Quantifying the economic and other benefits of enabling priority bus egress from bus stops

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Abbreviations and acronyms

AADT	average annual daily traffic
ACC	Accident Compensation Corporation
AT	Auckland Transport
BCR	benefit–cost ratio
CAS	NZ Transport Agency Crash Analysis System
CCTV	closed circuit television
CUTA	Canadian Urban Transit Association
DHSMV	Florida Department of Highway Safety and Motor Vehicles
ECAN	Environment Canterbury
EEM	*Economic evaluation manual* (NZ Transport Agency)
LED	light emitting diode
NPT	number of passengers affected
MoT	Ministry of Transport
MUTCD	Manual on Uniform Traffic Control Devices
PT	public transport
VOC	vehicle operating costs
YTB	yield to bus

N.B. When referring to North American literature, or in the context of North American studies, the term ‘yield’ is used and is equivalent in interpretation to ‘give way’ in New Zealand.

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Executive summary

Bus services in New Zealand do not have priority over other road users when exiting a bus stop into general traffic lanes. Buses re-enter traffic numerous times over a route and any delay has a compounding effect significantly impacting on travel time reliability, schedule adherence and the overall efficiency of network operations.

The purpose of the research project was to identify these delays and quantify the economic and other benefits that would result if buses had priority when exiting bus stops to merge into general traffic lanes. The research will form an evidence base from which existing regulatory settings could be reviewed with a focus on improving public transport investment and optimising infrastructure.

The specific objectives of the research were to:

- undertake a literature review to report on existing and evolving international best practice and known case studies. This would take into account and complement existing NZ Transport Agency (the Transport Agency) research relating to bus priority and increasing public transport efficiency
- examine general driver attitudes to a potential give way to buses rule
- understand the trade-offs between facilitating improved travel of buses and disbenefits to other traffic including travel time and safety aspects
- identify safety concerns with a rule change
- quantify travel time delays, operational efficiency and public transport customer disbenefits of the significant delays buses experience re-entering traffic at each bus stop
- compile robust evidence to support decision making with a focus on improving existing services and optimising infrastructure.

A review of the national and international literature was undertaken to identify studies that provide evidence of benefits or disbenefits to a transport network through the provision of priority bus egress at bus stops. Bus priority egress laws vary across different states, jurisdictions and countries along with their implementation and enforcement. The most distinct differences found were in the use of signage, pavement markings and education campaigns that supported the schemes. The research also briefly explored the perception of public transport in New Zealand. Reliability, performance and journey time were identified as the most significant attributes in the perception and satisfaction with public transport.

Consultation was undertaken with key stakeholders, and the views and experiences of road users were gathered through focus groups to understand experiences and current practices relating to bus egress movements and the likely implications of a change in give way legislation. The benefits of bus egress priority identified through the consultation and focus group engagement included:

- public transport reliability
- schedule adherence
- increased patronage
- reduced bus driver stress and frustration
- economic and sustainability benefits
- smoother ride and greater vehicle efficiency.

To quantify the economic and other benefits arising from a legislative change to prioritise bus egress movements a comprehensive data set was compiled using delays measured from video observations at five locations, on-board bus survey data and transaction records from the Auckland bus network on a typical day.

Montecarlo simulation was undertaken to calculate passenger and vehicle travel time benefits. A network wide total of 29.5 hours per day of delays to buses across all scheduled services was calculated. This is a measure of the estimated potential travel time savings for buses in the Auckland Region if a legislation change was effective in obtaining a 100% compliance of vehicles giving way to buses where it was safe to do so. This network wide travel time saving is the cornerstone for subsequent economic analysis to quantify the benefits of a legislation change.

There was no conclusive evidence to suggest an amendment to the existing Land Transport (Road User) Rule 2004 would result in better or worse road safety outcomes, based on New Zealand crash history records, literature review findings, stakeholder consultation or international case studies. International literature suggests some positive safety impacts may arise due to increased bus patronage, clarity of right-of-way at bus stops, and reduced friction and lane changes of motorists; however, this has not been substantiated and is not considered a tangible benefit.

The NZ Transport Agency's economic evaluation framework has been applied to quantify the tangible benefits of a law change. Travel time savings for buses and bus users and delays to general traffic were calculated from data collected from video observations of bus stop egress behaviour in Auckland and Christchurch, and during on-board travel surveys conducted on the Auckland network. These results were expanded based on transaction data from Auckland Transport HOP Card records and enabled tangible benefits to be quantified for the entire Auckland network, which in turn were expanded to calculate nationwide benefits.

The tangible costs of a legislation change largely relate to the costs associated with implementing a legislation change, the disbenefits to other general traffic, as well as any road marking and signage costs. International literature clearly shows that compliance rates and the success of give way to bus schemes are positively correlated to the extent of signage and education campaigns implemented. The costs of on-bus signage may be a significant portion of the implementation costs. Subsequently the economic analysis explored three signage options: LED signs, decals and no signage. Each of these was evaluated with robust assumptions concerning likely give way compliance outcomes.

Overall the assessment concluded that 'give way to bus' legislation provided a viable investment opportunity with resultant nationwide benefit–cost ratios (BCRs) ranging from 4.0 using LED signage to 4.5 using bus decals. A number of sensitivity test scenarios were assessed to ascertain the likely range of BCRs when a number of input assumptions were changed. This sensitivity analysis provided confidence in the robustness around the BCR calculations, with the BCRs being within a range of 2.9 through 8.7 as outlined in the table below. The significant up-front cost of investing in LED technology results in lower BCRs for the corresponding scenario however the decal and no signage options yield similar ranges of BCR.

Scenario	LED BCR	Decal BCR	No signage BCR
Default analysis	4.0	4.5	4.3
Maximum BCR	4.8	5.7	8.7
Minimum BCR	3.3	3.7	2.9

This study provides an evidence based input to inform further review of the existing regulatory settings and aid any policy decisions to increase the priority of buses on the New Zealand road network. Further contributions to consider may include:

- a review of possible 'give way to bus' schemes and types of implementation that would best suit the New Zealand road environment, and the most effective application of signage and road markings to achieve the greatest compliance levels should also be considered.
- a detailed assessment of the likely costs associated with an amendment to existing give way legislation. This would allow the cost side of this research to be firmed up and give a more accurate estimation of the likely realisable benefits.
- an evaluation of the change in give way legislation using the business case approach to give a full measure of investment performance.
- a review of the formula for calculating public transport reliability benefits as published in the *Economic evaluation manual* A18.1 (NZ Transport Agency 2013a). Confirmation of a value for time would reduce the ambiguity in application of the published formula.
- investigation into increasing priority measures for buses to include lane change and right turn movements on congested corridors.

Abstract

Buses are finding it progressively difficult to reenter traffic from a bus stop in urban areas. While there has been a focus on improving the efficiency and effectiveness of public transport through the introduction of electronic ticketing, bus lanes and priority traffic signals in recent years, buses in New Zealand currently rely solely on other road users' courtesy to merge back into general traffic flow when egressing from a bus stop. This research project identified and quantified the economic and other benefits that would likely arise if a change in legislation allowed buses leaving bus stops to have priority over general traffic.

The research explored international 'yield to bus' legislation and examined road user attitudes towards a potential give way to buses law change and the likely impacts of facilitating priority for buses at a network level. An economic assessment has enabled tangible values to be attributed to the likely benefits arising from a law change under a range of implementation and compliance scenarios.

This report provides an evidence-based assessment of the efficiency of a legislation change concluding that 'give way to bus' legislation provides a viable investment opportunity. The outcomes will aid a review of the existing regulatory setting and provide evidenced-based inputs to compile a full business case.

1 Introduction

The NZ Transport Agency (the Transport Agency) contracted Abley Transportation Consultants to quantify the economic and other benefits of a change in regulation to enable buses leaving bus stops to have priority merging into the general traffic flow.

With a trend of increasing congestion in urban areas during peak periods it is increasingly difficult for buses to reenter traffic flows from a bus stop. While there has been a focus on improving the efficiency and effectiveness of public transport through the introduction of electronic ticketing, bus lanes and priority traffic signals in recent years, buses in New Zealand do not have priority when egressing from a bus stop into general traffic. As a result, frequent delays can occur impacting on service reliability and operational costs.

The purpose of the research project was to identify these delays and quantify the economic and other benefits that would result if buses had priority when exiting bus stops to merge into general traffic lanes, in order to form an evidence base from which existing regulatory settings can be reviewed with a focus to improve public transport investment and optimise infrastructure.

The specific objectives of the research were to:

- undertake a literature review to report on existing and evolving international best practice and known case studies. This takes into account and complements existing NZ Transport Agency research relating to bus priority and increasing public transport efficiency
- examine general driver attitudes to potential give way to buses rule
- understand the trade-offs between facilitating improved travel of buses and disbenefits to other traffic including travel time and safety aspects
- identify safety concerns with a rule change
- quantify travel time delays, operational efficiency and public transport customer disbenefits of the significant delays buses experience re-entering traffic at each bus stop
- re-evaluate current regulatory settings with a focus on improving existing services and optimising infrastructure
- compile robust evidence to support decision making
- produce a comprehensive research report outlining the key findings of the report and an indicative implementation plan for disseminating and promoting the research.

A key strategic goal of the government is to improve the effectiveness and efficiency of public transport. A substantial amount of investment in recent years has gone into making efficiency gains through the implementation of electronic ticketing systems, bus lanes and traffic signal priority. Bus priority egress from bus stops is another potential implementation measure that could support and synergise the effectiveness of these public transport prioritisation strategies.

Reliability and punctuality are consistently rated as the most important factors influencing customers' decision to use public transport (Vincent 2008). If the implementation of bus egress priority can significantly improve the reliability of public transport this is expected to have a positive impact on patronage. This is consistent with the initiative of encouraging public transport service reliability and punctuality in the *Improving public transport effectiveness draft action plan* (Public Transport Leadership Forum 2010).

Identifying and quantifying the benefits or disbenefits associated with a legislative change will clarify the trade-offs between improving travel times and reliability of buses with the increased delays and travel times for other road users. This will focus on improving existing network services and optimisation of public transport investment and provide robust evidence to support decision making in a review of the current give way regulations.

This report provides an evidence-based assessment of the efficiency of a legislation change and presents the findings arising from all the research stages. The contents of the report are itemised in section 1.1.

1.1 Report structure

The report is organised as follows:

- Chapter 2 provides background for the research and outlines some key terms important to the context of the research. The chapter then presents the findings of international and New Zealand literature on bus priority egress at bus stops and considers the potential benefits and disbenefits associated with a legislative change.
- Chapter 3 provides a summary of the feedback received through consultation with key transport stakeholders.
- Chapter 4 uses focus groups to examine a wide range of different road users' attitudes, views and experiences to develop further understanding of current on-street behaviour and perception towards a law change.
- Chapter 5 expands upon the earlier reporting with a specific focus on developing case studies based on international experiences and knowledge.
- Chapter 6 provides an assessment of current on-street practices and behaviour in a total of five locations split between Auckland and Christchurch, where current driver behaviour at bus stops was observed during both peak and off-peak periods. These were supplemented by on-vehicle surveys in Auckland.
- Chapter 7 quantifies the tangible and defines the non-tangible benefits arising from a change in legislation.
- Chapters 8 presents the research conclusions.

2 Literature review

2.1 Introduction

A review was undertaken of New Zealand and international literature on priority bus egress and related matters. This chapter begins by defining key concepts and how they are regarded in the context of an economic evaluation in the New Zealand government framework, followed by a review of literature on:

- current New Zealand legislation and contractual obligations with regional councils
- international legislation and convention on prioritising bus movements
- the role of road markings and signage to support bus egress priority
- perception of public transport
- benefits and disbenefits associated with a legislative change.

2.2 Current New Zealand legislation and contractual obligations with regional councils

In New Zealand, the Land Transport (Road User) Rule 2004 (part 4; clauses 4.1–4.7) (Land Transport NZ 2005) is the current legislation governing the behaviour of vehicles on New Zealand roads in relation to stopping and giving way. Clauses under part 4 do not make any provisions for vehicles re-entering the flow of traffic from a stationary position.

The contractual arrangements between some regional councils and their bus operators has been found to have specific requirements in relation to give way signage despite this not being a legislative requirement. Any requirements for the bus operators in New Zealand to display 'Give Way to the Bus' signage on buses is merely a request for courtesy from other road users, but is not mandatory at a legislative level and therefore not enforceable.

Under the vehicle specifications of the partnering agreement between Environment Canterbury Regional Council and their bus operators, there is a requirement for Please Give Way signs to be installed on all buses operating on the Metro network, the region's public transport network. The specifications within the partnering agreement require a reflective white vinyl sign including the words Please Give Way to be displayed on the lower right-hand side of the back of the vehicle. On buses with a rear window, signage must be positioned on the lower right-hand side of the rear window as demonstrated in figure 2.1. The signage must be visible to traffic at all times, including when full vinyl bus backs are applied for advertising purposes.

Figure 2.1 Environment Canterbury give way signage specifications

Conversely, the Greater Wellington Regional Council does not have any contractual requirements for the operators to display the Please Give Way signage on buses operating routes on Metlink, the region's public transport network. No signage has been observed in the Auckland region.

In April 2012, the Green Party's Land Transport (Give Way to Buses) Members Bill (Genter 2012) was on the Order Paper for the first reading within the New Zealand Parliament (House). The bill stipulated the rule would only apply in urban areas where the speed limits are 60km/h or less. The clauses within the bill also stipulated bus drivers would be required to 'signal for 3 seconds before pulling out'. The bill was not drawn from the ballot of Notices of Proposal and therefore not debated within the House.

2.3 International legislation and convention to prioritise bus movements

Giving priority to buses when leaving a bus stop was first introduced in Germany, France and Switzerland in the 1970s following a recommendation of the European Ministers of Transport Meeting at the 1968 Vienna Convention of Road Traffic as an approach to mitigate bus delays and maintain safety (King 2003). Three states in Australia as well as Quebec in Canada introduced bus priority regulations in the early 1980s; however, it was the 1990s and early 2000s before this legislation spread through North America. 'Yield to bus' (YTB) laws now exist in at least eight American states (Florida, California, Oregon, Washington, Colorado, Minnesota, New Jersey and Montana) and four Canadian provinces (Quebec, British Columbia, Nova Scotia and Ontario) (King 2003). As an initiative to improve the speed and reliability of buses, Singapore introduced a mandatory scheme to give priority to buses exiting marked bus bays in 2008.

Internationally, the implementation and enforcement of bus priority egress laws vary across different and states, jurisdictions and countries. Some of the legislative and enforcement approaches are detailed in the following sections – this is not an exhaustive list of examples but includes a representative set of countries considered to be the most similar to the New Zealand context.

2.3.1 Australia

Throughout Australia the Give Way to Buses road rule is largely consistent whereby in a built-up area general traffic must give way to a bus that is signalling to pull out from the kerb and is displaying a Give Way to Buses sign. There are no supplementary roadside signs or pavement markings specified to support the Give Way to Buses law in Australia.

Under Rule 77 of the Australian Road Rules (National Road Transport Commission 1999) 'a driver driving on a length of road in a built-up area, in the left lane or left line of traffic, or in a bicycle lane on the far left side of the road, must give way to a bus in front of the driver if;

a) the bus has stopped, or is moving slowly, at the far left side of the road, on a shoulder of the road, or in a bus-stop bay; and
b) the bus displays a give way to buses sign and the right direction indicator lights of the bus are operating; and
c) the bus is about to enter or proceed in the lane or line of traffic in which the driver is driving.'

By definition of this rule,'Give Way means the driver must slow down and, if necessary, stop to avoid a collision.

The driver of the bus, when changing direction by moving from a stationary position at the side of the road or in a median strip parking area, is required to signal a change of direction long enough to give sufficient warning to other motorists and pedestrians. Sufficient warning under this rule is giving the change of direction signal for at least five seconds before the driver changes direction.

Some states, such as Queensland, further specify that 'when you are driving in a built-up area where the speed limit is 70km/h or less, motorists must give way to a bus that displays the GIVE WAY sign on its rear right-hand side and is signalling to enter traffic from:

- a bus zone, bus stop or bus stop bay
- the shoulder of the road, or the left side of the road' (State of Queensland 2009).

The penalties for failing to comply with the Give Way to Buses rule can vary. In Western Australia the penalty is three demerit points (State of Western Australia 2000), while in Victoria (State of Victoria 2009) and Tasmania (State of Tasmania 2009) the penalty is five penalty points. Likewise in South Australia (State of South Australia 2014) the penalty is three demerit points but can also be a fine of up to $2,500. Queensland and New South Wales (State of New South Wales 2014) have penalties of up to 20 demerit points.

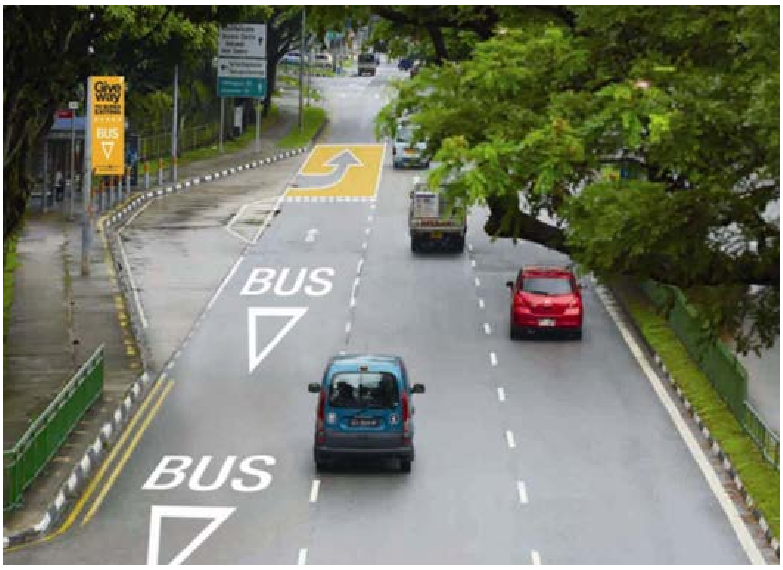
In Melbourne, the SmartBus scheme includes the provision of bus-friendly roadworks to improve bus reliability and the way buses move in and out of traffic (Public Transport Victoria 2015). One initiative to allow buses to more freely move in and out of traffic is to remove bus bays, with bus stops instead being placed in the kerbside traffic lane, which is similar to many bus stops in Queen Street, Auckland. This form of initiative provides bus egress priority without legislation but is likely to increase traffic delays especially on congested or high-volume corridors.

2.3.2 Singapore

The Mandatory Give Way to Buses scheme introduced in Singapore is different from other Give Way to Bus schemes seen internationally in that it initially applied to bus bays at selected bus stops along three specific bus routes as pictured in figure 2.3. The Land Transport Authority in Singapore was responsible for the implementation and monitoring of the pilot scheme. The scheme was trialled at 22 bus bays and the results of this trial found buses were able to exit the bus bays up to 73% faster. Given the positive results of the trial, the scheme has been expanded to additional bus stops over eight phases (Land Transport Authority 2014). As of November 2014, the scheme has been implemented at a total of 322 bus bays (One Motoring 2014).

The Land Transport Authority found an earlier study showed buses spent approximately 10% of their total journey time trying to exit from bus bays. The Authority stated it had previously tried to educate motorists to voluntarily give way to buses; however, with increasing demand for limited road space, and to meet commuters' rising expectation of a reliable and efficient public transport system, they felt it was imperative to make it mandatory for cars and other vehicles to give way to all buses exiting from bus bays and consequently speed up the journey of the majority who travel by buses (Land Transport Authority 2008).

Figure 2.2 Singapore mandatory give way to buses road markings and bus bay (source: One Motoring 2014)



2.3.3 Canada

In Canada the legislation governing the YTB came into effect in Quebec in 1982, British Columbia in 1999 and Nova Scotia in 2011. In Ontario, the YTB leaving bus bays provincial legislation came into effect in January 2004. This legislation was requested by the Association of Municipalities of Ontario, Canadian Urban Transit Association and several individual municipal transit systems with the aim of improving the flow of public transport in urban areas. Prior to the passing of the legislation, the Ministry of Transportation of Ontario (2014) found there were several transit systems (Toronto Transit Commission, OC Transport, Mississauga Transit) with voluntary programmes whereby motorists were encouraged to let the bus back in as a courtesy. The new legislation required buses to display the yield sign shown below on the rear of the bus.

