Improving Pedestrian LOS at Traffic Signals

Author and Presenter:
Axel Wilke
BE (Hons), ME (Civil), GIPENZ
Director, Senior Traffic Engineer and Transport Planner, ViaStrada Ltd

Co-author:
Jeanette Ward
NZCE, BE, CPEng, MIPENZ
Senior Engineer, ViaStrada Ltd

Co-author:
Susan McLaughlin
BA Environmental Science, MA Urban Design, AICP, LEED AP, NZGBC AP
Senior Planner – Urban Renewal/Transport, Christchurch City Council

ABSTRACT

Christchurch City Council commissioned an investigation into ways of improving pedestrian level of service (LOS) at traffic signals in the central city. In 2009, Gehl Architects prepared a study entitled Public Space Public Life (2010) that considered how people use public spaces and streets in central Christchurch. This precedent study resulted in Christchurch City Council's adoption of A City for People Action Plan (2010), which includes 66 related actions based on the recommendations in the study.

This paper covers Stage 1 of the investigation that addresses some of those actions, which involved developing a methodology to measure existing LOS for each signalised pedestrian crossing in the study area, allocating a LOS score to each signalised pedestrian crossing, and identifying tools for improving pedestrian LOS. There were 32 signalised intersections within the study area, equating to 110 signalised pedestrian crossings under consideration. The improvements considered for the project were restricted to changing traffic signal operations and adjusting signal hardware.

Several methods were investigated to improve the existing pedestrian LOS. Testing of these methods indicated that the largest improvement to LOS would be gained through the reduction of the cycle time. In a subsequent stage of the project, each signalised pedestrian crossing will be looked at individually to determine which method can best improve the LOS for pedestrians.

The methodology is easily transferrable to areas outside of the central city, and is applicable to other cities. Another major city has already expressed an interest in applying the methodology.

The underlying hypothesis of this project is that improving the pedestrian level of service of the central city will increase prosperity.

INTRODUCTION

This paper describes an investigation to improve pedestrian level of service (LOS) at signalised intersections in the Christchurch central city. The investigation was initiated from the recommendations of a study undertaken in 2009 by Gehl Architects, which considered how people use public spaces and streets in central Christchurch. The Christchurch City Council subsequently adopted A City for People Action Plan (CCC, 2010) for the implementation of 66 actions identified in the study. The actions relevant to this project are:

> *Action 2 of the Top Five (p.15) – Central City Street upgrades to improve pedestrian priority and amenity; establish 30 kph 'slow core'*
>
> *Action 4 (in two parts; p.16) Review LTCCP levels of service to provide better recognition of pedestrians; and Review traffic lights (SCATS) operations with the objective of providing higher pedestrian priority including extended 'green person' crossing times*

The objective of the action plan is to lay the foundation "for future growth and prosperity".

The CCC Action Plan focused on the area bounded by Kilmore Street, Rolleston Ave, St Asaph Street and Madras Street. This area has been adopted for this study, and there are 32 intersections with traffic signals as shown in Figure 1, with those intersections totalling 110 signalised pedestrian crossings.

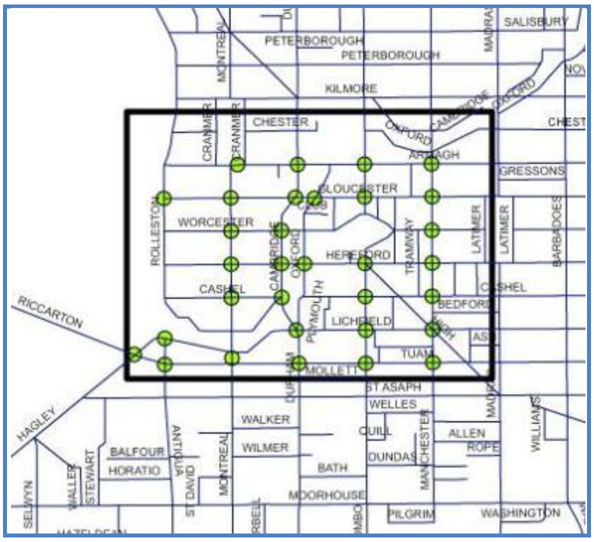

Figure 1: Study area (traffic lights highlighted)

Stage 1 of the study involved developing a methodology to measure existing levels of service (LOS) for each cross walk in the study area, allocating a LOS score to each signalised pedestrian crossing and identifying measures which improve the LOS. Stage 2 will determine the preferred improvement option for each signalised pedestrian crossing. The improvements possible as part of this project were restricted to changing traffic signals operations and adjusting signals hardware; physical changes to the road configuration were not within the scope of this project.

