Priority and Optimisation

Public Transport Design Guidance

Waka Kotahi

19 February 2024

V 1.1

WAKA KOTAHI NZ TRANSPORT AGENCY

Te Kāwanatanga o Aotearoa New Zealand Government

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1. Introduction

The Public Transport Design Guidance series, of which this document is a part, supports road controlling authorities – regional and local councils, and public transport contracting authorities and consultants to deliver consistent and user-centric public transport infrastructure. Each topic in the series is a one-stop shop of best practice guidance for a specific topic within the context of Aotearoa New Zealand's regulatory and operating environments.[1]

The public transport priority and optimisation topic sets out the tools needed to plan, design, implement and monitor street-based public transport priority and optimisation.

This guidance will be useful for:

- planning and delivering public transport services
- the design and operation of the street network
- communicating the benefits of public transport infrastructure projects to the public
- finding ways to make public transport more attractive and drive growth in use.

1.1. Importance of public transport priority and optimisation

An efficient public transport service is critical for the function of towns and cities as it enables access and reduces traffic congestion. By nature, public transport services must stop to pick up and drop off passengers, which takes time. Prioritising and optimising public transport services can help to recover this time to make it an attractive mode.

The terms priority and optimisation are subtly different but related.

Public transport **priority** involves placing public transport vehicles at an advantage compared with general traffic (for example, bus lanes and traffic signal priority for buses).

Public transport **optimisation** involves improving operational efficiency to support faster journey times without impacting other road users. Some examples include ticketing systems or bus stop design that supports efficient manoeuvring, shorter dwell times or rebalancing the number of bus stops.

Examples of priority and optimisation interventions are discussed in sections 3 - 6.

1.2. Improving journey times and service reliability

The overarching goal of public transport priority and optimisation is to improve journey times and service reliability, which in turn make public transport a more attractive and viable transport mode.

Some priority and optimisation measures also provide a cue or nudge by showcasing the importance of public transport, which, in turn, can influence travel behaviour. Therefore, public transport priority is an important tool to encourage mode shift towards public transport (and away from private cars), which in turn reduces harmful emissions.

While a customer's overall journey includes the time they spend getting to, waiting at and leaving from public transport stops or stations, as well as time spent on public transport, this chapter focuses on the in-vehicle component.

[1] The guidance topics are available from our website: Public transport design guidance.

In-vehicle journey time is the time it takes the vehicle to travel from a customer's boarding stop to their alighting stop. In mixed traffic environments, public transport journey times generally vary by time of day. Longer journey times are experienced at peak times when traffic is heavier, and congestion is worse. However, public transport priority measures can reduce or eliminate the difference between peak and off-peak journey times. Comparing peak and off-peak journey times is a useful way to understand the level of delay caused by congestion.

Service reliability relates to the amount of variation a customer experiences in their in-vehicle journey time from one day to the next. Service reliability is generally measured as the number of minutes public transport is early or late compared with the timetable.

Both journey times and service reliability are important to customers. People generally want to get where they are going with minimal delay and to know with reasonable certainty how long their journey will take. They also do not want their service to arrive early, causing them to miss it.

Similar factors influence journey times and service reliability, so measures to improve one will also often improve the other. Factors include the amount of congestion there is between intersections (mid-block congestion), the length of delays experienced at intersections, and how long a vehicle needs to wait at stops or stations.

1.3. Benefits of implementing prioritisation and optimisation measures

In cities and towns, street space is often constrained, so decision makers need to determine how much space to provide for each transport mode. Street space includes intersections, which are a typical source of delay for all vehicles and are a location where giving priority to one mode generally means longer delays for other modes.

Cities and towns are increasingly looking to increase the efficiency and capacity of their street corridors. Prioritising street space for public transport can make the most efficient use of existing and limited road space because it is such a space-efficient transport mode (illustrated in the figure below).

Figure 1 – Different amounts of space required to transport 69 people using different modes. Source: We Ride! Australia (website).

Prioritising public transport benefits existing public transport users and encourages people to switch to public transport as the service becomes more convenient and attractive relative to other modes, particularly driving. Shifting a private vehicle trip to a public transport trip has wider benefits for communities as summarised in the table below.

Table 1 – Wider benefits of public transport priority and optimisation

Wider benefits of public transport priority and optimisation	Description
Safety*	Fewer traffic crashes from a reduction in traffic volumes and a shift towards public transport, which is a safer mode per kilometre travelled. Fewer crashes per lane kilometre for public transport in bus lanes and, in particular, for centre-lane rapid transit compared with buses in mixed traffic.
Public health	Increased physical activity from people walking or cycling to and from stops. Reduced air pollution from fewer vehicle kilometres driven.
Environment	Reduced greenhouse emissions from a reduction in the number of trips made by private vehicles.
Travel choice	A more convenient public transport system connects people to where they want to go, especially for those who cannot or do not want to drive. Reduced private spending on transport because public transport is more affordable than owning and operating a car.
Economic prosperity	Increased business productivity from journey time savings Supporting urban development along key transport corridors

* For further information on the safety benefits of public transport priority, see N Duduta, C Adriazola-Steil, C Wass, D Hidalgo, LA Lindau and VS John. 2015. *Traffic Safety on Bus Priority Systems, Recommendations for integrating safety into the planning, design, and operation of major bus routes*. Washington DC: EMBARQ, World Resources Institute.

Source: Adapted from Waka Kotahi NZ Transport Agency. 2019. *Keeping Cities Moving*. Wellington.

Priority and optimisation measures also improve the efficiency and predictability with which public transport services can be delivered. This is because shorter journey times means a bus or light rail vehicle can complete more trips per hour than if no priority were provided (see the scenario illustrating this in the following table). These efficiency savings can be reinvested into providing a higher frequency service for marginal additional cost, which, in turn, can attract more people to public transport.

Table 2 – The influence of bus priority in achieving reduced journey time and service frequency without additional buses

	No public transport priority	With public transport priority
Scenario	 *Figure 2 – Buses in mixed traffic. Source: Dean Purcell.*	 *Figure 3 – Bus in a bus lane. Source: Greater Auckland.*
Journey time	60 minutes	30 minutes
Service headway	20 minutes	10 minutes
Vehicles required	3 vehicles	3 vehicles

1.4. Typical public transport priority and optimisation measures by service type

The following table summarises the features typically found on public transport services of different levels of quality:

- **Rapid transit** is a quick, frequent, reliable and high-capacity public transport service that operates on a permanent route (road or rail) and is largely separated from other traffic.
- **Enhanced public transport** is a bus or light rail system that has dedicated or restricted lanes for part of the route but otherwise uses general traffic lanes.
- **Standard public transport** is a service with limited or no public transport priority.

Table 3 – Priority and optimisation measures that might accompany three types of public transport services

Feature	Rapid transit	Enhanced public transport	Standard public transport
Mid-block			
Busway or transitway	✓	✗	✗
Public transport only streets	✓	✓	✗
Public transport only lanes	✓	✓	✗
Bus lanes	✗	✓	✓
T3 lanes	✗	✓	✓

Feature	Rapid transit	Enhanced public transport	Standard public transport
T2 lanes	✘	-	✓
General traffic lanes	✘	-	✓
Bus gate	✓	✓	-
Intersection			
Grade separation	✓	✘	✘
Unconditional active signal priority	✓	✓	✘
Conditional active signal priority	✘	✓	✓
Passive signal priority	✘	✓	✓
Queue jump	✘	✓	✓
Left turn lane buses exempt	✘	-	✓
Phasing based on vehicle throughput	✘	-	✓
Traffic access restrictions or bus gate	✓	✓	-
Stop or station			
Wide stop or station spacing	✓	✓	✘
Close stop or station spacing	✘	✓	✓
Stop or station located downstream of intersection	✓	✓	✓
Stop or station located upstream of intersection	-	✓	✓
Stop or station located at midblock	-	-	-
Stop or station with passing lane	✓	✘	✘
In-line bus stop or station layout	✓	-	-
Kerbside stop or station layout	✘	✓	✓
Indented stop or station layout with no passing lane	✘	-	-
Operating policies			
Ticket gates	✓	✘	✘
Proof of payment	✓	✓	✘
On-board payment – smart card and pass only	-	✓	✘
On-board payment – cash allowed	✘	✓	✓
All-door boarding	✓	✓	✘

Feature	Rapid transit	Enhanced public transport	Standard public transport
Front door boarding only	✘	✓	✓
Vehicle layout			
Layout optimised for standing passengers	✓	✓	✘
Layout optimised for seated passengers	✘	✓	✓
Three or more doors	✓	✓	✘
Two doors	✘	✓	✓
Level boarding platforms	✓	✓	✘
Near-level boarding platforms	✓	✓	✘
Standard kerb height	✘	✓	✓
Articulated vehicles	✓	✓	✓
Double-deck buses	-	✓	✓
Standard single-deck buses	✘	✓	✓

Key: ✓ means the feature is common; - means the feature could be used as a compromise; ✘ means the feature is not typically used.

2. Process and context

2.1. High-level process for planning public transport priority projects

The level of delay experienced by public transport services varies between corridors, by direction of travel and by time of day. Therefore, understanding the context of the street environment and the public transport service is important for identifying the causes of delay and assessing potential tools and measures. Public transport priority measures can vary in scale from limited priority at specific locations to absolute priority along a whole corridor. Similarly, priority measures may apply only at specific times (typically peak periods) or all day, every day.

The high-level process for planning public transport priority projects is illustrated and discussed below. For more details, see the practical process for selecting appropriate public transport priority treatments in Austroads On-Road Public Transport Priority Tool.

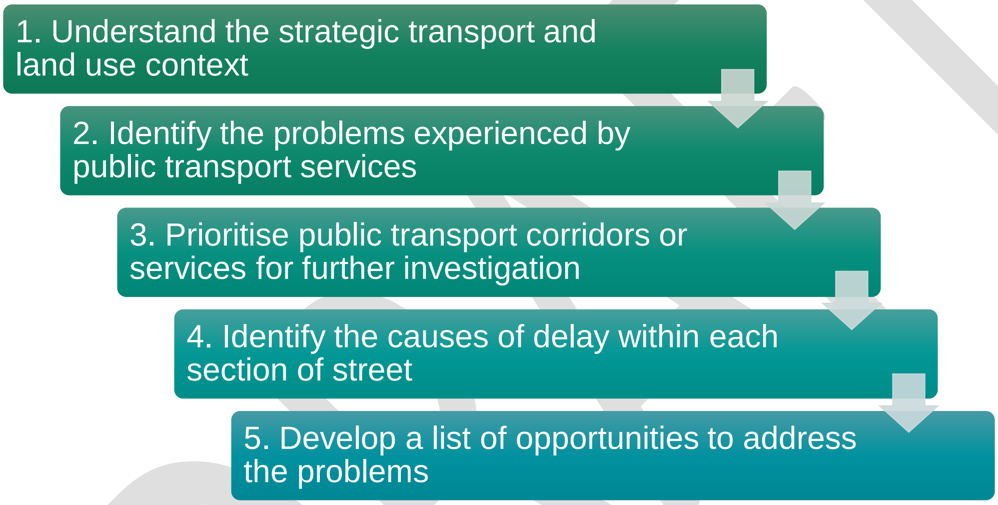


Figure 4 – High-level process for planning public transport priority projects. Source: Adapted from Austroads. 2020. On-Road Public Transport Priority Tool. Sydney.

2.1.1. Understand the context

The first step in developing public transport priority projects is to understand the strategic transport and land use context of the city or region.

The transport context is usually set out in strategic documents such as network operating frameworks or regional public transport plans, mode shift plans, and cycling programmes. A good example of a contextual transport plan is Auckland Transport's Future Connect. It may be identified that public transport is underserved on certain corridors relative to the strategic aspirations.

It is also important to consider the land use context contained in district and spatial plans that explain where residential and commercial development is planned to occur. This is because public transport services that serve higher density areas tend to also have higher public transport patronage.[2]

[2] J Walker, 2012. 'The obstacle course: Speed, delay, and reliability' in *Human Transit: How clearer thinking about public transit can enrich our communities and our lives*, ch 9. Washington: Island Press.

2.1.2. Identify problems

The second step in developing public transport priority projects is to obtain performance metrics for public transport services so you can compare between services. Typical performance metrics are:

- average operating speed (example in figure below).
- the difference between peak and off-peak travel times
- the level of timetable adherence
- average stop spacing
- the number of passengers carried
- the volume of public transport vehicles.

It is also important to take a multi-modal approach and consider problems experienced by users of other modes such as the level of service for people on bikes or the delay in crossing the street for pedestrians.

Performance metrics help to identify the public transport corridors that are most in need of improvement. Quantifiable data on public transport performance is also useful in later stages of the project, including for public consultation and funding applications.

2.1.3. Identify high priority corridors

The third step in developing public transport priority projects is to prioritise the corridors being considered for priority measures. Public transport networks can cover large areas of cities or regions therefore it is desirable to prioritise corridors that have:

- poor reliability
- slow travel times
- high passenger demand (or high latent demand).

Other considerations are:

- opportunities to link the implementation of priority measures to other projects such as road maintenance, cycleway construction or utility renewal projects
- planned changes to the public transport network so infrastructure provision is coordinated with network planning.

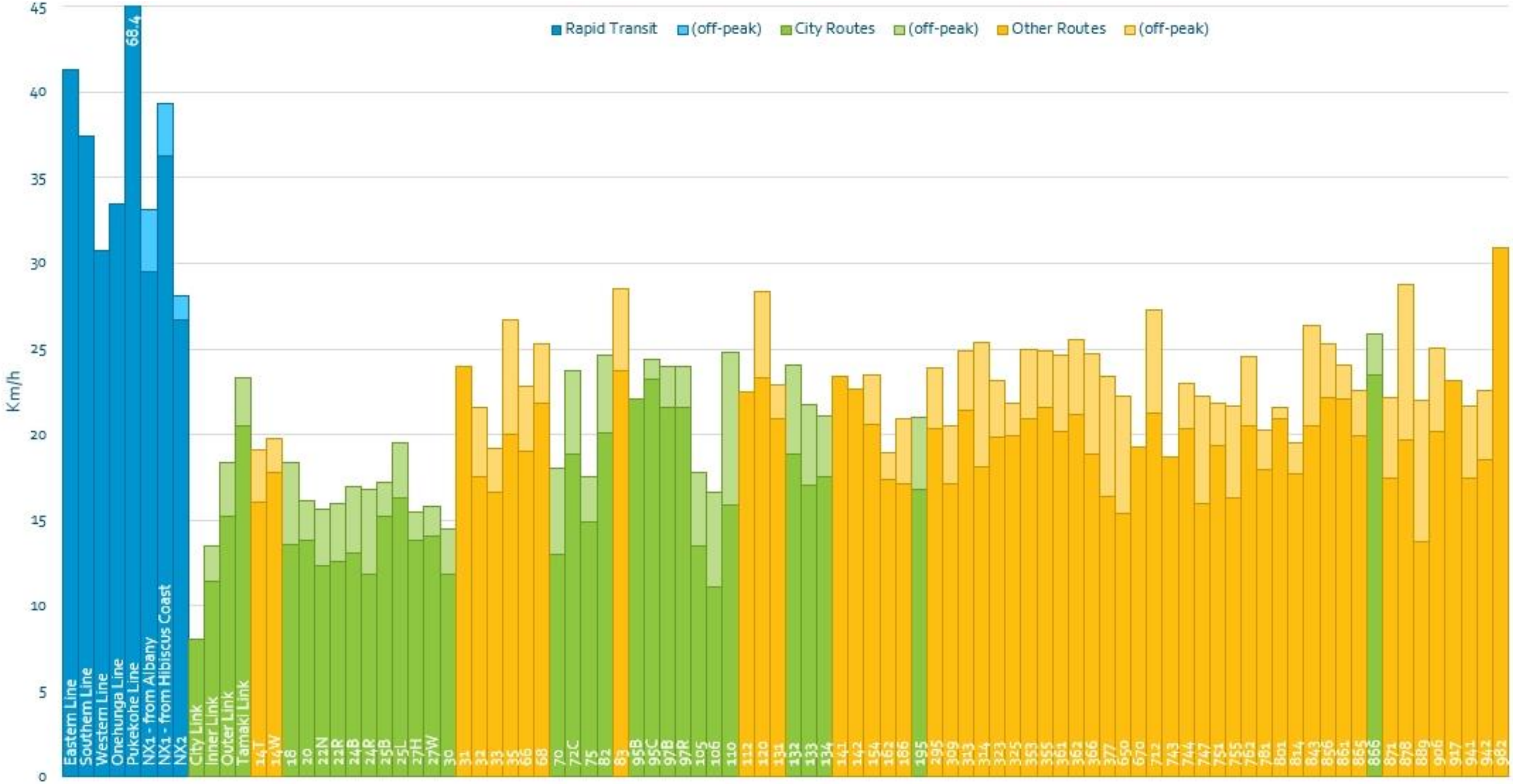


Figure 5 – Average speed of public transport, Auckland. Source: Greater Auckland.

2.1.4. Identify causes of delay

The fourth step in developing public transport priority projects is to identify in detail the causes of delay experienced by public transport services.

The causes of public transport delay are location specific, so break the corridor down into smaller sections as shown in the example below. Identify the causes of delay by analysing data on public transport journey times, which is generally automatically collected as part of real-time information systems. It is often useful to support journey time data with observations from site visits and information from discussions with public transport operators. Another potential source of information on public transport delay is transport models which have the advantage of being able to test future scenarios including new greenfield developments.

Potential causes of public transport delay include:

- congestion on the approach to traffic signals
- congestion at bus stops
- long dwell times at bus stops
- delays at pedestrian crossings
- mid-block congestion.

The threshold for which delay to public transport users is considered to justify priority measures varies between road controlling authorities. Examples of the thresholds used in Auckland and Western Australia are in Example processes (section 2.4).

An example of public transport issues presented visually is illustrated below.

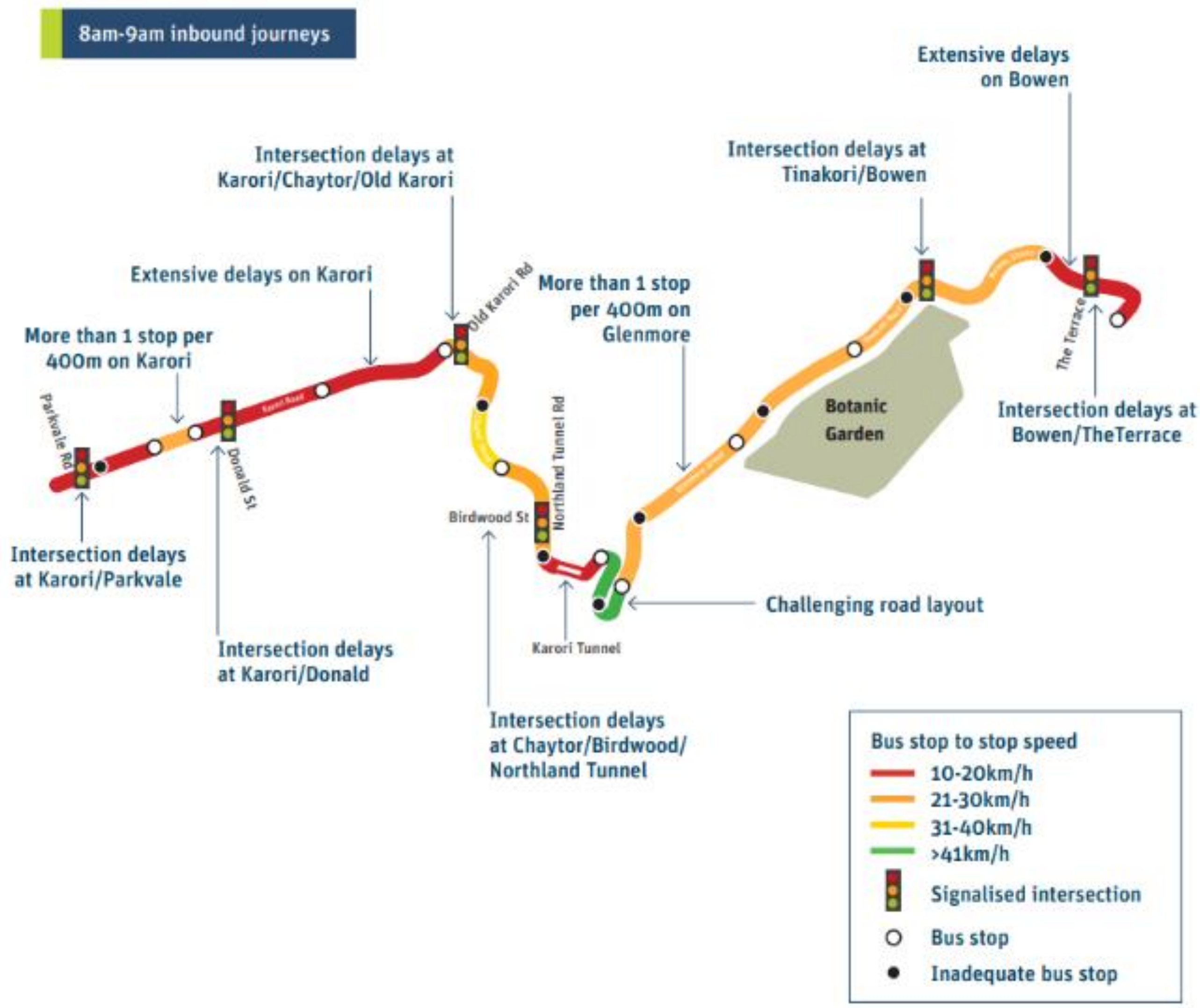


Figure 6 – Issues for inbound bus services from Karori, Wellington. Source: Metlink and Greater Wellington. 2019. Action Plan for the Wellington City Bus Network. Wellington.

2.1.5. Develop opportunities

The final step in developing public transport priority projects is to develop a list of opportunities to address the identified problems. Depending on the context, opportunities may include:

- lower cost options that are relatively easy to implement such as line marking to reallocate street space or traffic signal retiming
- treatments that are pertinent at only certain times of the day (for example, during the morning peak)
- higher cost options that require longer-term planning such as corridor widening.

For mid-block sections, use online tools such as Streetmix to quickly develop and communicate concepts before committing to further design.

In most business case processes, it is necessary to estimate journey time savings for each potential opportunity so the potential benefits of different options can be compared. Journey time savings can be estimated by comparing congested with free-flowing conditions or by using typical average speeds from comparable case studies.

An important consideration is the number of passengers on board the public transport vehicles at each segment of the corridor. This is because a modest journey time saving on a high demand corridor may be more valuable than a larger time saving on a low demand corridor.

2.2. Context – public transport service function

When investigating priority and optimisation measures, an early consideration is the function of the public transport services that use the street corridor. The two broad functions of public transport systems are typically to:

- enable people who have limited access to other forms of transport to travel around their town or city (the coverage goal)
- encourage the maximum number of people to use the service to reduce traffic congestion and emissions (the ridership goal).

Services that focus on the coverage goal tend to be lower frequency and less direct because the goal is to serve as large an area of the town or city as possible.

Services that focus on the ridership goal tend to have higher frequencies and travel direct to key destinations because the goal is to be competitive with other modes of transport.

A public transport network (particularly for larger cities) is made up of a combination of both types of service to balance coverage and ridership functions. Each public transport authority categorises its public transport services using different terminology. Terms used in three urban centres are shown in the table below.

Table 4 – Service category terminology from regional public transport plans

	Auckland	Wellington	Christchurch
Ridership goal (high frequency, more direct) ↓	Rapid	Core	Core
	Frequent	Local	City connectors
	Connector	Targeted	Cross town link
Coverage goal (lower frequency, less direct)	Other services		Specialist services

For public transport services focused on maximising ridership, journey times (in addition to service frequency) is a key determinant of the success of the service. Therefore, for corridors used by ridership-focused services, public transport priority measures are an important tool for achieving the goals of the service.

Coverage-focused services determine success by the number of people with access to the service and the importance of the destinations served. Therefore, public transport priority and any resulting improvement in journey time may not be essential for coverage-focused services.

In general, high frequency and direct services may justify a high level of public transport priority, with limited or no priority measures being appropriate for low frequency and less direct services. The link between service function and priority measures is shown in the figure below.

2018					
SERVICES LAYER		RAPID	FREQUENT	CONNECTOR	OTHER SERVICES (Local, rural-township, peak only, school, Total Mobility, on-demand services)
Defining feature		CORE – ALL DAY NETWORK			SUPPORTING NETWORK
Minimum hours of operation		6am – 11pm			No minimum
City Centre Services Minimum Headway		15 minutes		30 minutes	Driven by need
Non-City Centre services Minimum Headway	7am-7pm, 7 days	15 minutes		30 minutes	
	Outside those times	30 minutes		60 minutes	
Achieving Efficiency and Reliability		Dedicated Right of Way		Priority measures	Limited priority measures

Figure 7 – Hierarchy of services with reference to public transport priority measures on bottom row. Source: Auckland Transport. 2019. Regional Public Transport Plan 2018–2028, Auckland, p 14.

2.3. Context – street function

The next consideration when choosing the scale of public transport priority measures is the function of the street in the context of the transport network.

The One Network Framework provides a nationally consistent classification system for streets to encourage integrated transport and land use planning. The main concepts of the framework and how they relate to public transport infrastructure is shown below.

For more information, see One Network Framework.

The movement function within the One Network Framework relates to the strategic importance of a corridor for moving people and goods, across all modes, and the scale of the movement it intends to accommodate (illustrated below). High levels of movement mean not only cars and trucks but also public transport and people walking and cycling. Regardless of the mode of travel, the movement function assumes people moving within the corridor share similar objectives in terms of direct, safe and quick journeys with minimum disruption.

An important feature of the One Network Framework is that the movement classification represents the aspirational strategic importance of the corridor looking ahead to the desired state in 10–15 years.

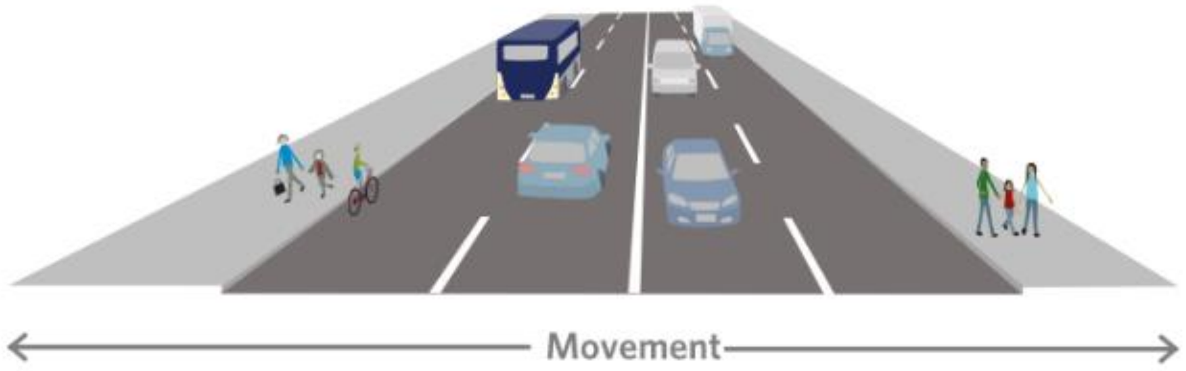


Figure 8 – Movement function cross-section. Source: Waka Kotahi NZ Transport Agency. 2021. One Network Framework (webpage).