The Ontario Highway Traffic Act 1990 (Ministry of Transportation of Ontario 1990, chapter H8 sec. chapter H8) is the legislation governing the YTB leaving bus bays rule which can be found under Rule 142.1 (1) stating 'every driver of a vehicle in the lane of traffic adjacent to a bus bay shall yield the right of way to the driver of a bus who has indicated his or her intention, as prescribed, to re-enter that lane from the bus bay'. Further to this, under Rule 142.1 (2) it is made clear the bus driver should not signal until ready, 'the driver of a bus shall not indicate his or her intention to re-enter the lane of traffic adjacent to a bus bay until the driver is ready to re-enter traffic'. Under Rule 142.1 (3) it goes on to specify when the bus must wait, stating 'no driver of a bus shall re-enter the lane of traffic adjacent to a bus bay and move into the path of a vehicle or street car if the vehicle or street car is so close that it is impractical for the driver to yield the right of way'.

The Ministry of Transportation of Ontario (2014) defines bus bays as bus stops that require buses to exit from and re-enter an adjacent lane of traffic. They include mid-block indented bays, the indentation in the sidewalk immediately before and after intersections, and bus stops between legally parked cars. In terms of enforcement, motorists failing to yield to buses can be fined CAN$90.

2.3.4 United States

In the US, seven states including Florida, Washington, Oregon, California, New Jersey, Minnesota and Colorado, have passed YTB laws. King (2003) states the primary purposes of implementing a YTB programme are to reduce delays and to enhance the safety of buses. The law is applied to make motorists yield to the bus when it attempts to re-enter traffic from a specifically designated bus pull-out bay (Zhou and Bromfield 2007). The laws vary in requirements and the circumstances under which motorists are required to yield. No fines or penalties have been specified for failing to yield, and they are largely unenforced. A number of studies have been carried out regarding YTB schemes and the supporting legislation in the United States. King (2003) undertook a study into the practices and experiences of YTB programmes at transit agencies in the states of California, Florida, Oregon, Washington and the province of British Columbia in Canada. Education, development and locations of YTB signage and identification and engagement with as many of the stakeholders as early as possible in the legislative process helps transit authorities ensure an effective YTB programme can be implemented.

Oregon, Washington, Minnesota, and Florida YTB laws state the basic requirement that motor vehicles should yield to publicly owned transit buses. In addition to this, Oregon, Washington, and Florida also state the bus driver should operate with due regard for the safety of all persons using the roadway. However, Oregon and California laws go further than this and define the specific yield signal to be implemented. Overtaking a bus is also classed as failure to yield the right-of-way under certain conditions. Originally, the New Jersey bill for the new YTB law specified a yield sign, but this was omitted from the law in 2004. In Washington State 40% of operators felt very few motorists were aware of YTB laws (King 2003).

Zhou and Bromfield (2007) found while the most effective technology used to supplement the YTB laws in North America is the flashing yield sign, different states may have different laws regarding the implementation of additional flashing lights on the backs of buses.

The *Manual on uniform traffic control devices* (MUTCD) (US Federal Highway Administration 2013) is the national standard in the US for all facets of using traffic control devices; however, each state differs in how it adopts the MUTCD and often includes a state supplement. MUTCD does not specify signage or pavement markings nor address any other traffic control devices for the YTB law. Zhou and Bromfield (2007) concluded roadside signage could provide additional information to motorists to warn them of the potential of buses merging into traffic. If a driver does not see the sign on the back of the bus, a roadside sign may serve to inform or remind them they must yield to the bus at bus bay locations. Roadside signage may not be necessary for all bus bay locations, but should be displayed at specific locations where rear-end collisions are high due to noncompliance with the YTB laws. Also, in high crash locations, additional pavement markings can be used to remind motorists to yield. Behzadi et al (2013) also reached the same conclusions stating 'the preferred traffic control device to support the YTB law is the roadside sign. Roadside signs provide a more direct message to the motorists than pavement markings'.

However, as many roads are already congested with roadway signs and pavement markings that give motorists more information than they are able to digest, any additional signs and pavement markings should be used with caution. Additional signs and pavement markings for the YTB law should be used under strict engineering judgment in areas where other measures may have failed (Zhou et al 2011).

In the case of Florida, YTB legislation has been law since 1999. Florida Statute 316.0815, duty to yield to public transit vehicles, requires 'the driver of a vehicle shall yield the right-of-way to a publicly owned transit bus travelling in the same direction which has signalled and is re-entering the traffic flow from a specifically designated pullout bay' and this 'does not relieve the driver of a public transit bus from the duty to drive with due regard for the safety of all persons using the roadway'. In the *Florida drivers handbook* (The Florida Department of Highway Safety and Motor Vehicles (DHSMV) 2015) under the 'Public transit' section it reiterates the legislative requirements.

Zhou et al (2011) reported the operational and safety effects of the YTB signage and law in Florida, and found even with the law implemented motorists typically did not yield to the bus and the decal currently implemented on the back of the bus had no significant safety or operational effect.

The study also found as Florida law made no mention of how the YTB law was to be implemented, this possibly contributed to the lack of law enforcement. Following the example of other states, it was recommended the Florida law be expanded to include a penalty for not yielding to a bus or a classification for the type of offence committed. DHSMV (2015) states that failure to yield to public transit vehicles carries a penalty of US$60 and three points. The viability of the law is partially dependent on how well it can be enforced and therefore, providing more information to inform motorists on the implementation of the law and penalties for failing to comply can be beneficial.

A system to evaluate the necessity of the law based on the total number of traffic collisions, traffic congestion issues, public opinion and the efficiency of transit operations was recommended by Zhou et al (2011). The current YTB law in Florida applies only to buses pulling out from a designated bus bay. The majority of bus operators there believed there were other conditions in which motorists should yield to a public transit bus, such as pulling out from shoulders and right-turn lanes, not just the specifically-designated bus pull-out bay. Other states have not specified that motorists should yield specifically at designated bus pull out bays, therefore buses that pull over in any off-line stop would be covered under the law.

2.3.5 Europe

Zhou and Bromfield (2007) found there is little information on the Give Way to Buses legislation in Europe because of:

> *a strong push for the exclusive bus lanes and other priority measures. In England and Germany, bus bays have been filled, and these stops have been turned into regular curb-side stops so that buses do not have the problem of re-entering the traffic. There seems to be more concern about the delay of buses than those of cars, so they allow cars to queue behind the bus. Implementation of the exclusive bus lanes also prevents bus merging problems.*

Nonetheless, Rule 223 of *The highway code* (Department for Transport UK 2015)) which relates to buses, coaches and trams states motorists are to:

> *give priority to these vehicles when you can do so safely, especially when they signal to pull away from stops. Look out for people getting off a bus or tram and crossing the road.*

Rules that are legal requirements within *The highway code*, which applies to England, Scotland and Wales, are identified by the use of the words 'must/must not' as opposed to rules that are advisory and use wording such as 'should/should not' or 'do/do not'. It is therefore not explicit that it is a legal requirement for motorists to give way to buses. It appears to be more a request to do so and consequently no penalties are identified for failing to give way to buses.

2.4 The role of road markings and signage

A number of sources stress the importance and effectiveness of flashing yield signs on the back of buses to supplement the YTB legislation, increase awareness of bus movements with other road users and reduce the likelihood of conflict.

Fabregas et al (2011) evaluate the effectiveness of the implementation of YTB legislation and an electronic merging sign on the back of buses in Florida by measuring the behaviour change of motorists behind buses in two locations. This study found the electronic merging sign had a significant effect on yielding behaviour, while the decal was less effective. Rear-view cameras aimed at the traffic behind the bus on a study corridor in Tampa observed 58% of motorists yielded to bus merging manoeuvres with buses using a decal on the back of the bus while this increased to 80% when buses used the electronic merging sign on the rear of a bus. A similar result was observed in Fort Myers, with 70% of motorists yielding for bus merging manoeuvres where the decal only was used and 88% when buses used the electronic merging sign on the rear of a bus.

In both the scenarios studied above, the electronic flashing 'Yield to Bus' signs increased the yield behaviour of motorists reducing the time buses were required to wait before being able to re-enter the general traffic stream. Buses in the Canterbury region are currently contractually obliged to use decals on the rear of buses requesting motorists to give way to the bus. There is no quantitative evidence to their current effectiveness; however, the Florida example suggests a legislative change in New Zealand supported by clear electronic signage on the back of buses would increase the number of motorists giving way to buses.

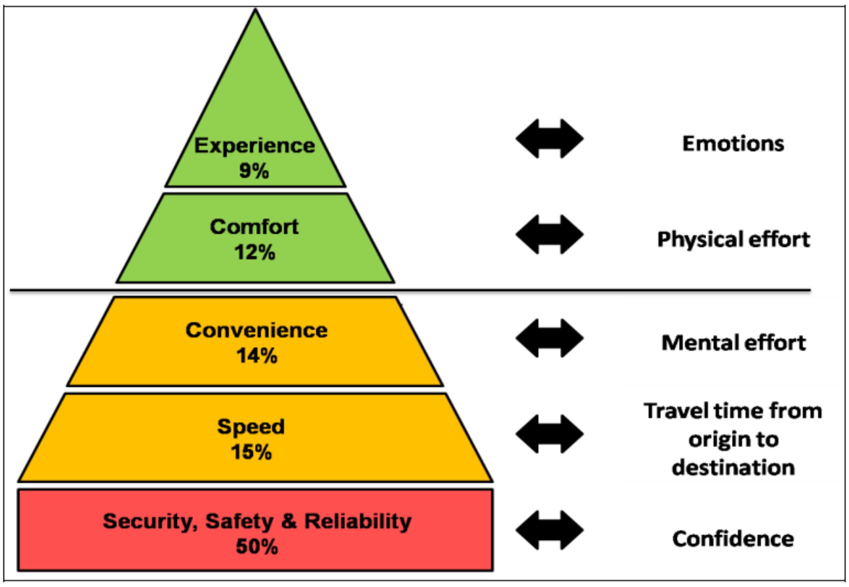
Roadside signage and additional pavement markings could be necessary at locations where rear-end incidents were high due to non-compliance with YTB laws. These measures provide motorists with additional information to warn them of the potential of buses merging back into the traffic (Zhou and Bromfield 2007).

2.5 Perception of public transport

Public perception often involves a disparity between the actual truth based on facts and evidence and a virtual truth shaped by opinions, rumours and reputation. Perceptions of modal reliability and the ability to meet people's needs can influence transport choices and opportunities. To understand the current public perception of public transport especially bus use, a brief review of current national and market research has been undertaken.

Five key aspects define public transport perception and are the most important quality aspects to determine the perception of a service and ultimately the mode choice of users and potential users (Van Dijk and Hitge 2012). As shown in figure 2.3 the dominant factor is security, safety and reliability with other factors carrying a smaller weighting.

Figure 2.3 Key aspects associated with perception of public transport (Van Dijk and Hitge 2012)



Vincent (2008) also highlights the importance of reliability on the perception of public transport services. There is a perceived lack of reliability associated with bus services due to delays in a congested environment, variance in travel times and an inability to meet time schedules.

Perception is directly linked to travel behaviour and mode choice therefore a decision to use public transport is related to an individual's perception of whether the bus service will meet an individual's transport needs. Unfortunately public transport in general suffers from a severe image problem. Bus transport is perceived to be unreliable, time consuming, inaccessible, inconvenient, dirty and unsafe (Cain et al 2009). Public transport is also often viewed as a social service for the transport disadvantaged including the elderly, disabled and lower socioeconomic groups (Perreau 2007). Evidence found in submissions to the Waikato Regional Public Transport Plan 2015–2025 (Waikato Regional Council 2015) suggests such a perception may still persist.

New Zealand regional authorities undertake regular monitoring of the public perception of public transport through ongoing surveying of customer satisfaction. Perceived performance of journey time reliability is one of the most significant attributes in the perception and customer satisfaction of public transport users in New Zealand. The two key reliability attributes measured are services arriving and departing on time and time taken for journey.

Auckland Transport customer satisfaction surveys undertaken in 2013 and 2014 indicate users are 68% satisfied with services arriving and departing on time and 77% satisfied with time taken for a journey. The overall customer satisfaction for all attributes assessed is 81% in Auckland.

Environment Canterbury's annual Greater Christchurch Metro user survey captures customer satisfaction using a 10-point scale with zero being dissatisfied and 10 being very satisfied. In 2013, 68% of users gave an 8–10 rating for the bus being on time. Overall satisfaction received an 8–10 rating by 86% of users although of the 2% that rated their satisfaction 0-5, the main reason for their dissatisfaction was 'keeping to schedule'.

2.6 Benefits and disbenefits of bus egress priority

A review of the national and international literature was undertaken to identify studies that provide evidence of benefits or disbenefits to a transport network through the provision of priority bus egress at bus stops. A number of literature sources related to bus egress priority and the application of it to improve service and travel time reliability were reviewed; however, there was no definitive evidence of the performance or effects of the legislation changes. It appears the only study undertaken to measure the effects of YTB treatments is in Florida. Fabregas et al (2011) have assessed the effects of motorist behaviour, traffic safety and operational benefits when YTB–LED signs are used on buses as reported in section 2.4

A key objective of this research was to quantify the benefits and disbenefits associated with measures supported by a change in legislation giving buses priority when exiting a bus stop. To scope these benefits and disbenefits, this section highlights the benefits and costs associated with the provision of public transport and the key role it plays in the overall transport network. Litman (2015) provides a concise summary of the range of benefits and costs public transport initiatives offer and emphasises many of these can be easily overlooked or undervalued in evaluations.

Priority bus treatments aim to improve speeds, reduce delay and increase reliability through modifying the environment or operations in which a bus operates. With 20–30% of a bus's run time held up by traffic signals or congestion delay, the benefits of implementing priority bus measures include improving bus travel times and schedule adherence, operating cost savings, a higher public profile and increased patronage (National Capital Region Transportation Planning Board 2011).

2.6.1 Travel time reliability

The travel time for all vehicles comprises the running time as well as dwell time when a vehicle is stationary. Travel time is determined by surrounding traffic conditions, road geometry, traffic control devices and legal requirements such as speed limits (Ryan 2012).

A reliable bus service will be an attractive form of transport. When a passenger can predict with some certainty the time it will take to travel, they are more likely to use the bus service. The concept of reliability although not directly measurable, is commonly measured through passenger wait time and has a significant effect on both public transport perception and patronage levels. As passenger perception and expectation will ultimately dictate patronage, and hence the viability of a service, passenger wait time provides the most appropriate measure of reliability as this has the most relevance to passengers (Ryan 2012).

As emphasised by Ian Wallis Associates Ltd and The TAS Partnership (2013), reliability is the most important attribute of bus services and the one attribute for which perceived performance is poorest, relative to its importance. Scheduled services that vary from the timetable lead to an increase in passenger waiting time and frustration. As this 'excess' waiting time is valued at 5–6.5 times the in-vehicle time the impact of unreliable services is significant.

Improving service stability and reliability have been identified as major sources of potential growth of public transport (Currie and Wallis 2008). From the stated preference survey undertaken by Vincent (2008), an average value of time of $8 per hour was determined, this is relatively consistent with the base value of times used in the *Economic evaluation manual* (EEM) (NZ Transport Agency 2013a).

The values of time attributed to trip purposes provide a measure for quantifying the benefit of travel time savings for work travel, commuting and non-work travel purposes. The flip side of this is that if general traffic is delayed through giving way to buses, therefore there is a travel time disbenefit to general traffic of equal or greater individual value. The amendment to the EEM published in *General circular – funding: no.13/07* (NZ Transport Agency 2013b) places an equal value of travel time to all modes for the monetising of travel time benefits.

Measures of public transport service reliability are frequently based on departure time, run time and arrival time variability. High variability in any of these factors potentially influences travel behaviour as waiting times increase along with concern and anxiety of arriving late to a destination. All these aspects can be expected to reduce the propensity to travel by bus (Ian Wallis Associates and The TAS Partnership 2013).

New Zealand research by Vincent (2008) emphasises reliability is important for public transport users and operators alike. Reliability is significant to service providers as unreliable services lead to issues with timetabling, resource planning and uneven loading leading and possible contractual performance measures.

Ian Wallis Associates Ltd and The TAS Partnership (2013) highlight potential measures for addressing unreliability due to traffic congestion and variability of delay through implementing bus priority measures including priority at stops. In those instances where buses may experience significant difficulty and accumulative delay in re-entering the traffic stream when pulling away from a stop, giving buses 'pull out' priority through local or national regulations and restricting parking near bus stops may reduce or overcome these delays and increase service reliability.

2.6.2 Travel time variation

Travel time variation and reliability are closely linked. The term 'reliability' in a transport context relates to the uncertainty in the time taken to undertake a journey and different modes have different uncertainty aspects of their journey. Variations in travel time occur particularly on heavily congested roads (Vincent 2008).

Ryan's (2012) study of the Christchurch's Orbiter route found the variation in both travel time and dwell time was considerable and contributed to the irregularity of the service. Dwell time was found to be slightly more variable than travel time; however, both variables are interdependent suggesting that reducing dwell time and/or travel time will have a positive impact on service reliability. The variability in dwell times at stops can be reduced through altering traffic regulations to give priority to buses re-joining the traffic as well as improving bus design and fare collection methods. Travel time variability can be reduced through using bus lanes along links and increasing the green time for buses approaching signalised intersections (Nicholson 2013). The quantity of this will be looked at in future stages.

2.6.3 Change in delays

Jepson and Ferreira (2000) report that environments with high levels of saturation provide the most opportunities to implement measures (such as bus priority) resulting in significant delay savings for buses, yet the low delay savings obtained in low saturation locations are still significant enough to counter the marginal effects on the operation of general purpose traffic.

Delay can be quantified by measuring the re-entry time of a bus. The 're-entry' time is defined as the time experience while waiting for a sufficient gap in traffic to allow the bus to merge back into the traffic lane. The *Highway capacity manual* (Transportation Research Board 2010) suggests these should be in the range of two to five seconds. Fabregas et al (2011) found the use of electronic YTB signs helped buses to re-enter traffic flows during periods of heavy traffic and congestion, reducing their delays and increasing the reliability of the service.

2.6.4 Increased patronage/demand

Currie and Wallis (2008) examine the patronage growth experiences in Europe, North America and Australasia focusing on the performance of bus improvement measures and provide clear evidence of the link between improved service reliability and patronage growth. The consistent principal drivers of patronage growth in urban bus services in Europe, Canada and Australia are service frequency improvements and measures associated with bus reliability such as bus ways, bus lanes and other traffic priority treatments. In cases where service reliability is poor, reliability improvements can provide patronage gains of 10–20%.

An internet-based survey undertaken in England by Mackie et al (2012) showed frequency, access/egress times, journey times, real-time information availability and comprehensiveness of service all influence demand for bus travel. The importance of reliability as a quality attribute was also conveyed as highly important.

2.6.5 Vehicle operating costs

High private vehicle usage raises congestion levels, vehicle emissions, fuel consumption rates, safety concerns and wider environmental impacts (Ryan 2012). A shift in travel from private vehicle to public transport will result in vehicle operating, ownership and use savings. These base vehicle operating savings are a function of the mean vehicle speed and road gradient (NZ Transport Agency 2013a). The impact of bus priority will encourage some private vehicle users to switch modes; however, the change in legislation may not effect some road users' mode choice. Vehicles that are delayed as a consequence of giving way to buses, are likely to experience increased delay and vehicle operating costs through the introduction of a speed cycle of deceleration and acceleration, potentially encouraging a shift to other modes of transport including public transport.

2.6.6 Emissions

Congestion increases fuel consumption and vehicle emissions through increased periods of idling for all vehicles. Increasing the reliability and patronage of public transport provides an opportunity to actively reduce fuel usage, emissions and the consequent impact on the environment. Buses are able to run on biodiesel and a Christchurch bus fleet has successfully converted all buses to biodiesel reducing greenhouse gas and particulate emissions to the environment. The use of biodiesel also conveys a positive, clean green image and provides an opportunity to reduce operating costs enabling a competitive advantage when tendering for bus contracts (EECA Business 2010).

Litman (2015) provides evidence of emission impacts resulting from a shift to public transport and highlights that emission benefits arise as a result of strategies that increase ridership with less proportional increase in vehicle mileage. It is challenging to quantify the impacts due to the many possible permutations of vehicles, engines and driving conditions. The same challenge occurs when trying to isolate the benefits as a direct result of a law change allowing bus priority. Delay in general traffic as a result of giving way to buses will have a negative impact on emissions, while the efficiency and smoother running of the bus is like to have a positive effect.

