NETWORK INFRASTRUCTURE FOR ARTICULATED BUSES

Public Transport Design Guidance

NZ Transport Agency Waka Kotahi

24 May 2024

Draft V0

NZ TRANSPORT AGENCY WAKA KOTAHI

Te Kāwanatanga o Aotearoa
New Zealand Government

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More information

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Published May 2024

ISBN Online – 978-1-99-106889-7

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1. Context

Articulated buses offer higher vehicle capacity and more efficient passenger boarding and alighting due to them having a longer length than a 'standard' bus. This additional length means, however, that there are extra considerations when designing or retrofitting infrastructure that will be used by articulated buses.

This guidance note outlines the key considerations for design of new or retrofitted network infrastructure that will be used by articulated buses. It is a standalone note, but the content will be incorporated into the Public Transport Design Guidance topics over time.

2. Typical dimensions of an articulated bus

2.1 Length, width, and height

Articulated buses are typically 17–18m (maximum) long with three or four axles and a maximum 3.4m in height. By comparison, standard 'rigid' single-decker buses are up to 13.5m long with two or three axles with the same maximum height of 3.4m.

The NZ Transport Agency Waka Kotahi website provides guidance on dimension requirements for heavy buses, including articulated buses, that may be used on New Zealand.

Vehicle dimensions and mass: Heavy buses | NZ Transport Agency Waka Kotahi (nzta.govt.nz)

Any buses, including articulated buses, that do not meet these requirements must meet NZ Transport Agency Waka Kotahi performance-based standards to be eligible for an exemption to operate. These standards help us determine whether non-standard heavy vehicles meet the safety performance requirements equivalent to those of standard vehicles.

Performance based standards | NZ Transport Agency Waka Kotahi (nzta.govt.nz)

2.2 Doors

Articulated buses are long enough to have three or four doors compared with the two doors common in standard buses. Additional doors decrease dwell times at stops but reduce the number of seats. For urban bus routes where passengers frequently board and alight, more doors could be desirable. However, for services where most passengers alight at the same stop (such as school services), then fewer doors may be desired.

Consider the impact of door location and numbers for the receiving environment. For example:

- Will the bus stop design and layout allow bus drivers to manoeuvre in and out in a manner that supports all doors being able to align with the kerb?
- If the bus stop is interacting with a shared path or cycleway bypass, has the design appropriately reflected the boarding and alighting movements associated with all of the bus doors?

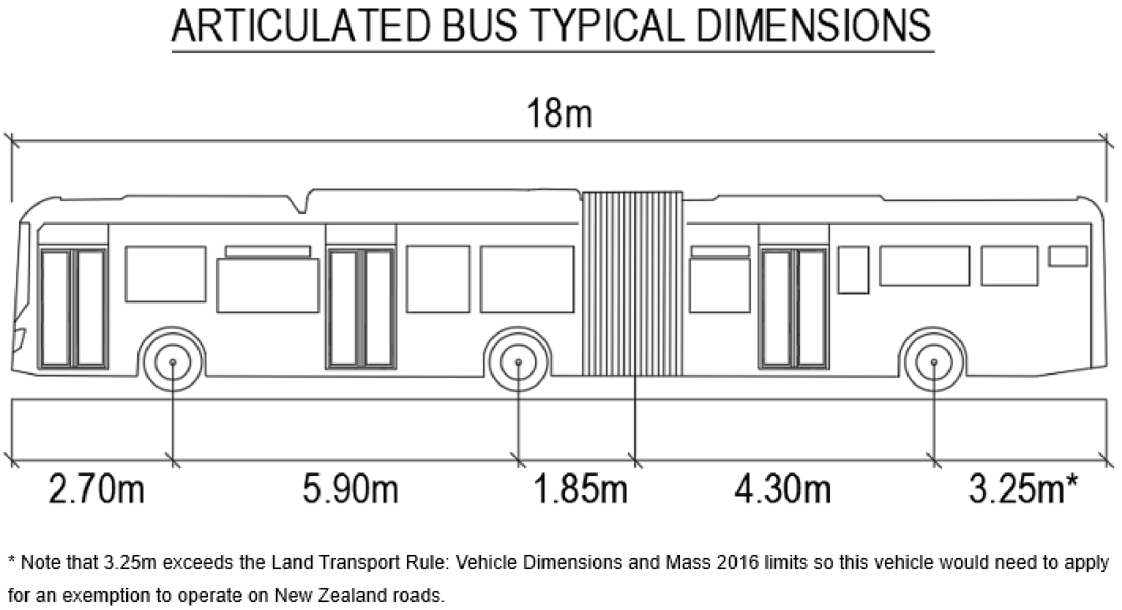

Figure 1: Dimensions of a three-axle articulated bus being considered for use in New Zealand. Source: Waka Kotahi.