This paper outlines the findings of Stage 1.

METHODOLOGY

This section outlines the level of service (LOS) concept and how it is defined with respect to this project.

LOS concept

Level of service is an accepted measure used to determine the effectiveness of elements of transportation infrastructure. While this measure is common for motor vehicles, there are no standard LOS methods available in New Zealand for pedestrian facilities at traffic signals. The Pedestrian Planning and Design Guide (NZTA, 2007) illustrates a LOS method for delay at uncontrolled crossing points and how this can be improved through physical changes. Other methods in NZ such as the Community Street Review (NZTA, 2010) and the Non-motorised User Audit (NMU Audit) (NZTA, 2006) can help identify problem walking environments.

A simple to use but robust LOS method was developed for the scope of this project in order to assess factors specifically relevant to signal timing. This method is described below.

Defining level of service

For the purpose of this investigation, the level of service for pedestrians at traffic signals is confined to factors that are related to geometric (crossing distance), operational (delay and green time) and traffic characteristics (volumes of opposing vehicles). Factors related to quality of the pedestrian environment (footpath surfaces, tactile pavers, kerb cut down alignment etc) have not been considered in the LOS process.

Safety is obviously important in terms of a good pedestrian environment, however it was not considered appropriate to include any crash data into the LOS scoring. This is primarily due to the fact that few pedestrian crashes are recorded in the crash database, resulting in a lack of a statistically reliable dataset. However, the risk of a pedestrian being involved in a crash has been accounted for by applying engineering judgement, in the 'exposure to risk' factor of the LOS methodology.

This approach has allowed the LOS definition to apply to all pedestrians regardless of ability as all the characteristics assessed are applicable to able bodied and impaired users.

The following four measures have been used to assign LOS scores to each signalised pedestrian crossing:

1. **Crossing distance**: measured from the point where a crossing pedestrian would first become exposed to passing traffic until the point where the pedestrian is once again clear of the passing stream.
2. **Delay time**: the average length of time before a walk phase begins.
3. **Green time ratio**: the ratio of delay to green walk time.
4. **Exposure to risk**: assess the conflicting turning volumes in the peak.

These are now explained in more detail in terms of how they are scored.

LOS criterion 1 – Crossing distance

The distance required to cross an intersection is considered part of the level of service experienced by pedestrians, although more so at uncontrolled crossings. As part of the LOS for Christchurch we considered the distance was important in terms of comparing the signalised pedestrian crossings.

The shorter the crossing distance, the higher the level of service is. In the USA it is considered desirable that signalised pedestrian crossings are less than 60 feet (18.3 m) (Dixon, 1997). Urban street widths in NZ are generally considerably less than this (there are no NZ standards on street width) and the length of most signalised pedestrian crossings in the Christchurch central city is around 14 metres (refer Figure 2).

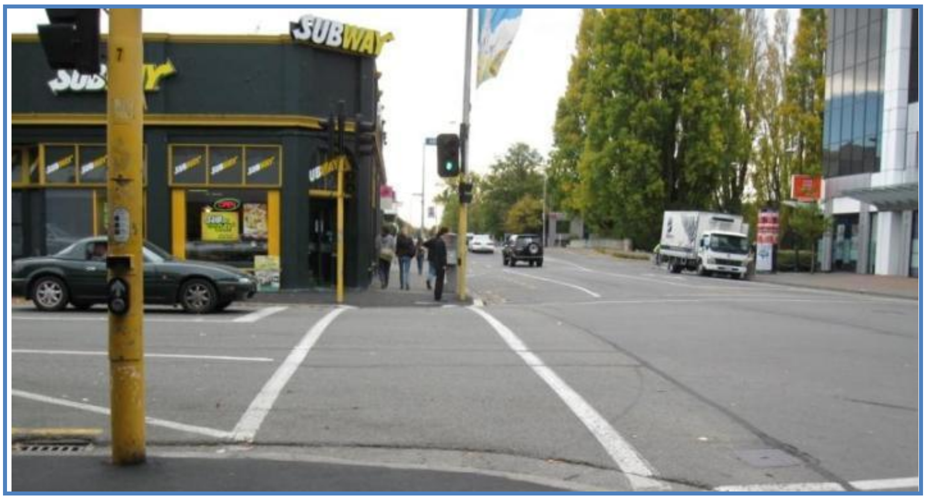

Figure 2: Typical 14 m wide signalised pedestrian crossing in the central city (Armagh / Manchester intersection)

On this basis the scores for distance were assigned as per Table 1.

