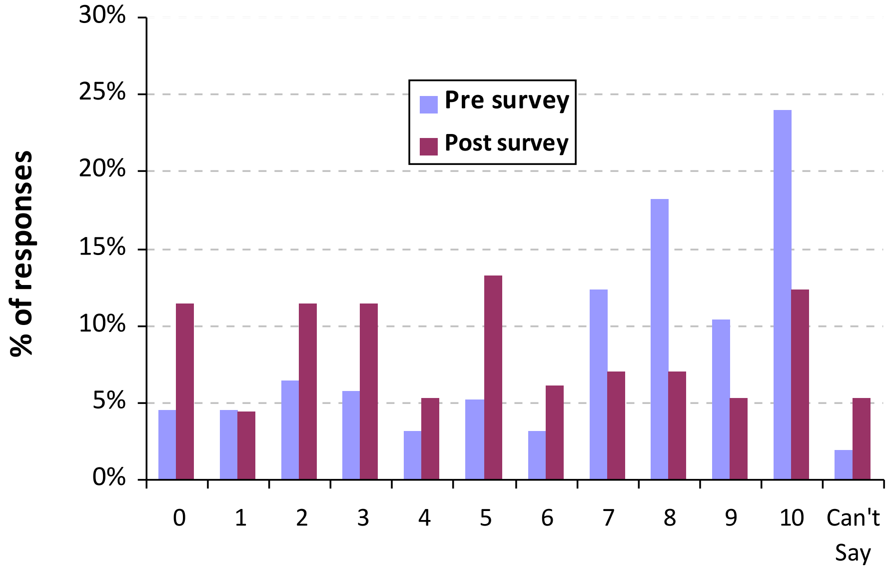

Figure 2 Pedestrians' perceptions of safety on Cramer Street (Pre N= 192 post N= 183)

This project demonstrated that traffic medians should be designed to accommodate pedestrians and incorporating pram crossings as they can improve pedestrian access and safety. The provision of medians needs to balance against the needs of other road users. The introduction of wide medians in Cramer Street Preston did reduce the number of traffic lanes from 4 to 2 (plus dedicated turning lanes) and drivers have experienced some increases in congestion and travel time. Also it is important not to trade-off other, possibly more important, pedestrian and cyclist facilities like wider footpaths or bicycle lanes which improve safety and connectivity. While raised traffic medians may not be applicable in all cases they certainly have greater potential in areas where multiple attractors exist on either side of the road, such as in strip shopping centres.

SIGNAL BASED PROJECTS

Summary of Local Projects that Involved Signal Changes

Through DOT's Local Area Access Program five projects were funded that aimed to improve safety and convenience for pedestrians at identified signalised crossings. The IMAP (Inner Melbourne Action Plan) Greenlight Project was the biggest of the four projects. This project looked at changes in pedestrian behaviour and perceptions at 24 study sites, 20 of which had changes to signal operations while four were used as control sites. The range of initiatives for the IMAP project is summarised in Table 2.

Table 2 Description of signal treatments completed as part of the IMAP Greenlight Project

Greenlight Treatment Type	Definition
Late Introduction	▪ Allows pedestrians to introduce pedestrian crossing for X seconds after the start of a phase ▪ Increases crossing opportunities ▪ Reduces pedestrian waiting time
Increased Pedestrian Clearance Time	▪ Increase clearance time or walking time to allow pedestrians to clear the crossing
PUFFIN Operation	▪ Detect pedestrians in the crossing and increase clearance time or walking time to allow pedestrians to clear the crossing
Pedestrian Head Start	▪ Vehicle start delayed when pedestrian crossing is introduced
Auto Introduction	▪ Commences a pedestrian crossing only if the phase attributed to that crossing runs (i.e. at particular times or demand levels) ▪ Pedestrian crossing initiated irrespective of pedestrian initiation ▪ Increases crossing opportunities ▪ Reduces pedestrian waiting time
Changed SCATS Data	▪ Changed phasing at signals

Source: Booz and Co, 2011

A similar project, Pedestrian Priority at Signals, was undertaken by the City of Darebin with DOT funding, where a further 5 sites had signal modifications. The Darebin project implemented many of the same treatments as the IMAP Greenlight Project except in Darebin pedestrian head-starts were also implemented. This treatment allows pedestrians to get established in the intersection before the green phase for vehicles. This treatment is believed to increase pedestrian safety, especially against turning vehicle movements, as visibility of pedestrians is enhanced. This section of the paper focuses on the combined results from the IMAP Greenlight and Pedestrian Priority at Signals (Darebin) projects. For both projects a full list of sites and the treatments that were implemented is included in Appendix 1.