3. Specific safety considerations

The considerations for safety in the Public Transport Design Guidance are applicable for articulated buses as well. However, there are additional considerations for safe operation of articulated buses relating to the increased length of the vehicle compared with standard buses, which influences swept paths, sightlines, overtaking distances and clearance times. Safety risks can be mitigated through measures such as driver training, driver aids and road design. This section discusses key considerations for designing infrastructure to safely accommodate articulated buses.

3.1 Swept paths

The swept path is the space a bus needs to manoeuvre safely. To comply with the Land Transport Rule: Vehicle Dimensions and Mass 2016, an articulated bus requires a maximum turning circle of 25m in diameter measured from the outside of the bus.

General Information on swept path tracking for buses is in the Public Transport Design Guidance section on bus dimensions for design:

PTDG: Bus dimensions for design

An articulated bus has the same vehicle-tracking requirements as a standard bus:

- A clearance of 0.5m must exist around the tracking envelope of the vehicle body to provide space for vehicle wing mirrors, bus tilt and driver error. Some encroachment into the clearance envelope may be acceptable in low-speed situations subject to the relevant road controlling authority's approval.
- A clearance of 1.0m must exist between the tracking envelope of the vehicle bodies for opposing bus movements (for example, left turn and right turn simultaneous movement).

See the example of a swept path in figure 2.