Table 1: Crossing distance scores

LOS Criterion	Crossing distance (m)	Score
Crossing distance	Less than 10	100
	10 to 13.5	70
	13.6 to 17	40
	Greater than 17	0

Sensitivity testing undertaken on these values showed that there was limited overall change to the score and ranking within the list of signalised pedestrian crossings.

LOS criterion 2 – Delay time

Delay experienced by pedestrians at intersections has a significant impact on their LOS. Long delays can result in pedestrian non-compliance at traffic signals, as supported by research showing that pedestrian impatience and risk taking behaviour increases after 30 seconds (Kaiser, 1994).

The delay used in the LOS scoring is based on the average delay per pedestrian. This is determined on the basis that all pedestrians arriving during the pedestrian clearance time and the pedestrian steady red time will wait until the beginning of the pedestrian green period. The delay (D) is determined from the following equation (Braun and Roddin, 1978), where C = cycle time and G = green time.

$$D = \frac{(C-G)^2}{2C}$$

For most intersections in the central city, where the cycle time is 80 seconds, the average delay was found to be 34 seconds. Compared to the two other major cities in NZ (Auckland and Wellington), this delay is actually quite low (Vallyon et al, 2009) and setting a maximum delay threshold at 35 seconds reflected a realistic scenario for Christchurch. However, this is based on the current transport network that accommodates high traffic movements through the central city; in time lower traffic volumes could enable lower cycle times with little impact on vehicular delay.

On this basis the scores for delay were assigned as per Table 2.

Table 2: Delay scores

LOS Criterion	Average delay (seconds)	Score
Average delay per pedestrian	Less than 14	100
	14 to 22	70
	22 to 35	40
	Greater than 35	0

Sensitivity testing was undertaken on a range of threshold values and as discussed above, the scoring was very sensitive to the maximum threshold, given the high proportion of signalised pedestrian crossings with delays of 34 seconds. This affected the final LOS score allocated to each signalised pedestrian crossing.

LOS criterion 3 – Green time ratio

The green time ratio was a criterion developed as part of this project; we could not find any other method that used this. It was felt that a measure that considers the available green time in relation to the average delay provides a useful proxy for how much time the system allocates to pedestrians. The green time is generally 6 seconds, however signalised pedestrian crossings on one way street approaches have a longer green time as there are no opposing movements and the majority of the phase time can be utilised. A small delay and long green time will result in a low ratio and hence a higher score.

As with the delay criterion, most intersections in the central city have a cycle time of 80 seconds, and where the green time is 6 seconds, the green time ratio is 5.7. We therefore concluded that setting the maximum at 6 reflected a realistic scenario. It needs to be noted that the green time ratio and the delay criterion are somewhat interrelated, and consequently there is a degree of double counting occurring. Table 3 outlines the scores for green time ratio.

Table 3: Green time ratio scores

LOS Criterion	Ratio	Score
Green time ratio	Less than 1	100
	1 – 3.5	70
	3.5 – 6	40
	Greater than 6	0

As expected the sensitivity testing undertaken on these values showed that the scoring was very sensitive to the maximum threshold chosen.

LOS criterion 4 – Risk

The risk criterion considered the volume of conflicting traffic volumes against pedestrian volumes. The logic is that the greater the amount of conflicting traffic, the higher the risk to a pedestrian. This was further developed to allow consideration of the types of conflicting movements, left turning, right turning or both. A risk matrix was developed to reflect the traffic movement bands and the relative pedestrian movement bands. The matrix also allows for the scenario of when there is high traffic and low pedestrian movements, where the risk to the individual is actually increased as the ‘safety in numbers’ effect is not present.