Three individual intersections projects were funded by DOT and are also discussed in this section:

- Fitzroy Street Foreshore Connections Project - major changes were made to traffic movements to reduce traffic volume and speed around a very highly patronised tram stop in the heart of the Fitzroy Street shopping and entertainment precinct.
- Napier Street and Johnston Street Intersection Project - a mid block pedestrian operated signal was moved to a nearby side street.
- Hoppers Crossing Pedestrian Access Project - signals were installed either side of the train line to create safer movement of people to the train station. This project involved moving a pedestrian operated signal 80m, to a location parallel with the level crossing.

Effects of Individual Changes to Signal Operations

From the IMAP Greenlight project the strongest and statistically proven finding was the relationship between clearance time given to pedestrians and their walking speed. Pedestrian speed was suggested to be inversely related to clearance time. On average every one-second increase in clearance time led to a 0.02m/s decrease in pedestrian speed on average (Booz and Co, 2011). Increases to clearance times helped to make people feel safer crossing the intersections. Intersections receiving this treatment as part of the IMAP Greenlight Project showed respondents' feeling of safety increasing by 24%. None of the sites in the Darebin project had clearance times increased.

A study of walking speeds in Canada found that crossing speeds are faster than normal walking speeds and that there is significant difference in walking speeds amongst different age groups (Montufar et al 2007). This is supported by the IMAP Greenlight finding where the median walking speed of adults was 1.57m/s and those using mobility aids were as low as 1.1m/s. As Fig. 3 illustrates, this is important when setting standard green time and clearance time. It is worth noting that even if the 10th slowest percentile walking speed for adults is used, most people with mobility aids (other than wheel chairs) will not be able to complete the crossing in the allocated time. Montufar et al (2007) suggests that, based on the normal walking speeds of people over the age of 65, design speeds should be set at 0.91m/s, thereby increasing the proportion of pedestrians who would complete the crossing to 80%. Currently the Victorian standards use a design speed of 1.2m/s for calculating the green time and 1.5m/s to calculate the clearance time. Clearance times should therefore be adjusted to be based on slower walking speeds where pedestrians are prioritised.

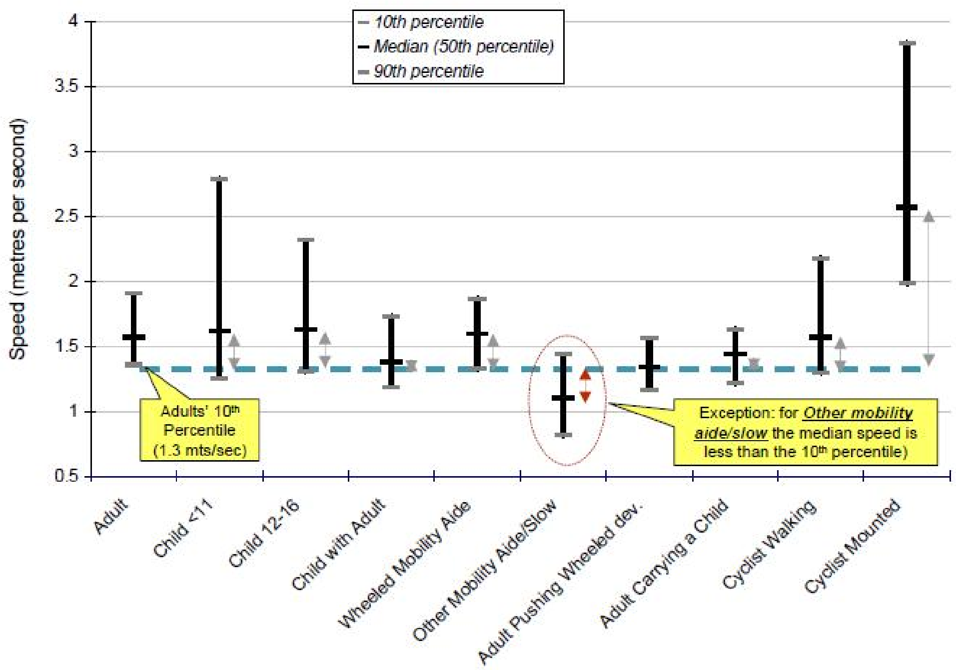

Figure 3 Crossing Speeds by Category (Source: Booz and Co, 2011)

PUFFINS were specifically developed to help reduce the instances of a person not completing the crossing within the allocated time. PUFFINS work by identifying people within the crossing by using infrared rays. If a person is still in the crossing the signal controller extends the clearance time. Based on Fig. 3, PUFFINS should be installed wherever high numbers of elderly, or people with mobility aids, are expected. They can also help in locations where large groups of people are wishing to cross together in the one signal phase, such as schools and Walking School Buses routes or around major attractions that have high group-visitor numbers. PUFFINS were installed at three locations in the IMAP Greenlight Project and at one other site as part of Darebin project. The sites that were evaluated as part of the IMAP Greenlight Project showed a 12% decrease in non-compliant crossing. However, average wait time was significantly increased, by 5.5 seconds. Unfortunately counts were not collected for the number of people that did not manage to complete the crossing in the allocated time.