For the purposes of the One Network Framework, ‘place’ is the extent to which a corridor (and its adjacent land use) is a destination in its own right (illustrated below). The place function also incorporates lateral movement where on-street activity increases demand for people wanting to cross carriageways.

While the movement function of a corridor focuses on saving time, the place function focuses on how attractive it is for people to spend time at that location.

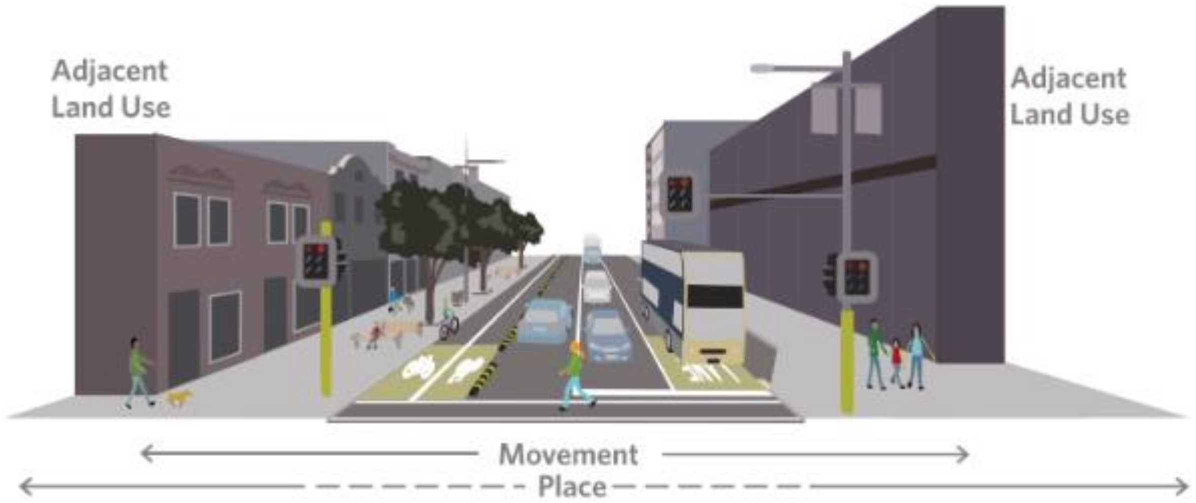


Figure 9 – Place function cross-section. Source: Waka Kotahi NZ Transport Agency. 2021. One Network Framework (webpage).

The One Network Framework classifies the movement and place functions of each section of street on a five-point scale. Movement and place values are used to assign a classification for each section based on the five-by-five matrix shown below. The two sets of street classifications are for urban streets and for rural streets.

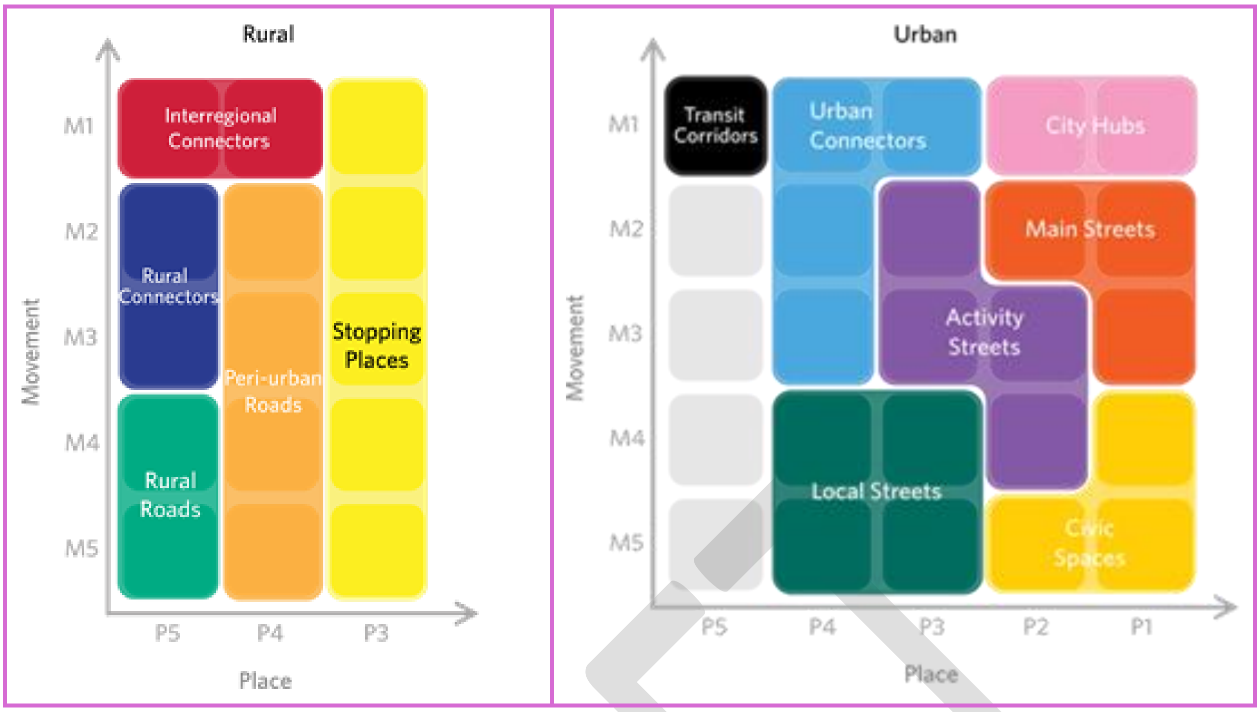


Figure 10 – Visualisation of street classifications. Source: Waka Kotahi NZ Transport Agency. 2021. One Network Framework (webpage).

The combination of movement and place in the One Network Framework street categories creates a picture of the urban form and function of that environment – in essence, a picture of the context.

For descriptions of the categories, see Street Categories.

The One Network Framework also classifies the movement function of different transport modes. For public transport there is a five-point scale for the classification of movement which is based on the strategic role, vehicle volume and people volume. The following table summarises the public transport classes.

Table 5: Summary of One Network Framework public transport classifications

Class	Public Transport Service Level descriptor	Strategic Significant (Role in Public Transport Network)	Indicative vehicle volume (bi-directional)	Indicative people movement (bi-directional)
PT1	Dedicated	Strategically significant corridors where rapid transport services are operated	≥ 4 services per hour	≥1000 per day
PT2	Spine	Corridors where many different PT services merge together to create very high frequencies	≥20 service per hour	≥1000 to 10000+ per day
PT3	Primary	Strategic corridors where frequent public	≥4 services per hour	≥500 per day

		transport services operate		
PT4	Secondary	Corridors where PT services operate at most times of day but less frequently	≥4 services per hour	100 to 1000 per day
PT5	Targeted	Corridors where services only operate at certain times of the day	NA	Variable

For prioritisation or optimisation to be most effective, it needs to fit with the context created by the street category. The tables below show how street categories and public transport classifications relate to each other (Table 6) and how priority measures relate to the public transport classification (Table 7).

Table 6 – One Network Framework urban street categories and typical supporting public transport modal classifications

Urban street category	Public transport modal classification
City Hubs	PT1 Dedicated PT2 Spine PT3 Primary
Main Streets	PT3 Primary PT4 Secondary
Activity Streets	PT3 Primary PT4 Secondary
Civic Spaces	May lack public transport within the street but likely to have it nearby
Local Streets	PT4 Secondary PT5 Targeted
Urban Connectors	PT2 Spine PT3 Primary
Transit Corridors	PT1 Dedicated PT2 Spine

The below table identifies indicative priority and optimisation philosophies and interventions for each One Network Framework public transport classification. Note that this guidance is provided for sample purposes; appropriate priority or optimisation interventions for any street, intersection, or area will depend on the local context and actual sources of delay.

Table 7 – Priority and optimisation philosophy and sample interventions for different public transport classifications

Classification tier	Indicative priority and optimisation philosophy	Sample priority and optimisation interventions
PT1 Dedicated	Greatest segregation from other transport modes and from surrounding land uses with dedicated right of way. Offers greatest potential for high reliability and shorter journey times.	Rail, light rail and bus rapid transit systems.
PT2 Spine	High level of separation from traffic along the corridor. Offers good level of reliability and reduced journey times Adjacent modes are actively discouraged and managed away from spine routes. Bus-on-bus congestion may be source of delay due to high number of public transport services	Bus-only lanes, bus lanes, signal priority, intersection queue jump lanes, in-lane bus stops.
PT3 Primary	Moderate to high level of separation from traffic along the corridor. Offers a good level of reliability and reduced journey times.	Bus lanes, signal priority, intersection queue jump lanes, in-lane bus stops and city centre bus gates.
PT4 Secondary	Some priority measures but will largely operate in general traffic lanes. Has separation during peak times, but at other times is shared with other modes or used for parking. Offers some reliability and reduced journey times during peak times but may be subject to delay at other times.	High occupancy vehicle lanes, signal priority, intersection queue jump lanes, in-lane bus stops, sometimes minimal.
PT5 Targeted	Largely operates in general traffic lanes with no protection from congestion or allowance for service priority, which, in busier parts of urban areas, can lead to slow and less reliable journey times. In less congested areas this may not be an issue.	None or minimal, for example best practice bus stop design and parking management

2.4. Example processes

This section sets out the processes Auckland Transport and the Public Transport Authority of Western Australia use to identify when public transport priority and optimisation measures may be required.

These processes are provided as examples to guide practitioners in understanding typical situations when priority measures may be used rather than to provide a rigid set of rules for use of priority measures.

The primary considerations in the development and assessment of public transport priority measures are the strategic, functional and contextual elements of the corridor and its problems as outlined above.

2.4.1. Auckland Transport

The 2013 *Auckland Transport Code of Practice* documents the process Auckland Transport uses when deciding between bus lanes, transit lanes and general traffic lanes.

The three main considerations in this decision are the:

- frequency of the public transport service along the corridor
- level of service for public transport
- productivity of the corridor under different lane arrangements.

For more information, see Auckland Transport Code of Practice 2013 (specifically, chapter 5, Special routes and road elements).

The decision process is shown in the flow diagram below.

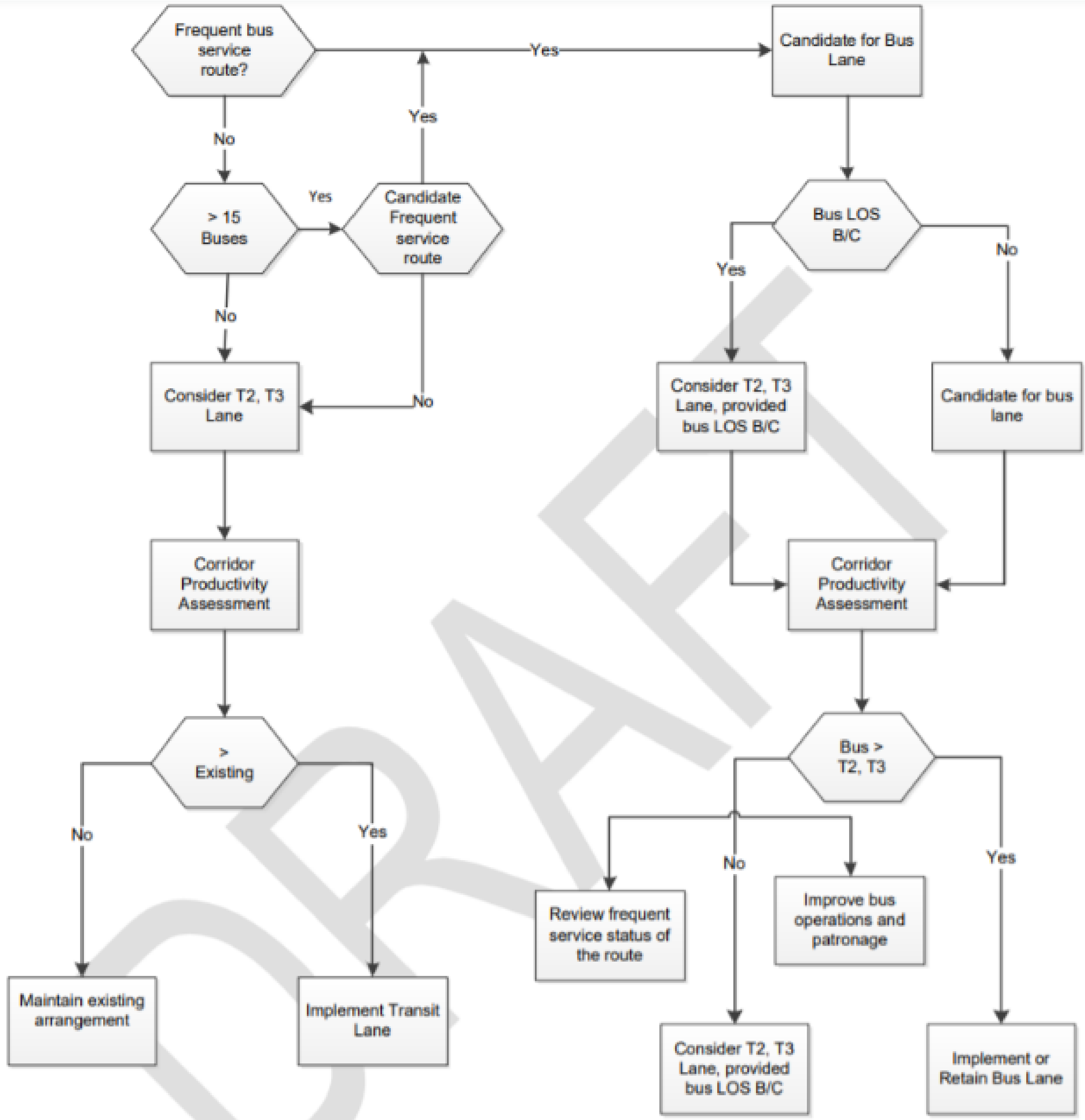


Figure 11 – Decision flow when deciding between bus, transit and general traffic lanes (LOS = level of service). Source: Auckland Transport. 2013. Auckland Transport Code of Practice 2013. Auckland, ch 5, figure 12, p 30.

An important consideration is the current and planned number of public transport vehicles that use or will use the corridor.

- A frequency of 15 or more public transport vehicles per hour is the minimum for 'special treatment' to be considered.
- A frequency of 25 or more public transport vehicles per hour means the provision of priority lanes is considered necessary.

The next consideration is the level of service for public transport vehicles. A level of service B or C (explained in the table below) is considered acceptable for urban and suburban arterial roads because it results in only moderate delays. Therefore, if the level of service for public transport vehicles is below level B or C, a bus lane may be warranted.

Table 8 – Characteristics of traffic movements by level of service

Level of Service (LOS)	Characteristics of traffic movement
A	Generally free flow traffic conditions with operating speeds usually at 90% of the free flow speed (or sign-posted speed limit). Vehicles are unimpeded in manoeuvring in the traffic stream, with little travel delays.
B	Relatively unimpeded operation with average speeds of about 70% of the sign-posted speed limit. Manoeuvring in the traffic stream is only slightly restricted and travel delay is low.
C	Stable operating conditions but with manoeuvring becoming more restricted and motorists experience some driver discomfort and delays. Average travel speeds are at about 50% of the sign-posted speed limit.
D	Conditions border on becoming unstable with increased delay and lower travel speeds of about 40% of the sign-posted speed limit. Manoeuvring is becoming difficult.
E	Conditions are unstable and characterised by queuing and significant delays with average travel speeds reduced to about 33% of the sign-posted speed limited or lower. Manoeuvring is very restricted. Stop-go conditions are typical.
F	Conditions are characterised by excessive congestion and delays with average travel speeds of 25% of the sign-posted speed limit and below.

Source: Auckland Transport. 2013. *Auckland Transport Code of Practice 2013*. Auckland, ch 5, table 4, p 25.

The final consideration is corridor productivity, which is defined as the number of people who can move through a corridor per hour. Corridor productivity is calculated by multiplying the number of person trips for each lane by the operating speed of the lane.

The corridor productivity of different lane configurations (for example, bus, T3, T2 and general traffic lanes) can be compared to determine which has the highest person throughput, so is the most productive. the example for Dominion Road in Auckland during the morning peak shown below illustrates that the current bus lane scenario has higher productivity than if both lanes were used for general traffic.

Table 9 – Corridor productivity calculations for Dominion Road, Auckland

Lane	Volume	%	Person trips	%	Speed	Level of service	Productivity
Current: One bus lane and one general traffic lane							
Bus lane	34	4	1,261	53	17	E	21,437
General lane	865	96	1,116	47	13	F	14,519
Both lanes	899	100	2,377	100			35,956
Scenario: Both general traffic lanes							
Kerbside lane	466	52	1,819	77	14	E	25,466
Central lane	432	48	558	23	15	E	8,370
Both lanes	899	100	2,377	100			33,836

2.4.2. Public Transport Authority of Western Australia

Indicative guidance on when to apply a specific bus priority treatment is in the Western Australia Public Transport Authority's *Bus Planning and Design Guidelines for Efficient People Movement*. This guidance uses measures such as bus volume, passenger volumes and delay to bus movements.

Of interest is that the authority uses a higher threshold for public transport lanes created by the conversation of an existing lane compared with public transport lanes created from street widening. This is because the conversion of an existing lane is seen as potentially affecting traffic to a greater degree than the provision of an additional lane.

For more information, see Bus Planning and Design Guidelines for Efficient People Movement.

Table 10 – Indicative guidance for thresholds for different priority treatments

Bus priority treatment	Desirable minimum public transport level
Bus gate Exemption to restricted movement	≥4 bus services during the peak hour in each direction
Public transport–only street	≥8 bus services during the peak hour in each direction
Queue jump	• ≥3,000 passengers per day in both directions, or • ≥500 passengers during peak hour in both directions, or • ≥6 bus services during the peak hour in peak direction
Installation of traffic signals	Delay to bus movement at non-signalised intersection during peak hour ≥60 seconds (averaged across the hour).
Active and passive bus priority	Where traffic volume is close to capacity, active and passive bus priority measures could improve traffic flow, benefiting bus movement to a level of service D or better.
Public transport lane (additional lane)	• ≥6,000 passengers per day in both directions, or • ≥1,000 passengers during the peak hour in both directions, or • ≥15 buses during the peak hour in peak direction
Public transport lane (conversion of existing lane)	• ≥9,000 passengers per day in both directions, or • ≥1,500 passengers during the peak hour in both directions, or • ≥22 buses during the peak hour in peak direction
Bus rapid transit	• ≥10,000 passengers per day in both directions, or • ≥1,500 passengers during the peak hour in both directions, or • ≥20 buses during the peak hour in peak direction

Source: Adapted from Public Transport Authority. 2015. *Bus Planning and Design Guidelines for Efficient People Movement*. Perth.

2.5. Planning and designing for safety

The safety of users of the transport network is paramount. When designing or considering public transport priority measures, the design should support Safe System outcomes and Vision Zero. This includes considering the health and safety of enforcement officers carrying out their duties.

For more information, see Road to Zero and Safe System.

To enable this approach, designers and planners should always apply Safe System principles when considering the design and location of public transport priority measures. These principles are:

- promote good choices but plan for mistakes
- design for human vulnerability
- strengthen all parts of the road transport system
- recognise shared responsibility.

For example, review existing highway layouts and public transport routes to understand the most suitable location for new public transport priority measures. Consider:

- how existing layouts and routes interact with other modes
- how pedestrians will get to and from stops.

An important consideration is to design layouts to minimise and manage the risk of pedestrian–vehicle conflict. This means considering:

- all passenger and pedestrian routes (desire lines)
- management of vehicle speeds
- how priority measures will be enforced.

Public transport vehicles often need to share the street with other road users, so the selection and design of priority measures should carefully consider the safety of all road users. Public transport priority measures can be associated with an overall improvement in road safety if they are appropriate for the street context.

Common safety considerations for the application of special vehicles lanes are discussed in:

Designing for safety in special vehicle lanes.

3. Mid-block interventions

This section identifies treatments that should be considered when looking to improve public transport journey times and reliability. These treatments focus on separating buses from general traffic through priority lanes or priority at intersections.

Another approach is to reduce private vehicle demand through measures such as parking pricing or congestion charging, which can improve journey times for buses operating in general traffic lanes.

For more information, see the Waka Kotahi intervention hierarchy.

In selecting an appropriate mid-block treatment consider:

- safety, efficiency and access benefits to priority road users (which are likely to include public transport users and people walking and cycling) and the availability of road space to find the 'right' fit for each corridor
- monitoring congestion regularly to determine whether public transport vehicles are delayed at times such as shoulder peak times; in which case the hours of operation for restricted lanes should reflect the new traffic conditions
- the correct length of special vehicle lane – too short and the gain by buses will be substandard, but too long and the bus may struggle to enter the lane because of adjacent traffic queuing.

3.1. Overview of Bus-only lanes, bus lanes and transit lanes (special vehicle lanes)

A special vehicle lane is a lane restricted to use by a specified class or classes of vehicle and includes bus, transit (T3 and T2), cycle,[3] and light rail vehicle lanes.

Signs and markings define the users permitted to use the lane.

Restrictions on the types of vehicle that can use these lanes may apply at all times of the day or only during specified times such as peak periods or weekdays.

Special vehicle lanes can support a more efficient public transport service. They promote and prioritise public transport by:

- providing dedicated road space for public transport
- restricting parking on the lengths that have lanes provided
- providing a clear length of roadway to keep public transport moving at congested times
- placing public transport above general traffic in terms of importance at critical points on the network.

Different types of special vehicles lane can be used to give public transport priority. The types range in exclusivity from public transport–only lanes to less restrictive lanes that allow other users. These lanes are described next.

[3] For guidance on cycle lanes, see Waka Kotahi NZ Transport Agency. 2023. Cycling network guidance (webpage).

3.1.1. Public transport–only lanes such as bus-only lanes

Public transport–only lanes are typically limited to bus-only lanes in Aotearoa New Zealand. These measures allocate street space for exclusive use by public transport vehicles. They include dedicated busways or tramways and public transport–only streets and lanes. See the examples in the table below.

Table 11; Types of public transport–only lanes

Exclusive lane	Description	Example
Dedicated busways or tramways	A bus or light rail facility physically separated from general traffic but linked to the street network at key points to enable public transport vehicles to access them.	Auckland northern busway, Brisbane busway network and Canberra light rail  *Figure 12 – Northern busway, Auckland. Source: Auckland Transport.*

Exclusive lane	Description	Example
Public transport–only streets (also known as transit malls)	A street used exclusively by public transport vehicles. General traffic is diverted onto other streets.	Manners Street, Wellington; Bourke Street, Melbourne; and George Street, Sydney  *Figure 13 – Bourke Steet mall, Melbourne. Source: Visit Victoria.*  *Figure 14 – Manners Street, Wellington. Source: Lorelei Schmitt.*

Exclusive lane	Description	Example
Public transport–only lanes	Bus-only and light rail–only lanes are dedicated lanes for exclusive use by public transport vehicles. Bus-only and light rail–only lanes have no barrier between the public transport lane and the adjacent traffic lane.	Manchester Street, Christchurch; Argyle Street, Sydney; and Antigua Street, Christchurch  *Figure 15 – Argyle Street, Sydney. Source: Austroads.*

General traffic can be excluded by using barriers in the case of busways or tramways or signage and lane markings in the case of public transport–only lanes.

Public transport–only lanes can be created by reallocating existing street space to public transport vehicles, widening the corridor, or creating new public transport–only corridors.

Although public transport–only lanes are restricted to public transport vehicles, limited exceptions may be appropriate such as for rubbish collection vehicles.

Guidance on signage and markings public transport–only lanes, including when they are only part-time lanes, is in:

- Legal requirements (section 3.5)
- Signs and road markings (section 3.5.1)
- Signs in Part 5 of the *Traffic Control Devices Manual*.

Advantages and disadvantages of public transport–only lanes

The main advantage of public transport–only lanes is that they tend to provide the highest level of priority for public transport vehicles. This is because delays caused by general traffic are greatly reduced or eliminated. However, it is important to consider how other travel modes, such as cycling, will be accommodated if there are no purpose-built cycling connections in the area. In the context of often limited road space, it can be challenging to dedicate space to public transport.

Public transport–only lanes are most applicable where the volume of public transport vehicles is high and a high level of service for public transport is desired. Therefore, they are typically used on congested corridors that are served by a frequent bus or light rail route or where multiple bus or light rail routes converge.

Public transport–only lanes are also more appropriate where people on bikes have been accommodated in alternative purpose-built lanes or infrastructure.

3.1.2. Bus lanes and transit lanes

Sometimes it may be most sensible to provide public transport priority through special vehicle lanes that restrict much of the general traffic but accommodate other high-priority users. For example, bus lanes give priority to buses but typically also allow for use by cycles, mopeds, and motorcycles (unless specifically excluded by the marking or sign).

Transit lanes are high-occupancy vehicle lanes in Aotearoa New Zealand. They typically accommodate these cycles, mopeds and motorcycles plus motor vehicles carrying at least two (T2) or three (T3) people.

Table 12 – Types of restricted lanes common in Aotearoa New Zealand

Restricted lane	Description	Example
Bus lane	A lane that gives priority to buses. In some instances, the lane can also be used by bicycles, motorcycles, mopeds and/or in-service taxis.	Papanui Road, Christchurch, and Hewletts Road, Tauranga  *Figure 16 – Papanui Road, Christchurch. Source: Christchurch City Council.*
T3 lanes	A lane that may be used by buses, motorcycles, bicycles and motor vehicles carrying three or more people.	Remuera Road, Pah Road and Manukau Road, Auckland  *Figure 17 – Manukau Road, Auckland. Source: Thomas Chu.*

Restricted lane	Description	Example
T2 lane	A lane that may be used by buses, motorcycles, cycles and motor vehicles carrying two or more people.	Constellation Drive and Albany Highway, Auckland  *Figure 18 – Albany Highway, Auckland. Source: Serena Chia.*

Advantages and disadvantages of 'less-restricted' special vehicle lanes

These 'less-restricted' special vehicle lanes balance improving public transport journey times and reliability with providing for other modes and, at times, on-street parking.

However, these less-restricted special vehicle lanes risk delays for public transport with other vehicles travelling or parking in the lane, which often needs to be managed through enforcement activities.

Other vehicles, such as high-occupancy vehicles in the case of transit lanes, may wish to change lanes when buses are stopped at bus stops (which are almost always in-lane stops in these types of special vehicle lanes). Depending on the amount of congestion, the merge between these vehicles and general traffic at bus stops can result in delays for general traffic.

Where to use less-restricted special vehicle lanes

Less-restrictive special vehicle lanes are best used on arterial roads, expressways and motorways that experience traffic congestion for specific periods and city streets used by high volumes of public transport vehicles.

For guidance on signage and markings for restricted lanes, see Legal requirements (section 3.5).

Bicycles using special vehicle lanes – further guidance

For guidance on incorporating safe designs for cyclists in bus lanes, see People cycling and riding other two-wheeled vehicles (section 3.5.1).

Electric vehicles using special vehicle lanes

Under the Land Transport (Road User) Rule 2004, electric vehicles may use special vehicle lanes if the road controlling authority specifically permits them to do so. Allowing electric vehicles to use bus lanes can provide an incentive for people to purchase electric vehicles.