Once the score was determined for each signalised pedestrian crossing based on traffic and pedestrian volumes, the protection regimes already in place (such as red arrows) and geometric factors (such as visibility issues) were considered and where appropriate, the scores adjusted. Table 4 illustrates the risk matrix developed.

Table 4: Risk scores

Vehicle conflicts with pedestrian movements	Peak volume (am + pm)	Score		
Both Right Turn and Left Turn	**>600**	0	0	0
	250-600	12	18	25
	<250	30	40	50
Right turn only	**>400**	5	15	25
	150-400	30	40	50
	<150	55	65	75
Left turn only	**>500**	30	40	50
	150-500	55	65	75
	<150	70	80	90
No conflicting movements	**NA**	100	100	100
		<6	**6 – 25**	**>25**
		Pedestrian movements per 5 min during count period		

Sensitivity testing was undertaken on a range of threshold values and the final values considered to be robust, in terms of the expected relative scoring between signalised pedestrian crossings.

Overall LOS score

Before the four LOS criterion scores were combined to provide an overall signalised pedestrian crossing score, a weighting was applied to each criterion score as shown in Table 5. This weighting approach was considered necessary as each LOS criterion has differing influence on the level of service to pedestrians and can therefore not be treated equally, as discussed below.

Table 5: Criterion weighting

LOS Criterion	Weighting
Crossing distance	10%
Delay	25%
Green time ratio	25%
Risk	40%

Risk was considered the most influential on level of service and therefore needed to be weighted higher than the other criteria. This approach was supported by a LOS study undertaken in Japan (Muraleetharan, 2005), where pedestrians were asked about their experiences crossing at traffic signals, where perceived risk was stated as the major factor. A user survey undertaken by ViaStrada (2008) for the Bealey Avenue / Colombo Street intersection (refer Figure 3) also found that the risk presented by vehicles turning across the signalised pedestrian crossing while pedestrians were crossing was a serious concern to pedestrians.

Figure 3: Pedestrian stranded on the median on Bealey Ave at Colombo St

Delay and the green time ratio were considered equal to each other in terms of their influence in defining level of service. As this project was not able to reduce crossing distances (physical changes are beyond the scope), the crossing distance was considered the least influential. On this basis we allocated 40% of the score to risk, 25% each to delay and green time ratio, and 10% weighting to the crossing distance.

Allocating a LOS rating

Once a final score was determined, a LOS rating was allocated to each signalised pedestrian crossing. The rating system uses the traditional traffic engineering approach of a LOS A through to F. Signalised pedestrian crossings with a LOS of A have the best level of service, and a LOS of F indicates the lowest level of service.

Table 6 outlines the lower and upper bounds applied; these are based on almost equal bandings across A to F. The bounds that apply to each rating are unique to this project.

Table 6: LOS rating allocations

LOS Criterion	Lower bound score	Upper bound score
A	100	83
B	82.9	66
C	65.9	49
D	48.9	32
E	31.9	16
F	15.9	0

CURRENT LEVEL OF SERVICE

Signalised pedestrian crossings at the 32 signalised intersections in the study area have been assessed for their level of service. This made use of the following data:

- the CCC traffic signal plans for phasing information;
- operational information from SCATS (the software used to operate the traffic signals);
- pedestrian volumes (obtained through short counts during site visits); and
- traffic volumes for conflicting movements (obtained from CCC turning counts).

From the various inputs a spreadsheet was developed to enable the quantitative assessment of each signalised pedestrian crossing. The LOS criteria and associated weighting were applied, and the LOS rating allocated as described above and shown in Table 6.

Table 7: Distribution of the LOS rating across the signalised pedestrian crossings

LOS	Number of signalised pedestrian crossings
A	9
B	15
C	15
D	53
E	18
F	0

The numerical distribution of the LOS ratings across the 110 signalised pedestrian crossings is shown in Table 7.

It was found that 22% of the signalised pedestrian crossings in the study area have a LOS of A or B; the remaining signalised pedestrian crossings are LOS C, D or E. No signalised pedestrian crossings scored a LOS F.

The signalised pedestrian crossings rated with a LOS A are located on one way street approaches where the walk time is high and there are no conflicting traffic movements. The signalised pedestrian crossings rated with a LOS E have low risk scores indicating that protection regimes will be useful to consider in the next project stage. There is no strong correlation between the overall signalised pedestrian crossing LOS and their length.