'Late' and 'auto introduction' are hypothesised to reduce the time a pedestrian has to wait at an intersection. Auto introduction is often argued for by pedestrians on the basis that they should not have to ask permission to cross (Henman, 2010). However, from a traffic-flow perspective they can decrease the movement of vehicles, especially turning vehicles. Evaluation of the IMAP Greenlight Project showed that the provision of late introduction for pedestrian phases decreased the instances of people crossing against the red man by 16%, and the proportion of people who reported feeling safe increased by 21%. Decreased crossing speeds were also experienced, while wait times increased slightly, by 1.8 seconds on average. Surprisingly, similar results were not experienced at locations where auto introduction was employed. However, the provision of auto introduction could have had some impact on improved compliance at the Darebin intersection of Edward and Spring Streer. This is discussed in the next section.

Overall effect on improving compliance at intersections

Research by Van Houten et al (2007) showed that an inverse correlation existed between compliance and wait-times at mid block signals. At the sites evaluated as part of the Darebin project most experienced only minor changes in non-compliance levels when changes to wait time, auto introduction and pedestrian head starts were introduced. However, the magnitude of the change in waiting time for the Darebin project sites was not as large as in the Van Houten study. At the Edward and Spring Street intersection the post-implementation counts showed that the proportion of people entering the crossing on the green man (compliant crossings) had increased on the two legs of the intersection by 3% and 7%, to 90% and 81% respectively. Whereas at Station Street the level of crossing compliance remained the same at around 80%. Surprisingly, the post-implementation results also showed an improvement in driver compliance with the traffic signals and associated line marking (Fig. 4), thereby improving pedestrian safety.

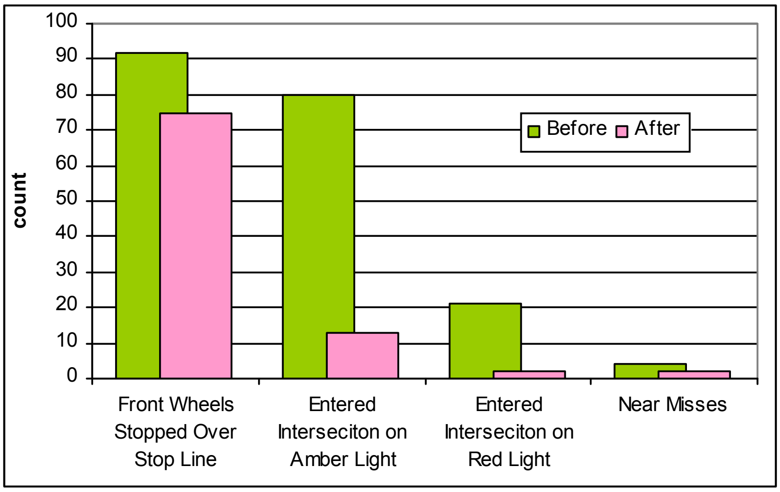

Figure 4 Driver compliance with Pedestrian Operated Signal at Station Street (over 3 hour period)

The IMAP Greenlight Project evaluation results demonstrated that the range of Greenlight treatments led to an overall decrease in non-compliance against the control sites. However, the regression analysis completed as part of the project did not identify any specific variable that significantly influenced the results. The range of variables tested did include waiting time. This demonstrates that while these treatments in combination showed positive results there is no single factor that can be isolated to explain non-compliance. This reflects the complexity of individual behaviour and decision making in relation to crossing against the red man. Individual differences in perceptions of safety and acceptable levels of risk play a key part in determining compliance.

Physical Factors Found to Influence Pedestrian Experience at Signalised Crossings

Through the IMAP Greenlight Project regression analysis, a number of physical factors that exist at traffic signals were tested against the intercept survey information. This section highlights the areas of intersection design that had a relationship with either walking speed or pedestrians' perceptions of comfort and safety. A comprehensive assessment of physical variables was not completed but a number of easy to measure variables were included in the analysis. These were distance, traffic volume, existence of a tramway and traffic island.

Time between before and after surveys was shown to have the most significant correlation with data from the intercept survey. There was a significant worsening of results in the post-implementation intercept survey both at sites that received treatments and those that did not. This is one of the reasons that a more robust conclusion could not be drawn. Regardless of this weakness, there are a number of trends and relationships that can be inferred from the regression analysis.

In relation to pedestrian speed, a very strong positive relationship between pedestrian speed and crossing distance was found. With every 1m increase in crossing distance there was a 0.03m/s increase in average pedestrian speed. This suggests that pedestrians walk faster when they have a greater distance to cover in the crossing.

Tramways were shown by the regression analysis to have a positive effect on pedestrians' reports of feeling rushed, and 'waiting too long'. Specifically, the presence of a tramway is suggested to lead to an improvement of 0.24 on a scale out of 5 for feelings of being rushed; and an improvement of 0.1 on a scale out of 5 in reports of 'waiting too long'. This finding may be due to a number of factors, including change in SCATS caused by the Trams, as well as increased cycle times, and the auto and late introductions delivered as part of the project in proximity to Tramways. This is counter to anecdotal evidence of people rushing to get to individual trams and warrants further examination.