2.6.7 Public transport operating costs

Some aspects of public transport operating costs are time based, so a reduction in overall costs can be achieved by increasing the timeliness of services, for example by enabling more efficient use of labour hours through reduced layovers and reducing the size of bus fleets.

Bus priority measures including the egress from bus stops is likely to reduce bus idling times, in turn reducing costs specifically related to transit vehicle performance (Litman 2015). Bus priority measures that can increase bus service speeds impact positively on public transport operating costs. Boyle (2014) studies the impact of increases in bus speed and highlights that even small increases in average travel speeds translate to reductions in operating costs to transport operators.

2.6.8 Safety

The Insurance Company of British Columbia initially opposed legislative change in Canada, but then commissioned a study into the safety implications of YTB legislation. The qualitative evaluation of the safety implications found there were no negative safety experiences related to YTB legislation in other countries with YTB laws. The study concluded YTB legislation could have some positive safety impacts arising from increased bus patronage, clarity of right of way at bus stops, and reduced friction and lane changes of motorists (King 2003).

A bus merging from a bus bay into a two-way road is conflict prone as it cannot gain speed to merge into the traffic flow as it is restricted by the bus bay limit. The posted speed also has an effect on the braking distance required to avoid any rear end conflicts.

No studies on safety impacts specifically relating to legislative change giving buses priority could be found; however, Goh et al (2013) explored the impact of bus lanes and traffic signal priority measures and overall found bus priority treatments reduced crashes. The key safety hazards identified were at bus stops and when buses attempted to merge back into traffic.

Fabregas et al (2011) compared the number of conflicts on merging manoeuvres between buses displaying electronic YTB signs with that of buses using rear YTB decals at two Florida locations. The proportion of merging instances presenting conflict on the test corridor in Tampa was 54% with buses using a decal on the back of the bus only. This reduced to 15% when buses used the electronic merging sign on the rear of a bus. The Fort Myers test corridor had a higher posted speed increasing the risk of conflict; however, the proportion of merging manoeuvers that presented conflict was 8.4% where the decal only was used and 6.25% when buses used the electronic merging sign on the rear of a bus. This study concluded that the use of electronic YTB–LED merging signs had a positive effect on yield behaviour without introducing new conflicts or compromising safety.

A study of safety outcomes following the implementation of YTB legislation in Florida concluded that signs and bus exterior lighting improved bus safety and operations, but law enforcement needed to be in place to change driver's yield behaviour and for the technology to be effective. There are also several types of conflict situations that arise as a result of a bus taking priority when moving back into traffic flow. Bus crashes may only be a portion of the crashes caused by buses attempting to merge into traffic. Hard braking manoeuvres, weaving into oncoming traffic, changing lanes abruptly behind the bus and secondary conflicts when motorists weave into another lane causing drivers in that lane to have to brake suddenly may also occur as a result of bus priority legislation. Public awareness of YTB laws and the dangers of hastily weaving behind a bus is vital to ensuring the safety of road users and minimise conflict situations (Zhou and Bromfield 2007).

The safety outcomes of a law change may well be compromised if the YTB signs are introduced without a proper public awareness campaign, education and enforcement. Proper use of the electronic YTB sign is also critical to avoid conflict situations arising from a bus driver's sense of entitlement (Fabregas et al 2011).

Figure 2.4 Example of Tri- Met YTB public education campaign (Fabregas et al 2011)

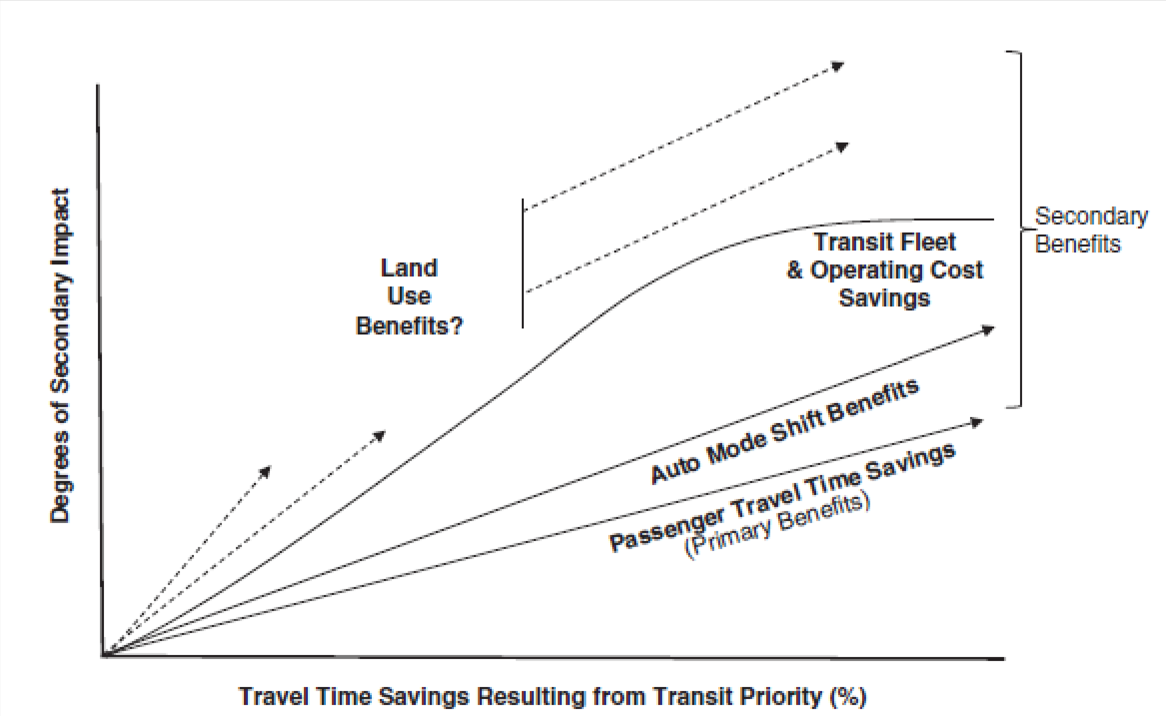
2.6.9 Secondary benefits

Currie and Sarvi's (2012) study challenges the theoretical model of wider secondary benefits that suggests:

- Public transport priority that reduces bus running times by up to 2.5 minutes generates benefits only in passenger travel time savings.
- A time saving of 2.5 to 5 minutes generates secondary benefits in saving operating costs and fleet resources.
- A time saving of 5 to 8 or 9 minutes generates secondary benefits by causing mode shift.
- A time saving of more than 9 minutes or so can change land use in a positive manner.

Evidence of priority impacts suggest the theoretical model understates the travel time savings threshold for mode shift and fleet resource savings will continue beyond the thresholds stated. The analysis of the position in figure 2.5 suggests an alternative model of transit priority secondary benefits and indicates that significantly higher net benefits could be generated as secondary benefits increase jointly and cumulatively with continued savings in travel time. Fleet resource and operating cost savings are also cumulative with travel time savings however it would appear that a ceiling may exist where fleet savings are no longer attainable from travel time reductions. Currie and Sarvi (2012) depict land use benefits in their model with a dotted line as these were not explored.

Figure 2.5 Currie and Sarvi (2012) suggested model of transit priority secondary benefits



Mackie et al (2012) found both bus users and non-users place an option value on the availability of a bus service in the form of a social insurance. The availability of the bus as a back-up mode of transport for car owners in an event their car is not available is important to non-users. This study also highlights the broader issue of assessing public policy towards the bus industry in which a transport cost–benefit analysis does not fully reflect the wider contributions the bus makes to the efficiency of the economy.

The smooth running of buses has a positive impact on labour market efficiency and increased labour market participation. With a proportion of the work force being dependent on buses, Mackie et al (2012) consider that a decline in bus service quality/availability to users would cause some people to have to drop out of the employment market leading to an economic welfare loss. Although this literature refers to public transport as a whole, it is logical that any measures able to improve the travel time and reliability of a bus service have the potential to deliver wider economic benefits.

3 Stakeholder consultation

Key stakeholders were identified in agreement with the research Steering Group and contacted to receive their inputs into this research topic. The following organisations were contacted via email and asked to complete a questionnaire:

- NZ Transport Agency
- Auckland Transport
- Environment Canterbury
- Bay of Plenty Regional Council
- Bus and Coach Association
- Automobile Association
- Taxi Federation
- Cycling Advocates Network
- Road Transport Forum.

The questionnaires contained specific questions although these were customised to each organisation and the opportunity was provided to allow respondents to expand upon the topics raised providing additional feedback. Copies of the questionnaires are included in appendix A

Responses were received from eight out of the nine organisations. The responses have been collated and aggregated to protect anonymity and address any commercial sensitivity. A total of 10 questions were posed with each being addressed in turn in the following sections.

3.1 Does the current lack of a clear 'Give way to bus' law and the reliance on courtesy cause confusion?

The general consensus among respondents was the current situation causes confusion for motorists if not all, then certainly some of the time. It was less evident whether respondents considered the current lack of a clear law to cause confusion for bus drivers. One respondent stated 'the only way the bus driver can tell is if they get a signal (wave, flash lights) from the car driver or cyclist, so they will try to wait until the way is clear'. There was some ambiguity around whether it caused confusion for cyclists. One respondent noted that 'behaviour from all road users is inconsistent and unpredictable at present'.

3.2 To what extent would a law change positively or negatively impact on road users' behaviour?

There was a mixed response although it was generally recognised there would be some resulting positive impacts on road users' behaviour. A number of respondents considered if a law change was well publicised and had public support, with reasonable enforcement, then it could have a positive impact on behaviour. Five responses stated it would create more certainty for bus drivers as there would be clearer obligations for all road users.

Three respondents also referred to the concept of road rage, whereby two considered it could potentially get worse while one was of the opinion that as there could potentially be less conflict with other road users, a law change would reduce road rage.

Negative impacts identified included poor public awareness of a law change, a lack of public support, or heavy-handed enforcement which could negatively impact on behaviour, especially if loading delays (that is delays while the bus driver is indicating) lead to traffic building up and road user frustration when the route ahead is clear. One respondent felt that encouraging courtesy rather than legislation, (which they considered to be unenforceable in any case), would be preferable to a law change.

Concerns were shared that a law change would initially create negative behaviour (for example angry car drivers) before the new pattern established itself and thereafter behaviour should return to the status quo. Priority for cyclists was raised as a concern given there are already problems between cyclists and buses – bus drivers would need to continue to take special care with cyclists.

3.3 What impact does delay, poor schedule adherence and poor travel time reliability have on the public perception of public transport, bus patronage and operating costs?

All responses agreed delay, poor schedule adherence and travel time reliability have a negative to significantly negative effect on public perception of public transport, with one respondent stating it 'is a common public perception that buses are slow and run late, so this (a law change for bus priority egress) could help improve this'.

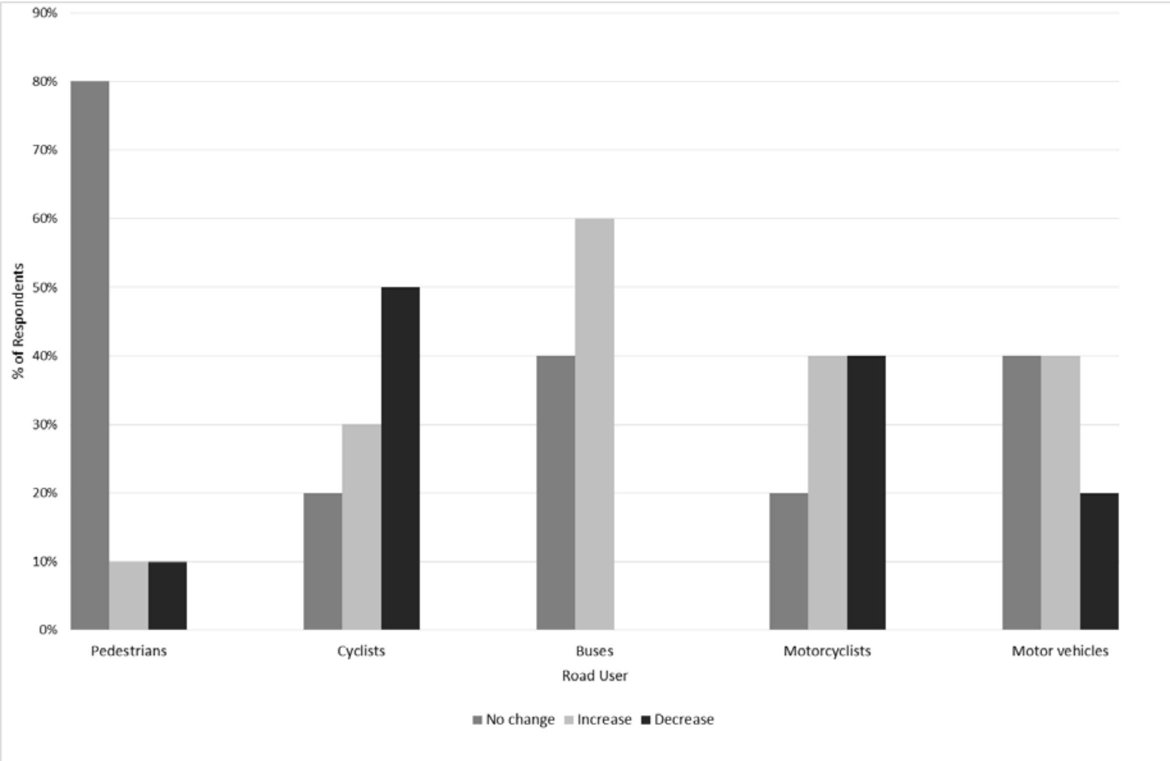
There was also general agreement amongst respondents that delays and unreliability have a negative impact on bus patronage numbers. If perceptions and reliability improve, then it was considered more people might see public transport as an attractive travel option which would consequently result in increased patronage. One respondent noted Auckland Transport has demonstrated for each 1% improvement in bus punctuality/reliability, there is a corresponding 1.5% increase in patronage.

The majority of respondents were of the view that delays and unreliability would have an adverse effect on operating costs to some extent. One respondent noted by improving reliability and predictability less 'recovery time' could result in an improvement in fleet utilisation and hence a reduction in operating costs.

3.4 Do you think a change in legislation to give buses priority when egressing from a bus stop will impact the safety of road users?

The respondents were asked if they considered a change in legislation might impact on the safety of various road users to any extent. A summary of the responses is shown in figure 3.1 whereby an increase in safety is synonymous with an improvement in safety outcomes and a decrease is a worsening in safety performance arising from a change in legislation.

Figure 3.1 Stakeholders' views on safety impacts



The majority of respondents did not think there would be any impact on the safety of pedestrians as a result of a law change; however, half the respondents thought the safety of cyclists would worsen if a law change was implemented. Most respondents thought the safety of buses would improve while the remainder said there would be no change. An equal number of respondents considered motorcyclist safety would improve or worsen, and similarly opinions were divided on the safety of motorists.

Feedback from one respondent stated 'answers depend on how you craft the legislation'. Another felt the overall safety would either improve or not change, as both bus drivers and other road users would be clearer about their roles, therefore possibly resulting in fewer crashes. A potential increase in the occurrence of nose-to-tail crashes was also highlighted by one respondent.

3.5 From your organisation's perspective, what benefits do you perceive from a law change?

All but one respondent stated they would expect benefits to their organisation arising from a law change. Three respondents considered there would be greater clarity and understanding of the roles of each road user group, and clarity about when (and where in the traffic flow) traffic must give way. Greater network efficiency and bus reliability were also highlighted by six respondents, and further to this, three shared the view there would be reduced operating costs for public transport and two noted increased patronage. One respondent also considered there would be better 'value for money' from their organisation's perspective through increased patronage. A further benefit identified by one respondent was that a law change could help planners locate bus stops much closer to intersections.

3.6 Which of these benefits will be most significant to your organisation?

The increased reliability of services was considered by two respondents as the most significant benefit to their organisation, while only one considered greater safety as the most significant benefit. Three respondents noted increased patronage as the main benefit, while three also noted it would make public transport a more attractive option to cars and promote a general pro-public transport message. It was recognised by a number of respondents that there would be more than one significant benefit to their organisation due to synergies between benefits such as reduced operating costs, greater efficiency, and reduced travel time.

3.7 From your organisation's perspective do you envisage any disbenefits as a result of a law change?

Three respondents stated they envisaged no disbenefits from a law change. The main disbenefit mentioned by respondents was the potential for increased delays to the general traffic flow during peak periods as drivers might need to slow down or even stop to let buses pull out from stops. One respondent also mentioned vehicle operating costs for general traffic might increase.

Safety was a common concern, particularly the potential for bus drivers pulling out without checking and failing to see cyclists or motorcyclists as mentioned by three respondents. To help reduce the safety risks or any ensuing disbenefit of a law change, educational campaigns and promotion of any changes were advised by several respondents, as they felt providing people with adequate information on any law change was necessary for it to be successful.

Other potential disbenefits included costs being incurred to support and publicise the outcome of any changes as well as costs being incurred for changes to signage/road markings depending on the requirements of the law. One respondent noted road users receiving infringements for non-compliance as a disbenefit.

3.8 What is your organisation's attitude towards a law change and do you envisage any impediments?

This question was put to three of the key stakeholders. The preference for one organisation was for education over enforcement, so in the absence of clear evidence to support a rule change, they would favour an educational campaign to raise voluntary compliance rather than a rule change. They also stated that if a rule change is enacted then it must be accompanied by a comprehensive education campaign before it is enforced. The remaining two respondents were in favour of the law change.

3.9 If a law change was to occur, how do you think this will affect local/regional/central government investment in public transport?

There was some level of uncertainty about how investment in public transport would be affected, if at all, by any change in the law. Two respondents noted more efficient networks would deliver better 'value for money' and potentially in larger urban areas more services could be provided for the same cost. Three respondents believed increasing patronage would lead to higher levels of investment being required.

3.10 Are there wider implications for your members from a law change that should be considered?

Feedback from respondents largely focused around education and awareness required to support a law change as well as training for bus drivers. The fact there are limited resources available to implement a significant campaign to inform people of any legislative change was also raised as a concern.

The need for changes to signage on buses or road markings was highlighted by one respondent. On a wider scale two respondents questioned whether the rule change would go far enough and if schemes should also allow buses to ‘queue jump’ or be increased to include priority for lane changes. One respondent mentioned in some cases bus stops block cycle lanes, and facilitating movement for buses out of the stop would free up the bike lane.

In relation to the specific requirements of any rule to be introduced, a number of questions were posed by respondents:

- When can a car can pull alongside a bus and when can it not?
- Who must give way? All vehicles or all motor vehicles (excluding cyclists)?
- Which buses get priority, all buses or only those on a metropolitan service?
- Do buses get priority when egressing from a stop only or in other circumstances?
- How long after the indicator comes on are drivers required to give way? Or will this depend on where the vehicle is in relation to the bus when the indicator comes on?

4 Focus groups

4.1 Introduction

This section supplements the stakeholders' consultation to capture the views of bus drivers and other road users to further develop the research team's understanding of current on-street practices and behaviour and balance the more administrative perspective of the stakeholders' assessment. A total of eight focus groups were held to examine a wide range of different road users' attitudes, views and experiences.

4.2 Methodology

The focus groups provided a forum for road users to share current behaviour and experiences on the road network, and consider the impacts and likely behaviour changes following a law change. Eight focus groups were conducted in two major urban cities as outlined in table 4.1. The focus groups covered a wide range of different road user groups including bus drivers, public transport passengers, commercial vehicles, private motor vehicles and cyclists, with four to eight participants in each group. Bus drivers from several companies in both Christchurch and Wellington participated in individual focus groups to ensure the views of drivers working on different routes and traffic environments were captured.