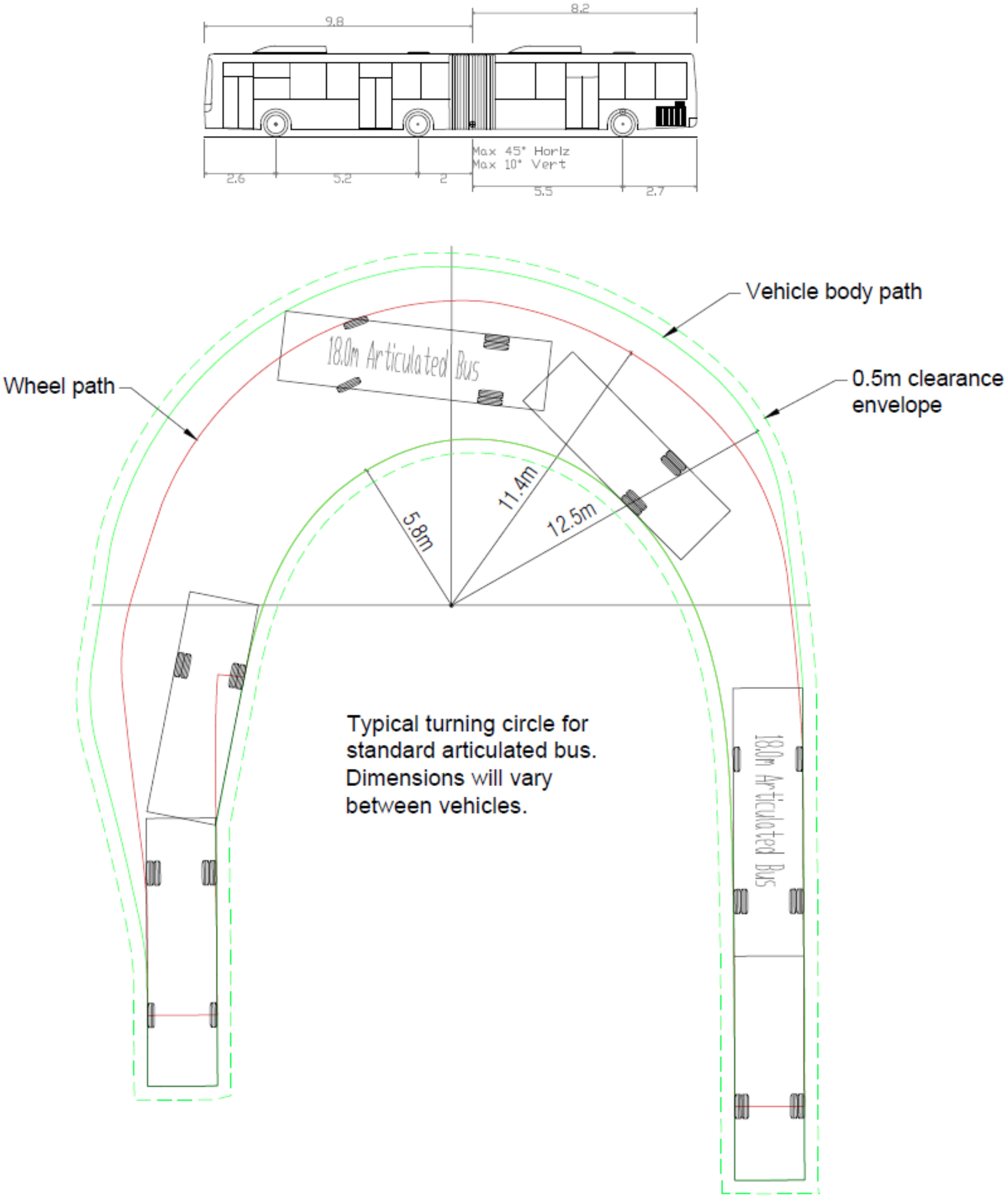

Figure 2: Example of tracking (in red) and swept path (in green) for an articulated bus.

Swept paths need to be checked at intersections, bends and bus stops. Although swept path and tracking are typically simulated in two-dimensional software we recommend in person site-visits to evaluate 3-dimensional objects such as trees and poles that may impact bus movement.

The turning circle of articulated buses is often similar to, or sometimes better than, standard rigid buses due to the articulation point. Nonetheless, a swept path analysis should be undertaken when considering changing fleet types because roads are often designed with a 12.5m long standard bus or truck as the design vehicle.

Also, turning characteristics can vary between bus models due to differences in axle placement, the location of the articulation point and the length of the front or rear overhang. Therefore, a design vehicle with comparable characteristics as the vehicle that will be used on the road should complete the swept path analysis.

The swept path analysis should consider the routes the articulated buses will operate on as well as dead runs to depots, routes that may be travelled between articulated bus routes and any detour routes. These routes should be clearly documented and communicated so bus operators know which roads can and cannot accommodate articulated buses if needed.

The swept path analysis should identify locations with insufficient clearance from other traffic lanes or road features. Analysis can be further informed by undertaking a trial run of routes that may be travelled by articulated buses by drivers with a range of experience to observe how the articulated bus performs in the environment compared with the swept path analysis. Once issues are identified, a plan can be developed to remove obstructions or guide buses away from obstructions with sufficient clearance.

On the next page, we provide an applied example of articulated bus swept path analysis for an intersection.

3.1.1 Applied example

In the below images we show an intersection where if an articulated bus were to turn left from the left-turn lane, it would track over the centreline when exiting the roundabout, heading into oncoming traffic. The driver of the articulated bus could correct for this by instead turning from the adjoining straight/right lane, however, this would pose a risk to left-turning traffic (cars, bicycles) trying to 'undertake' the articulated buses (i.e., pass on the left). Instead, an appropriate mitigation could be to remove the left turn lane so that all traffic approaching the intersection would be from one, more centred, lane. This would position the left turning articulated buses better to avoid lane encroachment while avoiding unsafe undertaking on the left.