Figure 4 shows the geographical distribution of LOS at the signalised pedestrian crossings.

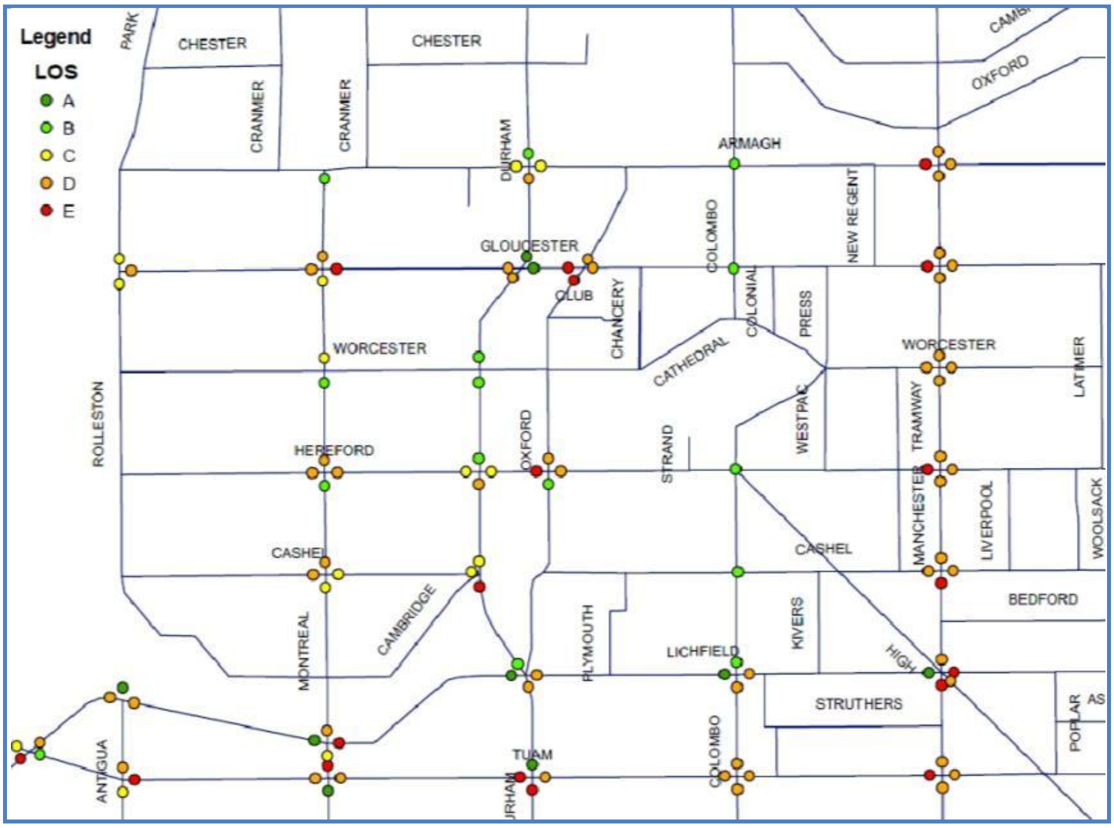

Figure 4: Distribution of LOS at individual signalised pedestrian crossings

METHODS TO IMPROVE LEVEL OF SERVICE

To improve the level of service of a signalised pedestrian crossing, there are a range of potential methods that could be used. Most methods directly influence the LOS score. Some methods may improve the perceived level of service, but their impact is not measured by the four LOS criteria; these are captured in a column labelled 'Perception'. Table 8 lists the methods that will be discussed in detail in this section and how they relate to level of service. In terms of pedestrian improvements, a double plus (++) indicates a definite benefit, a single plus (+) is a possible benefit and a minus (–) is a possible disbenefit.

Methods that influence the LOS score

Reducing the cycle time will reduce the average delay and improve the green time ratio. As an example, if the cycle time for the Armagh Street / Manchester Street intersection (refer Figure 2) is reduced from 80 seconds to 40 seconds, the average delay for western signalised pedestrian crossing decreases from 34 seconds to 14 seconds and the green time ratio improves from 5.7 to 2.4. This results in the LOS overall score increasing from 29 to 44, and the rating moves from LOS E to LOS D.