Table 4.1 Summary of focus groups

Location	Road user	Focus group date	Focus group time
Christchurch	Public transport users	18 March 2015,	6.00pm
Christchurch	Bus drivers group 1	19 March 2015	10.30am
Christchurch	Bus drivers group 2	20 March 2015	11.00am
Christchurch	Courier drivers	25 March 2015	12.15pm
Christchurch	Taxi drivers	26 March 2015	12.00pm
Christchurch	Private vehicles and cyclists	27 March 2015	5.30pm
Wellington	Bus drivers group 3	31 March 2015	10.15am
Wellington	Bus drivers group 4	31 March, 2015	1.30pm

The focus groups for bus drivers, courier drivers and taxis were arranged directly with each of the operators and held at their individual depots. Driver participation was voluntary and scheduled during a break or shift change. The Christchurch Metro Facebook page was used to attract participants for the public transport user focus group. Participants for motor vehicle and cyclist groups were sourced through personal and professional networks. An example of the flyer used to advertise the focus group is presented in appendix B. Each focus group took approximately 30–45 minutes, and refreshments were provided for all participants. The structure and content of the workshop is outlined in appendix C, and appendix D contains the survey sheet handed out to participants of the focus groups.

4.3 Focus group feedback

Each focus group session was a guided discussion providing participants with the opportunity to share their views and insight as to current practice, and what they believed might happen if a law change was to take place. Bus drivers work in the current road environment for many hours on a daily basis and their views and passion for this research came through clearly in the feedback. Other road users appeared to be affected less and this was reflected in the smaller number of comments compared with those of bus drivers.

4.3.1 General traffic behaviour

Bus drivers expressed divided opinion as to when it was most difficult to egress from bus stops. One Christchurch and one Wellington group felt during the peak hour when it was more congested, more people tended to give way compared with other times of the day when traffic was free flowing. The taxi drivers, cyclists and motorists also agreed in peak hours most people would give way, whereas bus users thought it was more the attitude of the road user rather than environmental conditions that governed whether people gave way to the buses.

Conversely, the other Christchurch and Wellington bus driver groups thought during the peak hour motorists were less likely to give way than during off peak. This concurred with the thoughts of the courier drivers who found when traffic was congested and not moving (particularly in the AM peak), then other motorists would not let buses back into the traffic.

Other environmental factors noted by bus drivers as affecting driver behaviour included the weather or events taking place, eg cricket world cup or rugby matches. It was also noted commemorative events could influence people, eg ANZAC ceremonies or earthquakes could motivate people to be more tolerant, patient and courteous. Time or lack of it, poorly placed bus stops and general ignorance were also identified as reasons for choosing not to give way.

All bus driver groups said currently they waved to motorists or put on their hazard lights in acknowledgement and to say thanks for giving way. This is something which they are advised to do as part of their training in a bid to encourage other road users to give way when the bus is indicating to pull out. One bus driver also noted that holding an arm out of the driver window, ready to say thank you, often speeds up the process of being let into the traffic. The acknowledgement by bus drivers was mentioned by the couriers and taxi drivers who appreciated this and stated bus drivers are generally courteous.

The courtesy Please Give Way to the Bus decal on the back of buses in Christchurch was introduced several years ago. Bus drivers who worked prior to the introduction of the decal were asked if they noticed any difference in motorists' behaviour subsequently. Overall, both groups of bus drivers felt the decal had made no difference and that other road users did not take any notice of the courtesy sign.

Bus drivers generally agreed it was relatively common to see motorists crossing the centreline or mounting a traffic island to overtake a bus when it was pulling out of a stop. Motorists would try to pass and cut in front of the bus to avoid waiting behind it even if they were only turning off into another property/road immediately up ahead. The couriers and taxis drivers also mentioned they had observed similar behaviour, whereby motorists tended to speed up to get past the bus before it pulled out rather than stop behind it. The bus users also mentioned they had seen cars crossing the centreline to try and overtake the bus while it was trying to pull out.

4.3.2 Bus driver behaviour

Bus drivers in both regions stated the time it takes to pull back out into traffic can vary greatly with some drivers commenting 'you could be there all day' if you did not slowly nudge your way out. All bus drivers agreed they needed to drive assertively when trying to egress from a stop. This is executed by slowly moving forward off the stop into the traffic, encouraging other road users to let them into the flow of traffic. However, if they put on their brake lights once they started to make their way out, then other road users would just see this as an opportunity to pass the bus.

One Christchurch bus driver group thought approximately 30% of motorists currently gave way, and couriers thought it was approximately 50% that currently give way. One of the Wellington bus driver groups thought approximately 50% of drivers might give way during peak periods, but only about 20% during off peak times. Taxis drivers felt the majority, between 50–90% of people, already give way as a courtesy. Furthermore, Christchurch bus driver groups noted where possible motorists would indicate a lane change and move into the other lane when they saw a bus indicating to pull out of a bus stop.

Most bus drivers thought the reason for some road users not giving way was they did not want to be stuck behind a bus as they thought the bus would travel slowly if it was running ahead of time and hence delay them. This corresponds with comments from motorists who stated their decision to give way could be influenced by where the bus was going; if they knew it was going to turn off soon then they were more likely to give way.

A number of bus drivers considered younger drivers were less likely to give way than other road users. They also thought tradesmen and motorists in larger vehicles were less likely to give way. Wellington bus drivers said they received no courtesy from taxis or couriers and these commercial vehicles even used the bus stop and felt it was their right as long as they had hazard lights on. Some bus drivers felt trucks were better as they had an appreciation for the size of the buses. The taxi drivers and motorists mentioned trucks might not give way, particularly if they had a heavy load as they did not want to stop or have to change gears to slow down.

Bus drivers acknowledged some bus drivers might not always indicate correctly, indicating left when trying to pull out or having the right indicator on while still loading passengers which confused other road users. The couriers and the taxi drivers also noted inconsistencies in bus driver behaviour, for example bus drivers started to indicate and pull out at the same time. Motorists and cyclists also agreed bus driver behaviour was sometimes unpredictable, citing examples of buses pulling out into the traffic aggressively and sometimes without indicating.

4.3.3 Confusion/clarity

All focus groups were asked if they considered there was confusion amongst road users as to who should give way or when to give way to buses egressing from bus stops. Bus drivers, motorists and cyclists all felt there was a definite lack of clarity on who should give way, but courier drivers did not agree. Bus users felt it was obvious other road users should give way to the bus although there might be confusion for cyclists rather than drivers. Wellington bus drivers thought it was not so much a lack of clarity but a generally negative attitude towards buses, and vehicles would try to get past the bus at all costs.

The majority of bus drivers and couriers stated any law change would have to make it very clear when it would be safe to give way. The motorists and cyclists also stated clear requirements were very important regarding how long the buses' indicator should be on, for example three seconds provided ample time for a car to pass but not for a cyclist.

4.3.4 Safety

All bus driver groups considered general safety on the road should improve with a law change as it would eliminate any confusion, as traffic giving way and following vehicles would be more aware around bus stops and able to anticipate their requirement to stop. Wellington bus drivers strongly identified a law change would improve the safety of bus passengers (especially children) by reducing the number of times they would need to brake heavily.

Opinions were mixed about cyclists and whether they currently gave way or not. It was generally agreed by all bus driver groups and the couriers that most cyclists tended to keep going and not give way even when the bus was indicating to pull out. The bus drivers said they tended to hold back and let a cyclist pass. The couriers and bus users suggested cyclists needed special consideration in terms of safety, and taxi drivers thought a law change would decrease safety for cyclists and motorcyclists.

One cyclist stated they always stopped and let the bus out; they were nervous when passing a bus as they were unsure whether it would stop for them or not. Another cyclist stated their decision to give way or not depended on their position on the road at the time the bus started to indicate and whether they were already adjacent to the bus. Cyclists gave a mixed response to the safety implications of a law change. They stated they were vulnerable road users and shared concerns about bus drivers not being able to see them.

The taxis drivers, motorists and cyclists initially thought a law change might be chaotic or cause confusion but overall they considered it would be safer and result in fewer crashes due to more predictable behaviour by bus drivers. They also generally agreed the overall safety of road users would increase.

4.3.5 Benefits

Improving the reliability of bus services was identified as the biggest advantage of a law change by all bus drivers. If the bus could get back into the traffic every time it indicated at each stop, then this would assist with schedule adherence. All drivers thought delays could be eliminated at stops meaning they would be more likely to run to time and keep to timetables. The bus drivers also agreed improving the reliability of the bus services would make public transport more attractive to people and consequently increase patronage while reducing congestion and emissions.

The bus users stated the reliability of the buses influences their decision when or when not to take the bus. If they need to be somewhere at a specific time they tend to take the car rather than bus whereas if time is not so crucial they take the bus. By improving the reliability of the bus they would opt to take it even more regularly. Bus drivers agreed passengers would also benefit from a law change due to improved reliability.

The motorists, taxi drivers and cyclists believed making public transport services more efficient would promote greater usage and have flow-on effects of reducing the number of private vehicles on the roads and resultant efficiency, economic and sustainability benefits.

Other benefits of a law change identified by focus group participants included:

- overall improvement in safety across all road user groups
- reduced stress and driver frustration
- a catalyst towards more courtesy and understanding between buses and other motorists
- increased awareness by general traffic so it would more likely anticipate bus movements
- a smoother ride, greater fuel and general vehicle efficiency as well as reduced emissions
- help to change other road users' perception of who has priority on the road

No focus group participants felt there would be any disbenefits or delay of any significance to other road users. The general rationale was vehicles that give way to a bus would subsequently pass the same bus when it pulled into the next stop, thus having a negligible impact on their individual journey time.

Some Wellington bus drivers thought a higher priority for buses at bus stops would result in a need for fewer bus lanes. They felt it was often better to use the general traffic lanes as the bus lanes tended to be used by cyclists and taxis and not enforced.

4.3.6 Enforcement

All bus driver groups thought without enforcement and consequences for not obeying the law, a behaviour change in other road users would be unlikely to occur. The motorists and cyclists also agreed and said the effectiveness of a law change would depend a great deal on how it would be enforced and if enforcement was carried out well this would improve the effectiveness of the law change. The issue of enforcement for cyclists was also raised by some bus drivers as there was no way of identifying them.

One of the Christchurch bus driver groups stated in Australia the requirement to give way to buses is clear and motorists know they are at fault if they hit a bus or do not give way. A number of bus drivers were also keen to see consistency in New Zealand and Australian legislation.

Bus drivers generally considered surveillance would help to enforce the law change, perhaps even using cameras on the backs of buses or at bus stops to capture evidence of road users not obeying the law. They cited the current legislation to reduce speed to 20km/h when passing a school bus, as an example of a law few motorists adhered to or were even aware of and felt it was never enforced.

4.3.7 Effectiveness

All groups were asked if they thought the law change would be effective, or what they thought would be needed to make it effective. It was mentioned by both Christchurch bus driver groups that the Transport Agency has already demonstrated a law change could be implemented successfully and effectively. This referred to the process surrounding the law change to the right-turn rule which bus drivers considered had gone very smoothly and was viewed positively. The taxi drivers also mentioned this and how the public got used to that rule change quickly and would become familiar with this potential law change too.

Participants generally thought additional lights or signage on buses highlighting other road users should give way would help make it clear for people not familiar with the road rules. They also felt if lights were included with the give way/thank you sign it would be a good way of acknowledging those who let the bus out.

All road user groups thought having Give Way markings on the road, a flashing sign midway up the bus and making the signs on the buses stand out more would help make more people aware they needed to give way. The taxi drivers agreed additional signage and flashing lights on the bus would help to remind people to give way while bus drivers, motorists and cyclists also thought making the signs on the buses bigger and more prominent, would help encourage other road users to give way.

To help make the law change effective, participants thought a nationwide advertising and education campaign, such as the campaign regarding the right-turn rule change, would be needed. All road users felt educating the general public regarding what they are required to do would be key to making the law change effective.

Bus drivers highlighted concerns with the effectiveness of current enforcement specifically vehicle speeds around school buses, while Wellington bus drivers described how much trouble they had with vehicles parking illegally on bus stops. Signage having to compete with advertising on the back of buses was raised by some bus drivers as a barrier to the effectiveness of a law change.

Bus drivers considered one of the main barriers to the effectiveness of a law change could be the attitude of road users, who might be reluctant to change their current behaviour.

4.3.8 Additional opportunities

Some Christchurch bus drivers experienced significant delays when trying to turn right, stating the majority of vehicles (80–90%) would pass before letting them make their turn. Bus drivers suggested this could be an opportunity to extend the law change to give priority to buses turning right.

The taxi drivers made the point if a law change were to occur, this should give priority to buses in all situations, eg priority when egressing from a bus lane back into the traffic lane. They considered this would avoid any potential confusion among other road users as to when you should give priority to the bus.

Bus drivers and patrons considered this was an opportunity to improve bus priority measures and bus users also felt that it would be a good time to promote the use of public transport.

4.4 Summary

Overall, there was unanimous support among all road user groups for a change in the law to enable priority bus egress from stops. One bus driver stated he had initially not considered a change to be necessary or effective, but after the group discussion felt it would work well and be an efficient way of changing things for everyone. The couriers stated it would not really cause them any additional delays and was something they currently tried to do anyway. Similarly, the motorists did not see a law change causing inconvenience or delays to their journey as it did not take very long to give way to a bus.

Views and opinions gathered from the focus group discussion indicated there was some ambiguity around giving way to buses egressing from bus stops. While the bus drivers and bus passengers unanimously agreed they were frequently delayed from returning to the general flow of traffic when exiting bus stops, it was unclear whether this was worse in congested or free flow conditions.

Other key themes arising from the focus group discussions were perceptions that:

- up to 50% of road users give way to buses currently
- there is a strong attitude of ‘get past the bus at any costs’ amongst drivers
- weather, special events, time constraints, poorly placed bus stops and ignorance influence drivers’ decisions.

If a law change was to take place, no significant disbenefits were cited by the focus groups with a broad range of benefits identified including:

- elimination of confusion would improve general safety on the road
- improving reliability and consistency of bus service run times
- increased bus patronage
- reduced bus driver stress and frustration
- increased safety of bus passengers and all road users.

Concerns around the effectiveness of a law change were raised in discussions, and it was generally concluded highly visible signage, a nationwide education campaign, advertising and law enforcement would assist in the successful implementation of bus egress priority legislation.

5 International case studies

A number of international case studies were introduced in section 2.3 of the literature review with the focus being on the legislation, and enforcement of bus priority egress at bus stops. This section expands upon the earlier reporting with a specific focus on the experiences and knowledge gained through the implementation process, predominantly in North American case studies.

5.1 Florida Yield to Bus programme

YTB legislation was enacted in Florida in 1999 with the aim of reducing the high incidence of rear end collisions with buses and speeding the re-entry of buses back into traffic flow. Florida Statute 316.0815 states that 'vehicles must yield the right-of-way to a publicly owned transit bus travelling in the same direction which has signalled and is re-entering the traffic flow from a specifically designated pull-out bay. The operator of the bus must also drive with due regard for the safety of all persons using the roadway'. The most common application of the YTB law in Florida is through the application of a single decal placed on the back of the bus. There are no roadside signs or pavement marking for YTB laws in Florida (Zhou et al 2011).

Zhou et al (2011) assessed the impact of the YTB laws in Florida by evaluating bus operators' perceptions of the law and the effectiveness of different signs and lights. Video footage of yield behaviour was also collected at eight locations in three Florida states.

The field observations highlighted that delay and yield behaviour were dependent on a number of variables including:

- location of bus stop
- hourly traffic volume
- number of lanes
- speed environment
- public attitude towards buses at a specific location.

It was noted when traffic volumes increased, the re-entry delay would increase significantly (Zhou et al 2011).

Dangerous weaving and conflicts with buses and other vehicles were observed as motorists moved lanes to avoid buses merging into traffic. The higher traffic volumes and smaller headways increased the number of conflicts. No difference in driver yield behaviour was observed with the presence of a decal on the bus. The site videos captured no YTB occurrences however during congested traffic conditions, buses were observed merging in between two stopped cars (Zhou et al 2011).

According to corresponding operator survey results, 70% responded that few people yielded to the bus re-entering traffic and 50% thought there was no noticeable difference in the percentage of motorists who yielded to the bus prior to and after the YTB decal implementation. In terms of signage and technology, 73% of bus operators perceived the LED merging to be more helpful in bus operations and a safer option than the decal. This reflects similar findings to that of the literature review (Zhou et al 2011).

The current Florida statutes have no law implementation strategy meaning there is no requirement for a public awareness campaign to inform motorists or any infringement penalty. This possibly contributes to the lack of law enforcement. The most common recommendation from the bus operator surveys was for more public awareness of the YTB legislation and better police enforcement of the laws (Zhou et al 2011).

The *Transit capacity and quality of service manual* suggests in US states with YTB laws, the re-entry delay can be minimised or eliminated depending on how well motorists comply with the laws (Kittelson & Associates and Transit Cooperative Research Program 2003).

5.2 Seattle – Washington

YTB related accidents have been assessed by Metro Transit Washington using their crash database Accident Code 227. Accident Code 227 is the failure of a vehicle to give right of way to a bus leaving a bus stop that is entirely out of the traffic lane. King (2003) compares Seattle Code 227 crash data eight years prior and eight years post-YTB legislation introduction in 1993.

An evaluation of the mean number of YTB crashes with and without the YTB programme revealed an increase in the mean number of incidents from 10.25 without YTB and a mean of 16.5 per year following the implementation of YTB. The number of crashes determined to be preventable, however, showed little change. During 1986–1993 25.6% of code 227 crashes were deemed to be preventable while during the YTB period from 1994–2001 26.5% of crashes were determined to be preventable indicating there was no significant increase in aggressive driving on the part of bus operators (King 2003).

King (2003) concludes the type of bus used, level of traffic congestion and an increase in the number of vehicle miles influence the likelihood of a YTB accident.

5.3 Colorado[1]

A telephone interview was conducted with Philo Shelton, Public Works Director, Los Alamos County, New Mexico, and formerly Public Works Director, City of Steamboat Springs, Colorado and Board Member of Colorado Association of Transit Agencies in March 2015 regarding the implementation of YTB legislation in Steamboat Springs Colorado. Steamboat Springs has a population of just over 12,000 and is a major tourist destination throughout the year. The city operates Steamboat Springs Transit as a municipal service consisting of eight routes.

During Shelton's role as Public Works Director with the responsibility for transit systems operations, the opportunity for YTB legislation arose as Steamboat Springs undertook an update to its Downtown Transportation Master Plan. The city's consultant developing the plan identified the measure as a method of reducing service delays and transit operating costs with a low implementation cost. At the time, the city was facing budget pressures to maintain transit operating budgets, but transit schedules were facing delays that resulted from traffic congestion and the inability of buses to move back into traffic from stop locations. Adding several minutes of travel time had ripple effects across the system, as it required additional operating budget and, more significantly, additional buses and drivers to maintain existing service frequency.

The introduction of an YTB law provided a cost-effective mechanism for a smaller city to improve operational performance (schedule and reliability) for a relatively low cost.

A key distinction in the Colorado implementation of YTB legislation from other North American jurisdictions is its use of a lighted and flashing yield sign that is activated when the bus driver is preparing

[1] P Shelton (Los Alamos County), pers comm, March 2015

to re-enter traffic. Most other jurisdictions use a low cost sticker, and research from the University of South Florida indicated a lack of effectiveness in static placards versus dynamic lighted signs (King 2003).

5.4 North America

Yield to bus – state of practice (King 2003) investigated the use and experience of YTB programmes in British Columbia, California, Florida, Oregon and Washington from the perspective of the transit agencies in each of these states; however, it should be noted the legislation and supporting programmes differ from state to state. YTB programmes were implemented with the primary objectives of reducing delays of buses merging back into traffic from a bus stop and to enhance the safety of those merging operations.

Surveys of the transit agencies provided feedback and a range of opinions on the success of the programmes. The level of satisfaction varied between locations, the type of signage used and the degree of the public education undertaken, with key points as follows.

- Transit agencies in British Columbia, California and Oregon rated their programmes 'very favourably'.
- Transit agencies that had conducted relatively large awareness campaigns rated the success of their YTB programmes greater than agencies that undertook smaller campaigns.
- All transit agencies that used flashing LED yield signals rated their programmes favourably.
- Transit agencies that only used a yield decal were less satisfied with their programmes, rating them 'fair' or 'poor' (King 2003).

The success of the YTB programmes had a positive correlation with the magnitude of public education. Transit agencies reported the most effective forms of public education were signage on the rear of buses, radio and television announcements, newspaper advertisements, billboards, posters and hand-outs. Operators were trained on the new YTB laws and with emphasis on the appropriate use of the yield sign, with the preferred location for the yield sign being approximately half way up and to the left side of the rear of the bus. This position made the signage more visible to the second and third vehicles in a queue (King 2003).