However, electric vehicles using special vehicle lanes present challenges:

- Increased difficulty of enforcement – differentiating electric vehicles from diesel and petrol vehicles is difficult.
- Lower people throughput – electric vehicles are less space-efficient than public transport vehicles and will reduce travel speed in the lane making the lane less efficient.
- Reduced safety for people using bikes – electric vehicles increase traffic volume in the lane, are quiet, and are smaller vehicles, so drivers may be tempted to 'squeeze pass' cyclists, which in turn may increase the likelihood of conflict with people using bikes
- Increased delay at stops – the increase in the number of vehicles using the lanes make in-lane bus stops less attractive, but indented bus stops are more difficult for buses to exit, which also increases delay
- Decreased service reliability – if these lanes are operating near capacity without electric vehicles, increasing the number of vehicles allowed to use them could increase travel time variability.

Because of these challenges, councils in Aotearoa New Zealand tend to disallow electric vehicles access to special vehicle lanes, given their potential to decrease the effectiveness of the lanes.

Allowing electric vehicles to use special vehicle lanes may be appropriate when lanes:

- are on highways or motorways that have no in-lane bus stops and no people using bikes
- have enough spare capacity to accommodate an increase in vehicle volume without significantly affecting on public transport journey times.

However, because the proportion of electric vehicles in the country's fleet is expected to progressively increase, road controlling authorities would need to regularly review the performance of the special vehicle lane. At some point, the volume of electric vehicles would reduce lane performance, so the authority would have to remove their access to some special vehicle lanes. It may be challenging to gain community support to discontinue access.

Trucks using special vehicle lanes

Trucks are of strategic importance to the transport system because they deliver most goods across the country, so have an impact on the economy. Because of this, some road controlling authorities are exploring ways to prioritise trucks. When limited road space is being reallocated to public transport, authorities may consider allowing trucks to use special vehicle lanes.

However, care needs to be taken to ensure the additional vehicles do not:

- increase safety risks for other lane users
- delay public transport users
- negatively affect the flow in adjacent traffic lanes.

Therefore, permissive access for trucks is generally discouraged.

Benefits and risks of enabling trucks to use special vehicle lanes are shown in the table below.

Table 13 – Benefits and risks of enabling trucks to use special vehicle lanes.

Benefits	Risks
Potentially faster and more reliable journey times for trucks. A more efficient freight system, which can result in cheaper goods for Aotearoa New Zealand consumers and more competitive exports.	Lower people throughput because trucks take up a large amount of lane space. Safety issues from increased interactions between trucks, buses and other lane users (for example, people cycling). Potential delay for general traffic from trucks pulling into the general traffic lane to go around buses at in-lane bus stops. Decreased public transport service reliability if the public transport lane is near capacity. Difficulty in defining the types of truck that should be allowed to use the lane (for example, light commercial vehicles compared with heavy commercial vehicles).

Because of the challenges listed above, special vehicle lanes that allow trucks are better suited to:

- highways or motorways where there are no in-lane bus stops, which removes the temptation for trucks to move between special vehicle lanes and general traffic lanes
- routes where people using bikes have a parallel cycling facility, so do not need to use the special vehicle lane
- special vehicle lanes with enough capacity to accommodate both buses and trucks, which is easier to achieve with a high threshold for the type of trucks permitted to use the special vehicle lanes in terms of weight vehicle weight or class.

Lane widths

Special vehicle lanes such as bus lanes often carry a high number of buses during peak times so ensuring adequate lane width is important to support safe and efficient operability of vehicles to ensure service reliability is not impacted.

If buses do not have an adequate lane width (for example, around bends), bus drivers may not use the special vehicle lane due to a concern about encroaching into other lanes or the footpath or hitting poles. This outcome would defeat the point of providing a special vehicle lane. However, overly wide lanes can be associated with unsafe speeds and greater crossing distances so this needs to be considered as well.

The appropriate width of a special vehicle lane depends on variables such as:

- the users likely to be permitted (such as buses, people on cycles and motorcycles, high-occupancy vehicles and/or trucks)
- the presence or not of bus stops along the lane and how they are positioned (in-lane or offline)
- the characteristics of public transport vehicles (such as their dimensions, whether they have front-wheel or rear-wheel steering, turning circles)
- whether dedicated cycling facilities are provided in parallel
- the geometric features of the road (such as its camber and curves)

- whether parking is provided at certain times of day
- whether the lane will be kerbside
- the presence of physical features on or near the road (such as the presence of adjoining cycling infrastructure) that will affect how drivers behave (for example, the path they will take)
- the desired speed environment

Auckland Transport offers further guidance on considerations when designing special vehicle lane widths in *Urban and Rural Roadway Design* (see section 7).

Confirm appropriate lane widths for a route by:

- tracking the largest urban bus likely to use the route with a bike rack deployed and accounting for the variables listed above
- visiting the site to confirm corridor characteristics
- undertaking drive-overs with a representative vehicle.

Note that:

- modern buses are slightly wider than older buses, particularly when wing mirrors are accounted for, so buffer or 'shy' space must be accounted for to allow for minor driving variability
- lane widths are likely to vary along the length of a corridor to accommodate geometric road features or other variables
- extensive guidance on design around bus stops for infrastructure cyclists will use is in the *bus stop* section of the Public Transport Design Guidance

The special vehicle lane width recommendations in the table below reflect modern buses and support an increased level of comfort for bus drivers.

These widths may require extra width to accommodate tight curves, obstructions adjacent to kerbs or other roadside features. Some councils may also opt to adopt narrower than recommended widths for pinchpoints given limited available roadspace. We recommend conservative tracking be performed in these instances.

Table 14 – Recommendations for special vehicle lane widths for ‘standard’ buses

Lane width	Public transport operability	Contexts for use	Cycling integration
Narrow – 3.4m Less preferable, use with caution	Minimum width. **Risks** • Bus drivers may find this width a bit tight in kerbside lanes, depending on geometric features. • If cyclist use is expected, public transport travel times may be affected.	Use: • in straight, lower speed environments (eg, 30km/h) • for, ideally, only short segments (eg, a queue jump lane) • for only full-time lanes (ie, the lane is not used for parking at some times) • if cyclist use is expected, an adjacent traffic lane to better support overtaking behaviours • if kerbside, being mindful of street trees (or other corridor clearance obstacles) and proximity to pedestrians.	Can be associated with conflicts with: • cyclists wanting to pass buses at bus stops • buses wanting to pass cyclists mid-block. Therefore, better to use only if: • dedicated cycling infrastructure is provided in parallel (eg, a bus stop bypass) • cyclist and bus volumes are low and dwell times are short • electric vehicles and taxis are prohibited if cyclist use is expected • the topography is flat or has a downhill gradient if cyclist use is expected
In-between – 3.5m-4.3m Preferable where cyclists have otherwise been accommodated for along corridor	Easier to accommodate buses around curves. **Risks** • Conflict created if buses and bikes attempt to pass each other when it is unsafe.	Use: • for bus-only lanes • for bus lanes, T2 lanes or T3 lanes where dedicated cycling infrastructure is provided • when bus dwell times are likely to be short, bus and bike speed differentials are low (eg, a downhill gradient), an adjoining lane is available for buses or bikes to merge into, and/or indented bus stops allow for cyclists to pass safely.	Unless bus frequency is relatively low, accommodate cyclists in separate cycle lanes or cycleways because this lane width can create conflicts with buses and bikes trying to pass one another when it is unsafe to do so. See the contexts for use column. Do not use if: • cyclists are not provided for • the lane will be used for parking part of day.
Wide – 4.4m and over Generally preferable	Comfortable for bus drivers, especially at higher speeds.	Use: • when cyclists will regularly use the lane	• This is the best width if cyclists will regularly use the lane.

Lane width	Public transport operability	Contexts for use	Cycling integration
	Much better width for tracking around curves. **Risks** • May result in unsafe speeds. • For T2 or T3 lanes, some vehicle drivers may try to overtake buses at stops if not prevented by treatments such as a solid median.	• in higher speed environments • where there is no cycling-specific facility • for part-time special vehicle lanes that are used for parking during some times of the day, so cyclists can pass outside the car door zone.	• This width allows buses and bikes to pass one another, although extra width (eg, 4.6m or more) is recommended at bus stops and on uphill road segments. • Catchpits should be bike-friendly and flush with road level. • If you have more than 5.0m consider providing for cyclists and buses in separate facilities.

Note: These recommendations are indicative only. Appropriate widths should be assessed on a case-by-case basis, considering the variables and process outlined above. For example, redesignated shoulders on motorways may be accommodated by 4.0m lanes for relatively straight motorway segments.

Figure 19 – Wide bus lane on Main North Road, Christchurch. Source: ViaStrada.

Bus lanes are unlikely to appeal to less-confident cyclists (that is, 'interested but concerned' users). Therefore, provide separated cycling facilities on routes where these types of cyclists are being actively encouraged, as shown in the image below.

Figure 20 – Separated cycleway next to a bus lane, Riddiford Street, Wellington. Source: Lorelei Schmitt.

Further information

- Influence of lane width on bus crashes (Dai et al, 2021)
- Accommodating cyclists at bus stops in bus lanes, Public Transport Design Guidance
- *Cycling in Bus Lanes* (Reid and Guthrie, 2004)

- Cycling Network Guidance.

3.2. Roadway configurations for special vehicle lanes

This section advises on possible roadway configurations for special vehicle lanes:

- kerbside and central lane arrangements
- one-lane (bidirectional) arrangements
- dynamic (contraflow) lane arrangements.

Kerbside and central lane arrangements

For multi-lane streets, an important design decision is the location of special vehicle lanes within the street corridor.

In Aotearoa New Zealand, special vehicle lanes for public transport are typically in a kerbside lane so buses have access to the kerb to pick up and drop off passengers. However, public transport vehicles in kerbside lanes can be delayed by cars parking and turning into side streets or driveways.

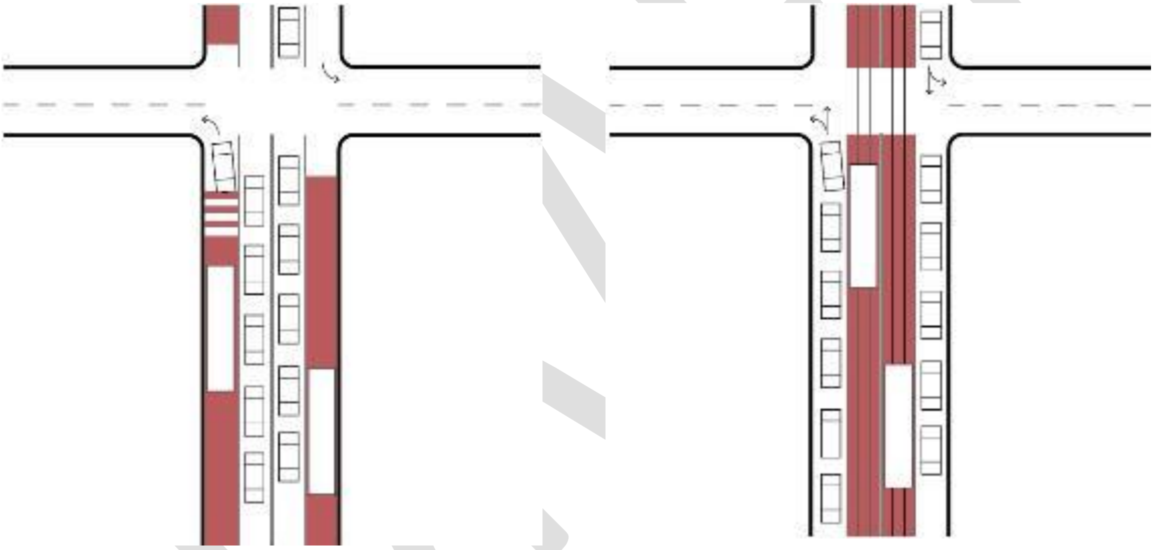


Figure 21 – Kerbside lane arrangement (left) and central lane arrangement (right). Adapted from: National Association of City Transportation Officials.

Where a high level of service for public transport is desired, central lanes can be used as an alternative, as they generally provide faster journey times and greater reliability than the kerbside lane arrangement.

For central lanes, stops or stations are in the middle of the street. Passengers generally access the stops or stations using signalised crossings.

The advantages and disadvantages of kerbside and central lane arrangements are summarised in the table below.

Table 15 – Advantages and disadvantages of kerbside and central lane arrangements

Roadway configuration	Advantages	Disadvantages
Kerbside lane	• Easier for pedestrians to access the station from the footpath • Less impact on turning movements for vehicles	• Public transport vehicles can be delayed by cars parking and turning into driveways or side streets • Station or stop infrastructure takes up footpath space • Locating large vehicles close to the kerb can affect amenity for people walking and cycling • May be subject to greater crossfall or camber, which can negatively affect public transport ride quality
Central lanes	• Improved journey times and reliability due to less conflict with parked and turning cars • Increased prominence of public transport infrastructure and stations • Reduced conflict between public transport vehicles and cyclists	• Greater impact on vehicles wanting to turn right at intersections • Requires more street space at stations or stops than kerbside lanes • May require public transport vehicles to have doors on the right-hand side if island platforms are used • Passengers need to cross one or more lanes to access the stop or station

One-lane (bidirectional) arrangements

When public transport frequencies are low (typically up to 10 minutes) and the corridor is highly constrained, short sections of the public transport corridor could be operated two-way with a single lane. In this configuration, public transport vehicles take turns using the one-lane section with passing occurring at stations or at two-way sections of the corridor.

Public transport systems that use a one-lane configuration include the Hataitai bus tunnel in Wellington (see the image below), Indianapolis bus rapid transit (IndyGo); Eugene bus rapid transit (Emerald Express), the Johnsonville rail line and the Wairarapa rail line (north of Upper Hutt).

To prevent conflicts between public transport vehicles on the one-way section, signalised traffic control is normally used so a green light is given only when the one-way section is clear.

Other important safety considerations are the management of turning vehicles and crossing pedestrians, which is typically accommodated at a signalised intersection.

Figure 22 – One-lane, bidirectional bus tunnel with one bus waiting for another to exit the tunnel, Hataitai, Wellington. Source: Lorelei Schmitt.

The advantage of one-lane configurations is that they require less street space, so have less impact on other road users and potentially avoid the need for street widening.

The disadvantage of one-lane configurations is that they can lead to lower reliability and slower travel times compared with more traditional two-lane bidirectional configurations. This occurs when service frequencies are higher public transport vehicles sometimes need to wait for others coming in the other direction (see the image of the Hataitai bus tunnel above). The threshold for when reliability and travel times start to be affected depends on the length of the one-way section and the operating speed of the vehicles but can be informed by monitoring and modelling.

One-lane configurations are most applicable for short sections of constrained corridor (such as narrow tunnels, bridges, or historic streets) in order to fit public transport priority within the available street space.

In these types of configurations, signs or signals must establish which direction can go at a given time. For example, B traffic signal displays are used at either end of Hataitai bus tunnel to create safe one-way operations and reinforce that the tunnel is bus only (illustrated below).

Figure 23 – B traffic signals manage the directional flows of a one-lane, bidirectional bus tunnel, Hataitai, Wellington. Source: Lorelei Schmitt.

Dynamic (contraflow) lane arrangements

Dynamic lanes (also called contraflow lanes) occur when the direction of the middle lane or lanes can be reversed so more lanes run in the peak direction of travel. Dynamic lanes may use movable barriers or over-head signs and in-carriageway lights to indicate the current direction of the changeable lane.

Dynamic lanes are most applicable to streets with strong tidal traffic patterns (for example, large streets where most vehicles travel in the peak direction) and have a low number of side streets and driveways. The provision of the public transport for the counter-peak direction requires careful consideration.

Dynamic lanes are used on the Auckland Harbour Bridge and Panmure Bridge. All dynamic lanes in Aotearoa New Zealand are general traffic lanes but the same principles could eventually be applied to public transport or transit lanes.

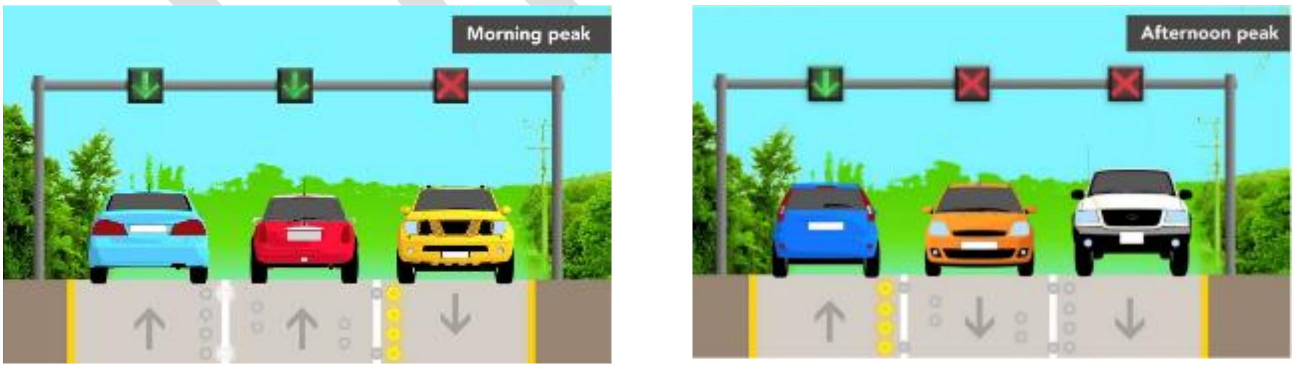


Figure 24 – Artist's impression of dynamic lanes. Source: Auckland Transport.

The advantage of dynamic lanes is they can reduce delays caused by traffic congestion without the need for expensive and disruptive street widening by making the most of an existing asset and the tidal flows of peaks.

The disadvantages of dynamic lanes are that:

- when used as bus lanes, they may have more safety issues than traditional bus lanes[4]
- safety needs to be particularly carefully managed such as for vehicles turning into side streets or driveways and ensuring drivers are aware of the lane direction to reduce the risk of head-on crashes
- pedestrian accessibility must also be maintained or improved because most public transport passengers walk for part of their journey.

Variable lane controls for general traffic are already used to direct traffic on or off certain lanes when events, incidents or closures occur or the movement of traffic needs to be optimised (such as tidal traffic flows to cater for peak volumes). Not all lanes need to be designated for traffic flow (for example, a three-lane road could sometimes comprise one lane for each direction of travel with the middle lane not designated for any traffic flow).

The Land Transport Rule: Traffic Control Devices 2004 specifically provides for this type of operation. It requires the use of certain lane control devices and sets out the sequence by which these devices must be used (see sections 7.13(1) to (5) of the rule).

For more information, see Part 4: Traffic control devices for general use – for intersections (draft, table 10-2) in *Traffic Control Devices Manual*.

Before dynamic lanes can be used for public transport or transit lanes, new traffic control devices may need to be developed and approved for use under the Traffic Control Devices Rule. This would probably be through a formal trial of the traffic control device.

3.3. Special vehicle lane segregation treatments

The special vehicle lane can be separated visually or physically from the general traffic lane. These treatments can improve compliance with traffic restrictions. The advantages and disadvantages of different treatments is summarised in the table below.

[4] N Duduta, C Adriazola-Steil, C Wass, D Hidalgo, LA Lindau and VS John. 2015. *Traffic Safety on Bus Priority Systems, Recommendations for integrating safety into the planning, design, and operation of major bus routes*. Washington DC: EMBARQ, World Resources Institute.

Table 16 – Advantages and disadvantages of treatments to improve compliance with priority lanes

Treatment	Advantages	Disadvantages	Typical use
Physical divider (kerbs, bollards and islands)  *Figure 25 – Artistic impression of airport to Botany rapid transit system, Auckland. Source: Auckland Transport*	Results, typically, in highest level of compliance Requires lower level of enforcement	Has a higher installation cost Needs wider priority lanes to accommodate the divider Requires two-way operation to enable public transport vehicles to overtake	Central priority lanes or separate corridors
Active signage (permanent or movable variable message signs)  *Figure 26 – Grafton Bridge vehicle restriction signage, Auckland. Source: Stuff.*	Can convey messages to road users	May not be noticed or complied with by all road users	Priority lanes with variable restrictions

Treatment	Advantages	Disadvantages	Typical use
Road markings  *Figure 27 – Fanshawe Street bus lane, Auckland. Source: Greater Auckland.*	Are relatively cheap and easy to install and maintain Allows the lane to be used for other purposes during off-peak times (eg, parking) Enables vehicles to enter the priority lane for turning manoeuvres	Results, typically, in lowest level of compliance Has higher requirement for ongoing enforcement	Kerbside priority lanes

3.3.1. Continuity lines

Continuity lines are not a priority or optimisation measure but are a treatment that can support special vehicles lanes at intersections. They can be used on the approach to an intersection to indicate where drivers may cross into the special vehicle lane to make a left turn.

As shown in the image below, continuity lines for bus lanes are dashed green and white lane markings that start 50 metres before the intersection and return to a solid lane marking after the intersection. At the start and end of continuity lines it is common to have the special vehicle lane symbol and corresponding sign to make it clear to drivers that they must leave the lane.

The advantage of continuity lines is that they make it clear where drivers can use the special vehicle lane to make left turns which helps educate roads users on the correct use of priority lanes.

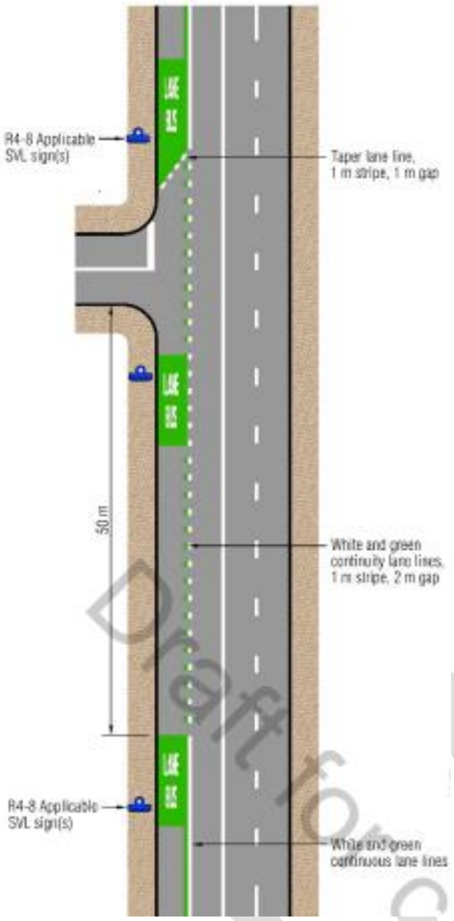


Figure 28 – Continuity lines on approach to a side street. Source: Waka Kotahi NZ Transport Agency. 2021. Part 4: Traffic control devices for general use – for intersections (draft), Traffic Control Devices Manual, p168.

3.4. Designing for safety in special vehicle lanes

Overall, special vehicle lanes such as bus lanes can support road safety outcomes. For example, research from Melbourne found bus lanes resulted in a 14% reduction in crashes by:[5]

- acting as a roadside buffer, reducing collisions with roadside objects and other vehicles
- shifting stopping buses from traffic lanes into dedicated bus lanes, reducing overtaking crashes
- increasing sight distances at unsignalised intersections, reducing crashes with vehicles to the side
- possibly increasing the density of other traffic, creating safety benefits through slowed traffic.

Nevertheless, there are some key important elements to consider in designs such as:

- People walking
- People on bikes, mopeds and motorbikes

[5] KCK Goh, G Currie and M Sarvi. 2013. 'Road safety benefits from bus priority: An empirical study', *Transportation Research Record: Journal of the Transportation Research Board* vol 2352(1). https://doi.org/10.3141/2352-05

- Times of operation
- Turning vehicles.

3.4.1. People walking

Special vehicle lanes, such as bus lanes, can increase the crossing distance for pedestrians where the street is widened or a parking lane is converted into a special vehicle lane.

To help crossing pedestrians, assess pedestrian facilities (for example, pedestrian refuges and traffic signals) as part of the project. Avoid zebra crossings on streets with more than one lane in either direction. This is because pedestrians may step out from behind a stationary vehicle into the path of moving vehicles in the other lane.

For guidance on selecting appropriate pedestrian facilities, see Pedestrian network guidance

3.4.2. People on bikes, mopeds, and motorbikes

People riding cycles, mopeds or motorcycles are often permitted to use special vehicle lanes such as bus lanes and transit lanes. Therefore, the safety of people using these devices must be considered when designing special vehicle lanes.

Where it is not possible to safely accommodate people riding the lane should be designated bus only. Therefore, bus-only lanes are typically used in higher-speed environments or where there is insufficient space for buses and cyclists to overtake.

For guidance on lane widths to support safe cycle and bus use of road space, see Lane widths section.

3.4.3. Times of operation

Special vehicle lanes operate 24 hours a day or for limited times in a day. To support a Safe System, Lane widths and hours of operations should be considered together.

Wide bus lanes:

- can operate full time or part time with little difference in terms of safety
- are often used for on-street parking or extra lane capacity during non-bus lane hours
- provide, at bus stops, enough space for a person on a bike to easily overtake a stationary bus within the width of the bus lane.

Narrow bus lanes:

- should operate full time (that is, 24 hours a day), because they are generally narrower than a standard traffic lane, so rider risk increases if other traffic is permitted in the narrow lane
- that operate part time with parking permitted during non-bus lanes hours, increase rider risk because they have to ride within the bus ‘door zone’ during those hours
- should, where possible, have bus stops indented at least 1m to provide enough space for a rider to safely overtake a stopped bus.

3.4.4. Turning vehicles

In multi-lane streets, vehicles turning right across a special vehicle lane can have limited visibility around queued traffic. Where a kerbside special vehicle lane is provided, this increases the risk of collision with traffic moving along the kerbside priority lane. Riders of two-wheeled vehicles are especially vulnerable, being less visible to turning vehicles.

This risk can be reduced by:

- using ‘keep clear’ markings to improve visibility
- banning right turns
- using advisory warning signs
- limiting the user types allowed in the bus lane (the most extreme option).

In the case of keep clear markings, consider the extent of the markings within the intersection. The two forms of marking, both coloured yellow, are the:

- fully capitalised words KEEP CLEAR (marking M4-1)
- cross-hatched marking (marking M4-2).

Irrespective of the form of marking, it should such cover all affected lanes, including the special vehicle lane. The keep clear marking layout illustrated below is not best practice, because it:

- fails to cover all the lanes travelling in the same direction (general traffic and bus lanes)
- is the wrong colour (white rather than yellow).

This ‘keep clear’ marking is **NOT** best practice. Keep clear markings should cover all traffic lanes travelling in the same direction and have yellow lettering.

Figure 29: Keep clear marking that does not represent best practice. Source: Glen Koorey.

A better example of a keep clear marking is illustrated below. The marking extends across both travel directions and the flush median. This supports better visibility of cyclists in the nearby cycleway.