However this method will increase vehicular delays at most intersections in the study area. There may be opportunities to reduce cycle times at times other than the peaks (as higher traffic demands require higher cycle times, hence cycle times can be reduced during non-peak times); this would require some modelling to assess the impacts on the network.

Table 8: LOS improvement methods

LOS criterion / Treatment	LOS 1 Crossing distance	LOS 2 Delay	LOS 3 Green time ratio	LOS 4 Risk	Perception
Traffic signals changes and modifications					
Reduce cycle time		++	++		
Lengthen pedestrian phase		++	++	-	
Barnes Dance	+	+	+	++	
Phasing changes				++	
Protection against conflicting movements				++	
Pedestrian 'green waves'		+	+		
Pedestrian countdown timers					++
Automatic call changes		+			++
Resting signals in pedestrian phase					
Near side signals					++
Physical changes to the surrounding infrastructure					
Reduce number of turning lanes				++	
Kerb build outs	++				
Retrofit signalised pedestrian crossings				++	

Lengthening the pedestrian phase will also reduce the average delay and green time ratio but not to the same extent. Using the Armagh Street / Manchester Street intersection example once more, if the green time is increased from 6 seconds to 12 seconds, the average delay for western signalised pedestrian crossing decreases from 34 seconds to 29 seconds and the green time ratio improves from 5.7 to 2.4. This results in the LOS overall score increasing from 29 to 36, and the rating moves from LOS E to LOS D.

The lengthening of the pedestrian phase is a method that will increase vehicular delays at most intersections in the study area; but to a lesser extent than that of reducing the cycle time. There may be opportunities to increase the green time at times other than the vehicular peaks. This could be achieved through adopting the 'walk for green' approach, which involves the SCATS system adjusting the green time to its maximum for each cycle in relation to the available cycle time. This approach is currently used at many intersections in Wellington (e.g. along Featherston Street and along the waterfront). A potential risk with increasing the green time is increased exposure of pedestrians to turning traffic.

The comparison exercise undertaken for the western signalised pedestrian crossing of the Armagh Street / Manchester Street intersection above was extended to three other signalised pedestrian crossings in the study area. The results of the comparison were plotted for various cycle times and green times. As can be seen in Figure 5 (where each coloured bar presents an individual signalised pedestrian crossing), a cycle time reduction to 50 seconds achieves the same overall LOS score as a lengthened walk time of 12 seconds (with a baseline cycle time of 80 seconds). However, a cycle time reduction to 40 seconds results in a LOS score that is not equalled by a lengthened walk time of 14 seconds, as highlighted by the orange lines.

When comparing cycle time reduction and lengthening the walk time, it was concluded that the greatest LOS improvement is achieved through cycle time reduction.

When comparing cycle time reduction and lengthening the walk time, it was concluded that the greatest LOS improvement is achieved through cycle time reduction. However there is a need to balance the benefits with the impacts on motor vehicle capacity in the city, as too much delay is unlikely to be accepted. These impacts can be quantified in the next stage of the project for signalised pedestrian crossings where either of these methods is further investigated.