Approximately one third of the 31 respondents reported some improvements in schedule adherence and travel time savings following the YTB programmes. Some anecdotal evidence of travel savings as a result of the YTB in low speed and moderate to high traffic flow environments was provided; however, no quantitative data was available to support the improvement in schedule adherence (King 2003).

A wide range of variance (8–71%) in the percentage of motorists yielding to buses when the buses signalled their intent to merge into traffic was reported. The YTB systems using the LED yield signal reported higher percentages than those displaying a passive decal. A high percentage of operators perceived the YTB programmes to assist with the operation of the bus (King 2003).

An increase in safety as a result of the YTB programmes was reported by 31% operators; however, there was no specific data to quantify this statement (King 2003). All respondents cited lack of enforcement of the YTB law, with bus operators commenting a higher level of enforcement could improve motorists yield behaviour (King 2003).

King (2003) concluded the information gathered from transit agencies was inconclusive, and more in-depth and controlled studies were needed to determine the impacts on the operational efficiencies and safety of YTB programmes.

5.5 Singapore give way to buses scheme

The Mandatory Give Way to Buses scheme introduced in Singapore has been implemented at a total of 322 bus bays (One Motoring 2014).

In December 2008, the Land Transport Authority in Singapore introduced a pilot scheme for the Mandatory Give-Way to Buses governed by Section 83 of the Road Traffic Act of Singapore. Under the scheme, it became a traffic offence if motorists did not give way to buses exiting from bus bays and the penalty for each offence is a fine of SG$130 (NZ$128). This Mandatory Give-Way to Buses Scheme resulted in making it compulsory for motorists to give way to buses exiting the bus stop, and was reinforced through road markings and signage.

Rigorous enforcement efforts through the use of CCTV cameras have reduced the number of violations of the Mandatory Give Way to Buses law from 3,325 offences in 2009 to 1,883 cases in 2013. The scheme introduced in Singapore was different from other give way to bus schemes seen internationally as it was initially applied to bus bays at selected bus stops along three specific bus routes (One Motoring 2014).

The Mandatory Give Way to Buses scheme is part of a range of initiatives implemented by the Land Transport Authority to make buses a priority on roads and provide smooth journeys; other initiatives include bus lanes and signal priority for buses at major intersections. Overall it has been found average bus speeds have increased from 16–19km/h to 20–25km/h and bus journey times improved by up to 7%. Commuters benefit through reduced travel and waiting times and increased reliability (Land Transport Authority 2015).

There are specific road signs and road markings which support the Mandatory Give Way to Buses scheme. When approaching a bus bay covered by the scheme, motorists will see triangular give way to bus markings on the road. These markings are to indicate to motorists to slow down when approaching these bus stops and be aware of buses pulling out of the bus bay. Road signs are also installed ahead of the bus stop to warn motorists they are approaching a bus stop where they must give way to buses. The supporting road markings and road signage are shown in figures 5.2 and 5.3.

A yellow box with an arrow is marked at the point where the buses exit the bus bay. Motorists should come to a complete stop before the give way line, located in front of the yellow box, and let buses exit from the bus bay. At no point should vehicles other than buses be stopped within the yellow box. Once buses have successfully exited the bus bay and no other buses are pulling out from the bus bay, motorists can continue on their journey. At bus bays where the road markings indicating to give way to buses are installed, motorists can be fined if they do not give way to buses exiting from the bus bays or if they are stopped within the yellow box (One Motoring 2014).

In terms of promoting and educating drivers of the Mandatory Give Way to Buses scheme, the Land Transport Authority send out 600,000 information brochures in four official languages to all registered car owners and taxi companies prior to the introduction of the scheme. These brochures contained detailed information on the scheme along with the rationale behind its implementation. Regular radio broadcasts also reminded motorists of the new requirements under the scheme. The Land Transport Authority also worked closely with bus operators in helping them to inform their bus drivers of the new scheme (Land Transport Authority 2008).

Figure 5.2 Mandatory Give Way to Buses road markings

Figure 5.3 Mandatory Give Way to Buses road signage (RizkiBeo the Transporter 2009)

6 Video data collection

6.1 Introduction

An assessment of current on-street practices and behaviour at egress points was completed by conducting observational surveys using video cameras with a view to understanding the impact new legislation may have on buses and other vehicles. Miovision Scout[2] units were set up at a total of five locations split between Auckland and Christchurch, and were used to observe current driver behaviour at bus stops during both peak and off peak periods.

The observations from the video footage provided the research team with an understanding of the subtleties of bus egress at a selection of sites. Site-specific observations focus on current driver (both general traffic and bus) behaviour, and consider the physical layout of the bus stop and the adjacent corridor and how this impacts on general traffic and bus driver behaviour. The analysis of video footage also provides insights into safety aspects including conflicts arising between buses and pedestrians, cyclists, cars moving into and out of adjacent properties, and parked vehicles near bus egress points.

This chapter presents details of the site selection process and preliminary results from the visual analysis of the footage. More detailed analysis has been undertaken as part of the technical analysis described in chapter 7.

6.2 Site selection

The camera locations were decided in consultation with the steering group and were located to target busy sections of public transport corridors that did not include bus lanes or clearways for public transport. These locations were considered to provide a significant volume of data to inform the research and varying degrees of yielding between buses and general traffic.

As far as possible the corridors were selected to represent a range of trafficked environments and demographics of road users. Two hours of peak (7am–9am) and off-peak (9am–11am) footage was collected on a ‘typical’ weekday during school term time.

The use of video footage allows for platooning effects to be captured as well as speed information which allows for these variables to be included in the technical assessment and the effect of these (and other) variables to be tested to determine their significance in terms of benefits or disbenefits.

The five sites are discussed in this section and the environmental factors for each site are summarised in table 6.1. Directional hourly traffic counts have been sourced from the corresponding local authority survey data sets unless otherwise noted.

The first site is shown in figure 6.1 and is situated on Buckleys Road in Christchurch outside the Eastgate shopping mall. Buckleys Road is a busy four-lane corridor used by all vehicle types including heavy goods vehicles. It has a raised median and speed limit of 60km/h.

The bus stop at the site is a double bus stop with a large taxi stand in front of it. When the taxi stand is not fully occupied, buses can creep forward when egressing from this stop. A cycle lane runs adjacent to the vehicle lanes and there is a high volume of pedestrians around this key activity centre. The bus stop

[2] Miovision Scout units are purpose build traffic surveying cameras that utilise Miovision Ultra SD Cards to record video footage for a variety of traffic studies. Each video file records roughly at 380 kbps or 140 MB per hour of video (https://miovision.com/scout/).

services two high frequency routes and four suburban routes and a set of signals is situated 130m upstream which provides gaps in the general traffic stream.

Table 6.1 Summary of environmental factors of bus stops observed by video

Site ID	Location	City	# of vehicle lanes	Cycle lane	Posted speed km/h	Bus services per hour	Traffic volume (8–9am)	Traffic volume (12–1pm)	Pedestrian volume
1	Buckleys Rd	Christchurch	2	✓	60	6	1,206	871	High
2	Riccarton Rd	Christchurch	1	x	50	8	915	784	High
3	Main North Rd	Christchurch	1	✓	50	6	1,012	801	High
4	Karangahape Rd	Auckland	2	✓	50	20	1,293	1,165	High
5	Ponsonby Rd	Auckland	2	x	40	8	700[3]	700	High

Figure 6.1 Site 1 Buckleys Road, Christchurch

The second site is located on Christchurch's busy Riccarton Road near the intersection of Matipo Street and adjacent to the Westfield Riccarton shopping mall and is pictured in figure 6.2. Riccarton Road is a two-lane corridor which experiences high levels of congestion. There is no median and the posted speed limit is 50km/h. There is a high pedestrian volume and no formal crossing near the bus stop although pedestrian crosswalks are available at signals located 120–140m away in either direction.

This site has no marked bus stop and there is the ability to creep forward when egressing from this stop due to the no stopping yellow lines in place. The bus stop services three high-frequency routes and five suburban routes and a set of signals is situated 130m upstream which provides gaps in the general traffic stream.

The third of the Christchurch sites is on Main North Road adjacent to Countdown Supermarket and close to the intersections of Sawyers Arms Road and Grassmere Street as shown in figure 6.3. Northlands Mall and Papanui High School are also close by.

Main North Road is a two-lane arterial with a speed limit of 50km/h and includes bus priority on other sections of the corridor. This site has a cycle lane running through the bus stop and the road narrows just

[3] Hourly directional traffic count has been estimated based on published AADT for Ponsonby Road site.

in front of the bus stop to accommodate a pedestrian island which prevents the buses from creeping forward to egress.

The bus stop services two high-frequency routes, four suburban routes and additional school buses at peak times and a set of signals is situated 130m upstream which provides gaps in the general traffic stream.

Figure 6.2 Site 2 Riccarton Road, Christchurch

Figure 6.3 Site 3 Main North Road, Christchurch

The first of the two Auckland sites is eastbound on Karangahape Road just west of the intersection of Pitt Street in central Auckland as shown in figure 4.4. The bus stop is in a retail area but not adjacent to any key shopping centres. Karangahape Road is a four-lane arterial with no median for much of its length; however, a small raised central island extends the length of the bus stop.

The bus lane ends just prior to this site and then turns into a left only lane at the signals. A high level of congestion is experienced at this site. Twenty services use the bus stop and the nearest upstream signalised intersection is approximately 300m away reducing the effect of any platooning of traffic.

The second Auckland site included here in figure 4.5 is on Ponsonby Road near the intersection of Picton Street and Richmond Road, and is situated in a retail and commercial district.

Ponsonby Road is a four-lane corridor with high volumes of traffic and a 40km/h speed limit. The bus stop at this location is immediately adjacent (downstream) to the signals at Picton Street and Richmond Road and has parking directly in front of it restricting bus movement from the site. This site was chosen to observe the platooning effect of vehicles given the proximity of the intersection and the behaviour of vehicles clearing the intersection while a bus is attempting to join the traffic stream. This bus stop services eight bus routes.

Figure 6.4 Site 4 Karangahape Road, Auckland

Figure 6.5 Site 5 Ponsonby Road, Auckland

6.3 Video analysis

6.3.1 Methodology

The video cameras captured four hours of footage at each of the five sites. The footage was clipped to record just the period when buses were egressing from the bus stop until they merged back into the traffic flow. Road user behaviour and any issues or conflicts encountered by buses while attempting to egress were examined and observations recorded during the video clipping process.

Over the five sites and four hours of data gathering, 383 bus egress manoeuvres were captured and recorded as individual video files. The video files were then categorised as those where a law change would potentially have assisted the bus in egressing from the bus stop earlier by identifying where vehicles that had the opportunity to give way chose not to, and those which would most likely be unaffected by a law change. The buses may have been unaffected for a number of reasons, including:

- A gap in the traffic stream coincided with the bus leaving the bus stop.
- The general traffic was congested providing an opportunity for the bus to egress.
- A vehicle voluntarily gave way to the bus at the earliest safe opportunity.

The video file analysis did not apply a set timing-based or distance-based rule to determine the earliest safe opportunity in categorising whether a vehicle could safely have given way to a bus and chose not to. The variability in the speed and congestion levels within the peak and off-peak periods made it difficult to delineate between the two situations. As such the decision was somewhat subjective but was mindful of safe stopping distances when determining whether a vehicle had the ability to give way to let the bus into the traffic.

Chapter 7 gives a technical analysis with a more methodical approach to determining the impact of a give way law change.

6.3.2 Key findings

The total number of buses recorded as egressing at each site was sensitive to the extent the bus stop was used. This ranged from some bus stops representing timing points on a particular route through to others only being used occasionally.

A total of 383 bus egress movements were recorded over the 20 hours of video footage and the preliminary analysis indicated that only 43 (11.2%) of the buses could potentially have benefited from a give way to bus legislation being in place while the remaining 340 (88.8%) would have been largely unaffected.

Table 6.2 summarises the bus egress manoeuvres that were captured during the video surveillance period at each site. The total egress movements have been broken down by those that would and would not be affected by a change in give way legislation. Of those that would benefit from a law change, the number of incidents where the bus was delayed by vehicles not giving way has been split to demonstrate the extent to which this occurred in congested network conditions, being only 2 of the 43 instances.

The final category included in table 6.2 represents when a bus was required to creep forward from the bus stop to emphasise their intention to re-enter the traffic flow in a timely manner. This was restricted in some instances by the physical layout of the bus stop and roadway and indicates the degree of congestion and frustration experienced by bus drivers.

Table 6.2 Summary of bus egress manoeuvres from video surveillance

	Total egress manoeuvres	Unaffected by rule change	Affected by rule change	Affected in congested conditions	Affected in free flow conditions	Bus required to creep forward
Buckleys Rd	70	67	3	1	2	7
Riccarton Rd	104	79	25	0	25	18
Main North Rd	106	94	12	1	11	5
Karangahape Rd	77	76	1	0	1	0
Ponsonby Rd	26	24	2	0	2	14

Egressing opportunities varied at each of the five sites. At all three of the Christchurch sites, buses often arrived two or three at a time providing the opportunity for the rear buses to allow the other buses to ease back into the traffic flow. Buses could also benefit from gaps provided at the end of a signal phase at the intersection of Russell Street about 120m north of the Buckleys Road bus stop. This was also observed at the other Christchurch sites to a lesser extent as they experienced higher side road flows turning into the corridor.

Pedestrians crossing in front of the buses delayed buses trying to egress on several occasions at both the Main North Road and Riccarton Road sites. While there is a pedestrian refuge island with pedestrian protection immediately in front of the bus stop on the Main North Road site, there is no crossing facility near the Riccarton Road bus stop. Pedestrians generally showed little concern for the buses, which were often delayed or forced to carefully negotiate both cars and pedestrians on the roadway when exiting the bus stop. The stop at the Main North Road site was adjacent to a narrow pinch point created by the pedestrian refuge island giving buses very limited ability to creep forward of the stop. This would force them to wait until a vehicle gave way or there was a gap in the traffic flow, although some tentative creeping forward behaviour was observed.

The Karangahape Road site had a very high volume of buses; however, very little delay was experienced. This was mainly because the majority of the buses were turning left at the lights at Pitt Street. The delay that was observed was largely due to cars queuing for the lights or due to congested conditions along the corridor.

The Ponsonby Road site also had very little observed delay. The main factor contributing to this was the close proximity to the lights meant buses could egress without delay during the change of phases at the signalised intersection with Picton Street. If the bus tried to egress during a green phase vehicles either changed to the outside lane or the bus would be forced to wait to until the end of the light cycle to egress. It was generally unsafe for vehicles to give way to the bus as they would be doing so on the exit to the intersection creating difficulties in legally clearing the intersection.

It was also noted vehicles were travelling much more slowly at this site (note the posted speed limit of 40 km/h) making it easier for the bus to exit from the stop.

Given the small number of observed delays captured in Auckland it would be more representative to remove Auckland egress movements from the analysis. This would increase the percentage of buses that could potentially have benefited from priority legislation being in place to 14.3%.

6.3.3 Risks and limitations

It should be noted the position of the camera, light, sun strike and footage quality sometimes made it difficult to view exactly when the bus doors closed and the bus started indicating their intention to exit the bus stop. It was assumed the precise time the bus indicated to re-enter the general traffic stream was the time the bus was looking for an opportunity to move into the traffic.

It is, however, possible the indicator may only have been used when the driver observed an adequate gap in traffic to egress into the traffic flow safely. The indicator may therefore not be representative of the time the bus attempted to exit the bus stop, therefore if a bus was observed moving prior to the indicator being visible, then this movement was taken as the intention for the bus to egress into traffic.

7 Technical analysis

7.1 Introduction

This section pulls together the data and feedback gathered in the earlier stages of the research with the aim of quantifying the tangible and defining the non-tangible benefits arising from a change in legislation giving buses priority when egressing from a bus stop.

During the scoping process of the technical analysis, the research team identified that the data gathered from the bus stop video footage was not comprehensive enough to use as a system-wide representation of the likelihood of vehicles not giving way to buses. The video data only provided a limited snapshot of bus stops and the resultant delays were sensitive to the bus stop design and proximity to adjacent intersections making it difficult to solely use this data to quantify delay representative of a broader area.

To increase the understanding of the likelihood and quantum of egress delay at a network level, an on-board survey was completed for a selection of peak and offpeak services on the Auckland network. The additional survey data together with Auckland Transport (AT) HOP integrated smart card records provided a more robust dataset from which to expand and calculate the likely economic effects at a network level in order to:

- quantify travel time delays, operational efficiency and public transport customer disbenefits of the delays buses experience re-entering traffic at each bus stop
- understand the trade-offs between facilitating improved travel of buses and disbenefits to other traffic including travel time and safety aspects.

Tables 7.1and 7.2 provide a summary of the benefits and disbenefits identified in the research to date. From this, the research team was able to identify the benefits that were quantifiable and proceed with a technical analysis of them. The EEM's evaluation framework quantifies safety benefits when significant crash data is evident; however, it did not apply in the context of this study as there was no tangible evidence to suggest either a positive or negative safety effect.

Table 7.1 Summary table of benefits

Primary benefit	Benefit	Stakeholder consultation	Focus groups	International case studies	Video observations
Travel time	Improved reliability	✓	✓	✓	
	Travel time savings (vehicle passenger)		✓	✓	
	Greater network efficiency	✓	✓		
Operational	Reduce bus delay at stops		✓	✓	✓
	Vehicle operating cost savings		✓		
Mode shift	Increase patronage	✓	✓		
Intangible	Create catalyst towards increased courtesy and understanding between buses and other motorists		✓		
	Clarity of driver obligations at bus stops	✓	✓		✓
	Introduction into driver training education			✓	
	Offsetting or deferring investment in		✓	✓	

Primary benefit	Benefit	Stakeholder consultation	Focus groups	International case studies	Video observations
	other bus priority measures				
	Increase public perception of buses	✓	✓		
	Reduce driver stress and frustration		✓		
Safety	Improve general road safety	✓	✓	✓	
	Reduce dangerous passing manoeuvres		✓		
	Improve safety of bus patrons		✓		

Table 7.2 Summary table of disbenefits

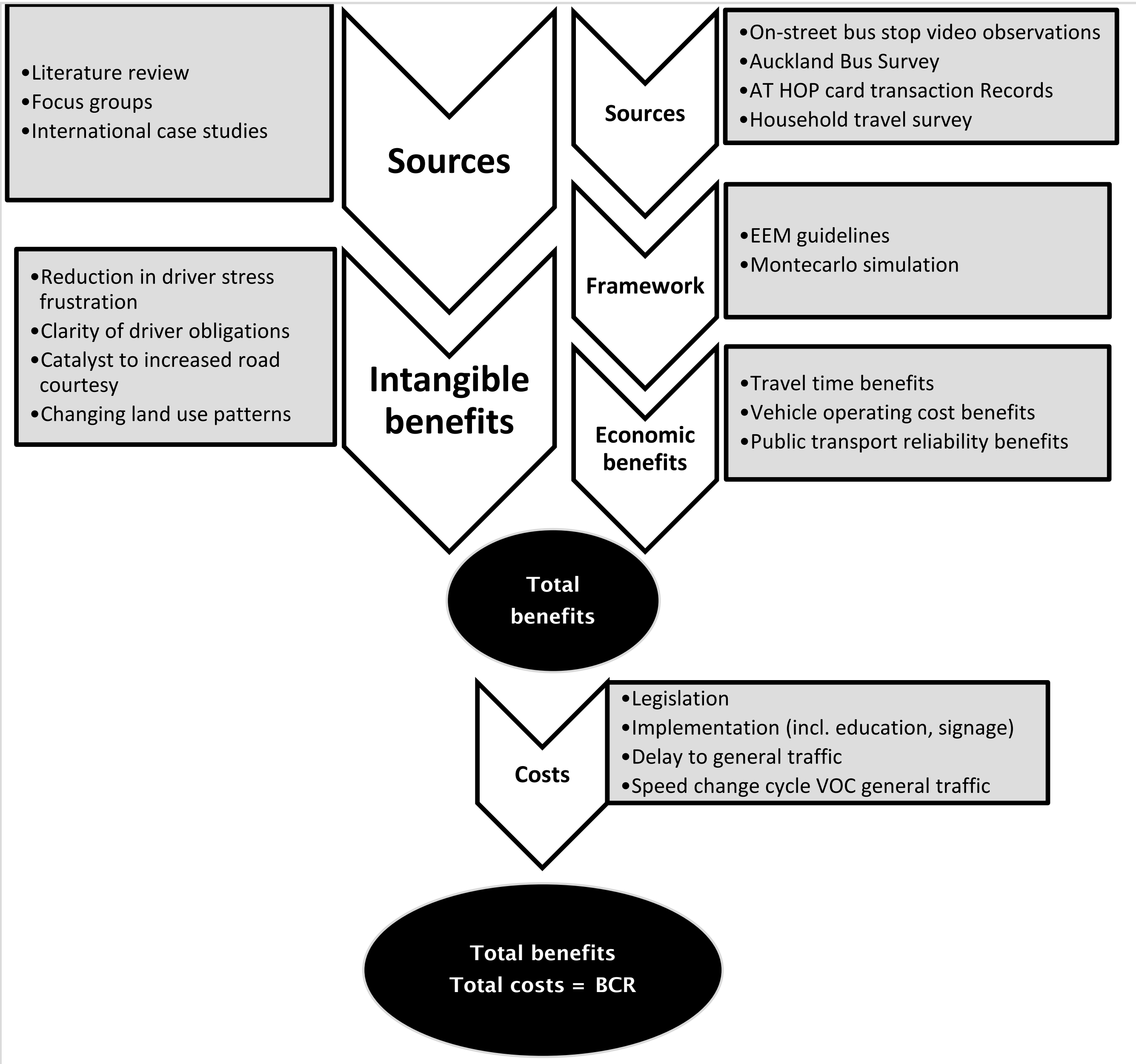
Primary disbenefit	Disbenefit	Stakeholder consultation	Focus groups	International Case studies	Video observations
Travel time	Delay to general traffic	✓			✓
Implement -ation	Education campaign costs	✓	✓	✓	
	Signage and implementation costs	✓	✓		
	Cost and resources required to enforce law change	✓	✓		
	Legislative change costs		✓		
Operational	Loss of advertising space on bus backs	✓	✓		
Intangible	Initial negative or chaotic behaviour	✓	✓		✓
Safety	Safety of pedestrians crossing near buses	✓			✓

7.1.1 Overview of methodology

The framework for the change in bus priority economic analysis is outlined in figure 7.1. Using the information and data gathered from the literature review, international case studies, focus groups and surveys as inputs, EEM procedures have been applied where possible to quantify the tangible benefits and costs arising from a legislative change to produce a BCR. The process of quantifying each component of the economic analysis is discussed in this section, including identifying a number of intangible benefits.