The regression analysis identified the presence of a traffic island is related to a worsening of pedestrian perceptions of safety. Namely, there is a worsening of 0.34 out of 5 when pedestrians are required to traverse a traffic island. This is a counterintuitive finding as raised traffic islands provides a safe space for pedestrians (Leong, 1970) and in Preston were proved to increase perceptions of safety. In reviewing VicRoads Traffic Engineering Manual, an idea of why this may occur becomes apparent. For a divided road the calculation of the pedestrian walk time is based on the distance of the widest road section plus the median and 1m, and not the full width of the road. This can lead to higher level of interaction with turning vehicles and pedestrians having to complete the crossing of the intersection in two legs. Also for the intersections included in this study in general the crossing distance is longer and this was shown to increase walking speed and lower the level of comfort.

As part of the Darebin signal project, Council identified a location at Murray Road, Preston, where it was felt that an existing fence was not effective and they would prefer to have it removed. Pedestrian fencing had previously been installed to reduce people crossing at locations other than at a designated crossing. This type of fencing can become a maintenance issue as well as taking away from the amenity of the area. The results of the post-removal evaluation showed a 3% increase (4% to 7%) in pedestrian crossings at points other than the designated crossing. However, the number of people who perceived the intersection as being 'very safe' increased, as shown in Fig. 5. Even with this increase in perceptions of safety, survey respondents often complained (21 respondents, or 20%) about the level of vehicle non-compliance. One respondent stated, "[I] noticed that some drivers seem to forget it's a crossing and drive through it without stopping on a red light". Unfortunately vehicle movements were not recorded as part of the evaluation. However, at a similar site, Station Street, Fairfield, over a period of nine hours on three different days only two cars entered the mid block intersection on red signal and in the same period 12 cars entered the crossing during the yellow signal. At this site a similar percentage of intercept survey respondents (24%) identified red light running in their general comments on pedestrian safety at the intersection. While not at the same intersection these statistics highlight the difference that often exist between perceived and real safety issues which can impact on the levels of pedestrian activity in any area.

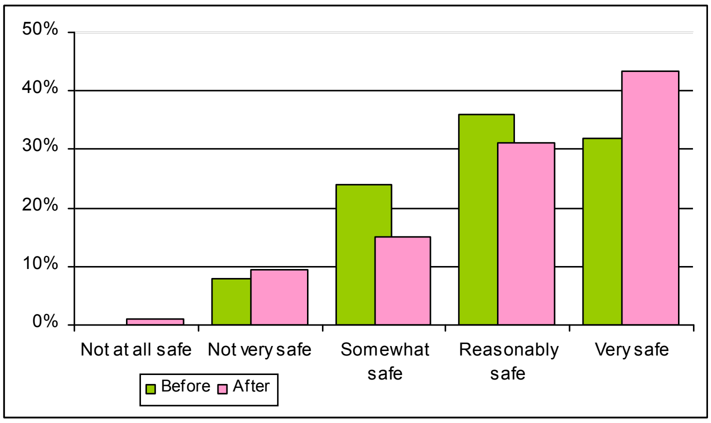

Figure 5 Perceptions of safety proportional response (before N=25, after N=106)

Location of Signals

At Hoppers Crossing Station two pedestrian signals were installed on Old Geelong Road parallel with at the level crossing. Previously, pedestrian operated signals existed on the northern side of the railway line near the local shops. These existing signals were approximately 80m from the level crossing on Old Geelong Road and some distance from the station entrance and closer to an intersection with a local road further north. As part of the Hoopers Crossing Pedestrian Access Project, these signals were removed and replaced by pedestrian signals at the level crossing closer to the train station entrance. The post-evaluation showed that on the northern side of the level crossing 50 people still continued to cross the road without using the pedestrian signals. However, in the evening period all but 10 people use the signalised crossing, down from 40 people who didn't use the crossing before the changes. This is interesting as it illustrates that pedestrians change where they walk based on the direction of their approach, and how ease of navigation can impact on crossing choices. With the addition of the second crossing adjoining the railway line on the south, the evaluation showed a number of other interesting results. Firstly, a noticeable reduction in the number of people who crossed the railway line where there is no pedestrian level crossing. Secondly, people were not crossing between the boom barriers as previously observed. This illustrates that the treatment significantly increased safety and reduced the risk of an accident between a pedestrian and a train.