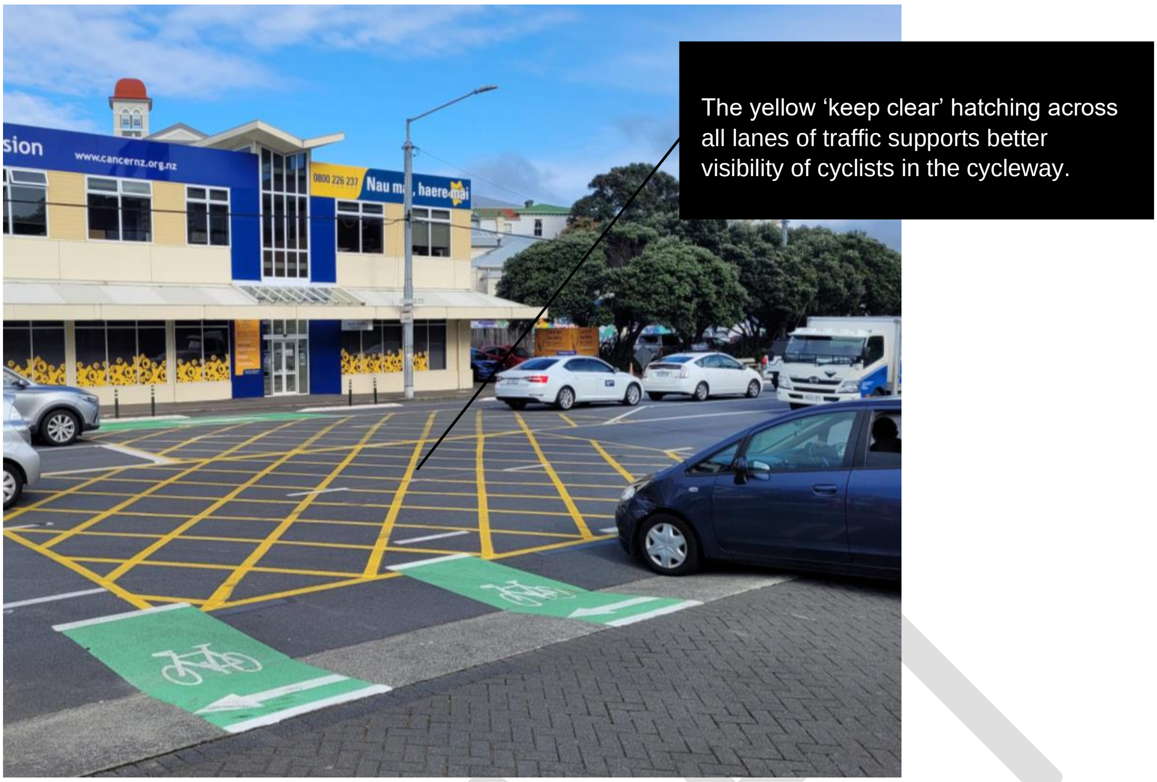


Figure 30 – Keep clear marking extending across both travel directions and the flush median. Source: Lorelei Schmitt.

The keep clear marking can also be used:

- when vehicles regularly encroach into the intersection and lanes from a side road
- to maintain access to and from public transport facilities.

Figure 31 – Keep clear marking maintaining access to and from Wellington bus station.

3.5. Legal requirements for special vehicle lanes

A special vehicle lane is defined in the Land Transport (Road User) Rule 2004 (r 1.6) as:

> a lane defined by signs or markings as restricted to a specified class or classes of vehicle; and includes a bus lane, a transit lane, a cycle lane, and a light rail vehicle lane.

The restrictions on the class of vehicles that can use a special vehicle lane can apply at all times or for specified times or days.

A driver must not stop or park a vehicle in a special vehicle lane unless that vehicle belongs to the class of vehicle for which the lane is reserved.

A driver of a vehicle type not permitted to enter and use the special vehicle lane must not do so, unless:

- they are making a turn, entering a driveway or parking in a space clear of the special vehicle lane and the manoeuvre is for more no more than 50m
- the vehicle is an emergency vehicle being used in an emergency
- they enter the lane to avoid a crash, to avoid an obstruction in the road or on the instruction of an enforcement officer.

When a road controlling authority decides to introduce a special vehicle lane, it needs to create the lane by some form of council traffic resolution. The resolution needs to establish and record such elements as:

- the type of lane it is
- the restrictions that apply to the lane (such as the vehicle classes permitted to use the lane, the times and days of its operation, any exemptions)
- where the lane starts and finishes,

Different types of special vehicle lanes used by public transport are described in the following table.

Table 17 – Types of special vehicle lanes used by public transport

Special vehicle lane	Description
Bus lane	A lane reserved by a marking and/or a sign installed at the start of the lane and at each point at which the lane resumes after an intersection for the use of: • buses • cycles, mopeds and motorcycles (unless one or more are specifically excluded by the marking or sign) • electric vehicles (if specifically included by the marking or sign).
Bus-only lane	A lane reserved for the use of buses only.
Light rail vehicle lane	A lane reserved for the use of light-rail vehicles by a marking or sign installed at: • the start of the lane (unless the lane is a continuous loop) • each point at which the lane resumes after an intersection.

Special vehicle lane	Description
Transit lane	A lane reserved for the use of (unless specifically excluded by a sign installed at the start of the lane): • passenger service vehicles • motor vehicles carrying not less than the number of people (including the driver) specified on the sign • cycles • motorcycles • mopeds • electric vehicles (if specifically included by a sign installed at the start of the lane).

The difference between a bus lane and a bus-only lane is whether cycles, mopeds and motorcycles are specifically excluded from using the lane. A bus-only lane means a lane reserved for the use of buses only.

Light rail lanes must be reserved for only light rail vehicles, so cycles, mopeds and motorcycles are not permitted to use the lane.

A special vehicle lane must be enforced. To enable enforcement, it must be clear to all road users where the special vehicle lane is (starts and finishes) and how it operates. This is achieved primarily by using road markings and road traffic signs.

3.5.1. Signs and road markings

For details about how to mark and sign a special vehicle lane, see Special Vehicle Lanes in Part 5 of the *Traffic Control Devices Manual*.

Signs and markings used must conform to the Land Transport Rule: Traffic Control Devices 2004. Sections 11.2 (special vehicle lanes) and 11.3 (light-rail vehicle facilities) in this rule are of particular relevance.

The traffic control devices rule sets out:

- the road markings and road traffic signs that must be provided
- what must or may be provided in terms of road markings and road traffic signs.

Section 11.2(1) of this rule states that when defining a part of a road as a special vehicle lane, a road controlling authority must, at the start of the special vehicle lane and after each intersection, along its length:

(a) mark on the road surface a white symbol that complies with *Schedule 2* defining the class or classes of vehicle for which the lane has been reserved; and

(b) if for other than a 24-hour restriction, install a special vehicle lane sign that complies with *Schedule 1*:

(i) defining the class or classes of vehicle for which the lane has been reserved; and

(ii) stating the periods for which the reservation applies.

This means:

- a road marking must always be present
- a sign is required when the special vehicle lane operates at set times rather than all day.

Road markings are the basic feature that must be present in all special vehicle lanes. These road markings consist of a:

- lane line to differentiate the special vehicle lane from the rest of the roadway, when necessary
- white symbol that complies with Schedule 2of the rule, defining the class or classes of vehicle for which the lane has been reserved.

For more information on signs, road markings, typical layouts and such like, see Special vehicle lanes in Part 5 of the *Traffic Control Devices Manual*.

A road controlling authority may provide additional features and traffic control devices to discourage the use of a special vehicle lane by other vehicles or to draw attention to the likely presence of vehicles entitled to the use of the lane. These features or devices include:

- additional white special vehicle lane symbols or signs (as described above) along the length of the lane
- for a 24-hour restriction, additional special vehicle lane signs
- a surface treatment that provides a contrasting colour or texture to that of adjacent lanes used by other vehicles at specific locations along part of or the whole the lane.

An road controlling authority may provide a coloured surface in the special vehicle lane to discourage non-permitted vehicles from using the. Colour used in a special vehicle lane has no specific legal meaning, but it can provide a strong visual cue to road users. As noted above, coloured surfacing may be used along the full length of the lane or at discrete locations along the lane (such as at the lane start, the lane end or intersections).

A road controlling authority:

- should have a policy for the clear and consistent use of colour surfacing to avoid differing design approaches
- if deciding to use coloured surfacing, should use green (AS 2700S-2011 colour G26 Apple Green or similar).

Typical layouts for a bus lane showing the markings, use of colour, and advance, start and repeater signs are in Special vehicle lanes in Part 5 of the *Traffic Control Devices Manual*.

3.6. Redesignating shoulders on motorways and high-speed roads

In some locations bus services use motorways and high-speed roads. As with other roads, congestion can delay these bus services, so providing bus priority in the form of bus lanes can help establish a reliable service.

Motorway bus priority lanes are increasingly prevalent where buses would otherwise be affected by congestion. They can be provided by:

- constructing purpose-built public transport priority lanes when motorways or high-speed roads are built

- reallocating general traffic lanes as special vehicle lanes for some or all of the time
- redesignating shoulders as an emergency stopping lane and a special vehicle lane (for example, a bus-only lane).

The first two options are straightforward and covered elsewhere in this guide. Designating shoulders for public transport use is more complicated. This is because the 'lane' still needs to accommodate emergency stopping (such as for punctures or mechanical failure), emergency services and enforcement activity but operates as a public transport priority lane at certain times of the day.

The use of the redesignated shoulder should reflect the traffic conditions prevalent in the adjacent general traffic lanes. When operating speeds are 50km/h or over, buses should use the general traffic lanes.

The advantages of redesignating the shoulder are that the redesignated lane:

- allows buses to bypass congestion at peak times, improving public transport service reliability
- is a way to retrofit public transport priority into existing motorways or highways without reducing private vehicle capacity.

There are two main disadvantages of redesignating the shoulder:

- The speed limit of the shoulder should be set at no more than 60km/h to prevent a high speed differential between shoulder traffic and mainline traffic. This lower speed limit reduces the risk of a serious crash should a vehicle pull into the lane for an emergency stop.
- Because the space also needs to be available for use in an emergency, public transport vehicles may sometimes need to merge into the general traffic lane to avoid a stationary vehicle.

Figure 32 – Bus shoulder, State Highway 1, Onewa Road northbound on-ramp. Source: Kevan Fleckney.

3.6.1. Legal requirements and signs and markings for redesignating shoulder on motorways or high speed roads

The Land Transport (Road User) Rule 2004, clause 2.12 (motorways), enables the provision of an emergency stopping lane at the side of the trafficked lanes on a motorway. A driver must not generally drive in this lane unless:

(a) the driver needs to drive in it to avoid a collision or to stop in an emergency;

(b) the driver's vehicle is disabled; or

(c) a sign at the entrance to the lane indicates vehicles of a specified class or classes may use the lane during the time specified on the sign and the driver is operating a vehicle of that specified class or one of those specified classes.

Of note is subclause (c), which specifically provides a road controlling authority with the ability to provide a special vehicle lane on the emergency stopping lane on motorways. The lane must still be gazetted as an emergency stopping lane and a special vehicle lane.

Signs

All regulatory requirements for special vehicle lane signs also apply to redesignated shoulders.

Emergency stopping lane and public transport priority lane signs should be on the same pole with a gap of about 300mm between the two signs.

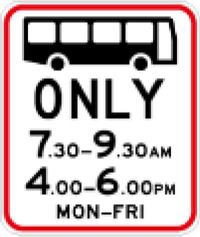
Variable message signs can be used to inform public transport drivers when:

- they may use the redesignated shoulder (for example, at peak periods and when downstream congestion is detected)
- they may not use the redesignated shoulder such as non-operating times or when obstructions are in the emergency stopping lane such as an unplanned event (for example, a breakdown) or a planned event (for example, maintenance work).

The end of the public transport priority lane should be obvious and clearly signposted.

Table 18 – Signs used on motorway public transport lanes.

Sign	Sign reference*	Sign description
	R4-12	Lane use – emergency stopping lane only
	R4-12.1	Emergency stopping lane – specified time.
	R4-12.2	Emergency stopping lane • Must be installed on sections of the motorway that are bus-only lanes operating during specified periods only. • Is installed in combination with a bus-only lane (or bus lane) sign that displays the times the bus-only lane operates. • Is installed above the bus-only lane sign. • Should be used at the start of the bus-only lane and on repeater signs, but not at the end of the bus-only lane. •

Sign	Sign reference*	Sign description
	R4-7.1	Lane use bus only • Instal on sections of the motorway for use as bus-only lanes at all times. • Install supplementary plates immediately below this sign to state the start or end of the restriction.
 	R4-7.2 R4-7.3	Bus lane, single peak period Bus lane, two periods same days • Must be installed where sections of emergency shoulder on motorways are for use during peak periods as bus-only lanes. • Install supplementary plates immediately below these signs to state the start or end of the restriction.
	R7-2.1	Supplementary – begins • Install as a supplementary sign underneath the R4-7.1, R4-7.2 or R4-7.3 sign to mark the start of the bus-only lane. • Ensure the width of this supplementary plate matches the width of the sign it is being used with.
	R7-2.2	Supplementary – ends • Install as a supplementary sign underneath the R4-7.1, R4-7.2 or R4-7.3 sign to mark the end of the bus-only lane. • Ensure the width of this supplementary plate matches the width of the sign it is being used with.
	A42-6	Advance advisory bus-only • May be used in advance of the beginning of a bus-only lane to indicate a bus lane is ahead.

Sign	Sign reference*	Sign description
100 m	A42-6.1	Advance advisory special vehicle lane supplementary – distance in metres (m) • May be used to advise road users that a bus-only lane begins at the distance stated ahead. • Must be used with an A42-6 or A50-1 sign.
BUSES MERGING FROM LEFT	A50-1	General advisory sign – buses merging from left • Use on bus-only lane through-running sites, where the bus-only lane merges into an adjacent lane drop lane. • Install this sign 100m before the end of the bus-only lane.
BUSES MERGING FROM RIGHT	A50-1	General advisory sign – buses merging from right • Use in a gated arrangement on the on-ramp approach to a bus-only lane through-running site, where intervisibility between the bus-only lane and on-ramp is limited.
BUS SHOULDER MAX SPEED 60 km/h	A50-1	Advisory maximum 60km/h bus lane speed • Position within each interchange for bus-only lane through-running sites, about 60m from the bus-only (R4-7.1) begins sign, so bus drivers are aware of the requirement, making it undesirable to use the bus-only lane when they can drive faster in the traffic lanes. • Install along with an associated '60' road marking.

* The sign references are from schedule 1 of the Land Transport Rule: Traffic Control Devices 2004.

Notes

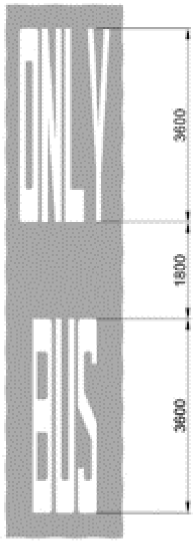
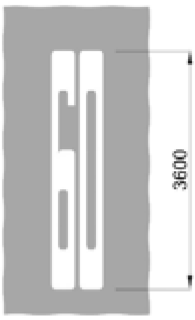
- Motorway shoulder bus priority should be provided in the form of bus-only lanes (rather than bus lanes) for safety reasons.
- Motorway bus-only lanes should be peak-period only special vehicle lanes unless a separate shoulder is provided for emergency stopping.
- Bus-only lane signs must be installed along the side of the motorway section subject to the restriction, at the start of the bus-only lane and at the end of the restriction, and should be installed at intervals of no more than 400m.
- All signs should be installed on frangible posts.
- The signs indicating the start of motorway bus-only lane should be visible to an approaching driver for a distance of at least 120m.
- Emergency stopping lane signs must be installed on part-time bus-only lanes to make it clear the bus-only lanes revert to emergency stopping lanes at other times.

Markings

All regulatory requirements for special vehicle lane markings also apply to redesignated shoulders.

Additional markings may also be useful. For example, a ‘bus-only ends’ sign is good practice, even though it is not a regulatory requirement. This sign establishes a clear end to the bus priority lane and supports a Safe System by advising public transport drivers that they need to merge and raising the awareness of other road users about the merge.

Table 19 – Road markings used on motorway emergency stopping lanes

Marking image	Marking reference*	Marking description
	Bus only M2-2.1	• Must be installed to establish the start of the bus only lane, thereafter at regular intervals and after on ramps. • Must be installed at the start of the restriction. • Should be installed at intervals of no more than 400m. • Must be installed after every intersection. • Must have a letter height of at least 3600mm.
	‘Ends’ M8-2 for standard lettering for road marking, 3600mm letter height (min)	• Should be installed in association with the bus-only symbol at the end of the bus-only lane. • Must have a letter height of at least 3600mm.
	‘60’ Advisory speed limit M8-1, standard numbers for road marking 3600mm numeral height (min)	• Should be positioned within each interchange for bus-only lane through-running sites, about 60m from the ‘bus-only begins’ sign, to ensure bus drivers are aware of the requirement and make it undesirable for them to use the bus-only lane when they can drive faster in the general traffic lanes. • Should be installed along with an associated 60km/h bus-only lane maximum speed advisory sign. • Must be at least a numeral height of 3600mm.

Texture

The redesignated shoulder needs to have been constructed in a manner to support traffic running on it. This might require isolated additional widening.

To support a Safe System, the surface needs to be of a type that helps manage speeds and discourage use by lighter vehicles (such as cars and motorcycles). Experience in Auckland demonstrated that the surface type influenced compliance and managed speeds.

The emergency stopping lane or bus priority lane should have a rough finish (such as a chip finish) to generate noise inside vehicles travelling on it at speed and a tactile vibration through the steering wheel. These features will help deter illegitimate use of the lane and inappropriate speeds.

Coloured surfacing

Coloured surfacing can help define where a lane starts and stops and that the lane is something different from a general traffic lane.

As described in the Land Transport Rule: Traffic Control Devices 2004, a road controlling authority may provide a surface treatment within a special vehicle lane that provides a contrasting colour or texture to that of the adjacent lanes, along the length of the lane or at discrete locations along the lane.

Green surfacing is often used for special vehicle lanes. However, using green for redesignated shoulders could lead to users assuming the redesignated lane operates as a standard bus lane with the same permitted users. Motorway and high-speed bus priority lanes are very different environments to other special vehicle lanes, so using green risks confusing users and putting them at risk.

Red is associated with 'risk'. Therefore, red surfacing is more appropriate on and around on-ramps, off-ramps and merge areas to highlight the potential risk of bus movements.

The red colour should be AS 2700S-2011 R13 signal red or similar and in accordance with *NZTA P33: 2017 – Specification for coloured surfacings*.

The remainder of the bus priority or emergency stopping lane should not be coloured green or red but the surfacing material might contain a coloured chip or colour pigment that is different from the adjacent general traffic lanes (for instance, grey or buff). This means higher risk areas can be highlighted as well as the lane being demarcated differently from the general lanes.

On-ramps and off-ramps

The two established methods to begin and end a special vehicle lane near on-ramps and off-ramps are the conventional and through-running methods.

The **conventional** method:

- begins the lane with a 25m opening taper (a longer taper would make the shoulder look like an additional lane to general traffic)
- ends the lane with a 90m taper no closer than 60m from the start of the downstream off-ramp diverge taper
- uses an edge line without gaps at the beginning and end of the redesignated shoulder.

Conventional redesignated shoulders are less likely to be seen as attractive for general traffic. They can be effective when the public transport service is not high frequency. Because the lane is in use only at congested times, merging and diverging occurs at a reduced speed.

The **through-running** method permits the bus to stay out of the adjacent general traffic lane by permitting through-running of specially marked ramp gore areas. Weaving and merging between traffic streams in advance of an off-ramp is provided for by a length of auxiliary lane, and it is achieved initially on the on-ramps with a sequential merge–parallel–merge arrangement. This arrangement is suitable for high-frequency bus services on roads with persistent peak congestion.

Typical layouts

Typical layouts for bus-only lanes are shown in the figures below.

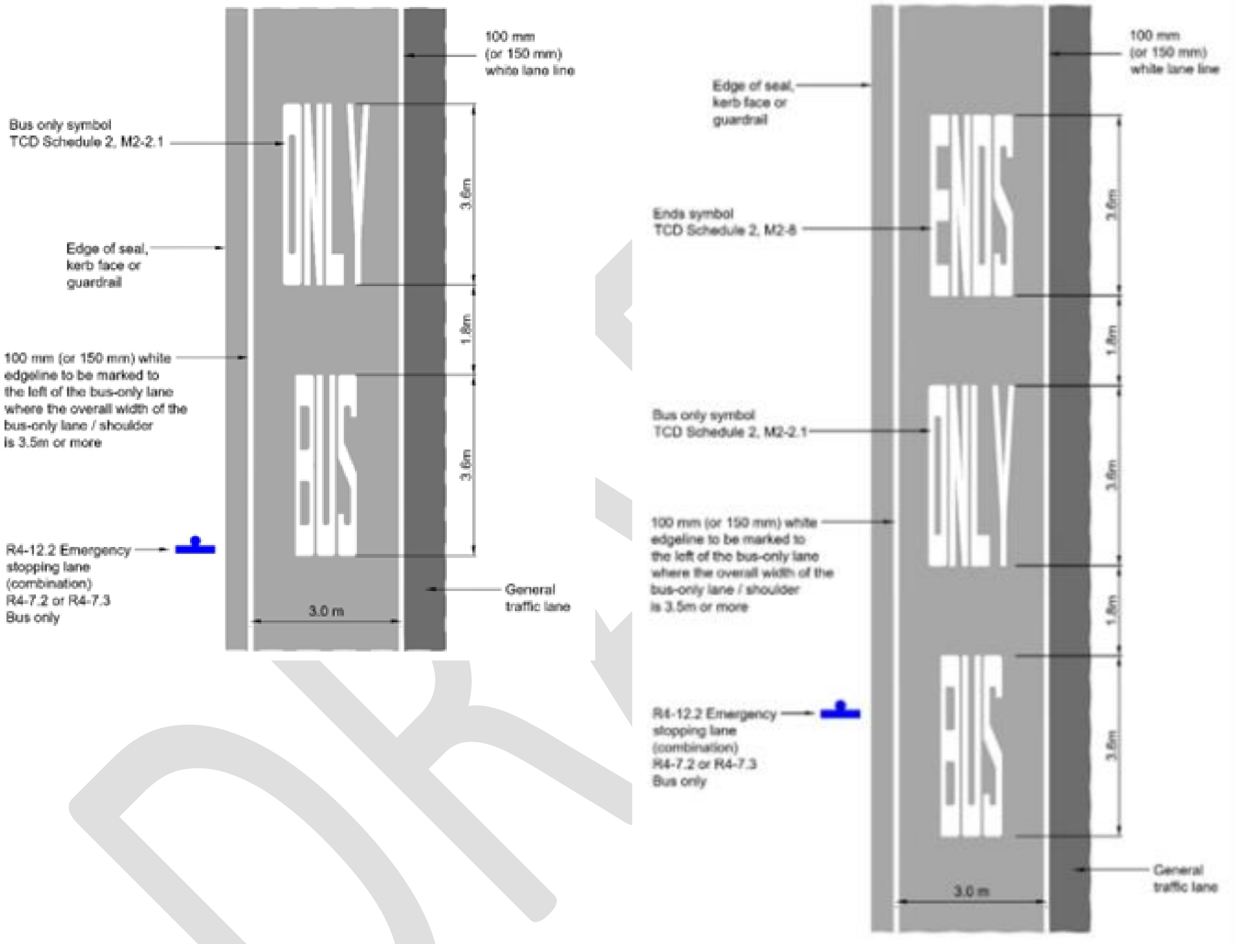


Figure 33. Typical layouts with bus-only symbol (left) and bus-only ends symbol (right).

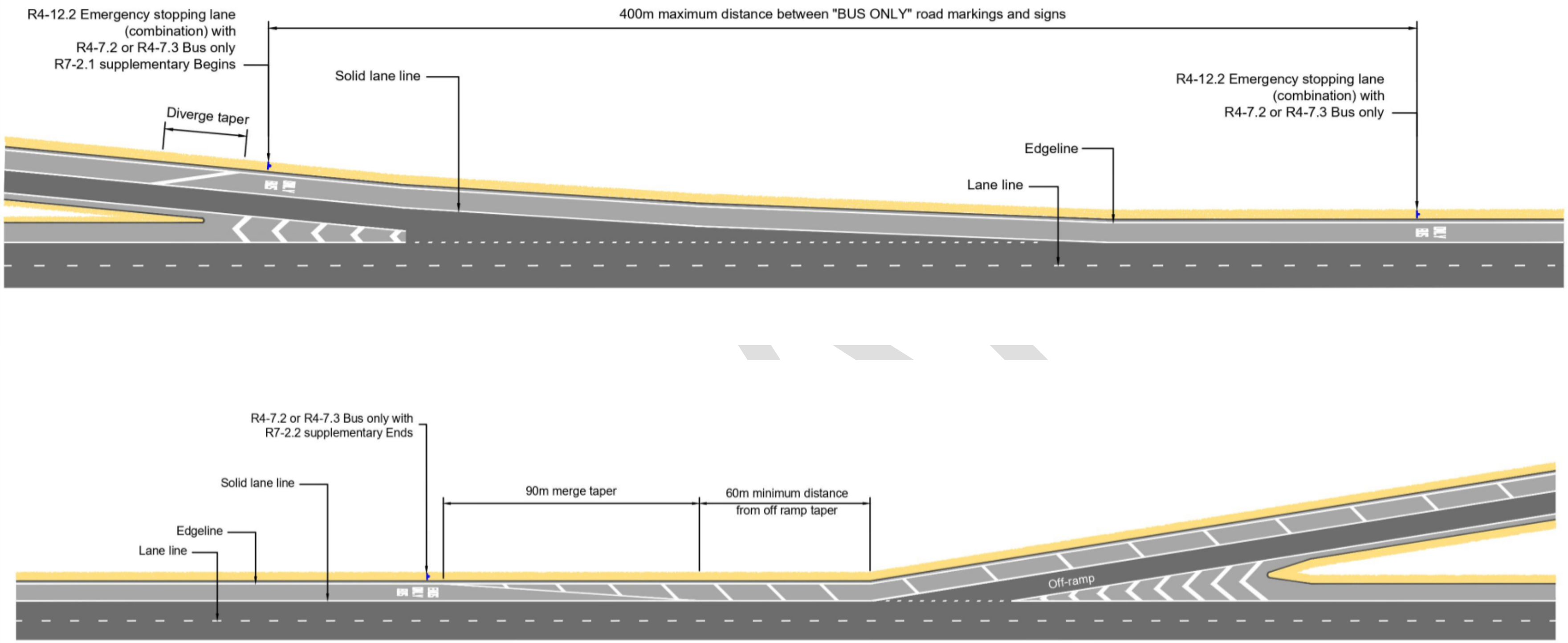


Figure 34 – Layouts for bus-only lane on-ramp (top) and off-ramp (bottom).

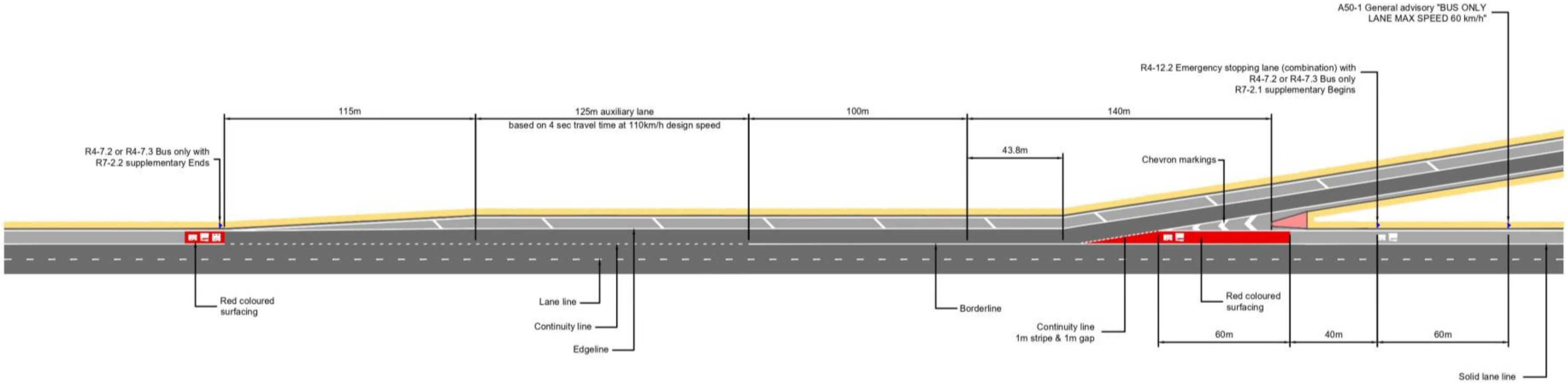


Figure 35 – Layout for bus-only through-running standard off-ramp.