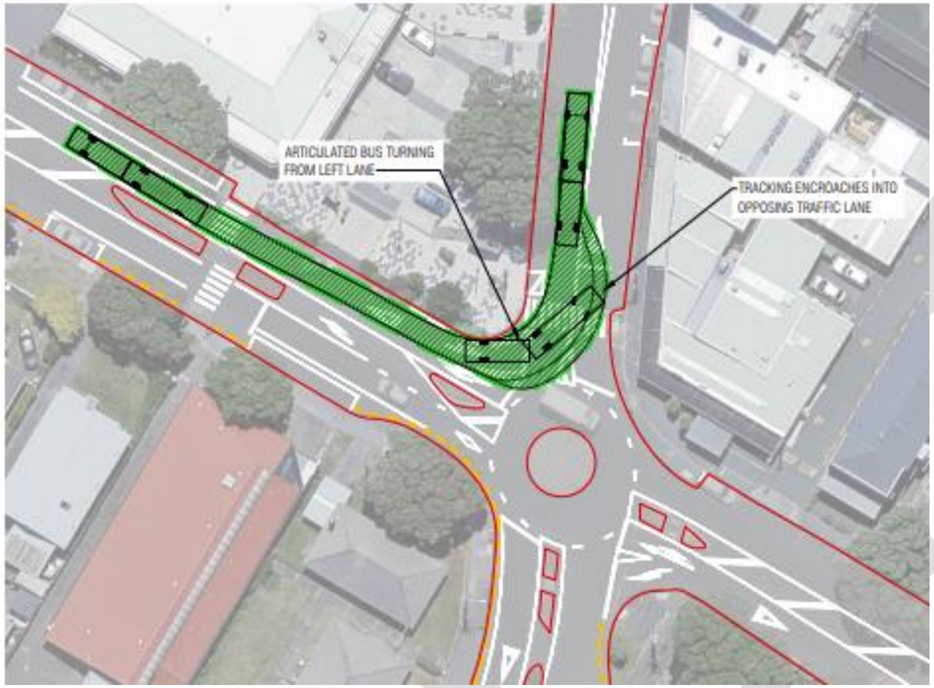

Figure 3: Existing geometry at an intersection. The left-hand turn lane is unsuitable for articulated buses. Also, buses turning left from the straight/right lane would put undertaking cars or bicycles turning left at risk.

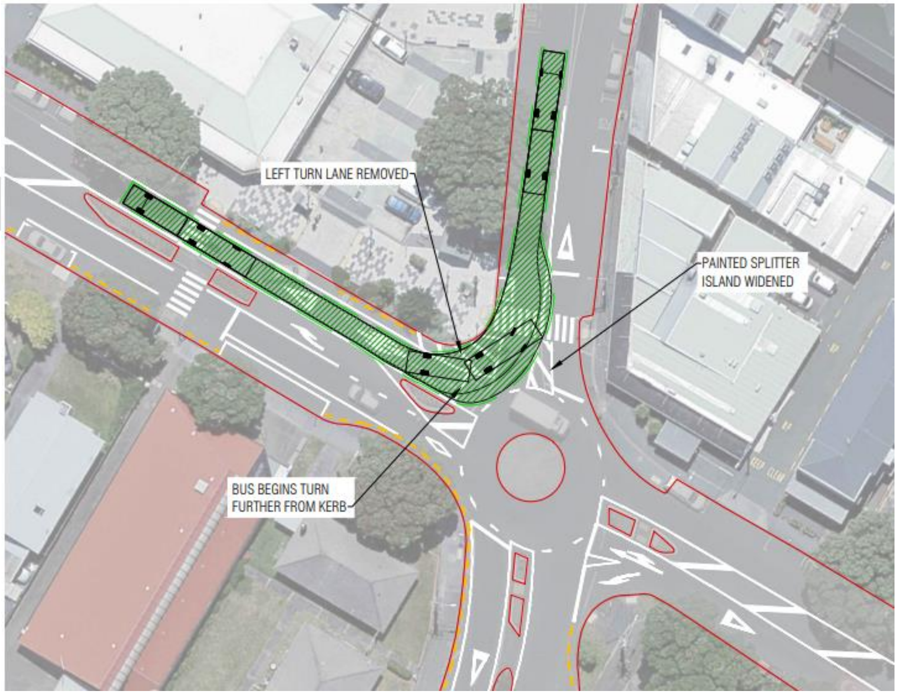

Figure 4: Potential reconfiguration to more safely accommodate articulated buses which involves removing the left turn lane and ensuring the remaining lane leads the bus to start their turn closer to centre of the road.

It is worth acknowledging that there are sometimes legacy issues with bus tracking in our road corridors (for example where buses regularly track out of their lanes). When performing tracking analysis compare the risk profile of the status quo (and whether it is tolerable) versus the risk profile once articulated buses would be introduced to understand if the introduction of articulated buses would increase risks. This should help inform the degree to which changes are required to support a safe system.

3.2 Blind spots

Articulated buses, like other buses and heavy vehicles, have blind spots on their left and right sides and at the rear.

The Requirements for Urban Buses (RUB) 2022 states that buses must be fitted with a blind spot camera system that provides a real-time image to the driver at all times. These cameras must provide a rear-looking view of both sides of the bus from at least the front axle and a rearward looking view of the back of the bus.