Another project involving relocation of signals focussed on improving the north-south movement of cyclist along Napier Street in Melbourne's inner north. This project removed an existing pedestrian operated signal on Johnston Street (10m to the east of the intersection) and replaced it with full signalisation of the intersection of Napier and Johnston Street. Before the installation of the signals in the north-south direction an average of 206 people were observed crossing Johnston Street over 6 hours. After installation of the signals an average of 290 people were observed making the same crossing over the same period of time. This represented a 35% increase in pedestrians crossing Johnston Street after the signals were moved. The lunch period saw the largest increase from an average of 53 people to an average of 101 people. This was quite significant and an unexpected result of the project. Moving of the crossing to the cross street allowed better connectivity with adjoining street. The change also meant that cyclist and cars could trigger calls for a green signal to cross Johnston Street. The combination of these factors led to a decrease in crossing wait times. In the case of cyclists, this is illustrated in Fig. 6. These results are being used as a proxy for pedestrian waiting times as this data was not collected.

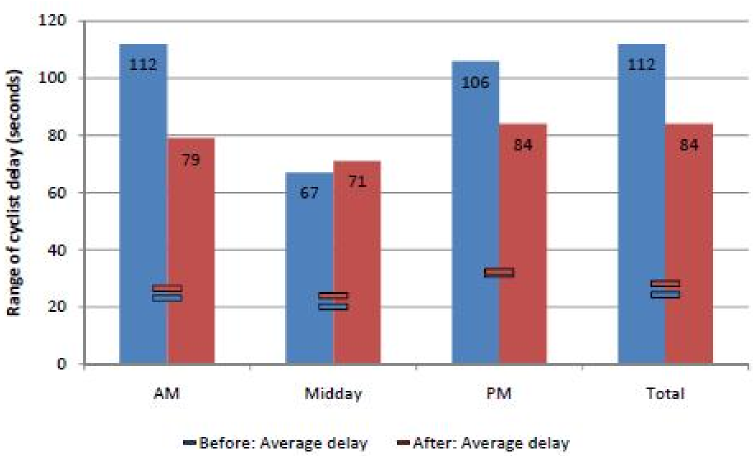

Figure 6 Cyclist delay at Johnston Street, before and after

Impact of location and wider pedestrian crossing provision

The significant investment from various state government partners and the City of Port Philip in the urban realm at Fitzroy Street in St Kilda as part of the St Kilda Foreshore Project provided many examples of interventions to support walking. These included traffic redirection, a wider signalised pedestrian crossing, a shared space and the trial of a 'Dwell on Red' approach to managing traffic in high pedestrian environments. Wider signalised crossings of the arterial road, Jacka Boulevard, was the component that received funding through DOT's Local Area Access Program and will be discussed in this paper. Aerial photos of the area before (Fig. 7) and after (Fig. 8) clearly show the changes in pedestrian crossings.

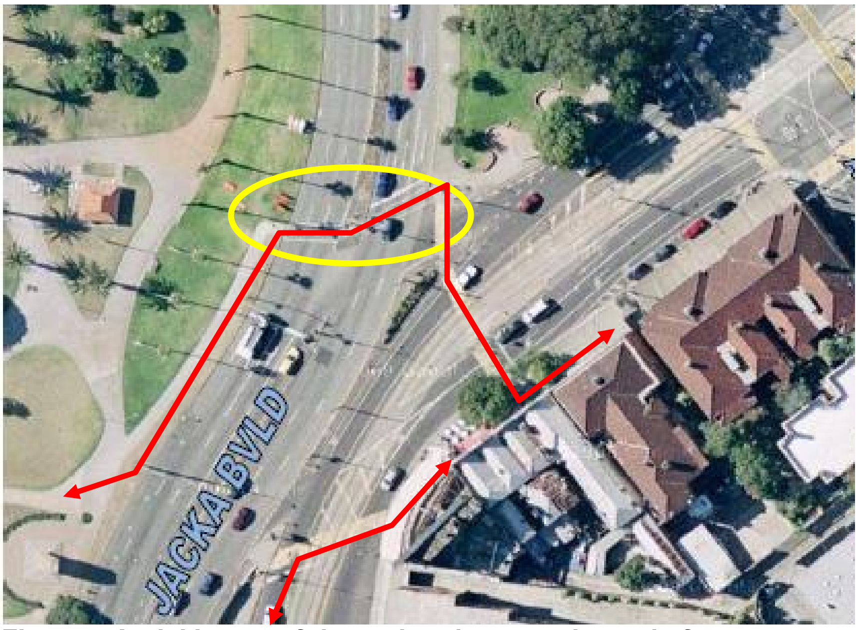

Figure 7 Aerial Image of the pedestrian crossings - before.