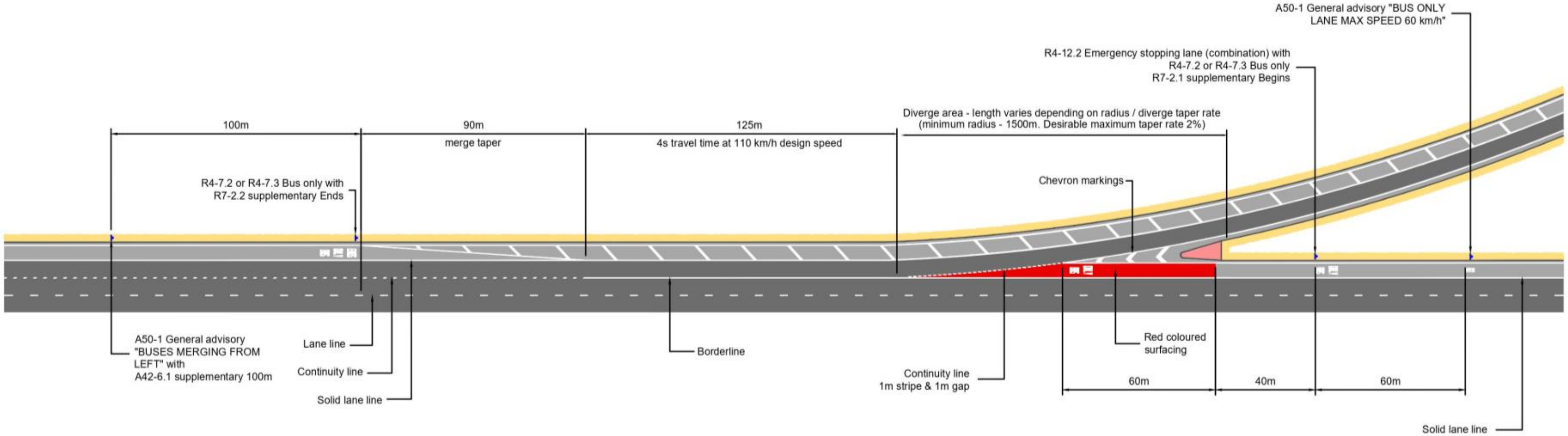


Figure 36 – Layout for bus-only through-running lane drop off-ramp.

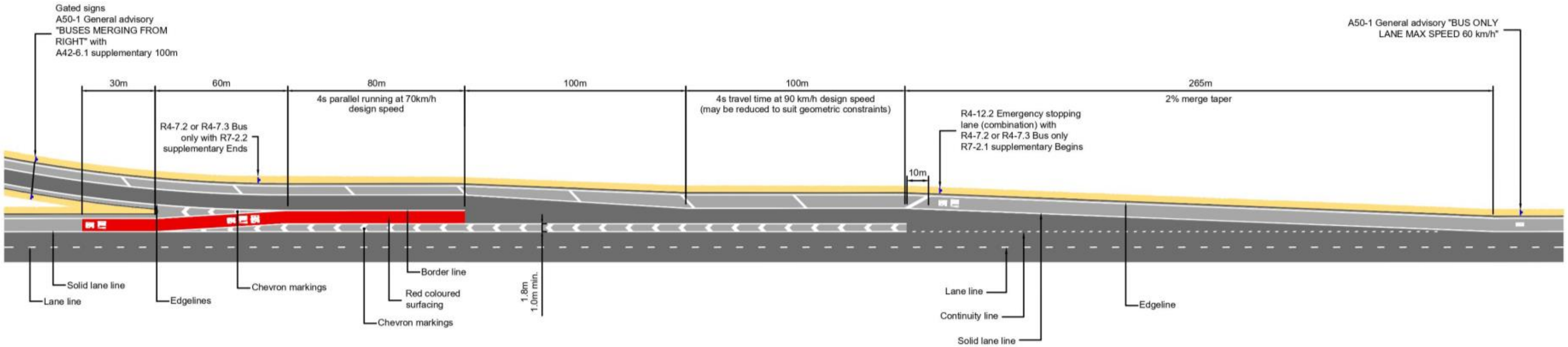


Figure 37 – Layout for bus-only through–running on-ramp.

4. Intersection interventions

There are a variety of ways to support more efficient public transport at intersections through priority or optimisation for public transport. This section covers:

- Exemptions to restricted movements
- Introduction to signal priority
- How to provide signal priority
- Public transport priority at roundabouts

4.1. Exemptions to restricted movements

One way to support public transport efficiency at intersections is to allow public transport vehicles to undertake movements that are banned to other vehicles. This can advantage public transport vehicles; for example, they can bypass a queue of traffic if a certain lane tends to be free flowing. They can also reduce access for general traffic to adjoining parts of the network to help optimise public transport. These exemptions can significantly reduce travel distances and travel time.

Note that these designs have no public transport phase or signal, so the public transport through-movement must run concurrently with the general traffic through-movement and receiving lanes must be considered. For instance, a 'left turn lane buses excepted' facility requires a receiving merge lane or public transport priority lane after the intersection to avoid delays from merging vehicles.

Figure 38 – Left-turn lane buses excepted facility at the intersection of Park Road and Carlton Gore Road, Auckland. Source: Aurecon.

The signage to support this type of general traffic restrictions is in Road user restrictions (table 15-1) in Part 5 of the *Traffic Control Devices Manual*.

In the above image, a general regulatory sign (traffic control device sign reference R7-10) describes this exemption.

If instead the left turn was banned for general traffic but permissible by buses the road controlling authority would likely use the ‘no left turn sign’ (R3-1) with the ‘supplementary – except buses’ (R3-5.1) as depicted in the images below.

Figure 39: No left turn (R3-1) sign

Figure 40: Supplementary - except buses (R3-5.1)

4.2. Introduction to signal priority

Traffic signals are typically optimised using measures of traffic delay such as level of service, total delay and intersection capacity. The goal of optimising traffic signals is to reduce overall traffic (vehicle) delay without excessive wait times for low-volume movements. However, these measures optimise traffic signals based on vehicle throughput and do not always consider how many people are carried in each vehicle.

In urban environments where the volume of people walking, cycling or using public transport is moderate or high, it is important to optimise the intersection based on people throughput or desired people throughput by mode. This is because walking, cycling and public transport can have a higher people throughput than private motor vehicles. By prioritising these modes, more people can travel through an intersection or a corridor, even with lower vehicle throughput.

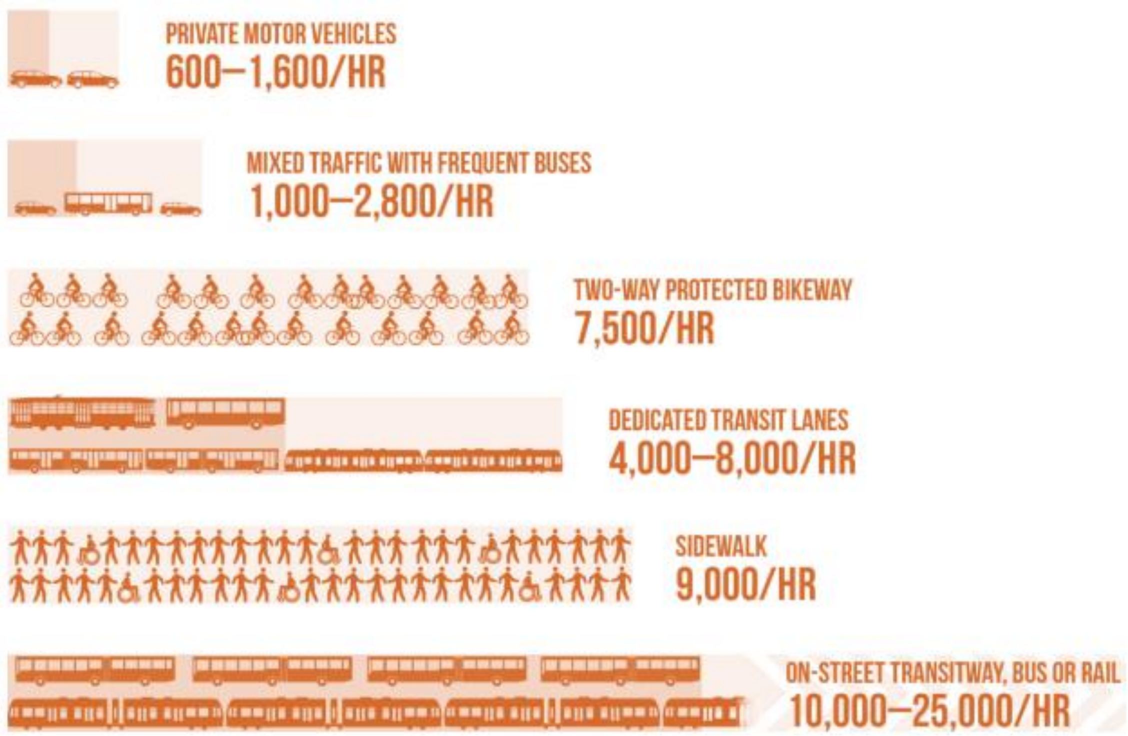


Figure 41 – Maximum capacity of a single lane by mode. Source: National Association of City Transportation Officials. No date. <u>Designing to move people</u>, Transit Street Design Guide.

4.3. How to provide signal priority

At signalised intersections, priority for public transport vehicles can be provided by modifying the operation of the signals to advantage the direction of travel for public transport. This can be achieved by:

- increasing the overall green time for public transport vehicles.
- coordinating green phases with the arrival of public transport vehicles

Methods that do not detect public transport vehicles and instead use pre-determined settings are called **'passive signal priority'** methods.

Signal priority methods that use technology to detect the presence of public transport vehicles and then respond in real-time are referred to as **'active signal priority'** methods.

4.3.1. Passive signal priority (green waves)

Coordinating traffic signals with the average speed of public transport services during a certain time of day along the route increases the likelihood that public transport vehicles receive a progression of green signals along the corridor. This is commonly called a 'green wave'.

This type of passive signal priority can be achieved by changing the pre-set signal timing along a corridor to account for the difference in typical speeds between general traffic and public transport services. Public transport vehicles typically travel slower than cars since they have to stop to pick up and drop off passengers.

Another consideration is the 'cycle time', which is how long it takes the traffic signal controller to complete all signal phases and return to the first phase. Shorter cycle times of 60 to 90 seconds are preferable for public transport green waves because longer cycle times increase the penalty for falling behind the signal progression.

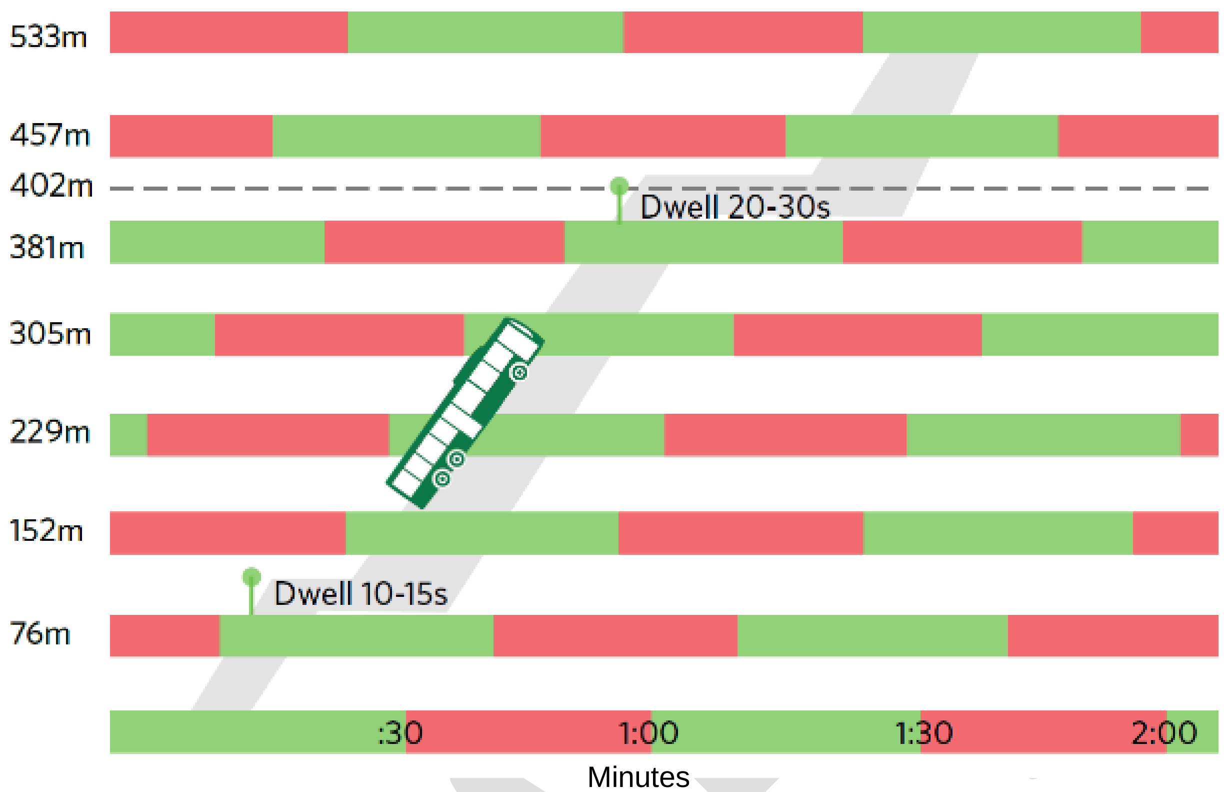


Figure 42 – Visualisation of a green wave for public transport vehicles (m = metres, s = seconds). Source: Adapted from National Association of City Transportation Officials. No date. Transit signal progression, Transit Street Design Guide.

The advantages of fixed signal timings are that:

- they are easy to implement
- do not require infrastructure changes
- may benefit people on bicycles as well who often have similar average travel speeds to buses.

The disadvantage of fixed signal timings is that the risk exists that public transport vehicles fall behind the signal progression due to delays at stops or in mid-block sections. This is particularly likely where the number of boardings at each stop is irregular, so hard to predict. Therefore, the benefits of public transport green waves may be reduced in corridors where public transport services have a high degree of travel time variability.

4.3.2. Active signal priority

Active signal priority involves using a standard signal display. A public transport vehicle approaching an intersection is detected, and signal phasing is adjusted in real-time to reduce delay for the public transport vehicle.

Where public transport vehicles use a special vehicle lane, in-ground loop detectors may be used to identify arriving public transport vehicles since only authorised vehicles should be present.

Where public transport vehicles operate in general traffic lanes a transmitter is usually fitted to all public transport vehicles to communicate with the signal controller.

Active signal priority may be conditional or unconditional.

The priority may be **conditional** on the public transport vehicle meeting certain criteria. For example, conditional transit signal priority typically considers whether a public transport vehicle is on schedule and gives priority to only those public transport vehicles running late, thereby potentially reducing the impact on other road users. Conditional signal priority is not commonly used here as it primarily provides only reliability benefits.

If the priority is **unconditional**, all public transport vehicles receive transit signal priority. This provides reliability and travel time benefits and is the most common type of signal priority used here for public transport.

The common types of adjustments to signal phasing to advantage public transport vehicles are green extension, green reallocation and red truncation.

Green extension lengthens the phase for the detected public transport vehicle so there is time for the public transport vehicle to clear the intersection. This may be the easiest type of active transit signal priority to implement because it does not require other phases to be shortened.

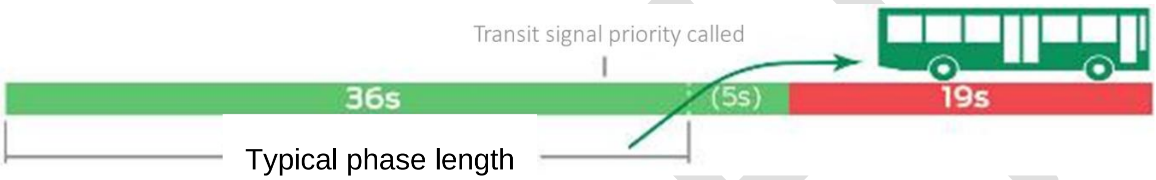


Figure 43 – Green extension in signal phasing (s = seconds). Source: National Association of City Transportation Officials. No date. Active transit signal priority in Transit Street Design Guide.

Green reallocation shifts when in the signal cycle the green phase for public transport occurs based on the expected arrival time of the public transport vehicle. This approach requires the public transport vehicle to be detected further away from the intersection than for green extension.

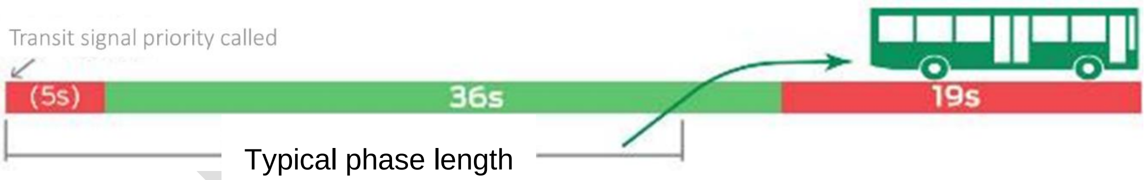


Figure 44 – Green reallocation in signal phasing (s = seconds). Source: National Association of City Transportation Officials. No date. Active transit signal priority in Transit Street Design Guide.

Red truncation shortens the conflicting phase, which provides a green phase for the public transport vehicle earlier than otherwise programmed. Red truncation requires the public transport vehicle to be detected far enough away so any pedestrian phase has time to clear.

Figure 45 – Red truncation in signal phasing (s = seconds). Source: National Association of City Transportation Officials. No date. Active transit signal priority in Transit Street Design Guide.

Active transit signal priority is most beneficial for public transport systems with frequent intersections and relatively long headways (that is, 5 minutes or more between public transport vehicles).

Where public transport headways are shorter than 2.5 minutes, it is generally difficult to implement unconditional transit signal priority because general traffic on other approaches would be in a near permanent red phase. In situations with high public transport frequencies, conditional transit signal priority may need to be used as it is more selective about which public transport vehicles receive priority.

The National Association of City Transportation Officials' Transit Street Design Guide provides further guidance on the above treatments and more advanced public transport signal options such as:

- upstream green truncation to manage re-entry delay
- phase insertions and sequence changes to support special bus-only phases
- phase reservicing to provide the same phase twice in a signal cycle.

Transit Street Design Guide

4.3.3. Queue jumps

A queue jump is when a public transport vehicle is allowed to enter an intersection in advance of other traffic, which reduces delays for public transport. Queue jumps can also help public transport vehicles make difficult turns such as a right turn across multiple lanes of traffic.

The image below shows a queue jump that has a short section of bus lane leading up to the intersection and a B signal that allows buses to travel to the receiving merge lane while the general traffic is held at the lights.

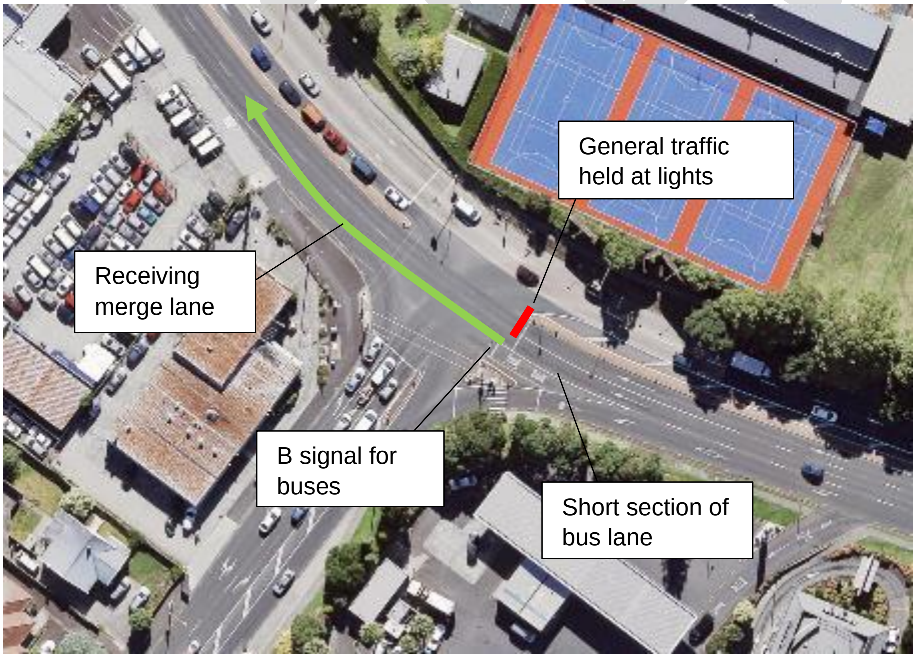


Figure 46 – Stand-alone queue jump with approach bus lane and receiving lane, intersection of Great North Road and West Coast Road, Auckland. Source: Auckland Council GIS viewer.

In Aotearoa New Zealand, queue jumps use a white B signal to indicate to the bus driver they can proceed. Other users of bus lanes, such as people on bikes, can also proceed on a B signal to avoid delaying buses. A white T could be used for the same purpose for light rail vehicles.

To enable the public transport vehicle to bypass the queue of general traffic at an intersection, a public transport special vehicle lane on the approach is generally required. The public transport special vehicle lane should be long enough that public transport vehicles can access the lane during congested peak-time conditions.

Queue jumps may be used as a stand-alone facility at a single intersection or at the end of a longer bus or light rail lane.

Queue jumps may also have a short receiving lane on the departure side of the intersection to help public transport vehicles merge back into the general traffic lane.

If there is traffic congestion immediately after an intersection, the benefits of a queue jump may be diminished, and a continuous public transport priority lane should be considered.

4.3.4. Signal displays

Signals used by road controlling authorities to show when buses may proceed (in advance of general traffic) must comply with the Land Transport Rule: Traffic Control Devices 2004 and be used in the manner described in that rule.

Whenever signals are operating, there will always be a 'primary signal display' in the form of a red, yellow or green disc or arrow. One of these displays will always be lit.

Additional signals may be used in conjunction with the primary signal display, including a red, yellow and/or white:

- B signal for buses or any vehicles permitted to use a bus lane
- T signal for light rail vehicles.

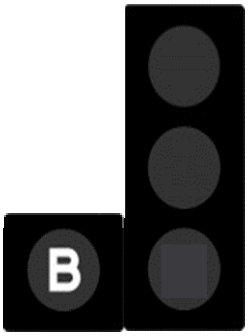
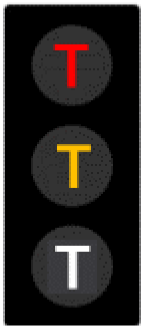
When a general red signal is displayed to general traffic, a white B signal lets buses proceed. Signal sequences involving B and T signals are described in section 6.4(2)) of the rule.

As noted in the rule (section 6.4(10) and (11)), whenever a bus lane, bus-only lane or light-rail vehicle track traverses an area controlled by traffic signals, the road controlling authority:

- must include a white B or T signal and may include a yellow B or T signal in the display of traffic signals to indicate when a bus is permitted to turn or proceed straight ahead from the bus lane when other vehicles are not allowed to make these movements
- must include a red B or T signal in the display of traffic signals to indicate when a bus may not proceed from the bus lane when other vehicles are allowed to move in the same general direction
- may include a column of white, yellow and red B or T signals in the display of traffic signals.

Note that when a special vehicle lane is present, the B or T signal applies to only vehicles in the special vehicle lane, not to any of the same class of vehicle that happens to be in adjacent general traffic lanes.

Table 20 – B and T signals and their applicability

Signal type	Applicability
B signal  	Indicates to bus drivers and other legal users of bus lanes that they can proceed ahead of general traffic. Is commonly used at a bus queue jump.
T signal  	Indicates to tram drivers and other legal users of tram lanes that they can proceed ahead of general traffic.

For additional details about traffic signals, see Part 4: Traffic control devices for general use – for intersections (draft, section 6) in *Traffic Control Devices Manual*.

4.3.5. Designing for vehicle detection

This section which provides more detailed guidance specifically on the technology and design to support vehicle detection.

At signalised intersections it is often necessary to detect the presence of road users to enable the dynamic operation of traffic signals. The signal controller uses the information detectors gather to place a demand for and determine the duration of phases.

Typically, in Aotearoa New Zealand:

- vehicles (including buses) are detected by induction loops
- pedestrians use call buttons
- cycles are detected primarily by specialist loops when they are on roads and push buttons when they are on footpaths, but this can vary.

Alternative methods for detecting vehicles, cycles and pedestrians are radar, thermal imaging and video cameras placed above-ground, typically on a traffic signal pole.

Induction loops consist of a section of wire buried in the road surface that has an electrical current passed through it to create a magnetic field. When a vehicle passes over a loop, the metal in the vehicle interferes with the magnetic field, which a detector unit registers.

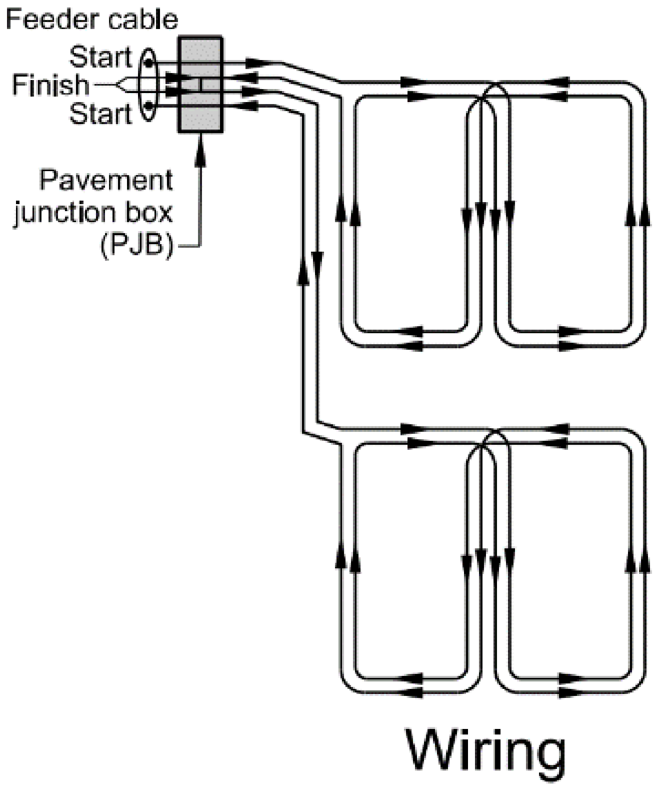


Figure 47 – Standard Sydney Coordinate Adaptive Traffic System (SCATS) quadrupole loop for stop line vehicle detection. Source: Waka Kotahi. 2020. P43 Specification for Traffic Signals (2nd ed). Wellington, figure A01, p 38.

There are three types of induction loops.