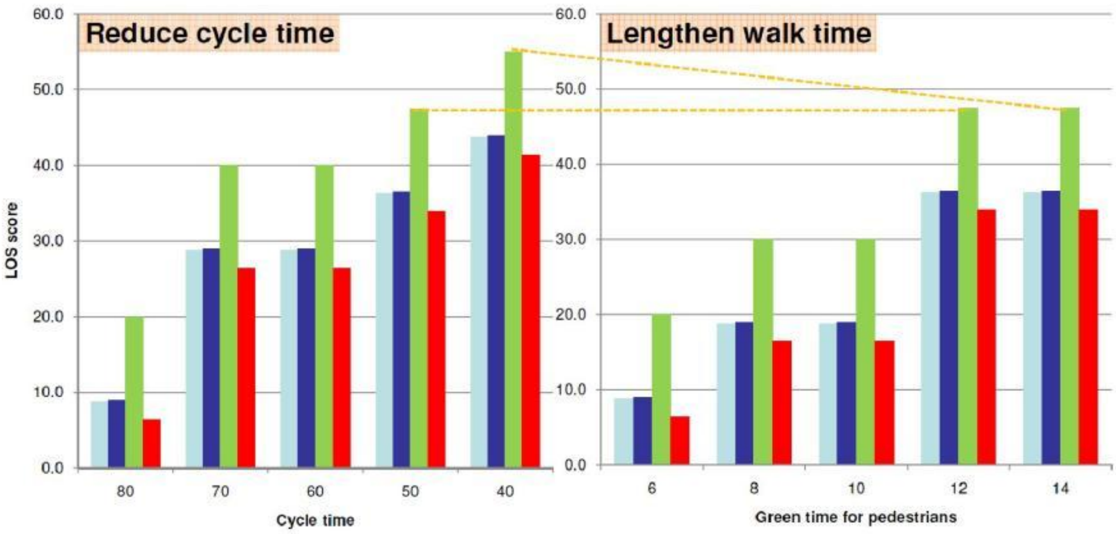

Figure 5: Comparison of cycle time reduction and lengthened walk time

The introduction of further **Barnes Dances** (all pedestrians cross at the same time, including diagonally) could reduce the average delay and green time ratio (if the cycle time is kept constant) for signalised pedestrian crossings with a poor LOS. However, any benefits gained for one of the signalised pedestrian crossings may not be achieved for the other signalised pedestrian crossings; this is the case for intersections where one approach may be a one way street, which currently has a high LOS.

This method will result in increased vehicular delay and is incompatible with reducing cycle time. There are limited opportunities in the study area to utilise this method.

Making **changes to the phasing** of an intersection could reduce the risk aspect if the pedestrian movement is run in a phase with less turning traffic or fewer issues, and at the same time lengthen the walk time (i.e. improving the LOS). There are few intersections with more than two phases in the study area, so opportunities are limited.

Protection against conflicting traffic will improve the risk criterion score. Protection can include the provision of red arrows to hold back turning traffic, or giving the pedestrian an advance green man ahead of the vehicles moving. This can only be achieved where exclusive turn lanes exist. For example, if right turning traffic with limited forward visibility (from Durham Street into Gloucester Street) that crosses the western signalised pedestrian crossing is held back, the LOS D can be improved to LOS C.

The implication of protection regimes is the potential delay experienced by motor vehicles, depending on how many vehicles are making that turn, and for how long they are being held back.

Another method of protection is **reducing the number of turning lanes** that conflict with the pedestrian movement. This type of physical change is not within the scope of the project, though.

Pedestrian **green waves** are the concept of providing a high level of service to a particular route through the provisions of timed arrivals. This approach would improve the delay LOS score. The option of a pedestrian green wave was seen to have little merit despite being technically challenging. With the variability in walking speeds, the difference in time between a fast pedestrian and a slow pedestrian both walking one block can be as much as half the cycle time of the signals. It is clearly impractical to provide coordination with such variability and be aiming to coordinate to a green window of only 10 sec of green walk time.

Reducing the crossing distance will improve the crossing distance criterion score. Physical road layout changes are outside of the scope of this project. However this tool may be used when intersections are upgraded in the future as a separate project, e.g. a safety improvement project.

Retrofitting signalised pedestrian crossings, although not improving an existing signalised pedestrian crossing LOS score, can aid the overall intersection level of service. This is also outside of the scope of this project.

Methods that improve the perceived level of service

Pedestrian countdown devices inform pedestrians of the time remaining before they can cross the road in the green man phase. They are used extensively overseas and were trialled in Auckland City. These devices have recently been included in the Traffic Control Devices (TCD) Rule, and their use will be restricted to midblock signals only and Barnes Dances (Ministry of Transport, 2010).

Figure 6: Nearside signal display (UK)

Nearside pedestrian signals are signal displays that are located adjacent to the pedestrian and are not visible to drivers as shown in Figure 6. As with the countdown timers, these have recently been included in the TCD Rule, and their use is also restricted to mid-block locations (Ministry of Transport, 2010).

Extending the automatic call arrangements will improve the perceived LOS through the lack of need to call the crossing phase. The extension to the current arrangement could include the zone this applies to, the hours of operation and the days of operation. For example the city's cultural precinct in the western part of the study area has high pedestrian movements in the weekends, so the automatic call could be extended to Saturdays and Sundays. This will be considered further by ViaStrada in Stage 2.

Resting signals in pedestrian phase at night will improve the perceived LOS through the lack of need to call the crossing phase. This method would be most appropriate at Barnes Dances. This will be considered further in Stage 2.