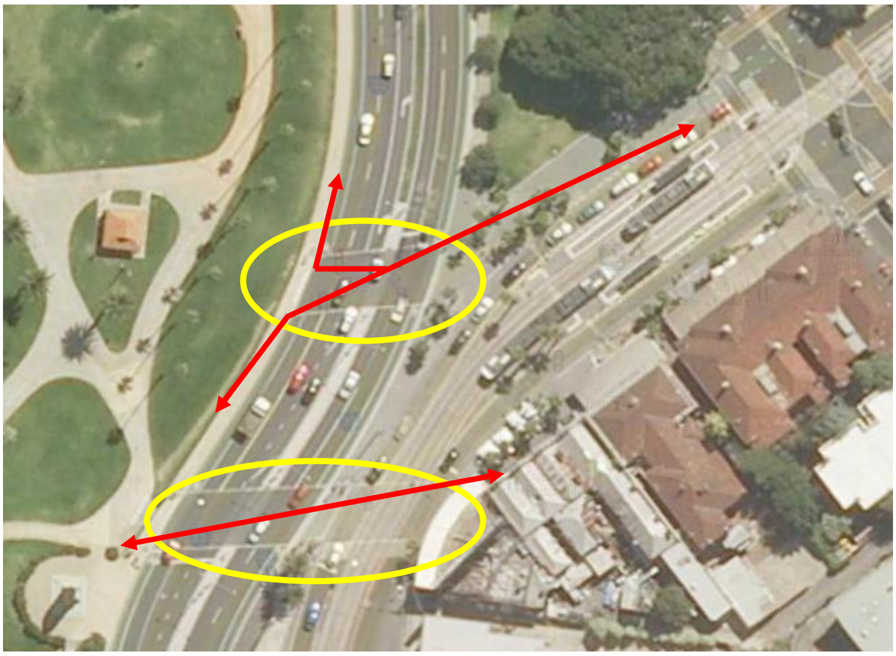

Figure 8 Aerial Image of the pedestrian crossings - After

The new pedestrian crossings cover a 450m^2 area previously dedicated to vehicles for access into Fitzroy Street. The removal of turning movement also allowed for a second crossing directly inline with the foot path on the south-eastern side of Fitzroy Street. These two crossings provided direct access to the foreshore from the Fitzroy Street commercial precinct whereas the previous convoluted crossing involved multiple legs (which were not coordinated) and an extra 50m in distance, represented by the red lines in Fig. 7 and 8.

Before and after-implementation pedestrian counts revealed a very large increase in the number of people crossing Jacka Boulevard (Fig 9). This significant change in pedestrian crossing behaviour, while influenced by the adjoining treatments, would not have been achieved if the two crossings did not align with the pedestrian paths along Fitzroy Street and offer wide and clear crossing of Jacka Boulevard. These new crossings reinforced that pedestrians 'belong' and have lots of opportunity to cross. The larger scale of the crossing did cause some initial concerns with vehicles undertaking illegal right turns from Jacka Boulevard into Fitzroy Street via the pedestrian crossings. However, this was attributed to people not yet being familiar with the changes in the road layout and this is expected to decrease in frequency (Ratio Consultants, 2010). The changes to the crossings had no effect on the levels of pedestrian non-compliance.

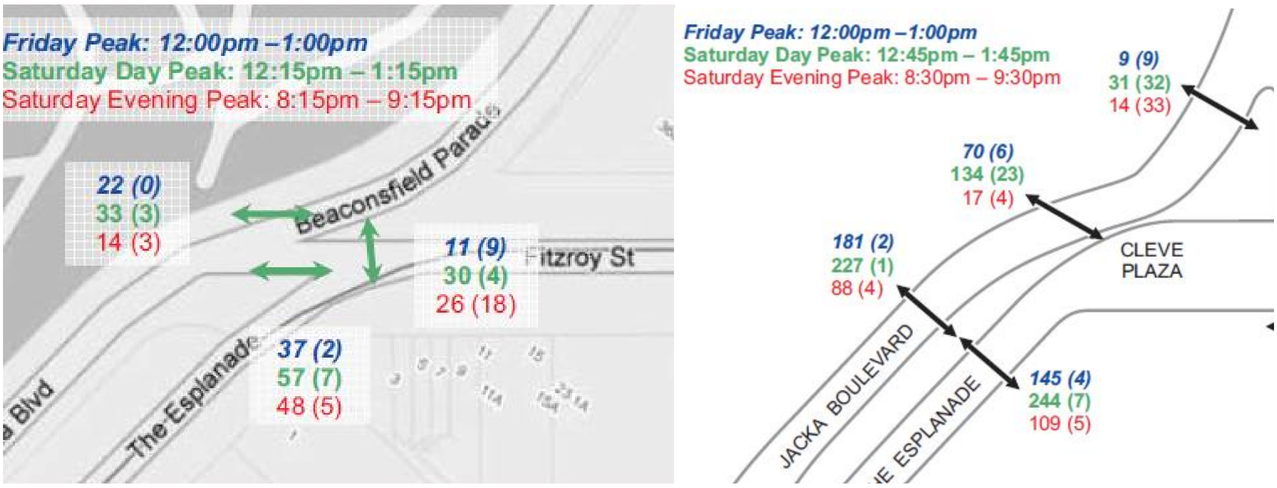

Figure 9 Pedestrian Counts – Before May 2008 and After April 2010

SUMMARY OF RESULTS FROM LOCAL EXPERIENCES

Effective treatments

In this paper a number of different treatments are discussed in relation to providing improved access for pedestrians and addressing the barrier effect created by roads and traffic. Most treatments were also assessed in terms of their ability to improve safety as a prerequisite for encouraging more walking. While the full segregation of pedestrians from vehicle traffic provides the highest level of safety, this offers limited access and therefore often results in a lack of use of underpasses. At the other end of the spectrum minor improvements in signal timing has been shown to improve pedestrians' comfort and increase crossing opportunities. The list below highlights some of the effective treatments to addressing the barrier effect of roads:

- Wide raised traffic medians, particularly in areas with multiple destinations. These should be at least 1.8m in width to provide for; groups of people, wheel chairs, prams and even bicycles.
- Shorter crossing widths were proven at signalised intersection to have a positive effect on pedestrian comfort (through reduced crossing speeds).
- Increased clearance time and green time for pedestrians (based on normal walking speeds) improved the feeling of safety and decreased walking speeds.
- PUFFINS are important to provide safe crossings for the elderly or people with mobility aids but this should not be in place of more frequent crossing opportunities or longer standard crossing times.
- Late introduction of pedestrian phase where long traffic cycle time exists, or if time does not allow an auto introduction of the pedestrian phase, to increase compliance.
- Removal of pedestrian fencing in some situations can increase the perception of safety.
- Pedestrian operated signals are less effective than signalising a nearby local road as demonstrated by the Napier/Johnston Street Project.
- Direct, wider crossing areas with enough time to cross in a single phase can significantly increase pedestrian demand.

Requirements for further research

An important area for further research is to better understand human behaviour when it comes to walking. A behaviour science approach is needed to focus on the key factors that create the barrier effect, key factors that encourage people to walk and how decisions about when to cross are made. Individual perceptions of when it is safe to cross and the amount of risk that is acceptable vary significantly. In order to improve compliance and safety, further research is needed to understand the decisions to cross against a signal. This research however should not be limited to pedestrian behaviour but should consider how driver behaviours effect pedestrians and what influences those driver behaviours.

Consistent and systematic project evaluation should also form a component of every project completed by government in the area of improving provisions for cyclists or pedestrians. It is only through this continual evaluation of projects that investment decisions can be improved and better outcomes achieved. These evaluations are critical to continue to develop a broader evidence base about which projects work and what the critical success factors are.

Lesson for effective evaluation

The evaluation result of these projects, particularly signal projects, was limited by the mix of different treatments that were implemented at each site as well as environmental factors. This made it very difficult to determine what impacts were attributable to which treatment. The reality of working in a live traffic environment and trying to seek the best outcomes for the dollars invested means that a controlled experiment will always be difficult to achieve. However, here are some simple ideas that can help in future evaluations:

- Consistent before and after surveys are required as a minimum.
- Evaluation measures should be based on what you would like to see change (outcomes) and specific enough to be effected by the project - For example if you are installing head starts for pedestrians, you need to measure how many people enter the intersection, and if the behaviour of drivers have changed and if avoidance manoeuvrers decrease.
- Before-implementation data is critical as it can not be collected again. If in doubt collect a broad range of information that you expect the project to influence - this can include other modes of transport and observations of behaviour.
- Asking people if they like particular changes can lead to biased results. Also it may be difficult for people to recognise or perceive very small changes, especially in signal operations.
- How the data is going to be analysed is very important in designing data collection, especially for questionnaires.
- Pedestrian and cyclist counts are more likely to change based on day of the week, time of year and local weather. Therefore counts should be conducted over multiple days and before and after counts at similar times of year.
- Survey results are significantly affected by time. Therefore before-implementation counts should be conducted just weeks before works commence, even if this means repeating a count that was undertaken to inform the design. Post-implementation counts and surveys should take place between 2 and 6 months from completion. It is difficult to find a balance between letting the treatment 'settle in' and not being able to attribute impacts to the project. This is where longitudinal is data is important.

CONCLUSIONS

This paper presents a range of ideas, lessons and evidence on how to improve pedestrian access and crossings through a series of Victorian projects funded through the DOT's Local Area Access Program. Through this experience it has become clear that it is not always easy to measure and attribute the impacts to these small scale projects, especially given the many factors that influence walking and people's behaviour. However, these projects have demonstrated that minor steps can be achieved towards the objective of increase walking levels. They have also demonstrated that traffic signals can play a role in better balancing the needs of pedestrians and vehicles at intersections and in reducing the barrier effects caused by arterial roads.

The most effective projects in providing for pedestrians, such as Fitzroy Street Foreshore Connections and Preston Connect, combine the professional skills of both traffic engineering and urban design. These two projects along with the Napier and Johnston Street Intersection Project created direct, clear and connected walking links demonstrating that increasing access can lead to increased levels of walking locally. It will only be through continuing these small steps of delivering, evaluating and sharing the lessons from pedestrian projects that the broader objective of increasing walking can occur.