- **Surface sawcut loops** involve a saw cut being made into a finished road surface, then a strand of insulated wire being laid into the slot and covered over with sealant. For existing road surfaces, the slot is about 5mm wide and 40mm deep to provide a minimum top cover to the wire of 12mm. For newly constructed road surfaces with a deep base course of at least 60mm, the saw cut can be a deeper 65mm with a 40mm wearing course above the wire. Surface sawcut loops are the most common type of induction loop used in Aotearoa New Zealand.
- **Sub-pavement prefabricated loops** are made off site. The insulated wire is held in the desired configuration by top and bottom layers of paper. The prefabricated loop is then placed on an underlying asphalt surface and covered with another layer of asphalt.
- **Sub-pavement sawcut loops** are cut into a sub-layer of asphalt during road construction with layers of asphalt laid over the top. The depth of the loop from the surface is 50mm to 150mm.

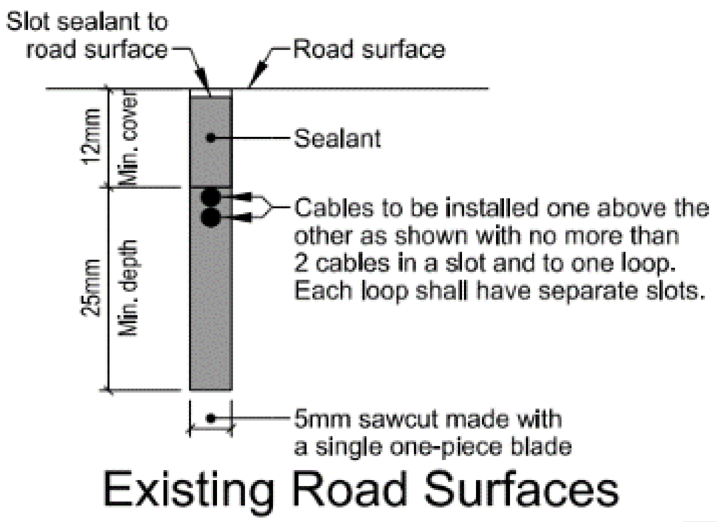


Figure 48 – Cross-section of induction loop installation for existing road surfaces. Source: Waka Kotahi. 2020. P43 Specification for Traffic Signals (2nd ed). Wellington, figure A01, p 38.

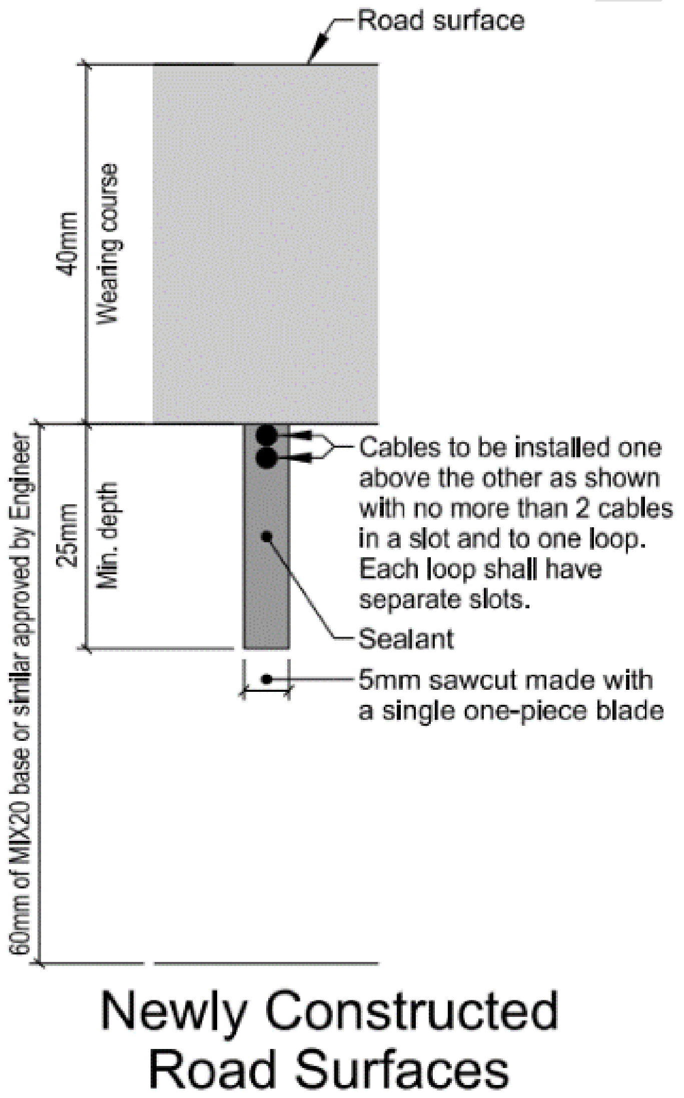


Figure 49 – Cross-section of induction loop installation for newly constructed road surfaces. Source: Waka Kotahi. 2020. P43 Specification for Traffic Signals (2nd ed). Wellington, figure A01,38.

As with all assets, induction loops are subject to wear and tear, so over time they need to be replaced. Replacing induction loops can be an expensive task due to the need for temporary traffic management to close the lane so the loop can be re-cut.

The most common causes of induction loop failure are:

- road pavement failures (rutting and potholes)
- road excavation for services or pavement reconstruction
- a break in the loop wire or damage to the loop insulation
- loose connections.

Road pavement failures can occur:

- more often on heavy vehicle routes (including bus routes) than general traffic routes due to the higher load placed on the pavement and induction loops buried in the wearing course
- in high temperatures that soften asphalt and chip seal, resulting in increased load being placed on the induction loops, especially those close to the surface
- if the loop wire is not set deep enough, so gets pushed to the surface and worn through vehicle contact.

In locations with a history of induction loop failures, to reduce the frequency of maintenance required consider:

- strengthening the road pavement by using deep lift asphalt or polymer-modified asphalt
- using sub-pavement loops, which are buried deeper into the pavement, so are below the wearing surface
- using above-ground detection such as radar instead of induction loops
- using GPS tracking or wireless systems for tracking buses to trigger priority phases rather than induction loops.

4.4. Priority at roundabouts

Roundabouts can create delays for public transport services due to queues on the approaches to the roundabout and difficulty in finding gaps in traffic. However, it can be difficult for road designers to provide public transport priority measures when the predominant public transport movement conflicts with high-volume general traffic movement. This section discusses approaches to identifying the problem, then developing public transport priority options for consideration at roundabouts.

Because most public transport trips start and end with people walking to their destination, improvements to pedestrian accessibility should be considered as part of any public transport priority project.

Relevant walking resources are:

- Pedestrian network guidance – for details on pedestrian crossings and such like
- Walking, Public Transport Design Guidance
- Walking access, Public Transport Design Guidance

No two roundabouts are the same. Each location and configuration involves unique movement as well as place-based challenges and aspirations.

Start option development by identifying a wide range of functional and contextual issues such as the following:

- Delay and queues – consider whether delay and queues at the roundabout are dictated by the roundabout itself or the downstream environment.
    - If a queue dissipates downstream, priority will likely be needed only on the approaches to the roundabout used by public transport.
    - If the queue is continuous through the roundabout, priority will likely need to be considered on approach to, through and on departure from the roundabout.
- Modal priorities – consider modal priorities, including the strategic importance of the routes that pass through the roundabout for each mode. This will help you identify the modes and approaches where the level of service needs to be improved and where the level of service could be maintained or potentially reduced.
- Function of the public transport services – consider the current or desired function of the public transport services that pass through the roundabout, including whether they are core or primary routes or local or secondary routes. This will help you identify the desired level of service.
- Safety – Consider safety at the roundabout for all users. Roundabouts tend to be safer than signalised intersections for motor vehicles due to the lower speed of vehicles and the impact angle. However, roundabouts can lack safe crossing facilities for pedestrians, which may make them harder to cross than a signalised intersection, leading to delay, stress and community severance. Furthermore, multi-lane roundabouts contribute to a larger proportion of cycling-related injuries than other types of intersection. Consider modifying roundabouts to be cycle-friendly by reducing multi-lane roundabouts to single lane approaches, lowering speeds, and/or building cycle bypasses.
- Place function – Consider the current and desired place functions of the street, where the roundabout is located, and whether the roundabout is compatible with or working against the desired place outcomes.
- Location – Consider the location of public transport stops in relation to the roundabout, which may influence the priority measures required (such as a queue jump to assist buses to move from a kerbside lane to an inner lane).

A variety of options exist to improve travel time and reliability for public transport vehicles at existing roundabouts while potentially also addressing other movement or place deficiencies. Options can generally be classified into six categories:

- public transport vehicle queue jump with priority on approach
- metering major conflicting traffic movements
- signalising approaches (replacing give-way arrangements)
- continuous priority lane through the roundabout
- converting the roundabout to a signalised intersection
- grade separation of the public transport movement.

4.4.1. Public transport vehicle queue jump with priority on approach

A public transport queue jump is when general traffic is held at traffic lights and public transport vehicles are allowed to proceed to the roundabout ahead of general traffic (as discussed in

Queue jumps (section 4.3.3)). A public transport priority lane is typically also used on approach to the queue jump signal so public transport vehicles can bypass queued traffic.

Having public transport vehicles proceed along the approach route and through the roundabout in advance of general traffic can significantly reduce delay for public transport vehicles. Furthermore, a queue jump facility allows public transport vehicles to manoeuvre from the kerbside lane (where public transport stops are typically located) to the inner lanes at multi lane roundabouts, which can assist with movements they may need to make such as right turns.

The traffic signals associated with a queue jump typically include a white B or T signal for public transport vehicles.

The advantage of a public transport queue jump is that it can be applied to a roundabout where the provision of a continuous public transport priority lane is not feasible. However, public transport queue jumps are less effective where traffic congestion blocks the circulating lanes and exits to the roundabout.

An example of a queue jump facility combined with a pedestrian crossing is the Kent Terrace approach to the Basin Reserve in Wellington. As shown in the image below, several bus services travel in the outermost left lane along Kent Terrace in Wellington so they can stop at bus stops to drop off and pick up people. This lane is a bus lane during the evening peak and used for parking at other times. A queue jump helps buses get from the outermost left lane, across multiple traffic lanes to the righthand lanes where they need to be to traverse the remainder of the route. The traffic signals at the pedestrian crossing are activated by the presence of the bus, turn red to stop general traffic, run a pedestrian-crossing phase when relevant, and then signal a B for the buses to proceed out, ahead of the other traffic.

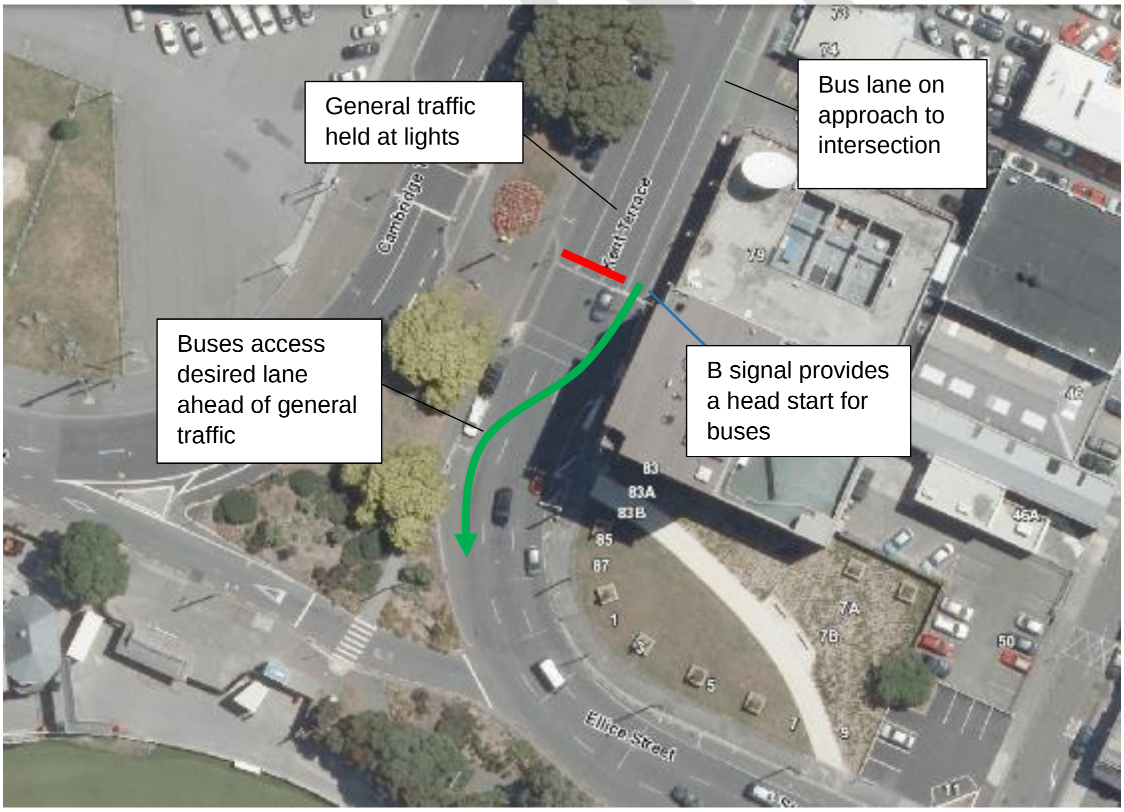


Figure 50 – Fully signal-controlled queue jump at the Basin Reserve roundabout, Wellington. Source: Wellington City Council.

An example of a standalone public transport queue jump is the former layout of the Williamsons Road and Porter Street roundabout in Melbourne (see the aerial image below). This roundabout has since been replaced with a large signalised intersection with bus lanes on most approaches.

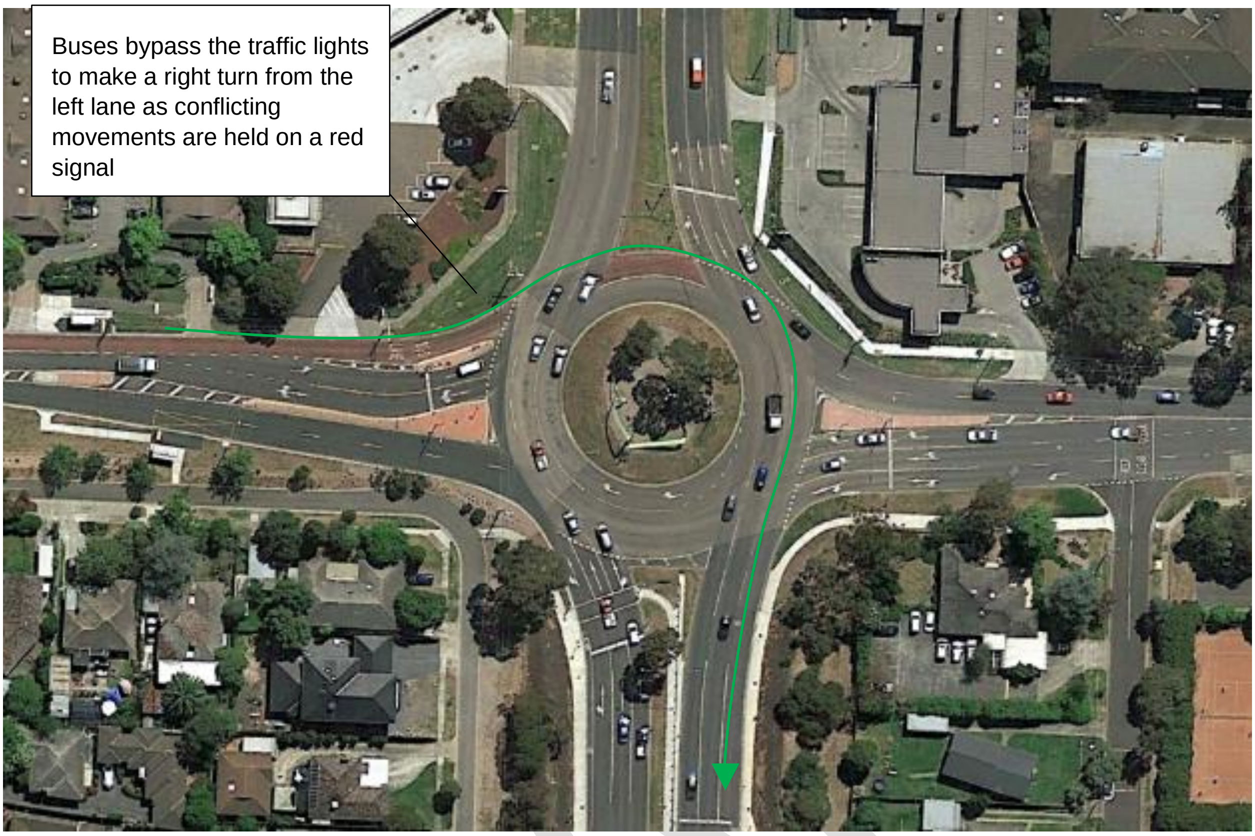


Figure 51 – Unsignalised queue jump for buses at Williamsons Road and Porter Street, Templestowe, Melbourne. Source: Google Earth.

4.4.2. Metering major conflicting travel movements

When a roundabout has uneven traffic volumes, vehicles on the minor approach roads can experience significant delays as they need to give way to a steady stream of traffic. This can be a major problem, particularly if the minor road is a bus route, resulting in peak period delays and travel time variability.

Metering is when traffic signals are used to provide gaps for vehicles on the minor approaches to enter the roundabout.

Metering:

- is generally used at only peak times
- is achieved by stopping traffic on the major approach in advance of the roundabout so gaps in traffic are provided for vehicles on the minor approach
- can be used on roundabouts to provide priority for turning public transport vehicles that, due to their size, may otherwise find it difficult to find a gap in traffic.

An example of a metered roundabout is Paremata roundabout in Porirua, which reduced delays for public transport vehicles exiting Paremata Station.

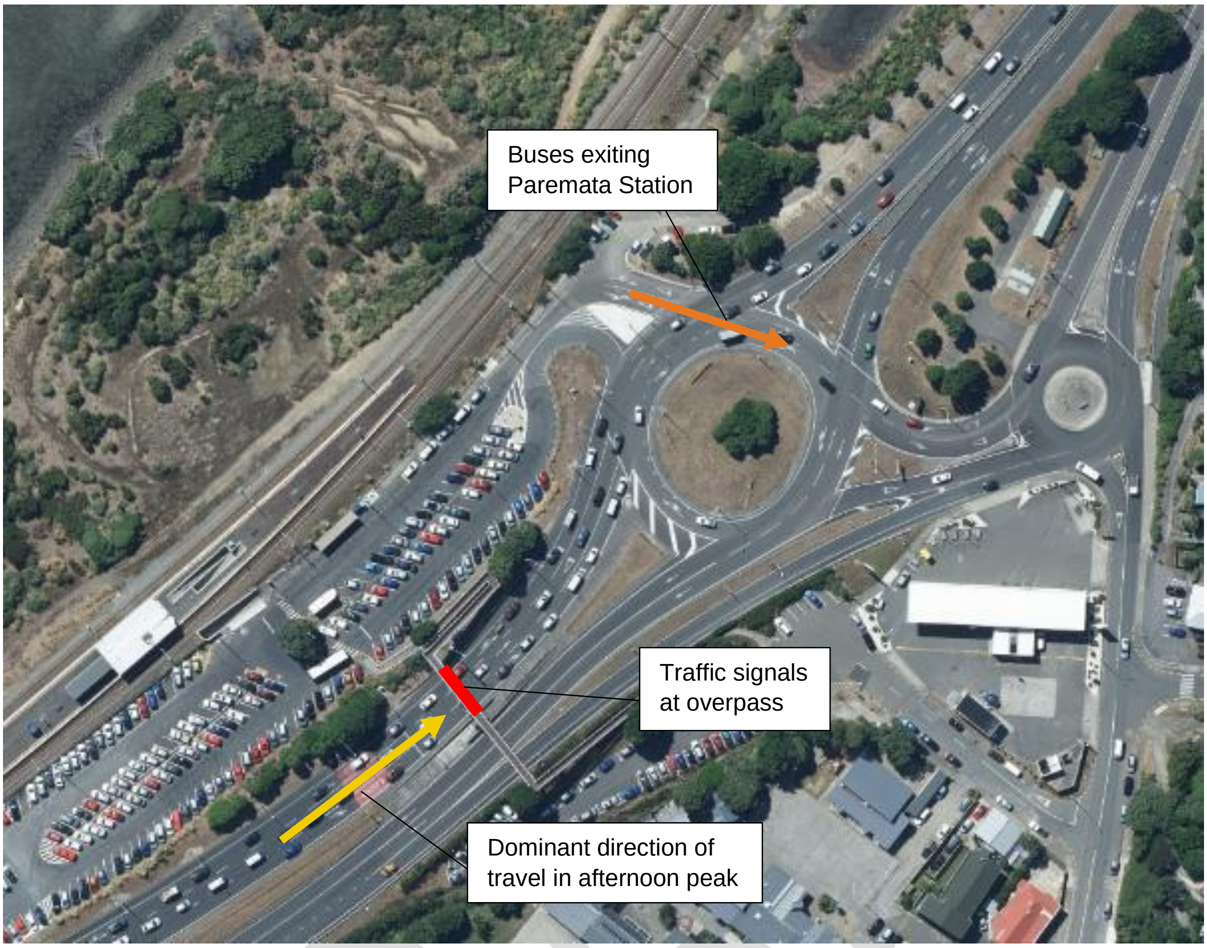


Figure 52 – Metered roundabout at intersection of State Highways 59 and 58 and Paremata Station access. Source: Porirua City Council.

4.4.3. Signalising approaches (replacing give-way arrangements)

Signalised roundabouts replace give-way control with traffic signals for some or all approaches to the roundabout. For each approach that is signalised, the conflicting circulating traffic lanes on the roundabout also need to be signalised. However, this requires sufficient storage space for the stationary vehicles within the roundabout.

The advantage of signalised roundabouts is that the volume of traffic entering the roundabout from each approach can be controlled. The phasing of signalised roundabouts can be set to provide a higher level of priority for public transport vehicles through active or passive signal priority.

For a discussion of the different types of signal priority for public transport vehicles, see Signal priority (section 4.3).

A disadvantage of signalised roundabouts is that the signal phasing tends to prioritise circulating vehicles, which can result in long waits for crossing pedestrians. Use analysis of pedestrian desire lines to inform a phasing design that provides fair levels of delay to all roundabout users.

Signalised roundabouts also tend to require a large amount of space, which makes them less suited in constrained urban areas. An example of a partially signalised roundabout is the intersection of State Highway 29A, Turret Road and Maungatapu Road in Tauranga.

Figure 53 – Partially signalised roundabout, Tauranga. Source: Tauranga City Council.

An example of fully signalised roundabout is the intersection of Sunshine Motorway and Maroochydore Road in Sunshine Coast, Australia (see image below).

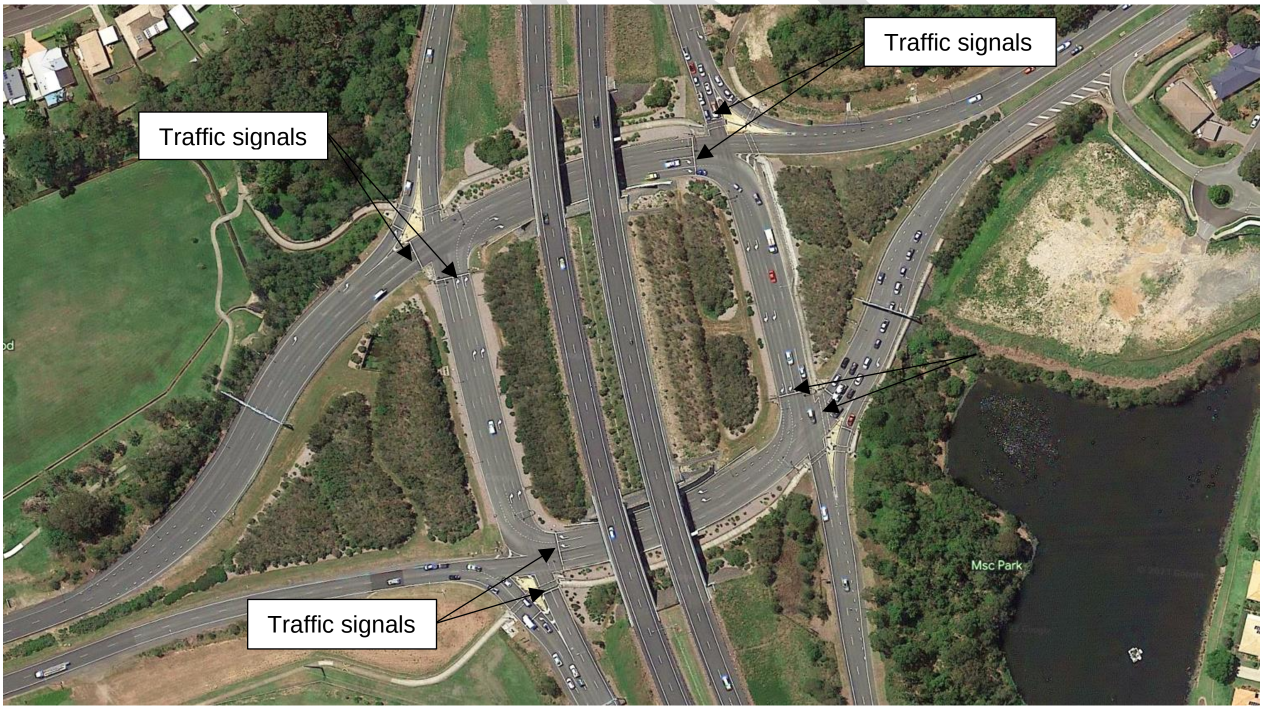


Figure 54 – Intersection of Sunshine Motorway and Maroochydore Road, Sunshine Coast, Australia. Source: Google Earth.

4.4.4. Continuous priority lane through the roundabout

Priority lanes can be continued through a roundabout most commonly with the use of signal control to manage conflicts between turning vehicles and public transport vehicles.

These lanes are generally configured in one of two ways:

- circulating around the roundabout island, typically in the centre to reduce conflicts with traffic exiting the roundabout
- directly through the middle of the roundabout, providing a straighter alignment through the intersection (and with pedestrian crossings provided across each approach lane).

In both cases, the public transport lanes are typically located in the centre of each approach road. This minimises the conflict between a straight-through public transport movement and traffic exiting the roundabout onto intermediate roads. Detectors identify an approaching public transport vehicle and activate signals to control conflicting traffic movements, allowing the public transport vehicle to cross into, then out of, the roundabout. Depending on the operation of the signals, public transport vehicles may be able to proceed through the roundabout with little or no delay.