Removing pedestrian call buttons was initially raised as a potential method in the *Public Space Public Life* study. Gehl architects found them to be a system that required people to seek permission to cross the road, perceiving them an anti-pedestrian priority device. However in New Zealand the push buttons also serve another purpose – that of aiding the visually impaired. As long as this system is used, the push buttons cannot be removed.

IMPLEMENTATION OPTIONS

Given the results of the relative LOS rating for each signalised pedestrian crossing in the study area, and the potential tools available, possible implementation strategies were developed (see Table 9).

The largest improvement to LOS can be gained through the reduction of the cycle time. Therefore, this approach offers the greatest overall benefit in the study area. However due to the complexity of the traffic system, a strategy that applies an area-wide broad brush treatment, such as reducing the cycle time, may cause cumulative vehicular delays across the network.

Hence, a matrix of options was developed. This covered the various strategy approaches that are possible, what strategy approaches would go with every focus, and how those actions could then be applied to the network. There are three different ways that the strategy approaches could be applied to the network (in decreasing order of impact on the network):

- Apply to all 2 phase intersections, or
- Apply to all but the one way street intersections, or
- Consider each signalised pedestrian crossing on its merits.

The decision was to look at each signalised pedestrian crossing on its merits and decide which method best suits the characteristics of the intersections to improve the LOS. Table 9 shows the approach that will be taken during Stage 2 of the work.

Table 9: Implementation strategy options

	Focus of Strategy	Strategy Name
Try this first	Delay improvement strategies	Reduce cycle time – interpeak only
		Reduce cycle time – all times
Then look at these	Walk time improvement strategies	Lengthen walk time – by x%
		Lengthen walk time – all to y seconds
	Risk reduction strategies	Full protection
		Partial protection

The consideration of network effects and the use of traffic modelling (either as an isolated intersection or as part of a network model) are likely to be required where cycle time reductions are considered a feasible option. Finding project team agreement on acceptable reductions in LOS for motorists will be one of the more challenging parts of the Stage 2 project. It is evident that the system in place has developed over time with a view of maximising the system performance for drivers. There is a lot of scope for improvements for pedestrian LOS and the issue is finding the right balance with the previous approach.

Changes in LOS for motorists can be analysed on an intersection basis, or alternatively travel times on specific links could be looked at. The use of the Christchurch CBD Paramics model can inform the debate.

As the intersections that are rated LOS E have low risk scores (i.e. pedestrians are facing an above-average risk), the provision of protection regimes is likely to be a useful tool to improve these signalised pedestrian crossings.

CONCLUSIONS

As there was no suitable level of service (LOS) methodology available for pedestrians at traffic signals, one had to be developed for this study. It is based on four quantifiable criteria that take signalised pedestrian crossing characteristics, timing and risk into consideration. Each signalised pedestrian crossing was assessed individually. The LOS in the Christchurch study area compares favourably to central city locations in Wellington and Auckland. Even though the central city with its high pedestrian volumes was studied, it became clear that the traffic signal system has developed over the years with a clear view of maximising its performance for motorised traffic. Consequently, there is significant scope for improving system performance for pedestrians.

A range of tools has been identified that can be used for improving LOS for pedestrians. Some tools directly affect the LOS rating, whereas other tools may result in a perceived improvement, which is not quantifiable with the method presented here. The scope of this particular work excludes physical works beyond additional traffic signal hardware, which thus excludes some of the possible tools. It was found that overall, decreasing cycle time is more effective for pedestrian LOS improvements than an increase in pedestrian green walk time. Apart from network wide considerations, each signalised pedestrian crossing needs to be looked at individually in order to identify opportunities and address particular problems.

At the next project stage, once detailed proposals have been determined, microsimulation modelling is likely to be employed to test the improvements that will be put forward for each signalised pedestrian crossing. Once the feasibility of the proposals has been confirmed, the pedestrian LOS analysis can be repeated. Hence, changes in network performance for motorists can be reported from the outputs of the microsimulation model, whilst changes for pedestrians can be quantified by the spreadsheet analysis introduced here.

The underlying hypothesis of this project is that improving the pedestrian level of service of the central city will increase prosperity. The project is well on its way to achieve the level of service improvements.

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