The literature review, consultation and focus group feedback concluded any disbenefits to other road users of a law change would be either marginal or negligible. As a vehicle in the general traffic stream stops or slows down to give way to a bus, the impact on their overall travel time would largely be offset as they would most likely pass the same bus at an earlier or later stop on the same corridor. Although general vehicle travel time disbenefits are stated as being marginal they have been included as part of the economic analysis to provide a conservative assessment of the relative benefits and costs. The initial cost required to implement a law change including advertising and education is significant.

Figure 7.1 Summary of technical analysis components



7.2 Calculation of benefits

7.2.1 Auckland bus survey

A vehicle rider survey of a sample of buses across the Auckland metropolitan network was carried out over several days to provide a more comprehensive dataset from which to quantify the potential travel time benefits. To ensure a good representation of the network was captured, a selection of routes was surveyed by riding a single bus trip on each of the selected routes from each of the five suburban areas; North Shore, western suburbs, Central Auckland, eastern and southern suburbs during both a peak and off-peak period.

To quantify the likelihood and quantum of delay experienced by buses due to vehicles not giving way, the bus delay and number of cars passing the bus, which could have safely stopped, were recorded at each bus egress movement along the length of the surveyed route. A total of 18 services were surveyed as detailed in table 7.3.

Table 7.3 Auckland on- board bus survey schedule and results

Area	Service number	Service	Service start time	Total number of bus stops on route	Number of bus stops egress delay experienced	Total number of cars not giving way
Central	Outer link	Outer city link	06.45	69	11	17
Central	Outer link	Outer city link	11.20	38	2	2
Central	Outer link	Outer city link	13.15	31	4	8
South	304	City to Otahuhu via Manukau Rd	14.00	61	5	6
South	472	Otahuhu to Manukau	15.25	55	2	4
South	471	Manukau to Britomart	16.20	76	1	1
West	195	Britomart to New Lynn Interchange	06.45	61	4	4
West	195	Britomart to New Lynn Interchange	10.10	23	2	3
West	249	New Lynn Interchange to Victoria St West	07.45	54	6	12
West	249	New Lynn Interchange to Victoria St West	11.15	55	4	5
East	550	Britomart to Cockle Bay school	06.45	62	2	2
East	550	Britomart to Cockle Bay school	13.25	62	2	5
East	501	Cockle Bay School to Britomart	08.15	63	4	5
East	550	Cockle Bay School to Britomart	14.55	61	2	2
North	879	Mayoral Drive to Browns Bay	10.50	63	2	2
North	839	Browns Bay to Mayoral Drive	12.10	69	5	5
North	875	Mayoral Drive to Browns Bay	17.10	45	9	11
North	858	Browns Bay to Mayoral Drive	18.40	63	2	2
Total					69	96

The number of times the bus stopped on the service, and the number of stops an egress delay occurred due to a failure to give way was recorded. The difference between the two was the number of stops where there were no cars approaching and the bus egressed immediately, or the bus entered a gap in a congested traffic stream as soon as it was able, or the first car which could stop safely chose to do so. Each of these situations would result in no change in travel time for the bus if a law change were implemented as there would be no impediment to re-joining the traffic stream.

At each stop where a bus was delayed the number of vehicles observed passing the bus which could have safely stopped were counted. Using the survey data and Monte Carlo simulation, a probability profile (table 7.4) has been developed to determine the likelihood that a specific number of vehicles, which could have safely given way to the bus, will travel past the bus at any given stop.

Table 7.4 Probability of vehicles failing to give way

Number of vehicles not giving way	Probability x vehicles not giving way
0	84.60%
1	9.59%
2	3.51%
3	1.62%
4	0.27%
5	0.14%
6	0.27%

The survey results show buses experienced an egress delay at 15.4% of stops. This correlates well with the video observation data from Christchurch sites, which showed of the 280 bus egress movements recorded 14.3% of the services could potentially have benefited from give way to bus legislation being in place. The Auckland video observation data was largely non-conclusive with a lack of egress delays observed at sites, due to the proximity of the bus stops surveyed to adjacent intersections.

In the context of the Auckland network, AT HOP card data for Wednesday 22 April 2015 shows buses make a total of 121,216 stops (outside of bus priority) on a typical week day. If buses experience a delay egressing at 15.4% of these stops, a total of 18,667 stops would be affected across the network on this day.

7.2.2 Calibrating delays to buses

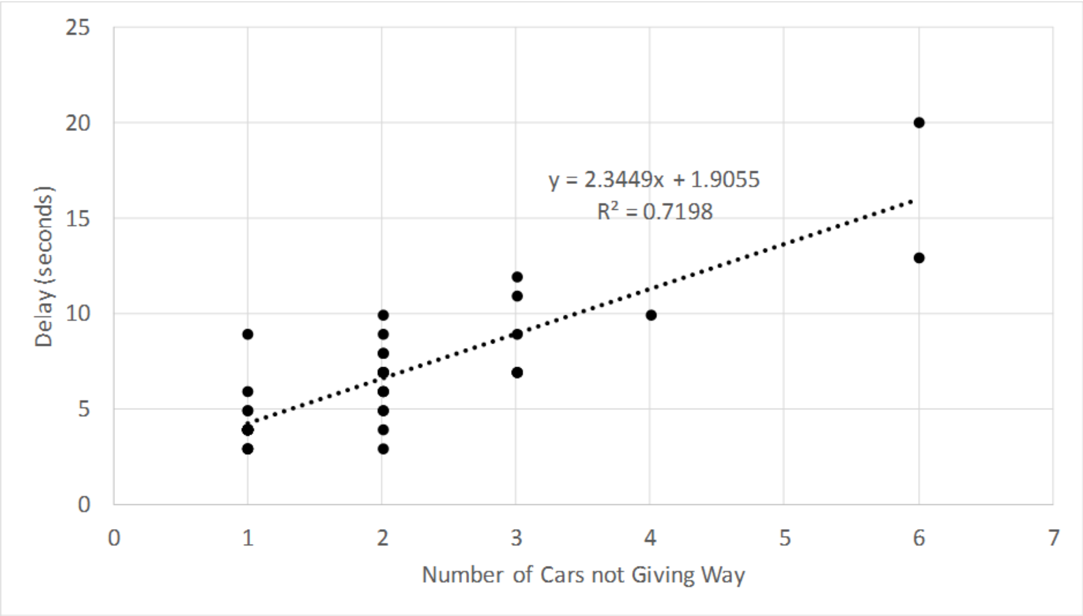
The egress observations captured in the video data where vehicles failed to give way were reviewed and each incident timed to calculate the delay to buses. The resultant delay ranged between 3 and 20 seconds per event, with an average of 6.39 seconds. The number of vehicles observed not giving way ranged from one to six vehicles with an average of 1.9 vehicles per incident. While surveyors attempted to time the corresponding delay to buses while riding the buses in Auckland (as reported in section 7.2.1) it was difficult to determine the exact start and finish time of the delay from inside the vehicle. Of the sample that were taken, delay times ranged between 3 through 16 seconds with an average of approximately six seconds, which while being less reliable does validate the video observations well.

The relationship between the number of cars and the delay to buses was established by mapping the data points from the video analysis as shown in figure 7.2. A linear trend line is shown and this is specified in equation 7.1 with the corresponding R-squared goodness-of-fit statistic of 0.72 indicating the linear equation provides a reasonable representation of the underlying data.

Where the number of cars is greater than zero

$$\text{Delay} = 1.9 + \text{Number of cars} \times 2.3 \qquad \text{(Equation 7.1)}$$

Figure 7.2 Scatterplot of bus egress delay and number of vehicles not giving way from video data



Using the probability profile from table 7.4 and the delay equation 7.1 developed from the video observations, the average delay to buses egressing from a stop where at least one vehicle does not give way equates to 5.69 seconds. This is consistent with the *Highway capacity manual* (Transportation Research Board 2010).

7.2.3 Auckland bus network travel totals

The Auckland bus network for the month of March reported patronage of 5,982,231 with a total of 56,617,441 passengers for the year ending March 2015 (Auckland Transport 2015). These totals exclude the Northern Express Service. Auckland Transport has an integrated fare and ticket system branded AT HOP. This is a smart card system developed by Thales to facilitate a tag on and tag off system on the Auckland public transport network. To understand how frequently buses egress from bus stops on any given day on the Auckland network an AT boarding report of tag on and tag off bus data for a typical day was obtained from Auckland Transport. This data set of 207,539 line items included 420,303 trips (tag on and tag off transactions) made using either an AT HOP card or cash transaction ticket for one day (Wednesday, 22 April 2015). An additional file containing the sequence and unique identifiers of bus stops for each service was also supplied by Auckland Transport to support the interrogation of the AT HOP card data for analysis.

Spatial analysis of the AT HOP card boarding data was undertaken using ArcGIS specialist software. Using the IPTIS based route list with stop sequence data, routes lines were generated for each route based on straight line lengths between the bus stop locations corresponding to each route. These routes were used as the basis for generating trip lines along the route and identifying the number of boarding and alighting bus stops visited by each service from transaction data in the Thales boarding report. Prior to generating these trip lines, transactions were removed where either the start and/or stop bus stop identification was unknown (for example where patrons paid in cash).

Accordingly, the total number of unique stops (and therefore the number of egress movements) made across all scheduled services was determined on a network wide basis and this equated to 131,656. This was then filtered down based on bus priority lane information which was also sourced from Auckland Transport. By spatially interrogating whether each bus stop was situated inside or within 5m of a bus priority lane or facility and undertaking a match between the scheduled running time of each service and bus priority operation hours a total of 10,440 bus egress movements were removed from the data set as the corresponding bus would not be egressing into the general traffic stream.

The AT HOP data was also analysed at a route level of calculate the total trip length in kilometres and at a transaction level to determine the average trip length undertaken by passengers and the extent to which bus priority was installed along the length of the route where the bus was most heavily laden with patrons. The analysis of AT HOP card transactions found while 92.1% of bus egress movements involved buses returning into general traffic, there was a tendency for a higher volume of passengers along sections of routes with bus priority installed. When filtering the routes based on the sections of routes between boarding and alighting stops for all transactions it was found that when weighted on a per passenger basis, 86.1% of egress movements occurred on non-bus priority corridors.

The GIS analysis enabled a range of statistics to be calculated for buses only (excluding rail and ferry) on the Auckland Transport network and these are summarised in table 7.5.

Table 7.5 Key travel statistics for Auckland Transport network

Auckland network key statistics		Value
A	Number of stops made by Auckland bus fleet per day	131,656
B	Number of stops per day outside bus priority	121,216
C	Individual boarding records per day	240,714
D	Number of bus services per day	7962
E	Average number of boardings per service (D/E)	30.2
F	Average bus route length (km)	17.24
G	Total person km all transactions	1,108,132
H	Total person transactions	151,292
I	Average person ride distance (km) (per service) (G/H)	7.32
J	Average person ride as percentage of full service	42.5%
K	Average number of passengers on service at any one time (J*E)	12.8
L	Average number of stops per service (excl bus priority) (B/D)	15.2
M	Average number of stops where benefit can be realised per service (=L*15.4%)	2.34
N	Average travel time savings per service (=M*5.69sec)	13.34

7.2.4 Monte Carlo simulation

A Monte Carlo simulation technique has been applied to determine the network wide totals of travel time savings which are likely to occur due to bus priority egress. Monte Carlo simulations are a type of algorithm well suited to managing probabilistic elements, and involve running multiple individual (single-run) simulations to obtain a range or distribution of outcomes when there is a probabilistic element involved. In this instance it was the likelihood that a vehicle gives way to a bus for the 121,216 non-bus priority egress movements across the Auckland network on any given day.

The video and ridership data has been used to determine the probability that a given (say x) number of vehicles fail to give way to the bus and relate this to the travel time delay experienced by buses. The Monte Carlo simulation has been run 1,000 times to simulate a range of potential scenarios from which the network wide travel time savings for buses can be enumerated, so a confidence interval for the total travel time savings can be calculated.

The key inputs to the simulation of the 121,216 egress movements, are the probability profile calculated from video and ridership data (included as P(x) in table 7.6), the calibrated delay equation from figure 7.2 and randomly generated numbers for each of the 121,216 movements between 0 and 1. Where a random number for a given stop is between the p-start and p-end values shown in table 7.6, the corresponding number x of vehicles are simulated as not giving way to the bus. The totals in the four columns marked 'Run 1' through 'Run 4' correspond to the total number of bus egress movements at which x cars fail to give way to the bus based on the first 4 of the 1000 simulations undertaken in the analysis.

Table 7.6 also includes the total network wide delay caused by vehicles failing to give way to buses for the four runs which when added up across a total of 1,000 simulations equates to an average delay of 29.51 hours per day assuming full compliance of a give way rule change, and a 5th percentile and 95th percentile of 29.17 hours and 29.87 hours respectively which is a range of +/- 1.2% around the mean.

Table 7.6 Monte Carlo simulation results

Monte Carlo simulation inputs					Number of stops where x vehicles fail to give way			
x	**P(x)**	**Delay (sec)**	**p Start**	**P End**	**Run 1**	**Run 2**	**Run 3**	**Run 4**
0	0.8460	0	0.0000	0.8460	102,330	102,766	102,642	102,620
1	0.0959	4.2	0.8460	0.9419	11,865	11,452	11,484	11,607
2	0.0351	6.5	0.9419	0.9770	4,282	4,276	4,288	4,185
3	0.0162	8.8	0.9770	0.9932	1,958	1,964	1,974	2,004
4	0.0027	11.1	0.9932	0.9959	331	289	345	321
5	0.0014	13.4	0.9959	0.9973	142	165	169	152
6	0.0027	15.7	0.9973	1.0000	308	304	314	327
Delay (seconds)					106,768	104,802	105,953	105,770
Delay (hours)					29.66	29.11	29.43	29.38

The calculated network wide delay of 29.51 hours is synonymous with the potential travel time savings for buses in the Auckland Region if a legislation change was effective and 100% of vehicles gave way to buses where it was safe to do so. This figure is the cornerstone of the subsequent economic analysis, and it is acknowledged a general traffic give way compliance rate may be significantly less than 100%.

7.2.5 Travel time benefits

Quantifying the travel time benefits attributable to a change in legislation allowing bus egress priority is derived from two components:

- vehicle and freight travel time benefits
- passenger travel time benefits.

Using the calculated network wide delay for Auckland of 29.51 hours, the value of travel time benefits per day for each of these components can be quantified using EEM procedures. The specific values are calculated in equations 7.2 and 7.3 and are as follows:

*Vehicle and freight travel time benefits = 29.51 hours x $17.10/hour * 1.42 = $716.68* (Equation 7.2)

(Source: Table A4.2 of EEM for bus vehicle and freight time in July 2002 $/hour and table A12.3 for 1.42 update factor to July 2014)

*Passenger travel time benefits = (29.51 hrs * 12.8 * 0.935) * $7.34/hour * 1.42 = $3693.44* (Equation 7.3)

(Source: Table A4.1(a) of EEM Base value of time for Car driver (all modes valued equally) in July 2002 $/hour and Table A12.3 for 1.42 update factor to July 2014.

For the purposes of calculating bus passenger travel time savings, the 29.51 hours of bus travel time savings have been multiplied by the average number of passengers on board at any one time (12.8 persons) and then scaled back to 86.1/92.1 = 93.5% of this value to take into account the higher volumes on passengers on bus priority corridors alluded to in section 7.2.4.

The composition of the value of time applied in these calculations assumes 1% work travel purpose, 30% commuting and 69% non-work travel purpose. There is no specific data to substantiate the number of work travel purpose trips but it is likely to be very low on public transport. Journey to Work (JTW) data has been extracted from Statistics New Zealand 2013 census data and equates to 29,700 trip to work by buses which approximates to 59,400 commuting trips per day. This corresponds to 25% of the 240,714 boarding transactions per day recorded from AT HOP data and acknowledging that many commuting trips are likely to include bus transfers a total of 30% of boardings are estimated to be commuting trips. The remaining 69% are therefore non-work travel.

7.2.6 Vehicle operating cost benefits

The vehicle operating cost (VOC) benefits will arise from improved efficiencies for public transport through reduced total driver operating hours on the network and reduced idle times for buses. The EEM provides the unit value of operational costs in table A15.3 and the additional fuel costs associated with increased idling as a result of egress delay as outlined in table A5.22.

Using the calculated network wide delay for Auckland of 29.51 hours the value of vehicle operating cost benefits per day can be quantified using EEM specified values and explained in equations 7.4 and 7.5 as follows:

*Idle time VOC benefits = 29.51 hrs * 5.247 c/min * 1.07 = $99* (Equation 7.4)

(Source: Table A5.22 of EEM for bus VOC by vehicle class in July 2008 $/hour and table A12.3 for update factor to July 2014)

*Driver time operating cost benefit = 29.51 hrs * 22.00 $/hr * 1.07 = $695* (Equation 7.5)

(Source: Table A15.3 of EEM for operating costs and table A12.3 for 1.07 update factor to July 2014 based on VOC rates). It is acknowledged that in practice these may be difficult to realise because of the small quantum of savings per driver.

The priority egress for buses will not enable any reduction in number of kilometres travelled by buses or facilitate any savings from change in speed cycles as the increased priority does not alter these components of each bus trip. Vehicle utilisation savings could also be applicable if savings were substantial enough to improve vehicle fleet resourcing as a consequence of faster operation. In the Auckland scenario this is very unlikely so a conservative approach has been taken by not including any vehicle utilisation savings.

Other considerations will be the potential for reduced vehicle maintenance costs through less heavy braking and smoother vehicle running. Appendix A15 of the EEM provides values to quantify these; however, this would require a greater understanding of operating costs from bus operators and is likely to be marginal at best.