ACKNOWLEDGEMENTS

The author would like to acknowledge the efforts of all the council staff who managed these projects from Manningham City Council, City of Port Phillip, City of Yarra, Wyndham City Council, Darebin City Council and the IMAP Group of Councils. Staff from partner organisations such as VicRoads and YarraTrams are also gratefully acknowledged. This paper would not have been possible without the information that has been provided to DOT in formal project reports as well as through open and honest feedback. The author would also like to acknowledge Booz & Co, SKM and Ratio Consultants for their work as consultants on the evaluation of these projects.

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Appendix 1: Intersection treatments by site for IMAP Greenlight and Darebin Intersection Project.

Site ID	Address	Intersection Type	Greenlight Treatment 1	Greenlight Treatment 2	Non Greenlight Treatment	Observed Pedestrian Volumes	Observed Traffic Volumes	
							AM	PM
1	Pickles, Ingles & Dorcas Streets	Cross	Late Introduction	Increase Clearance Time	N/A	299	7,005	,9422
2	Graham Street @ Port Melbourne	Mid Block	Increase Clearance Time	N/A	N/A	382	N/A	N/A
3	Chapel Street/Inkerman Street	Cross	PUFFIN Operation	N/A	Increase Walking Time	901	4,006	8,178
4	Brighton Road/Brunning Road	Mid Block	Increase Clearance Time	N/A	Increase Walking Time	836	4,903	9,021
5	Carlisle Street/Westbury Street	Cross	Late Introduction	Increase Clearance Time	Increase Walking Time	2,815	2,363	6,112
6	Rathdowne Street/Grattan Street	T Intersection	Late Introduction	N/A	Increase Cycle Time	644	5,127	8,620
7	Wellington Street/Clarendon Street	Cross	Late Introduction	N/A	Increase Cycle Time	7,275	4,229	7,055
8	Albert Street/Lansdowne Street	Cross	Late Introduction	N/A	N/A	2,024	6,080	11,218
9	Alexandra Avenue/Anderson Street	T Intersection	Increase Clearance Time	Late Introduction & Pedestrian Head Start	N/A	2,106	1,339	4,749
10	Domain Road/Park Street	Cross	Late Introduction	Increase Clearance Time	N/A	1,587	3,015	5,120
11	Chapel Street/Toorak Road	Cross	Auto Introduction	N/A	N/A	5,515	5,648	10,771
12	Chapel Street/Malvern Road	Cross	Auto Introduction	N/A	Increase Cycle Time	8,388	3,975	7,322
13	Chapel Street/High Street	Cross	Auto Introduction	N/A	Increase Cycle Time	8,394	7,417	12,379
14	Chapel Street/Garden Street	T Intersection	Auto Introduction	N/A	Decrease Cycle Time	7,329	3,693	9,782
15	Chapel Street/Chatham Street	T Intersection	Auto Introduction	N/A	Increase Cycle, Walking & Clearance Time	11,024	2,850	7,996
16	Bridge Road @ Richmond Town Hall	Mid Block	PUFFIN Operation	Changed SCATS Data	N/A	1,183	3,929	6,342
17	Johnston Street/Hoddle Street	Cross	Increase walking time by 2 seconds during high cycle	Changed SCATS Data	Increase Clearance Time	1,008	15,806	28,201
18	Brunswick Street/Alexander Parade	Cross	Changed SCATS Data	N/A	Decrease Cycle Time	772	14,888	31,560
19	Elizabeth Street/Church Street	Cross	Late Introduction	Increase Clearance Time	N/A	1,117	3,316	6,169
20	Scotchmer Street/Nicholson Street	Cross	Puffin Operation	Late & Auto Introduction	Increase Cycle Time	1,070	4,224	9,120
C1	Chapel Street/Alma Road	Cross	N/A	N/A	*	109	N/A	N/A
C2	Albert Street/Clarendon Road	Cross	N/A	N/A	*	172	N/A	N/A
C3	Church Street/Swan Street	Cross	N/A	N/A	*	180	N/A	N/A
C4	Johnston Street/Smith Street	Cross	N/A	N/A	*	9,656	N/A	N/A

** Unknown – SCATS data not analysed at Control Sites.*
Source: Booz & Company Analysis 2011

Address Intersection	Type	Treatment 1	Treatment 2	Treatment 3	Evaluation Showed
Edwards St and Spring St, Reservior		Auto Introduction of pedestrian call-up	Head-start for pedestrians	PUFFIN	Slight increase in safe behaviour by pedestrians but also significant improvement in driver behaviour.
Station Street, Fairfeild	Mid-block	Max green time for vehicles set at 30sec = increased crossing opportunities	Queue detection		Slight increase in safe behaviour by pedestrians but also significant improvement in driver behaviour.
Murray Rd, Preston	Mid-block	Maximum pedestrian wait time set at 30 sec (after call)	Removal of fencing		7% decrease in the legal use of the crossing – mostly people now crossing nearby. But increase in perceptions of safety.