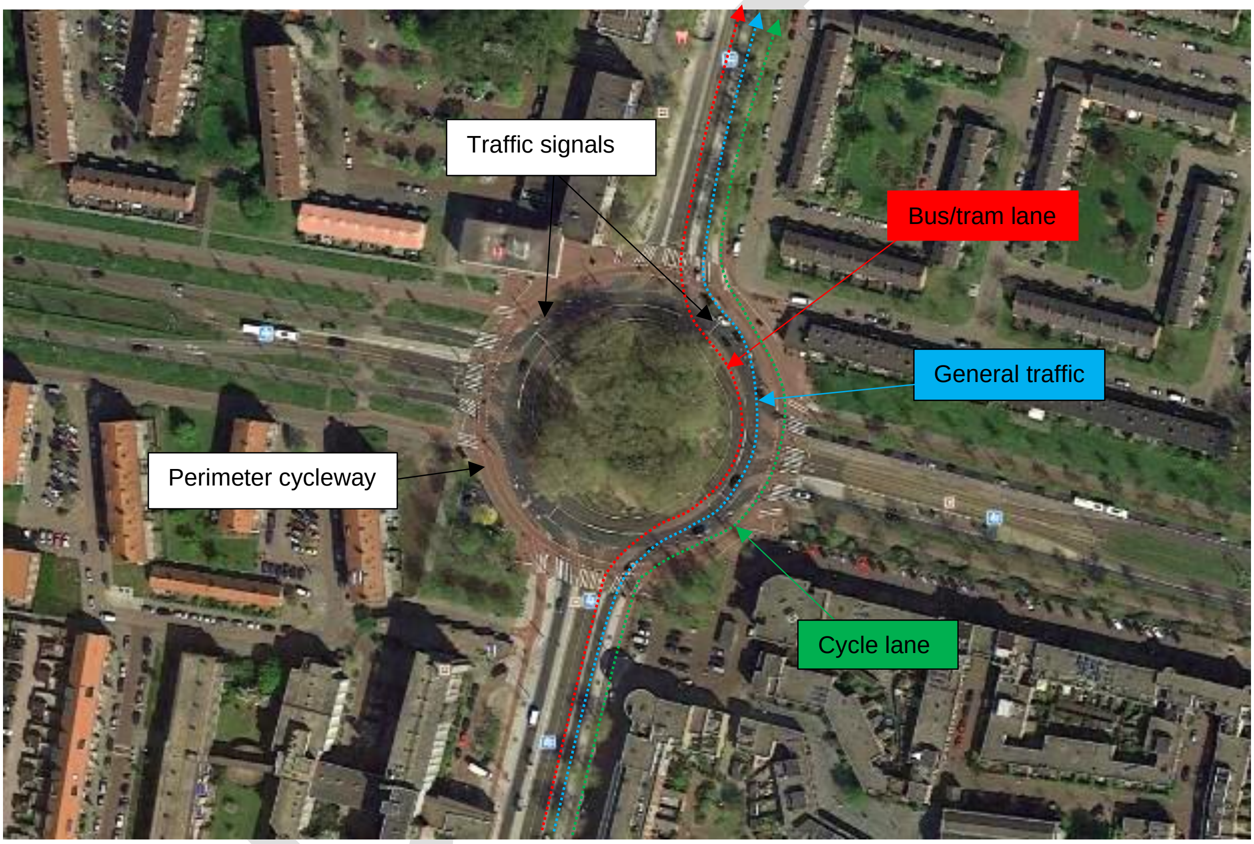


Figure 55 – Roundabout with exclusive public transport lanes (bus and tram) along the inside of the roundabout island and a cycleway around the perimeter, Slotermeerlaan, Amsterdam, Netherlands. Source: Google Earth.

Figure 56 – Roundabout with light rail lines through the middle at the intersection of South Horne and East Main Street, Phoenix, United States. Source: Google Earth.

4.4.5. Converting the roundabout to a signalised intersection

Signalised intersections provide a greater level of control over traffic flows than an unsignalised roundabout, which can make it easier for road designers to provide public transport priority. Additionally, signalised intersections are often more space efficient than multi-lane roundabouts. Therefore, the reduced footprint required to provide the same capacity for general vehicle traffic could result in surplus space that could be used for dedicated public transport priority.

However, the choice of intersection type is influenced by a wide variety of factors, including:

- safety for all road users
- pedestrian crossing demand
- cycle demand
- site constraints
- road hierarchy
- delays (for all road user groups).

A detailed assessment of the most appropriate type of intersection control should be completed.

For guidance on the intersection selection process, see the Austroads *Guide to Traffic Management Part 6: Intersections, interchanges and crossings management*.

The speed at which motorised vehicles travel through a signalised intersection can be significantly higher than speeds through a roundabout. This is because with a signalised intersection vehicles can travel straight whereas with a roundabout, vehicles need to steer around a central island. Therefore, the road safety risks of the proposed configuration need to be carefully assessed with potential mitigation measures considered such as using tighter geometry or vertical deflection.

An example of an urban roundabout that was recently converted to a signalised intersection with public transport priority is Panmure roundabout in Auckland.

Figure 57 – Former Panmure roundabout. Source: Auckland Council.

The new layout has some bus lanes and bus only lanes on the approach and departures of the roundabout, notably in and out of Panmure Interchange.

Figure 58 – New Panmure signalised intersection with bus priority. Source: Google Earth.

4.4.6. Grade separation of the public transport movement

Grade separation involves the public transport lanes or right of way going above or below the traffic lanes using an elevated structure or tunnel. Where there are high traffic volumes and a high level of priority for public transport vehicles is sought, grade separation can provide a solution.

Grade separation:

- is typically the most expensive option to construct but provides absolute priority to public transport vehicles without delaying general traffic
- can improve road safety by removing conflicts between public transport vehicles and pedestrians, cyclists and motor vehicles.

An example of a roundabout with a grade separated public transport facility is shown below.

Figure 59 – Roundabout with grade separation between vehicles and trains, Capelle aan den Ijssel, Rotterdam, Netherlands. Source: Google Earth.

5. Bus gates and traffic management interventions

This section looks at bus gates and traffic management interventions.

5.1. Bus gates

A bus gate is an entry obstacle (e.g. bollard or signal) to support traffic restrictions for a short section of street that only buses and possibly other authorised vehicles are permitted to use. It is activated using a selective detection device such as a transponder on a bus or loop system. The restrictions on private vehicles can be made using physical barriers or enforcement cameras.

Bus gates are generally designed to limit the amount of general traffic travelling through an area and encourage mode shift to public transport and active modes. This is achieved by making public transport trips quicker than the equivalent car trip, which must take a longer route to the destination. Bus gates can apply 24/7 or for set periods (typically daytime hours on weekdays).

Examples of bus gates are at Grafton Bridge, Auckland, and Bridge Street, Cambridge, United Kingdom. For more information, see the Cambridgeshire County Council video What is a bus gate?

Bus gateways need extensive and clear controls, which may be traffic signs, traffic signals, road markings or active barrier controls.

Figure 60 – Bus gate that uses enforcement cameras, Bridge Street, Cambridge, United Kingdom. Source: Cambridgeshire County Council.

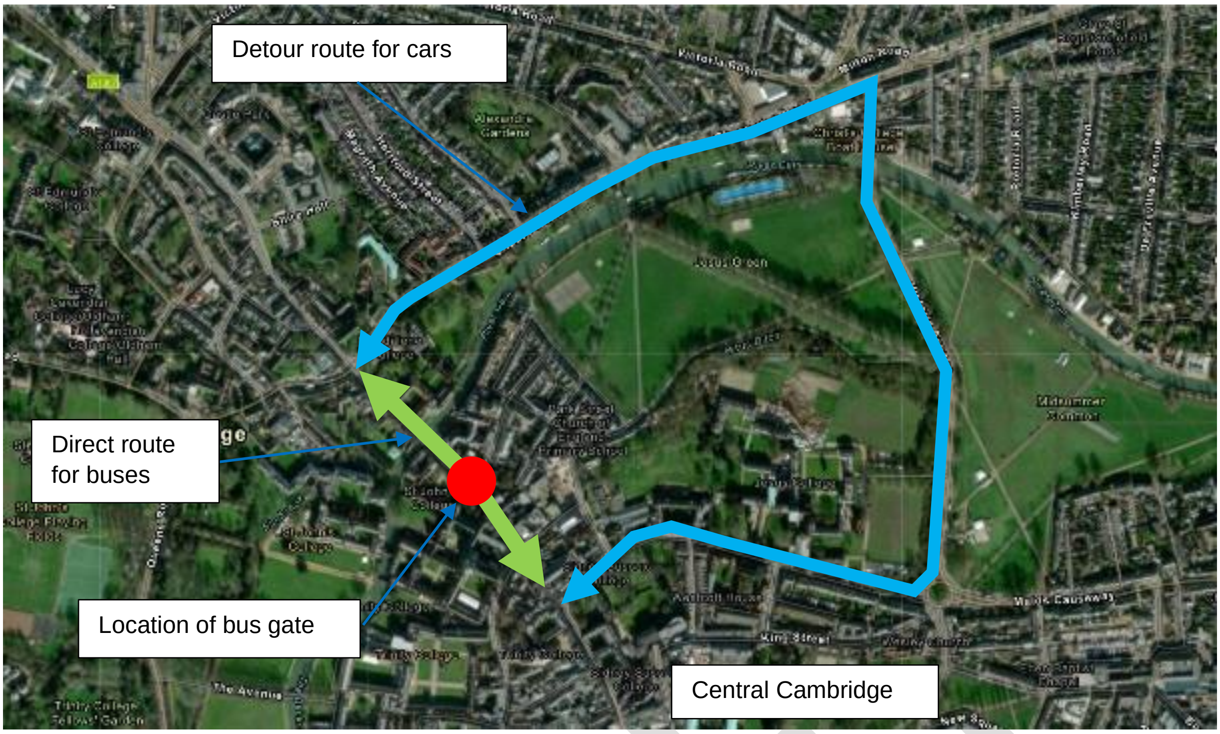


Figure 61 – Comparison of the route for buses and cars resulting from the Bridge Street bus gate in Cambridge, United Kingdom. Source: Esri.

5.2. Traffic management

Another tool, which is most often applicable in city centres, is to negatively affect select road user groups to indirectly and positively support the modes that are unaffected. This is done by imposing an access restriction on certain road uses (for example, general traffic) that operates all the time, at certain times, on certain days or a combination of these.

Access restrictions work best when implemented in a dense, constrained urban environment with the restriction starting at a natural gateway to assist enforcement.

This approach:

- emphasises what modes are important and publicly elevates certain modes ahead of others
- indirectly promotes mode priority
- reduces competition for space in the road environment beyond the restriction, which improves road safety, improves road operation, makes it easier for buses to get in and out of stops, and means modes such as walking, cycling and public transport can co-exist without dedicated mode-specific facilities (for example, bus lanes)
- enables the road space beyond the restriction to operate with fewer signs and markings than would be necessary with dedicated mode-specific facilities.

Figure 62 – Access restriction starting at a natural gateway to assist enforcement. Source: Mark Edwards.

Another approach to this type of restricted access is to establish a ‘low emission zone’. A low emission zone is a defined area where access by higher-emission vehicles is restricted or deterred to improve air quality. This zone may favour alternative fuel vehicles, hybrid electric vehicles, plug-in hybrids and zero-emission vehicles such as all-electric vehicles. This not only potentially helps prioritise public transport but may encourage the faster uptake of low emission bus fleet vehicles.

Some cities are increasingly moving towards zones of this type. For example, the Auckland Central City Masterplan 2020 proposed such a zone for the Queens Street Valley area of the city. The masterplan states:

> The [zero emissions area] substantially reduces emissions in the densest part of the city centre. Combined with low- or no-emissions public transport, this initiative could give Auckland the cleanest air of any million-plus city in the world.

For more information, see Zero emissions area.

Figure 63 – Zero emissions area, Auckland. Source: Auckland City Council. 2019. Zero emissions area (webpage).

6. Service design interventions

6.1. Public transport vehicle design

Public transport travel times can be optimised through some aspects of design of the public transport vehicles themselves.

In Aotearoa New Zealand, on-road public transport services have typically been delivered using buses and the terms 'bus lane' and 'busway' have described priority measures. However, cities such as Auckland and Wellington are considering whether to add light rail to the public transport system and both have heavy rail networks. Wellington also has a cable car, and Christchurch has a tourist tram in its central business district. This section aims to be vehicle-type neutral, so uses the word 'bus' to describe rubber tyre–based modes and 'light rail' to describe street-running rail-based modes. The same concepts for how to give public transport vehicles priority over general traffic are applicable to both groups.

This section discusses the elements of public transport vehicle design that influence boarding and alighting delays at bus stops: seating and standing arrangements, the number of doors and floor height. This section is most relevant when procuring a new bus or light rail fleet or considering changes to the internal layout of existing public transport vehicles.

The Public Transport Design Guidance on bus dimensions for design outlines the critical dimensions and performance characteristics of buses that typically operate in New Zealand.

www.nzta.govt.nz/walking-cycling-and-public-transport/public-transport/public-transport-design-guidance/bus-dimensions-for-design/

6.1.1. Seating and standing arrangements

When purchasing buses or light rail vehicles, the manufacturer generally gives public transport contracting authorities or operators options of how to arrange the layout of the interior of the vehicle. In addition, public transport contracting authorities or operators may choose to refurbish bus or light rail interiors and change the interior layout. These decisions present a trade-off between the number of standard seats, the number of accessible seats, the size of the luggage area, the amount of standing room and the width of the aisle.

Traditionally, buses in Aotearoa New Zealand have been designed to maximise seated space (illustrated in the figure below), which results in limited standing space and narrow aisles.

In accordance with the 2021 requirement for urban buses in New Zealand:

- small buses and double-deck buses must be able to carry at least one person using a wheelchair
- medium and large buses must be able to carry at least two people using wheelchairs.

Figure 64 – Interior of a bus optimised for seating with two seats on either side of the aisle. Source: Global Bus Ventures.

However, buses with limited standing space and narrow aisles have longer delays at bus stops if the bus is carrying standing passengers. This is because alighting passengers must squeeze past passengers standing in the aisles to get to the door. An alternative arrangement is to design the public transport vehicle to have more standing space and wider aisles, which makes it easier for passengers to move to the door when alighting (illustrated in the figure below). Seats are still provided for people with limited mobility and people travelling longer distances, but people travelling shorter distances are encouraged to stand.

Figure 65 – Interior of a bus optimised for standing room with a standing area and wheelchair space near the door and standard seats placed away from the door. Source: Van Hool.

Another consideration when designing the interior of public transport vehicles is that people standing take up less space than people seated. Therefore, public transport vehicles that optimise standing passengers generally have higher capacity than the same-sized vehicle optimised for seated passengers. This assumes axle weight limits do not determine the capacity of the public transport vehicle.

The typical situations where public transport vehicles are optimised for seated or standing passengers are listed in the following table. Most public transport vehicles provide a combination of seats and standing space.

Table 21 – Typical situations where public transport vehicles are optimised for seated or standing passengers

Optimised for seated passengers	Optimised for standing passengers
Low demand routes where all passengers can easily find a seat, even at peak times.	High demand routes where maximum possible capacity is required.
Where most customers alight at the same point, which is typically at the end of the route.	Public transport routes where passengers make short trips such as where passengers board and alight at different points along the route.
Where dwell times at bus stops are not an important issue because the bus stops have plenty of spare capacity.	Where short dwell times at bus stops are required because bus stop capacity is limited.
Routes with high operating speeds such as those that travel along expressways or motorways for part of the journey.	Routes with moderate to low average operating speeds (about 30km/h or slower).

6.1.2. Number of doors

Another factor of public transport vehicle design that influences dwell times at bus stops is the number of doors.

In Aotearoa New Zealand:

- small buses must have one front door
- medium and large buses must have a front door and rear door.

Public transport contracting authorities may permit the use of medium or large buses with only a front door for limited stop or school services.

If additional doors are provided (that is, three or more doors as illustrated in the figure below), the dwell time at bus stops is likely to decrease because alighting passengers are closer to a door. This is particularly important for high-capacity public transport vehicles, which carry more passengers, so have the potential for longer dwell times at stops.

The disadvantage of having additional doors is that fewer seats can be provided because doors must be clear of obstructions. However, this is less of a problem for buses or light rail vehicles that are optimised for standing passengers.

Figure 66 – Bi-articulated bus with four double doors, Metz, France. Source: Van Hool.

6.1.3. Floor height

When the floor of a public transport vehicle is higher than the footpath or platform, passengers must step up or down to board or alight. This results in longer dwell times at stops because the need to make a step slows passengers compared with when the floor and footpath or platform is level.

The need to step up and down is also a barrier for people with limited mobility even when a bus kneels.

In New Zealand, the height of front and rear doors of urban buses must be equal to or less than 370mm at normal ride height and between 245mm and 280mm when kneeling.[6] However, the height of a standard kerb is 150mm, which results in a gap of 85mm to 120mm when kneeling. There is more advice on bus stop kerb design here:

Bus stop: Accessibility | Waka Kotahi NZ Transport Agency (nzta.govt.nz)

Some overseas public transport systems use alternative platform and fleet designs to reduce or eliminate the step height (see the table below).

[6] Waka Kotahi NZ Transport Agency. 2021. *Requirements for Urban Buses in New Zealand for Consistent Urban Bus Quality (2021)* (version 4.1). Wellington.

Table 22 – Advantages and disadvantages of different platform and fleet designs for delay at stops and public transport accessibility

Technique	Advantages	Disadvantages	Example
Standard kerb height with on-bus ramp Kerb height is 150mm	Is lowest cost as no need to change footpaths or bus fleet Has a kerb height that does not conflict with bus front or tail swing	Has longer dwell times at bus stops due to step height Some customers may still struggle to board or alight especially if bus drivers do not kneel for them. There are more accessible boarding designs.	Most bus stops in Aotearoa New Zealand  *Figure 67 – Double-deck bus next to a standard kerb, Auckland. Source: AT Metro*

Technique	Advantages	Disadvantages	Example
Near-level boarding platform with on-bus ramp Platform height is 200mm to 250mm	Is compatible with most existing bus fleets Has easier boarding and alighting compared with a standard kerb Reduces risk of damaging the underside of the bus	Has longer dwell times compared with level boarding platforms Requires the use of ramps for wheelchair users Is appropriate only for in-lane bus stops that do not have any front or rear tail swing that could damage the kerb	Emerald Express, Eugene, and IndyGo Red Line, Indianapolis  *Figure 68 – Bus lined up with bus platform, supporting near-level boarding. Source: Indianapolis Public Transport Authority.*

Technique	Advantages	Disadvantages	Example
Level boarding platform Platform height is about 300mm or the same height as the floor of the bus	Reduces dwell times because boarding and alighting is easier for all passengers May not require the use of on-bus ramps for wheelchair users	Might not be compatible with existing bus fleets (depends on the design of bus) Requires the bus to line-up straight with the platform to avoid damage to the underside of the bus Has higher infrastructure costs from constructing raised platforms Is better suited to guided public transport systems (whether tracks, kerbs, or optical guidance)	Sydney Light Rail, Sydney  *Figure 69 – Level boarding platform for a tram, Sydney. Source: Mark Edwards.*

Technique	Advantages	Disadvantages	Example
Level boarding platform with bridge (high floor bus) Platform height is the same height as the floor of the bus	Reduces dwell times because boarding and alighting is easier for all passengers Has automatic deployment of bridges, so does not involve a manual task for the driver Reduces risk of damaging under of bus because the bus stops away from the platform with a bridge covering the gap Does not require guidance systems as tolerances are higher	Higher fleet costs because custom bridge systems are required Has higher infrastructure costs from constructing raised platforms	Curitiba Bus Rapid Transit, Brazil  *Figure 70 – Bridges formed from platform extensions and on-board bus ramps connect high floor buses with the bus station, in Curitiba. Source: Mario Roberto Duran Ortiz, Creative Commons Attribution 3.0 Unported licence.*

6.1.4. Double-deck buses

Double-deck buses are a high-capacity public transport vehicle that, unlike articulated buses, can use standard-sized bus stops. However, double-deck buses can have longer dwell times because alighting passengers on the upper deck must walk down the stairs to exit the bus.

Therefore, double-deck buses are most suited to:

- longer distance routes with a limited number of stops
- routes with high operating speeds such as routes that use expressways or motorways
- routes where most passengers alight at the same point such as express routes.

Dwell times can be reduced by providing an additional set of stairs and door at the rear of double-deck buses (illustrated below) instead of just a single set of stairs at the front. However, alighting passengers still need to walk down stairs and the additional set of stairs reduces the capacity of the bus.

An alternative for high demand routes is to use articulated buses.

Figure 71 – London Routemaster, which is double-deck bus with three sets of doors and two sets of stairs. Source: Ron Ellis.

Further information

Traffic Safety on Bus Priority Systems

Requirements for Urban Buses

6.2. Stops and stations

This section describes the factors of stops and stations that influence public transport journey times and reliability.

In general, the same stop or station principles apply to bus and light rail services. An exception is that light rail vehicles must stay on the tracks so cannot overtake as buses can. Therefore, when the same principles apply, buses and trams are referred to collectively as 'public transport vehicles'; where differences exist between modes, separate terms are used.

The term 'stop' generally refers the section of footpath from which buses pick up and drop off passengers. The term 'station' generally implies more infrastructure than is at a stop such as platforms or a covered off-road facility. In this section, bus stops, bus stations and light rail stations are collectively referred to as stops.

6.2.1. Stop spacing

The space between stops should support the fine balance between efficient journey times and convenient access to services. Public transport services with close stop spacing support short walks to access services, but tend to have slower and less reliable journey times. Public transport services with wide stop spacing are quicker and more reliable, but customers must walk further to access stops.

The factors that determine optimal stop spacing are discussed in Bus stop spacing, Public Transport Design Guidance, and should be read in conjunction with the getting to and from public transport topic, notably the walking and cycling sections that advise on catchments:

Bus stop spacing

Getting to and from public transport

6.2.2. Stop location

The three categories of stop location in relation to signalised intersections are near-side (before an intersection), far-side (after an intersection) and mid-block (between intersections).

The advantages and disadvantages of different stop locations are summarised in the table below. For more details, see Bus stops near intersections.

Table 23 – Advantages and disadvantages of different stop locations.

Stop location	Advantages	Disadvantages
Near-side	Reduce the risk of blocked intersections, because public transport vehicles queue into a mid-block section of street. Pedestrians can use the signalised intersection to cross.	Red phase can prevent public transport vehicles from leaving the stop, which increases delay.
Far-side	Less delay because public transport vehicles can leave the stop independent of traffic signals. Pedestrians can use the signalised intersection to cross.	Risk of public transport vehicles queuing back into the intersection if the stop is over-capacity (most applicable for high-volume stops).

Mid-block	Less delay because public transport vehicles can leave the stop independent of traffic signals.	Reduced walking catchment area because the stop is located away from side streets. Requires a separate pedestrian crossing facility.

6.2.3. Stop layout

The three main types of stop layouts are kerbside, in-lane and indented.

Typically, in-lane stops have the lowest dwell times because the public transport vehicle stops in the traffic lane, so has no delay when re-joining the traffic lane. Whereas for kerbside and indented stops, the driver must wait for a gap in traffic before pulling into the traffic lane.

The exception to this is when bus frequencies are very high (a bus every 2 minutes or less), then in-line stops can increase delays because buses are unable to overtake one another. In this scenario, an indented stop with a bus-only passing lane would enable buses to overtake another bus in front while ensuring the passing lane is free of general traffic.

Indented stops with bus-only passing lanes may be used for bus rapid transit systems such as the Auckland Northern Busway.

For more details on bus stop layout, see the Bus Stop topic, particularly sections on bus stop layout and capacity:

Bus Stop Layout

Bus Stop Capacity

6.2.4. Stop capacity

Stop capacity is a measure of how many public transport vehicles per hour can use a stop before it becomes occupied too much of the time and public transport vehicles start to queue to enter the stop.

Insufficient capacity at stops can result in delays and unreliability for public transport services because of the additional wait for the stop to become available. The capacity of a stop varies according to factors such as board time per passenger, passenger volumes and location of the stop relative to signalised intersections.

Assess stop capacity using Bus transit capacity in *Transit Capacity and Quality of Service Manual* (chapter 6).

Additional bus stop capacity can be provided by splitting the bus stop into multiple independent stopping or boarding points, which involves assigning bus routes to certain stop points. An example of this is Kilbirnie Interchange in Wellington where route 2 uses stop B and route 3 uses stop C.

For more information about the considerations for splitting stops, see Bus stop capacity.

For light rail, additional stop capacity can be provided by lengthening the stop so passengers can board and alight two light rail vehicles simultaneously.

An alternative approach to addressing stop capacity problems is to reduce dwell times, which means more public transport vehicles can use the stop. The variety of techniques to reduce dwell times such as Public transport vehicle design (section 6.1) and Operating policies (section 6.3).

6.3. Operating policies

6.3.1. Fare collection

In Aotearoa New Zealand, most bus services use on-board payment and validation systems where the customer can purchase a ticket using cash, show a prepaid pass, or use a smart card reader near the door.

For on-board payment systems, the bus driver is responsible for selling and validating tickets, and all boardings occur at the front door. This results in longer dwell times at stops because passengers can only board as fast as the driver can sell and validate tickets. However, alternative fare collection methods each have their own advantages and disadvantages, as discussed in the table below.

Table 24 – Advantages and disadvantages for alternative fare collection methods.

Fare collection method	System features	Advantages	Disadvantages	Examples
On-board payment – cash allowed	Bus driver sells and validates tickets. Boarding is through the front door.	Has lower labour costs. Can accept most types of payment.	Has longer dwell times because all passengers must board through the front door. Has higher operating costs because of the delays at stops. Is a less reliable public transport service due to variable delays at stops.	Most bus services in Aotearoa New Zealand.
On-board payment – smart card and pass only	Bus driver or smart card reader validates tickets. Boarding is through the front door.	Has lower labour costs Has shorter dwell times compared with systems that allow cash Improves driver safety by removing cash boxes.	Can present financial barriers to people if they must pay up-front for a smart card.	Selected bus routes in Sydney and Brisbane, Australia. Selected regions in Aotearoa New Zealand (eg, Snapper card in Wellington and Bee card in selected regions).
Proof of payment	Customers use kiosks or smart card readers at stops. Customers board through any door. Roving ticket inspectors check proof of payment.	Reduces dwell times significantly because the driver does not validate tickets. Lowers operating costs and improves reliability of public transport services.	Has higher labour costs from the need to hire ticket inspectors. May have more fare evasion. Is difficult to check tickets on crowded services.	Wellington rail network Melbourne trams and rail

Fare collection method	System features	Advantages	Disadvantages	Examples
Ticket gates	Separate paid and no paid areas at stops. Ticket gates used to validate ticket and allow passenger to pass into paid area. Customers board through any door.	Reduces dwell times significantly because the driver does not validate tickets. Lowers operating costs and improves reliability of public transport services.	Has higher infrastructure costs from the need to construct gated areas. Requires more space at stops.	Auckland rail network at main stations

6.3.2. Smart card readers

For on-board payment systems, it is best practice to have smart card readers located on the right-hand side of the front door and both sides of the rear door and any middle doors. This is so passengers can form two lines to board and alight, which reduces dwell times at stops.

Figure 72 – Interior of Melbourne Tram with card readers on both sides of all doors. Source: Chris Gordon, Vicsig.

6.3.3. All-door boarding

In Aotearoa New Zealand, passengers tend to board the bus at the front door and can exit the bus from the front and rear doors. The advantage of this procedure is that the bus driver can check for proof of payment, which reduces staffing costs compared with employing separate ticket inspectors.

On the other hand, some overseas jurisdictions (including San Francisco, Berlin, and Oslo) allow passengers to board buses at all doors, reducing dwell times at bus stops and increasing service efficiency. For example, a before and after comparison of all-door boarding in San Francisco found the average dwell time per boarding and alighting reduced from 4.3 seconds before implementation to 2.7 seconds after implementation of all-door boarding. When measured on a per passenger basis, a 1.6 second reduction in boarding and alighting time might not seem like much. However, a busy bus route can have 100 boardings per trip, which equates to 2 to 3 minutes saved per trip.

All-door boarding is common for other modes of public transport such as light rail (trams).

Some jurisdictions may be concerned with increased fare evasion with all-door boarding. Fare evasion concerns lead to the cessation of all-door boarding for some buses in London. When considering all-door boarding, develop a payment enforcement plan to combat fare evasion. For example, San Francisco did not experience an increase in fare evasion as a result of all-door boarding, because a roving ticket inspector checked proof of payment. All-door boarding typically necessitates a proof of payment or closed fare system to reduce fare evasion.