7.2.7 Public transport reliability benefits

A benefit can be attributed to factors that improve the reliability of public transport, especially as the literature review indicates these are given a high weighting. A reduction in uncertainty of the time taken to travel a journey generates a benefit to users and influences their trip making behaviour. The formula for calculating public transport user reliability benefit is detailed in appendix A18 of the EEM and specified in equation 7.6 as:

$$Reliability\ Benefit = EL \times (VTT(\$/h/60) \times AML \times NPT \quad \text{(Equation 7.6)}$$

Where EL = equivalent time to a minute late ratio from EEM table A18.1

VTT = vehicle travel time ($/h)

AML = reduction in average minutes late

NPT = number of passengers affected.

The equivalent time to a minute ratio is understood to correspond to the extent to which a delay in a service is perceived by users to be equivalent to time spent in transit. This is then multiplied by the reduction in average lateness to determine the perceived penalty to users.

The equation from the EEM suggests this should be multiplied by the resultant equivalent perceived user travel time reduction by vehicle and freight travel time and the number of affected passengers. The research team consider this would grossly overstate the public transport user reliability benefits and the passenger travel time as applied in earlier sections should be used in preference to the vehicle and freight travel time. This would also be consistent with the definition of reliability in appendix A18 of the EEM which states it relates to users and not vehicles and freight. To be consistent with the travel time savings calculation, the same value of $7.34 has been applied in this analysis.

The fourth term in the equation is the number of affected passengers. In this instance the number of affected users who can benefit from a reduction in travel times is at least 7% or 16,850 of the total 240,714 daily users, as Auckland Transport records indicate approximately 7% of services depart the first bus stop behind schedule. The reduction in average minutes late is a modest 0.22 minutes (13.34 seconds) as set out in table 7.5. Again a conservative approach has been taken to the application by only using this 7% and it is acknowledged other services may lose time early on in their run affecting the reliability of the service. A sensitivity test has been included in section 7.5 to reflect a less conservative approach wherein users are affected by late running of services.

Essentially the whole network benefits, not just the services running late. This measure of gain is captured in the intangible benefits. As part of monitoring performance, service providers evaluate routes with regular difficulties with reliability and build additional time into the timetable.

The resultant conservative evaluation of public transport user reliability benefits is:

$$PT\ user\ reliability\ benefits = 4.8 * (\$7.34)/60 * 1.42 * (13.34/60) * 16850 = \$3,124.16 \quad \text{(Equation 7.7)}$$

(Source: Section A18.1 of EEM for Reliability benefit in July 2002 $/hour and table A12.3 for 1.42 update factor to July 2014).

The public transport user reliability benefits ($3,124.16) are less than the travel time benefits ($3,693.44) which is consistent with the EEM guidelines and it is acknowledged if a less conservative assumption around the percentage of affected users were made, this would not be the situation.

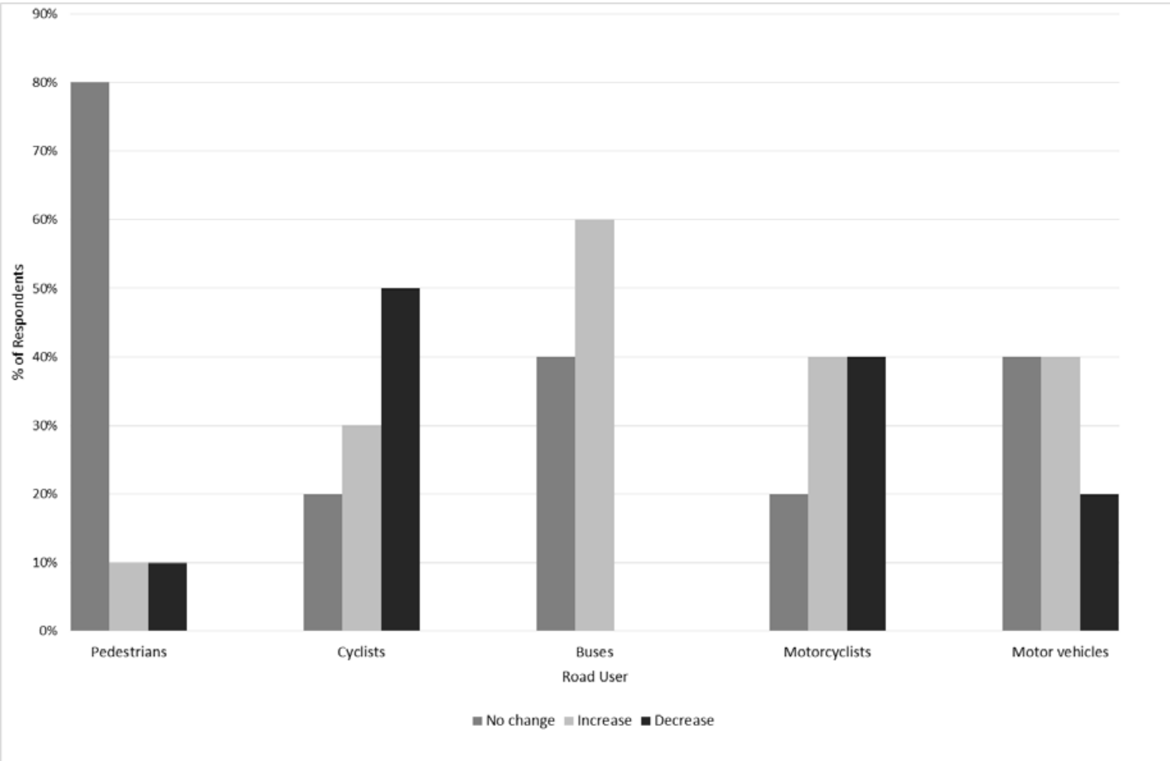
7.2.8 Safety

International case studies look at the safety impacts of the introduction of bus priority legislation at bus stops and this was the subject of some discussion with focus groups. It has been identified that the most dangerous traffic aspects of buses are the slowing down and merging traffic movements around buses. The risks evident due to uncertainty and confusion around current give way protocols when buses egress bus stops are:

- dangerous driver behaviour around bus stops as vehicles attempt to pass a bus by crossing the centre line or mounting traffic islands
- passengers falling as a result of heavy braking to avoid conflict with vehicles not giving way.

Figure 7.3 summarises the views of stakeholders on the likely change in safety outcomes as a result of buses receiving priority to egress. The general feeling from both stakeholders and focus group participants was safety would improve or stay the same through more certainty, greater clarity and awareness for both bus drivers and other road users of their obligations. The most common safety concern expressed by stakeholders was the potential for bus drivers to pull out without checking and failing to see cyclists or motorcyclists.

Figure 7.3 Stakeholder views of safety impacts



The Transport Agency's Crash Analysis System (CAS) data has been interrogated and no reported incidents specifically attributed to bus egress movements were found in the data relating to the last five years. Operators were also contacted to determine if there were any minor incidents that would not have been recorded in CAS. The general response was there were no records of any incidents including one operator quoting 'This is not a road safety issue and shouldn't be treated as one. It would be a pity to see it knocked back for lack of crash stats'.

The Accident Compensation Corporation (ACC) has been contacted to find out if there is any information relating to injuries caused due to falls when buses brake heavily. The ACC does not specifically seek to collect or categorise any claims according to proximity to a bus stop, pulling in and out of traffic or sudden braking due to difficulties with traffic merging. A brief survey of the free-text crash description indicated approximately 20% of new bus claims had an element of sudden/unexpected braking or accelerating; however, crash descriptions are not precise enough to narrow down the reason for the sudden braking or acceleration. Information available would suggest there are very few if any claims that could be related to an incident at bus egress point.

To quantify a safety benefit there would have to be sufficient evidence to suggest a change in legislation would reduce the number of nose-to-tail crashes, or crashes involving conflict with buses at bus stops. Based on New Zealand crash history records, literature review findings or international case studies there is insufficient evidence to suggest there would be either a positive or negative effect on safety associated with a law change. This is consistent with King (2003) who cited a study commissioned by The Insurance Company of British Columbia, which found there were no negative safety experiences related to YTB legislation in countries with YTB laws and concluded the YTB legislation could have some positive safety impacts arising from increased bus patronage, clarity of right-of-way at bus stops, and reduced friction and lane changes of motorists.

7.2.9 General traffic road user disbenefits

Road user cost disbenefits to general traffic will most likely be marginal and were considered by the focus groups to generally be negligible; however, it is important to consider the magnitude of disbenefits, particularly in light of the relatively small travel time savings for buses.

The initial and immediate impact of one or more vehicles choosing to give way to a bus (that otherwise would not have done so without a law change) would be the loss of one place in a stream of traffic queue for each vehicle giving way to a bus. In a typical urban condition the headway between vehicles would be approximately two to three seconds in a platoon of traffic, subsequently this is the estimated initial and immediate increase in travel time experienced on the network.

Extended out across an entire journey this increase in travel time may be negated as the vehicle could overtake the same bus at the next or a subsequent bus stop on the same or other corridor, thus retaining their previous position in the traffic stream and incurring no delay over the length of the journey. On the other hand the immediate two to three seconds delay from giving way to a bus could result in the vehicle missing a turning opportunity or green phase at a signalised intersection later in the journey that the vehicle would otherwise have benefited from.

Subsequently, the subtleties of the interaction between the vehicle and the remainder of the network and traffic on the network would have to be considered over the entire length of each affected journey to accurately understand the impact. To provide a coarse estimate of the aggregated effect of the delays to general traffic, the upper end of the headway range being three seconds is assumed to be the incremental delay to any given journey corresponding to the loss of one place in a queue of moving traffic. Using the Monte Carlo simulation results presented in section 7.2.4 it is calculated that with full compliance to a give way law change an average of 30,085 general vehicles per day would be affected with an incremental delay of three seconds on the Auckland network.

The resultant road user cost disbenefits for these vehicles are as follows:

- travel time disbenefits
- additional vehicle operating cost due to speed change cycles.

Using the network wide total of 30,085 vehicles in general traffic affected by up to three seconds delay, these components can be quantified using the EEM procedures, wherein the specified values are explained in equations 7.8 and 7.9 and are as follows:

*Travel time disbenefits = 30,085 * (3 sec / 3600) * $16.27/hour * 1.42 = $579.22* (Equation 7.8)

(Source: Table A4.3 of EEM for urban arterial all periods travel time in July 2002 $/hour and table A12.3 for 1.42 update factor to July 2014)

*Additional VOC due to speed change cycles = 30,085 * .024 * 1.07 = $772.58* (Equation 7.9)

(Source: Table A5.37 Urban arterial additional VOC initial speed 50km/h final speed 10km/h in July 2008 $/hour and table A12.3 for update factor to July 2014)

7.2.10 Intangible benefits

The research identified a number of additional benefits that are important to consider as part of the overall bus egress priority legislation change evaluation; however, they are of an intangible nature so are not quantifiable using existing evaluation methods and procedures. These are described in further detail in earlier sections and include:

- increased clarity of driver obligations at bus stops
- legislation change creating a catalyst towards increased courtesy and understanding between buses and other motorists
- introduction of give way to bus legislation into new driver training and education programme
- increased perception of public transport on road user hierarchy
- potential to offset or defer investment in other bus priority measures at some locations.

In addition to direct benefits, literature by Currie and Sarvi (2012) suggests that improved bus priority through a change in legislation could have secondary benefits including generating mode shift. Evidence of mode shift effect suggests when travel savings of five to eight minutes are generated through priority measures mode shift from private vehicles would occur (Currie and Sarvi 2012). The technical analysis using the Auckland data generated an average travel time savings per service of 13.34 seconds (as documented in section 7.2.3) which is not sufficient to enumerate a mode shift benefit. The small levels of travel time savings identified are also not considered to be substantial enough to induce secondary benefits such as operational savings through the reduction of fleet resources or positive changes in land use.

7.3 Calculation of costs

The literature review, consultation feedback and focus group feedback established the following tangible disbenefits or costs needed to be considered as far as practicable in the technical analysis:

- education campaign, legislative change and other implementation costs
- vehicle signage costs including potential loss of advertising space on bus backs
- road marking and road signage costs

7.3.1 Education and legislative costs

The implementation, signage, legislation and resourcing costs of a legislative change are one off costs, but are likely to be considerable. The degree of investment in this area has been noted through literature and international case studies to be an important aspect of the likely success of a legislative change. The change in Give Way legislation in New Zealand in 2012 was communicated well to the public and deemed to be successful by focus group participants.

Consultation with the Transport Agency informed us that based on their previous experience, the costs associated with a legislation change may be highly variable. A change in bus priority legislation is not envisaged by the Transport Agency to be complex, with the main components of costs being for public consultation, creation of a new offence code for enforcement, updating of the Transport Agency website, publication of factsheets and public advertising of the law change. The most variable element in terms of cost is the degree of advertising and extent of the education campaign. Following consultation with Transport Agency it was agreed the total education and legislative costs were likely to be in the order of $1 million.

7.3.2 Bus signage costs

The inclusion of signage on buses to reinforce the law change is a further significant cost but will be sensitive to the type and extent of signage applied. The impact of signage is considered further in the calculation of costs in the following section which considers two scenarios, specifically:

- The installation of LED lights on the rear of buses, with an estimated cost of $1.5 million based on an installation cost of $1,500 per bus for the approximate 1,000 vehicles in the Auckland fleet. This figure compares with Zhou and Broomfield's (2007) estimate of YTB LED lights to cost between US$250 and US$600 per bus. The total cost doubles to about $3m for the nationwide fleet of approximately 2,000 buses.
- The application of decals on the rear of buses – with an estimated cost of $50,000 based on a sticker cost of $4 per bus (this is the current cost incurred by Environment Canterbury for decals) which needs to be replaced every month as advertising changes, which is approximately $50 per bus per annum for the approximate 1,000 vehicles in the Auckland fleet. Zhou and Broomfield (2007) estimate the costs of decals to be between US$5and US$20 per bus. The total cost has been doubled from $4 per bus to $8 per bus to align more closely with Zhou and Broomfield (2007) and to allow for larger stickers than those used by Environment Canterbury to be applied. The resultant $100 per bus per annum extrapolates to $200,000 for the nationwide fleet of approximately 2,000 buses but unlike the LED lights which are an initial investment, this is an ongoing annual expense.

A related operational disbenefit that may also be of relevance in some urban areas is the potential loss of revenue arising from less space on the back of buses which may be allocated to advertising. The likely economic impact of this for operators could be minimised with the choice and placement of Give Way to Bus signage.

Additional costs for road marking and signage have not been quantified as part of this analysis but would need to be considered as part of a Give Way to Bus scheme implementation decision and design. The inclusion of road marking and signage would most likely be a positive contribution to the compliance rate and these benefits would offset the costs.

7.4 Summary of economics

The preceding sections evaluating the daily benefit and cost components are largely informed by service and patronage data collected in March 2015 across all services in the Auckland Region. To extrapolate the results to be representative of annualised benefits, two expansion factors have been applied, one for bus-related benefits and a separate factor for passenger-related benefits.

As at April 2015, Auckland Transport estimate that the typical fleet size on a weekday is 900 buses and on weekends and public holidays is 300 buses. Based on 245 typical weekdays in a year and 120 weekend and public holiday days per annum the resultant annual expansion factor based on fleet sizes is (900*245 + 300*120)/900 = 285. This factor has been applied to the vehicle-related benefits that have been quantified including driver, vehicle and freight travel time and vehicle operating costs.

The expansion factor for passenger travel time and user reliability benefits has been calculated separately to account for March being one of the peak months of the year in terms of patronage. Auckland Transport patronage data indicates an average of 4.72 million boardings per month for the year ending March 2015, and in March 2015 a total of 5.98 million boardings were recorded. To be representative of typical patronage trends across the financial year, an adjustment factor of 79% (=4.72/5.98) has been applied to the March 2015 patronage values, subsequently the annualisation factor for passenger travel time and reliability benefits is 225 (=79%*285).

These two expansion factors are included in the summary of benefits in table 7.8 and costs in table 7.9. The discounting procedures applied assume a year zero of 2014, use a discount rate of 6% and conservatively assume uniform series present worth factors from the EEM (that is the analysis conservatively assumes no growth in service coverage, fleet size or patronage over the evaluation period). A 10-year evaluation period (ie horizon over which benefits are accrued) is considered to be more suitable for the evaluation of travel demand management activities (NZ Transport Agency 2013a) and therefore this has been included as in the economic evaluation in preference to a 40-year period which is typically used in the evaluation of infrastructure projects.

Table 7.8 Summary of benefits for Auckland Region

Type of benefit	Daily benefit	Expansion factor	Annual benefit
Vehicle and freight travel time	$717	285	$204,300
Passenger travel time	$3,693	225	$830,200
Vehicle idle time VOC	$99	285	$28,300
Driver time VOC	$695	285	$198,100
Public transport reliability benefits	$3,124	225	$702,100
Driver delay (general traffic)	-$579	285	**- $165,100**
Speed change cycle (general traffic)	-$773	285	**- $220,200**
Total benefits	**$6,976**		**$1,577,700**

Table 7.9 Summary of costs for Auckland Region

Type of cost	Total cost
Education and legislative implementation costs	$1,000,000 nationwide one-off cost
Vehicle signage (LED option)	$1,500,000 one off cost
Vehicle signage (decal option)	$100,000 per annum

The presentation of benefits and disbenefits in table 7.8 and table 7.9 both correspond to the Auckland Region and to provide a nationwide analysis further expansion of the results has been undertaken. The Ministry of Transport (MoT) collect total bus passenger boardings per annum by regional authority as part of the wider Transport Monitoring Indicator Framework (TMIF) available at MoT (2015). The published 2013/14 figures show that 55.85 million of the total 109.15 (that is 51% of) bus passenger boardings nationwide occurred in the Auckland Region in 2013/14. To expand the Auckland economic evaluation to a nationwide figure it is proposed the annualised benefits and disbenefits presented in table 7.8 be factored up accordingly. While some public transport use is in less populated urban and rural areas, the significant majority of 86% of all bus boardings were in Auckland, Wellington and Christchurch with the remainder being predominately in regions with large urban areas such as Waikato, Bay of Plenty and Otago.

The benefits and costs presented in table 7.8 and table 7.9 assumes a 100% compliance rate of vehicles giving way to buses as a result of a change in bus egress legislation. Any compliance rate less than this would reduce the benefits to buses and bus passengers and reduce the disbenefit to general traffic. The literature review and case studies highlighted the importance of education being instrumental to the successful implementation of a law change but also demonstrate the importance of appropriate signage. The impact of signage is considered further by developing three scenarios specifically:

- The installation of LED lights on the rear of buses – international experience demonstrates the installation of LED lights results in high compliance rates and has been an effective means of clearly exhibiting bus priority. Fabregas et al (2011) tested the effect of YTB LED signs on yield behaviour on corridors in Tamp and Fort Myers, Florida. They found the proportion of bus egress manoeuvres where general traffic yielded with the use of LED signage was up to 80% in Tampa and 88% in Fort Myers. On this basis it is conservatively assumed the installation of LED would correspond with compliance rates in the order of 75%. The total implementation cost would then become $1,000,000 education and legislation and $3,000,000 to install LED lights on a nationwide fleet of approximately 2,000 buses (that is twice the size of the Auckland fleet).
- The application of decals on the rear of buses – international and local experience suggests the presentation of decals is a less successful means of exhibiting bus priority. Fabregas et al (2011) established a yield rate using a decal of 58% in Tampa and 70% in Fort Myers. It is conservatively assumed in this assessment that with decals of a suitably large size, a modest but substantial compliance rate in the order of 50% is achievable. The total implementation cost would then become $1,000,000 education and legislation and $200,000 to install decals on a nationwide fleet of approximately 2,000 buses (that is twice the size of the Auckland fleet).
- No signage on buses – while there is no clear evidence on the likely level of compliance if no signage is included on the rear of buses, as a sensitivity test a 20% compliance rate has been assumed. The total implementation cost would then be just the $1,000,000 education and legislation cost.

A summary of the nationwide benefits, costs and resultant BCR is presented in table 7.10 for the three signage scenarios specified above. The implementation costs have been split evenly across years 1 and 2 of the evaluation period, the LED signage cost has been allocated to year 1, an decal costs are ongoing annual expenses from year 2 onwards.

Table 7.10 Summary of nationwide benefit-cost ratios

Scenario	Implementation cost	PV benefits	PV costs	Compliance rate	Discounting period	BCR
LED signage	$4,000,000	$14,887,000	$3,746,000	75%	10 years	4.0
Bus decals	$1,200,000	$9,925,000	$2,200,000	50%	10 years	4.5
No signage	$1,000,000	$3,970,000	$917,000	20%	10 years	4.3

7.5 Sensitivity tests and discussion

The BCRs published in table 7.10 are based on a number of assumptions including:

- average bus, passenger and general traffic delays as observed from surveys
- extrapolation of observed delays over all peak and off-peak services
- no growth in services, patronage or fleet size over the next 10 years
- estimated implementation costs based on Transport Agency experience
- Auckland benefits extrapolated to represent nationwide benefits based on relative passenger numbers
- application of EEM procedures with a 6% discounting rate
- no late running of services beyond the proportion of services which start behind schedule.

Seven sensitivity tests are introduced in this section to provide some context around each of these key assumptions.

7.5.1 Test one: Variation in bus egress delays

Observations from the on-board bus surveys have been used to calculate the average sampled delay incurred by buses when vehicles do not give way but could have done so safely. The video observations only correspond to a small sample of the full population of bus egress movements on any given day, therefore the actual population mean delay will lie within a range which can be determined through appropriate statistical testing. More specifically, as only 448 egress movements were observed it is important to understand the uncertainty around the 15.4% of egress movements where a delay was observed when applied to the full population of 121,216 egress movements per day on the Auckland road network.

To determine the range of delays and impact on BCR, a binomial proportion confidence interval has been calculated and applied to the average number of bus egress movements that were observed to experience a delay. The binomial distribution is appropriate in this instance as the bus egress movement for the purposes of this analysis is repeated a fixed number of times (121,216 per day), each egress movement has two possible outcomes (a delay to the bus occurs or does not occur), the probability of a delay is essentially the same for each egress movement and the likelihood of a delay occurring for any given egress movement is statistically independent of other egress movements. The confidence interval has been calculated using the Wilson (1927) score interval which is calculated using equation 7.10.

$$\frac{1}{1+\frac{1}{n}z^2}\left[\hat{p}+\frac{1}{2n}z^2 \pm z\sqrt{\frac{1}{n}\hat{p}(1-\hat{p})+\frac{1}{4n^2}z^2}\right] \quad \text{(Equation 7.10)}$$

where z is the test statistic = 1.96 at a 95% confidence level

p is the binomial proportion (ie 0.154 proportion of bus egress movements experiencing delay)

N is the sample size (ie 448 observed egress movements)

The resultant 95%ile confidence interval corresponds to delays to buses occurring at between 12.4% (lower) and 19.0% (upper) of bus egress movements. When the lower and upper confidence interval values are substituted for the 15.4% mean value in the BCR analysis, the updated range of BCRs across the three signage scenarios sits approximately 0.7 to 0.9 above and below the default BCR values, in a range between 3.3 and 5.4.

7.5.2 Test two: Calculate peak and off peak delays separately

The technical assessment of the benefits has been calculated by determining the delay to buses and general traffic as an average of all peak and off-peak observations and applying this to all services irrespective of the time of day. As a sensitivity test, the delays to buses which result from vehicles not giving way have been calculated separately for peak and off-peak services. The percentage of bus egress movements at which vehicles were observed not giving way when it was safe to do so was 15.4% aggregated across all services. During the peak periods of 7–10am and 3–7pm the percentage was slightly lower at 11.6% and outside these hours was slightly higher at 18.2%.

The resultant impact when expanded across all peak and off-peak services is the network-wide observed delay to buses of 29.5 hours decreases by 7% to 27.5 hours. Further to this by assuming a lower patronage outside peak periods (and a lower value of time as relatively fewer commuters are likely to travel by public transport outside the peak periods) it was calculated passenger time benefits would reduce by approximately 10%.

The net effect of the reduced benefits results in slightly lower BCRs being calculated with the reported range of 4.0 to 4.5 reducing by approximately 10% to a range of 3.6 to 4.1.

7.5.3 Test three: Growth in services, patronage and fleet sizes

The economic evaluation conservatively assumes no growth in bus patronage, service coverage or bus fleet size over the 10-year period that benefits are accrued. While Auckland Transport has at the time of writing not formally published strategic growth targets for the uptake of public transport over the next 10 years, their aspirations for strong sustainable growth in this sector are clear and are reflected in this sensitivity test. The indicative growth figures assumed in this test as suggested by Auckland Transport is compounding growth in patronage of 3% per annum, which is well below the current level of growth being realised on the network. There are several potential strategies to accommodate this quantum of growth in passengers without adding congestion to the Auckland roading network, including providing vehicles with greater capacity and running services more efficiently. In acknowledgement of improved efficiencies the sensitivity test assumes the fleet size would only grow at around 1% per annum to accommodate the 3% growth in passenger numbers.

The resultant BCR range increases in the order of 5–10%, from 4.0 to 4.5 in the default analysis to a range of 4.2 to 4.9 in the updated analysis. The BCR for the LED signage option increases the least due to the additional capital expense of adding LED lighting to the new vehicles in the fleet. It is further understood that Auckland Transport intends to roll out additional bus priority across the regional network with plans to expand the on-road bus priority infrastructure by 40km in the short-to-medium term. The impact of this may erode the additional benefits calculated in this sensitivity test to some extent as there would be fewer instances of the bus egressing into general traffic, particularly at peak times.

7.5.4 Test four: Implementation costs

The implementation costs have been estimated by the Transport Agency based on their previous experience with legislation change and associated publicity and education campaigns, and an approximate implementation cost of $1 million has been suggested. While it is recommended a more specific estimate would be helpful to the evaluation in this report, a sensitivity test has been undertaken to consider the impact if the cost was in the range of $0.5 million through to $1.5 million. Note the signage costs remain fixed as per the assumptions made earlier in this chapter.

The resultant BCR is least sensitive where the signage expenses are higher, that is for LED signage with the BCR increasing from 4.0 to 4.5 for a less expensive implementation cost and decreasing to 3.5 for an additional $0.5m expense. By contrast the scenario with no signage is most sensitive as implementation costs represent a greater relative share of the total cost with the BCR increasing from 4.3 to 8.7 or decreasing from 4.3 to 2.9 in each instance.

7.5.5 Test five: Extrapolation of nationwide benefits

The survey data used to calculate delays to buses and general traffic is focused primarily on the Auckland experience although video data from Christchurch suggests that give way behaviour and subsequent delays in Christchurch are not dissimilar to Auckland. With approximately 86% of bus boardings in New Zealand being on the Auckland, Wellington and Christchurch urban networks, it is reasonable to assume the Auckland findings can be extrapolated for these other centres. However, there is less certainty around the impact that bus priority egress may have on the remainder of New Zealand bus services corresponding to the residual 14% of boardings.

A sensitivity test has been undertaken whereby no benefits are attributed to the 14% of services operating outside the three main centres. The resultant impact on the BCR values is a decrease from the 4.0 to 4.5 range for the three signage scenarios, to 3.4 to 3.9 if there are no benefits outside Auckland, Wellington and Christchurch.

7.5.6 Test six: Discounting rate

The EEM procedures provide for a default discounting rate of 6% and include discount rates of 4% and 8% for the purposes of sensitivity testing. The application of the higher and lower discounting rates results in BCR values for each scenario which are approximately 0.2 to 0.4 higher (@4%) or 0.3 to 0.5 lower (@8%), subsequently the analysis is not overly sensitive to the discounting factor applied.

7.5.7 Test four: Late running of services

The calculation of public transport reliability benefits includes an assumption regarding the number of passengers affected by the late start and late running of services. In the economic evaluation, the number of affected users that can benefit from a reduction in travel times has been assumed to be 7% of the total daily users as Auckland Transport records indicate approximately 7% of services depart the first bus stop behind schedule. This is a conservative approach acknowledging other services may lose time subsequent to the start of the service, further affecting the reliability of the service.

A sensitivity test has been included to reflect a higher proportion of 10% of all bus users potentially being affected as a result of delays accruing during the operation of the service. The resultant increase in public transport reliability benefits increases the BCR from a range of 4.0 to 4.5 to a range of 4.7 to 5.4.

7.5.8 Summary of sensitivity test results

The recalculated BCRs corresponding to each of the sensitivity tests are presented in table 7.11.

Table 7.11 Sensitivity test benefit cost ratios

Scenario	LED BCR	Decal BCR	No signage BCR	LED BCR change	Decal BCR change	No signage BCR change
Default analysis	4.0	4.5	4.3			
Delay upper confidence interval	4.8	5.4	5.2	0.8	0.9	0.9
Delay lower confidence interval	3.3	3.7	3.6	-0.7	-0.8	-0.7
Peak/off-peak analysis	3.6	4.1	3.9	-0.4	-0.4	-0.4
Growth in public transport	4.2	4.9	4.8	0.3	0.4	0.5

Scenario	LED BCR	Decal BCR	No signage BCR	LED BCR change	Decal BCR change	No signage BCR change
Implementation $0.5m cost	4.5	5.7	8.7	0.6	1.2	4.3
Implementation $1.5m cost	3.5	3.7	2.9	-0.4	-0.8	-1.4
No benefit outside of A/W/C	3.4	3.9	3.7	-0.6	-0.6	-0.6
4% discounting factor used:	4.3	4.7	4.7	0.4	0.1	0.4
8% discounting factor used:	3.7	4.4	4.0	-0.3	-0.1	-0.3
10% of users affect by late running	4.7	5.4	5.2	0.8	0.9	0.8
Maximum BCR	4.8	5.7	8.7			
Minimum BCR	3.3	3.7	2.9			

The sensitivity analysis provides robustness around the BCR calculations and demonstrates that regardless of the input assumptions, the BCRs for each of the three scenarios sit within a healthy range of 2.9 through 8.7. The significant up-front cost of investing in LED technology results in generally lower BCRs for the corresponding scenario; however, the decal and no signage options yield similar ranges of BCR.

8 Conclusions

Giving way to buses leaving a stop is currently only considered a courtesy, creating a delay for buses. This delay repeated numerously through a bus route significantly impacts on travel time reliability, the efficient operation and perception of public transport. The aim of this research was to quantify these delays and their impacts at a network level.

The research identified and where possible quantified the benefits and disbenefits that may arise from a legislative change providing buses with priority when egressing from bus stops into the general traffic lanes. This forms an evidence base from which existing regulatory settings can be reviewed with a focus to improve public transport investment and optimise infrastructure.

The benefits arising from bus egress priority were a combination of tangible and intangible benefits, with some of these able to be monetised through the application of the EEM's economic evaluation framework including travel time, vehicle operating cost and public transport reliability benefits. A range of intangible benefits was also identified through the literature review, focus groups and data collection stages of the research including a reduction in driver stress and frustration, clarity of driver obligations, providing a catalyst towards improved road courtesy and improving the profile of public transport for all road users.

Reliability (including punctuality) is one of the most important (often the most important) attributes of urban bus services in New Zealand, as in other countries, as perceived by users and potential users of the services. It is also one of the attributes for which perceived performance is poorest, relative to its importance. This indicates improving service reliability warrants very high (or the highest) with the intention to enhance customer satisfaction and to increase patronage. (Ian Wallis Associates and The TAS Partnership 2013).

Focus groups identified the main benefit from prioritising bus egress movements would be an improvement in the reliability and consistency of bus service run times. This would be likely to lead to improved perception of public transport and increased bus patronage. This reduction in uncertainty is recognised through the calculation of a public transport reliability benefit. Other benefits cited included improved courtesy and understanding between buses and other motorists with increased clarity of driver obligations at bus stops and reduced bus driver frustration. An amendment to existing give way legislation to prioritise buses merging into general traffic was also viewed as having the potential to offset or defer investment in other bus priority measures in some locations.

Stakeholders and focus group participants were invariably supportive of a move to review and change existing legislation, with both motorists and commercial road users considering if a law change was to take place, there would be no significant disbenefits for general traffic.

There was no conclusive evidence to suggest an amendment to the Land Transport (Road User) Rule 2004 would result in better or worse road safety outcomes, based on New Zealand crash history records, literature review findings, stakeholder consultation or international case studies. International literature suggests some positive safety impacts may arise due to increased bus patronage, clarity of right-of-way at bus stops, and reduced friction and lane changes of motorists however this is not substantiated and has not been considered as a tangible benefit.

The EEM's economic evaluation framework has been applied to quantify the tangible benefits of a law change. Travel time savings for buses and bus users and delays to general traffic were calculated from data collected from video observations of bus stop egress behaviour in Auckland and Christchurch, and during on-board travel surveys conducted on the Auckland network. These results were expanded based on transaction data from AT HOP card records enabled tangible benefits to be quantified for the entire Auckland network, which in turn were expanded to calculate nationwide benefits.

The tangible costs to amend current give way legislation largely relate to the costs associated with implementing a legislation change, the disbenefits to other general traffic, as well as any road marking and signage costs. International literature clearly shows that compliance rates and the success of give way to bus schemes are positively correlated to the extent of signage and education campaigns implemented. Subsequently, the economic analysis explored several signage options and potential compliance outcomes.

Overall the assessment concluded that give way to bus legislation provided a viable investment opportunity with resultant nationwide BCRs ranging from 4.0 using LED signage to 4.5 using bus decals. Sensitivity test scenarios were assessed to ascertain the likely range of BCRs when a variety of input assumptions were changed. This sensitivity analysis provided confidence in the robustness around the BCR calculations, with the BCRs being within a range of 2.9 through 8.7. The significant up-front cost of investing in LED technology results in lower BCRs for the corresponding scenario; however, the decal and no signage options yield similar ranges of BCR.

This study provides an input to inform further review of any policy decisions to increase the priority of buses on the New Zealand road network. Further contributions may include:

- a review of possible give way to bus schemes and types of implementation that would best suit the New Zealand road environment
- consideration of the most effective application of signage and road markings to achieve the greatest compliance levels
- a detailed assessment of the likely costs associated with an amendment to existing give way legislation. This will allow the cost side of this research to be firmed up and give a more accurate estimation of the likely realisable benefits
- an evaluation of the change in give way legislation using the business case approach to give a full measure of investment performance
- a review of the formula for calculation of the public transport reliability benefits as published in the EEM A18.1. Confirmation of a value for time would reduce the ambiguity in application of the published formula
- investigation into increasing priority measures for buses to include lane change and right turn movements on congested corridors.

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Appendix A: Questionnaire

QUESTIONNAIRE (Stakeholder name here)

Abley Transportation has been commissioned by NZ Transport Agency to undertake research to quantify the economic and other benefits/disbenefits of introducing a law change where general traffic would legally be required to give way to buses egressing (exiting) from a bus stop. The first step in the research process is to undertake a literature review of international best practice, current legislation and its impact on public transport effectiveness, and to engage in stakeholder consultation. As key stakeholders in the transport industry it is important to understand your current thoughts and the implications a law change may have from your perspective.

Please respond by email by Friday 20 February 2015. Thank you.

1. Do you think the current lack of a clear 'give way to bus' rule/legislation and the reliance on courtesy causes confusion for:

    a) Cyclists Yes/No/Sometimes/Unsure
    b) Bus drivers Yes/No/Sometimes/Unsure
    c) Motorists Yes/No/Sometimes/Unsure

2. Acknowledging that many road users currently give way to allow buses to egress from bus stops, to what extent do you believe a law change would positively or negatively impact on road user's behaviour?

3. What impact do you think delay, poor schedule adherence and poor travel time reliability have on:

    a) Public perception of public transport/use of public transport
    b) Bus patronage
    c) Operating costs

4. Do you think a change in legislation to give buses priority when egressing from a bus stop will impact the safety of road users:

    a) Pedestrians Increase/No change/Decrease
    b) Cyclists Increase/No change/Decrease
    c) Buses Increase/No change/Decrease
    d) Motorcyclists Increase/No change/Decrease
    e) Motor vehicles Increase/No change/Decrease

5. From your organisation's perspective what benefits do you perceive from a law change?

6. Which of these benefits will be most significant to your organisation?

7. From your organisation's perspective do you envisage any disbenefits as a result of a law change?

8. What is your organisation's attitude towards a law change, and do you envisage any impediments?

9. Are there any other wider implications to cyclists from a law change that should be considered?

Appendix B: Give way to buses survey

Give way to Buses Survey

Research is currently being undertaken to understand the potential benefits/disbenefits of introducing a law change that would require traffic to give way to buses egressing (exiting) from a bus stop into the general flow of traffic. As part of this project we are conducting focus groups to understand road user attitudes to a potential change in ‘Give Way’ legislation. It is important to understand the thoughts of a wide range of road user groups surrounding potential implications a law change may have from your perspective.

The views of bus users and your experiences are important to this research.

A focus group will be conducted in South Christchurch at the **South Christchurch Library** 66 Colombo Street, Cashmere from **6.00pm on Wednesday 18 March 2015**. This will involve a group discussion and the completion of a survey which we anticipate to take approximately 30 minutes. **Refreshments will be provided.**

The survey is only open to people who do not study/work in a transport related field. To take part in the survey please email (*insert email address here)* with the subject ‘Give Way to Buses survey’ So that we can survey a range of road users please briefly describe your age and what is your main mode of transport in the email. ***Numbers are limited.***

The survey will not collect any sensitive information or details by which participants might be identified.

Focus group will be conducted by Abley Transportation Consultants. Any questions can be directed to Aimee via email (*insert email address here).*

Appendix C: Outline of focus group workshop content

Introduction of the project, and explanation of the context of the research outlining the strategic goal of the government to improve public transport. Provide an explanation of why the research was being undertaken and the stages of the project. Describe what the processes completed to date and where the focus group fits into the research.

Describe that the aim of the workshop is to have a general discussion and gather everyone's opinions and experiences with buses merging back into traffic after stopping at a bus stop. Reiterate that their opinions are important to the research and that there are no right or wrong answers. Welcome discussion and questions.

The discussion was led and covered the following main themes:

1. Confusion or lack of clarity as to who should give way in the current environment and who this affects most.
2. Share experiences of buses moving back into traffic.
3. Discuss what factors currently influence a decision as to whether to give way or not.
4. Safety.
5. What proportion of motorists currently give way?
6. Impact of a law change on business.
7. Benefits/Disbenefits.
8. Enforcement, education and road markings.
9. Support of law change?
10. Encourage comments and further discussion on last page.

Participants were given the opportunity to complete a questionnaire (Appendix D) with their thoughts and views. This provided the opportunity for any quieter members of the workshop to be able to express their opinion without feeling intimidated by more dominant or vocal participants.

A.1 Equipment

Survey response forms

Power point with egress and yield to bus images

Laptop for taking notes

Refreshments

Appendix D: Focus group survey

Give way to Buses Focus Group Survey

1. **What is the main mode of travel you use on a day-to-day basis?**

   Please tick the appropriate box

   - ☐ Bicycle
   - ☐ Public Transport (Bus)
   - ☐ Private vehicle (Car)
   - ☐ Motorbike
   - ☐ Pedestrian
   - ☐ Other (Please specify)_______________________________________

2. **Do you think a lack of a clear 'give way to bus' law and the reliance on courtesy causes confusion for:**

   Please circle the one you think is appropriate for each

Cyclists	Yes / No / Sometimes / Don't Know
Bus Drivers	Yes / No / Sometimes / Don't Know
Motorists	Yes / No / Sometimes / Don't Know
Motorcyclists	Yes / No / Sometimes / Don't Know
Pedestrians	Yes / No / Sometimes / Don't Know

3. **Explain your experiences with buses merging back into traffic after leaving a bus stop**

4. **What factors currently influence your decision to give way or not e.g. congestion, speed, time of day?**
   (Not applicable from perspective of bus users)

5. **Do you think there are any negative implications of a law change to give buses the right of way to pull back into traffic for:**
   a) Pedestrians
   b) Cyclists
   c) Bus users
   d) Motorcyclists
   e) Motor vehicles
   f) Bus operators

6. **How do you think a change in legislation to give buses priority when egressing from a bus stop would impact the safety of the following road users?**
   Please tick the box you think is appropriate

	Increase Safety	**No Change**	**Decrease Safety**	**Don't Know**
Pedestrians				
Cyclists				
Buses				
Motorcyclists				
Motorists				

7. **Do you think there are any barriers to a law change?**

8. **Do you think there are any opportunities?**

9. **In your opinion would any groups or individuals in particular benefit or be disadvantaged by a change in the law?**

10. **Do you think travel behaviour by other road users will adjust as a result of a law change?**

11. **Would you support a change in the law to give priority to buses exiting from bus stops? Why/why not?**

12. **Any other comments**