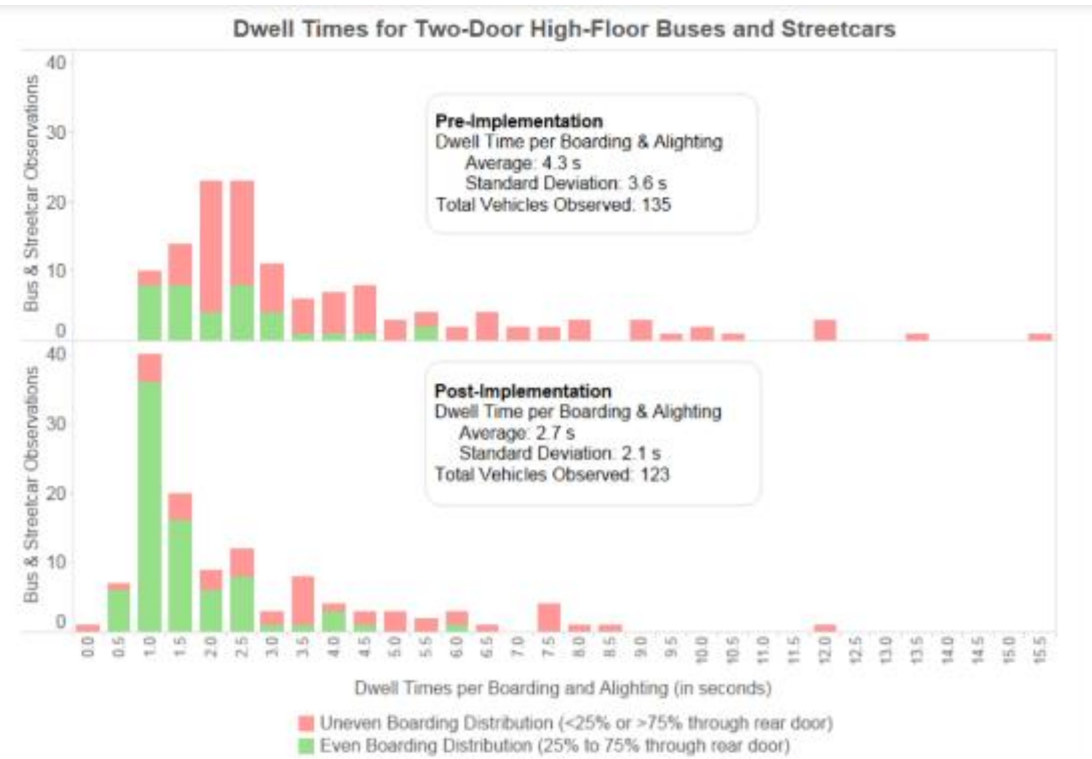


Figure 73 – Dwell times at stops before and after all-door boarding was implemented. Source: San Francisco Municipal Transportation Agency. 2014. All-door Boarding Evaluation.

6.4. On-street parking management

Managing parking (by time of day or location or both) or removing it entirely (for example, by using a clearway or preventing parking) is a means of providing reliable and efficient public transport. On many parts of the transport network, good and basic parking management, especially in peak hours, acts as way to optimise public transport operations and, in some instances, provide priority. This is because this can support a clear (or clearer) path for traffic, including public transport, to use.

The importance of managing parking and loading in the vicinity of bus or light rail stops should not be underestimated. Clear entry and exit paths to and from the stop are essential for efficient and accessible public transport operations. Reallocating road space currently dedicated to parking to ensure best practice bus stop design could be considered a public transport priority or optimisation measure. For further information on best practice bus stop design, including entry and exit path dimensions (also called lead in and out facilities), see Bus stop layout.

Synergies exist between managing on-street parking provision and enforcing parking restrictions and providing and enforcing public transport priority measures. Road controlling authorities manage on-street parking spaces, parking restrictions and prohibitions. Fees are typically set through bylaws.

Bylaws are enforced by parking enforcement officers the road controlling authority has appointed. These officers may issue parking notices or impose other forms of penalty such as having illegally parked vehicles towed away. Enforcement officers are usually the same officers used to enforce features such as bus lanes.

For guidance on:

- the required signage associated with parking management, see Part 13: Parking controls in *Traffic Control Devices Manual*
- on-street parking management, see *National Parking Management Guidance*.

7. Implementing priority and optimisation

7.1. Street space allocation

The Waka Kotahi intervention hierarchy (shown below) indicates that integrated planning, demand management and making the best use of an existing network should be considered ahead of building new infrastructure such as new roads. Therefore, an early consideration when implementing public transport priority is determining whether space exists within the existing street corridor to fit the priority measure.

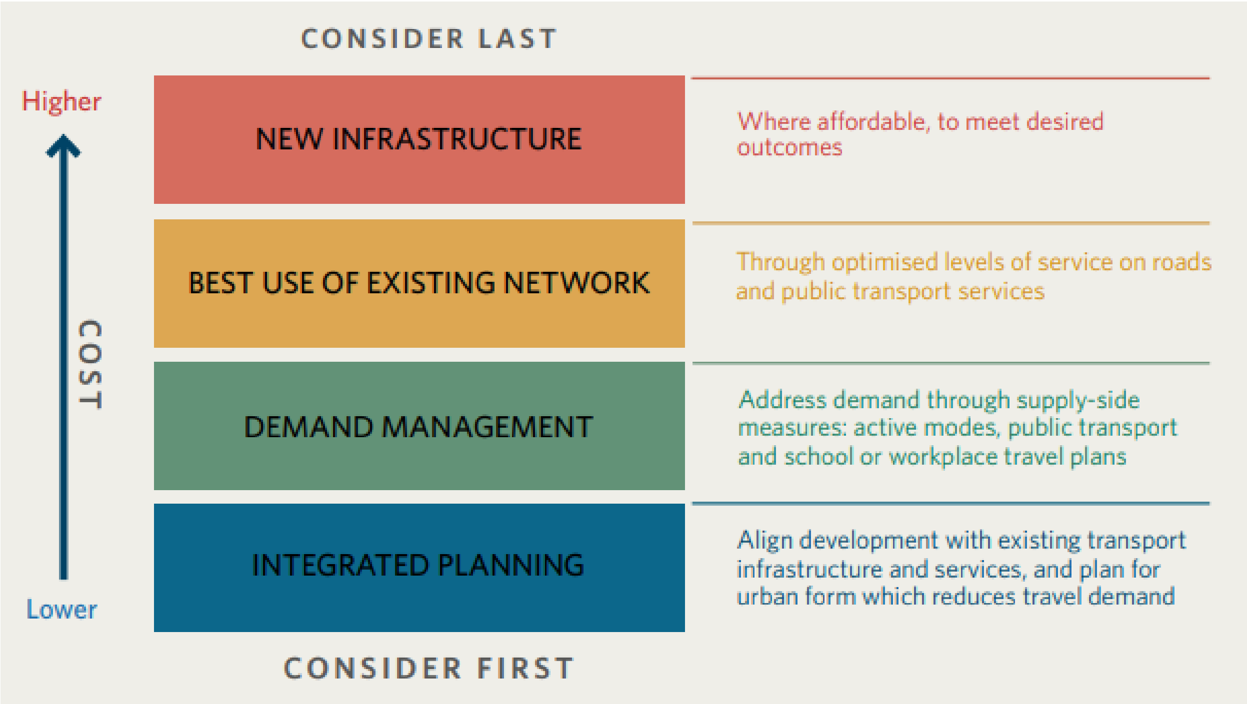


Figure 74 – Intervention hierarchy for National Land Transport Fund investments. Source: Waka Kotahi NZ Transport Agency. 2020. Intervention hierarchy (webpage).

Street space allocation should be investigated ahead of road widening or new corridors. In line with the intervention hierarchy, it may be more appropriate to convert a general traffic lane or parking lane into a public transport priority lane rather than widening the street to add another lane. This is because new infrastructure has a higher cost and can negatively affect adjoining communities. This approach is also consistent with most modal hierarchies, which suggest prioritising travel for people walking, cycling and using public transport ahead of people using private cars.

7.1.1. Road space reallocation

It can be difficult to reallocate road space from general traffic lanes or parking. A strong evidence base supports well-informed discussions and decision-making.

When transitioning from 'off-line' bus stops (where buses pull out of the movement line of traffic) to in-lane (or in-line) bus stops on two-lane roads, use our calculator, which lets you adjust the parameters to calculate the total level of delay for movement by numbers of people: In-lane bus stop calculator tool.

When reallocating space from general traffic lanes or adjusting signal phasing, use the tool to calculate total people throughput (for current and predicted future public transport occupancy) in terms of travel-time effects and the carrying capacity of the corridor.

When reallocating street space from parking, use our National parking management guidance, which advises on parking utilisation and developing parking management plans, which can support parking space reallocation.

7.1.2. Pragmatic strategies for public transport priority implementation

Road space reallocation can be difficult. Pragmatic strategies for public transport priority implementation in car-centric cities are set out in the table below.

Table 25 – Strategies for implementing public transport priority in car-centric cities in Aotearoa New Zealand

Approach	Strategy	Description
Build legitimacy before implementation	Technical enquiry	Undertake (additional) formal studies and investigations to support the case for public transport priority.
	Transport planning	Link the need for public transport priority to strategic plans (such as regional public transport plans) the community has endorsed.
	Public processes and hearings	Use formal public policy and decision-making processes to investigate, debate and demonstrate the appropriateness of public transport priority.
Avoid impacts on private vehicles	Grade separation	Move on-street public transport services onto their own dedicated right-of-way (elevated or underground) to provide full separation from traffic.
	Building new capacity	Implement public transport priority measures through road widening or other approaches that mean the status quo for private motorists is largely unaffected.
	Subservient priority	Increase public transport priority as much as possible without significantly affecting other road users.
Build legitimacy through implementation	Bottom-up and incremental	Increase public transport priority gradually through small changes in conjunction with maintenance or other works.
	Pop-ups	Prioritise public transport using low-cost and temporary interventions and tactical urbanism style of engagement.
	Trials	Build support for an experimental implementation to test the viability of permanent public transport priority.

Source: Adapted from J Reynolds and G Currie. 2021. New approaches and insights to managing on-road public transport priority, in G Currie (Ed), *Handbook of Public Transport Research.* Cheltenham, UK: Edward Elgar Publishing, ch 10.

In car-centric cities, large-scale road space reallocation may be difficult. Therefore, grade separation, additional road capacity or subservient priority may be useful to avoid significantly affecting private vehicles (which could threaten the social licence of the road controlling authority to implement projects). However, if additional street space is required or a separate public transport corridor is being considered, then the project will likely be more complex, be more expensive and require a greater level of project management.

Sometimes street space can be made available by reallocating space from lower priority uses gradually, supporting project implementation as part of business-as-usual activities (bottom up and incremental measures as described in the table above). In this situation, you increase transit priority gradually through small changes, possibly in conjunction with maintenance works such as track renewal, road resurfacing or other work. Similarly, the optimisation of traffic signals to reduce delay for public transport vehicles can generally also be implemented by road controlling authorities as part of business as usual.

7.2. Engagement

A critical part of implementing changes to the street network is engagement with the community and other stakeholders.

Engagement early in the planning and design process gives all stakeholders an opportunity to contribute to the street design, which can improve the quality of the final design. Engagement also provides an opportunity to build consensus on the way forward and the social licence the road controlling authority needs to proceed.

It is common for members of the public to focus on what will be lost through the proposed changes, whether this be on-street parking or general traffic lane capacity, rather than the longer-term outcome. Therefore, it is good practice to begin the engagement conversation with the high-level outcomes being sought (such as people being able to get to work, schools and shops quicker and more easily) rather than the detail of how the street will be designed.

During the engagement process, include a wide variety of people in the conservation because people who make different types of trips or use different modes will likely offer different perspectives. In general, people who are directly affected by the proposal or have more free time are more likely than others to respond to traditional engagement approaches such as workshops or drop-in sessions. Consider using online tools to encourage people who may have an interest in the proposal but less time or ability to attend a meeting.

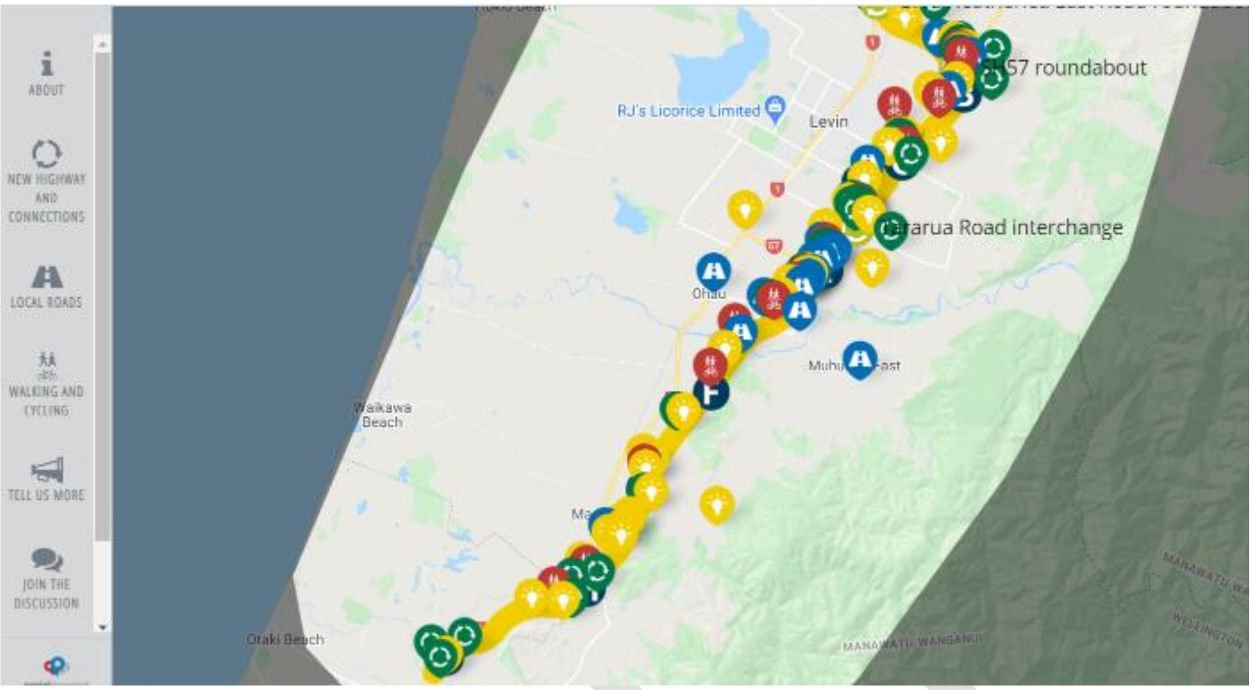


Figure 75 – Interactive map about the Otaki to north of Levin changes that the community could use to provide feedback online. Source: Waka Kotahi.

7.3. Regional public transport plans

When implementing priority measures, associated changes may be required to public transport services so full use will be made of the new or improved infrastructure. These changes could mean increases in service frequencies or changing routes to use the faster corridor. When changes to public transport services are planned it is important the regional public transport plan is also updated. This is because a regional public transport plan is a statutory document that encourages integrated land use planning as well as financing of public transport services within a region.

Public transport contracting authorities and road controlling authorities must work collaboratively to improve public transport. An example of the inter-relationship between infrastructure and service provision is the Northern Express bus service in Auckland that was implemented in coordination with the opening of the Northern Busway.

7.4. Tactical public transport

An emerging approach to implementing public transport priority measures is the use of low-cost and temporary materials to test street layout changes. This can be called a 'tactical transit' approach since it borrows practices from tactical urbanism but focuses on reducing public transport travel times to improve customer experience.

Tactical public transport projects are quick to implement and easy to reverse or change, which can streamline design and consultation processes. Piloting a design on a street enables people to experience how the street could be used and allows designers to adjust the layout based on feedback received.

Tactical public transport projects are best suited to street space reallocation projects for short sections of urban streets that have high traffic congestion and low public transport speeds.

Tactical public transport projects can include the use of cones, water-based paint or removable line markings to install priority lanes and the use of temporary traffic management to implement bus gates. For the traffic controls associated with tactical public transport projects to be legally enforceable, the road controlling authority may need to create a traffic resolution.

An early tactical public transport project was the bus-only lane pilot in Everett, Massachusetts, United States. This project involved testing a 1.6km-long peak bus lane using cones. The bus lane reduced public transport travel times by at least 20% and sometimes 30%, so the bus lane was made permanent.

Figure 76 – Bus-only lane being piloted, Everett, Massachusetts, United States. Source: Massachusetts Bay Transportation Authority.

A tactical urbanism approach aims to make it faster and easier to transition streets to safer and more liveable spaces by piloting initiatives and ideas and taking the community on a journey as co-designers and owners of the project.

An example of this has been the Waka Kotahi Streets for People programme. Resources to developed to support this programme are also relevant to tactical public transport projects and are available from the Streets for People’s resources webpage.

8. Post-implementation

8.1. Benefits reporting

Public transport priority measures can deliver benefits to existing public transport users, people who may shift modes and the wider community.

Where funding is sought from the National Land Transport Programme to implement public transport priority measures benefits must be identified and, where possible, quantified.

For guidance on the recognised benefits and how they are measured, see Benefits management guidance.

The benefits that have the greatest relevance to public transport services are the following impacts (note the section numbers after each reflects the relevant section of the guidance linked above):

- of mode on physical and mental health (see further section 3.1 of Non-Monetised Benefits Manual)
- of air emissions on health (3.2)
- on network productivity and utilisation (5.2)
- on greenhouse gas emissions (8.1)
- on users experience of the transport system (10.1)
- on mode choice (10.2)
- on access to opportunities (10.3)
- on community cohesion (10.4)
- on townscape (11.3).

The potential benefits of public transport priority include direct benefits in the form of travel time savings for existing customers and indirect benefits in the form of mode shift with people switching to public transport. Demonstrating the potential for mode shift is important and strengthens the case for public transport priority. This is because benefits such as improved physical health, fewer air emissions and higher network productivity are all derived from people changing their travel behaviour towards public transport.

A relationship exists between public transport travel times and the demand that can be expected for the service. As public transport travel times are improved relative to the times of other modes, public transport becomes increasingly attractive, and people may change their travel behaviour as a result. The degree to which demand is sensitive a change in price or other characteristic is referred to as ‘elasticity’. Waka Kotahi’s *Monetised Benefits and Costs Manual* provides guidance on elasticities for public transport projects.

The example in the table below shows that each 1% decrease in public transport travel time may result in about a 0.4% increase in public transport patronage.

Table 26 – Overall (short-run) direct elasticity estimates at 12 months after service change

Attribute	Overall best estimate[a]	Typical range[b]
Fare levels[c,d]	-0.35	-0.2 to -0.6
Service levels[e]	+0.45	+0.2 to +0.6
In-vehicle time[f]	-0.40	-0.1 to -0.7
Total generalised cost[g]	-1.30	-0.8 to -2.0

Adapted from: Waka Kotahi NZ Transport Agency. 2023. *Monetised Benefits and Costs Manual* (version 1.6). Wellington, Table 81, p 154.

Notes:

- These are best estimate short-run elasticities for each attribute for typical urban public transport journeys, averaged over all market segments and time periods. More disaggregated estimates (as given in Table 82 in *Monetised Benefits and Costs Manual,* p 155) should be used where information is available. Positive values indicate that demand increases when the attribute increases; negative values indicate the opposite (eg, fare increases result in reduced demand). The 'short run' refers to the impacts roughly 12 months after the change in the service attribute.
- All fare elasticity estimates relate to fare changes in real terms (ie, after netting off any effects of inflation on fare levels).
- In situations with competing public transport modes or services, the estimates given here assume that the fares on all such modes or services are adjusted in the same proportions (ie, these are 'conditional' elasticities).
- The service level attribute is often calculated as the number of in-service bus kilometres in the area of interest. For situations where the route structure is unchanged but the levels of service on the existing routes are adjusted, the service frequency (number of bus trips per hour) may be taken as the measure of service level.
- In-vehicle time may be taken as being the time that the 'typical' passenger spends on the service, between initial vehicle boarding and final vehicle alighting.

Other methods for estimating mode shift include willingness to pay surveys and multi-modal transport models.

Researchers from Monash University reviewed the results from 22 public transport priority schemes in Australia, North America and Europe [7] They found a strong relationship between the percentage of travel time savings resulting from public transport priority and reductions in automobile driving. They also found that public transport priority can generate mode shift from car drivers at relatively low levels of travel time savings.

8.2. Monitoring

After a priority measure has been implemented it is best practice to continue to monitor public transport delay and to update the priority measure in response to any problems identified. This is because, over time, traffic congestion changes, so delays may be experienced at different times or in different locations than when the priority measure was first implemented. For example, traffic congestion may become common outside the hours when a part-time bus lane is operational or a longer queue at an intersection may prevent a public transport vehicle from accessing a priority lane. In such instances, consider updating the time restrictions and length of the priority lanes to maintain public transport journey times and reliability.

[7] G Currie and M Sarvi. 2012. New model for secondary benefits of transit priority, *Transportation Research Record: Journal of the Transportation Research Board* 2276(1). https://doi.org/10.3141/2276-08

Furthermore, public transport patronage may increase over time to a point where a higher level of priority may be justified (such as bus lanes instead of transit lanes). In this case, update the vehicle type restrictions to reflect the proportion of people carried by public transport vehicles.

8.3. Maintenance

The remarking of road markings and replacement of signs for priority lanes should be included in the street corridor’s maintenance programme. This is because priority lanes that have faded road markings or missing signs are likely to have poorer compliance because the distinction between the priority lane and general traffic lane is less clear.

8.4. Operations – vehicle exemptions, education, and enforcement

8.4.1. Vehicle exemptions

Our cities have finite space and many competing demands for road space. Some vehicles may be permitted exemptions to use special vehicle lanes such as rubbish trucks, service vehicles (e.g. for bus shelter maintenance), or others, though road controlling authorities may wish to stipulate the times of day that they are able to use special vehicles lanes. Note that emergency vehicles by default will have access.

Figure 77 – Rubbish truck stopped in a bus lane to pick up rubbish. Source: Lorelei Schmitt.

8.4.2. Education and enforcement

The ongoing education about, and enforcement of, the rules for using priority lanes or public transport–focused signals is important for achieving high levels of compliance with the vehicle class restrictions. Without adequate education and enforcement, it is likely restricted vehicle types will use priority lanes, which will increase delays for public transport vehicles and reduce the benefits of such priority measures.

Educating road users about the rules for using priority lanes is especially important when implementing new priority lanes because, over time, road users will become familiar with the revised road layout. It is also necessary to implement enforcement measures (infringement fines) to discourage the minority of road users who do not follow the rules.

8.4.3. Enforcement measures

Figure 78 – Bus lane enforcement, Wellington. Source: Lorelei Schmitt.

Parking wardens have the power to enforce the provisions of a stationary vehicle offence or special vehicle lane offence (under section 128E of the Land Transport Act 1998).

Enforcement of stationary vehicle offences typically involves wardens manually checking that part-time priority lanes are clear of parked vehicles before the peak period starts.

Enforcement of moving vehicle offences is typically completed using mobile or permanent cameras to record vehicles driving in the priority lane. For the enforcement of moving vehicle offences, it is necessary to have markers (such as cones) that are 50m apart in order to prove that the vehicle travelled more than 50m in the special vehicle lane.

The use of cameras has several benefits, including the ability to review footage off-site and to have evidence that an infringement occurred. The advantages and disadvantages of mobile and permanent enforcement cameras is discussed in the table below.

Table 27 – Advantages and disadvantages of different enforcement cameras

Camera type	Advantages	Disadvantages
Mobile camera	Has a lower equipment cost as a single camera may be used for multiple priority lanes. Can use the same parking warden to check for cars parked in the priority lane.	Requires a parking warden to set up and monitor the camera. Is less suited to 24-hour priority lanes.
Permanent camera	Does not require a parking warden to set up or monitor the camera. Can record footage 24/7, which can be reviewed separately.	Is less flexible as the camera generally has a fixed location. Has a higher equipment cost.

8.5. Promotion of public transport

Public transport is effective at moving large numbers of people with relatively few vehicles. However, this can create the perception that public transport lanes are not being fully utilised.

From the perspective of a motorist using a congested general lane, an adjacent free-flowing public transport lane appears empty most of the time. This perception can translate into political pressure on road controlling authorities to ‘fix’ the empty lane by removing the restrictions to general traffic using the lane. However, the ‘empty’ public transport lane can often be carrying as many (if not more) people than the ‘full’ general traffic lane (which is illustrated below).

Downgrading a priority lane will only discourage public transport use and/or carpooling, which increases traffic volumes and results in slower journeys for everyone.

Figure 79 – Number of people in three full traffic lanes with one busway lane (assumes average car occupancy of 1.5 people per vehicle and 70 passengers per bus), Auckland Northern Motorway. Source: Auckland Transport.

One tool available to road controlling authorities to combat the perception of under-utilised public transport lanes is to proactively promote the success of the priority lane to the public through advertising.

Advertising should include easy-to-understand facts such as the number of people carried by the priority lane compared with the general traffic lane or the number of car trips taken off the road from an increase in public transport usage.

Facts that illustrate the positive impacts of priority lanes on the transport system are also useful for press releases should road controlling or public transport authorities be asked to comment on street space allocation decisions.

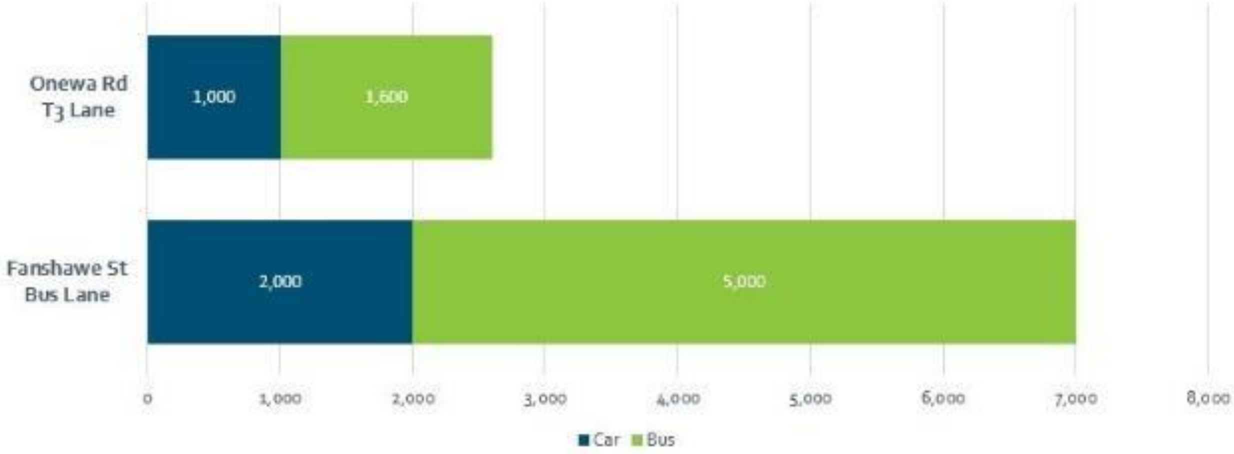


Figure 80 – Comparison of the number of people using different modes on the Onewa Road transit lane and Fanshawe Street bus lane, Auckland. Source: Greater Auckland and Auckland Transport

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