Requirements for urban buses in New Zealand | NZ Transport Agency Waka Kotahi (nzta.govt.nz)

3.3 Safety around people cycling

Consider whether articulated buses will be sharing corridors with people on bicycles. Be mindful that the longer length of articulated buses (approximately 45% longer than ‘standard’ rigid buses) can make it more difficult for bus drivers and cyclists to safely overtake one another. Additionally, note that the length of the articulated buses may be intimidating for some people cycling.

Road corridor design should support safe outcomes for vulnerable road users such as people on bicycles. For example, conflicts can be reduced by providing space that is physically separate from a traffic lane that an articulated bus is using. This is preferable but if articulated buses and bicycles will be sharing traffic lanes it is recommended that wide bus lanes (over 4.4m) are adopted.

Recommended bus lane widths are available in the Public Transport Design Guidance.

PTDG: Priority & Optimisation

The Cycling Network Guidance provides advice for designing cycling facilities.

Cycling Network Guidance

At intersections, the conflict between cyclists going straight and left-turning vehicles can be managed through cycle-friendly intersection design (such as cycle signals, advanced stop lines, and buffered advanced stop boxes). Further guidance on these treatments is in the Cycling Network Guidance.

CNG: Signalised intersections

A safe system can also be supported by vehicle technology. For example, driver aids such as vulnerable road user detection and active brake assist systems can improve safety. Vulnerable road user detection systems typically use radar to detect cyclists and pedestrians to the side of the bus and then use lights and buzzers to warn the driver. In vehicles fitted with an active brake assist system, if a critical risk of collision with a cyclist or pedestrian is detected, the system warns the driver and initiates partial braking.

Another way to improve safety around cyclists is to permit only experienced bus drivers to drive articulated buses. Additional training should be provided for drivers moving from standard to articulated buses to account for the increased length of the vehicle and its different turning characteristics. Note that additional training would need to be offered on an ongoing basis as people move in and out of jobs involving driving articulated buses.

3.4 Reversing manoeuvres

Bus network design should minimise or eliminate the need for articulated buses to be reversed, especially on a public road or at an interchange. This is because reversing an articulated bus is complicated and requires a high level of visibility and operational skills to reverse the vehicle safely.

Drivers must be highly familiar with routes for articulated buses to lessen the risk they take a wrong turn that leads to a need to reverse.

Bus stop and interchange design should not require reversing manoeuvres by an articulated bus to enter or exit.

3.5 Intersections

Articulated buses, compared with standard buses, have longer clearance times through intersections and require more space on departure lanes to clear the intersection. Therefore, it is best practice to review traffic signal timings along articulated bus routes if inter-green times are short and/or the route is congested.

3.6 In-lane bus stopping

Sometimes buses stop partially or fully in traffic lanes to pick up or drop off passengers, notably at stops designed for in-lane stopping, at bus stops operating above capacity, or at bus stops that do not have adequate entry and exit tapers. In some of these contexts other road users may want to pass the stationary buses. When articulated buses will use such stops other vehicles will need to cover a greater distance to overtake them, should they wish to do so. Therefore, a greater sightline is usually required to safely complete this manoeuvre. The sightline should be checked when locating in-lane bus stops, bearing in mind likely other road users (for example, cars in a general traffic lane or possibly people on bicycles in bus lanes that permit them). It may be desirable to restrict overtaking manoeuvres at in-lane bus stops using tools like traffic islands or road markings.

For general advice related to checking sightlines please refer to Austroads:

Austroads Guide to Road Design Part 4A (for intersection sightlines):

AGRD04A-23-Ed3.2 | Austroads

Austroads Guide to Road Design Part 3 (for mid-block sightlines):

Sight Distance | Austroads

3.7 Bus driver visibility

While less of a road safety issue and more of a security issue, one disadvantage of an articulated bus is that the bus driver is less able to see the back of the bus. This can increase the likelihood of vandalism. The same disadvantage is present in the top level of a double deck bus. Therefore, standard buses may be preferrable on routes where there are particular concerns about vandalism.

4. Corridor clearance

4.1 Vertical clearance

Articulated buses are the same height as standard single-deck buses, being a maximum of 3.4m. The same corridor height clearance applies when designing for articulated buses.

4.2 Horizontal clearance

The guidance for horizontal clearance at bus stops also applies for articulated buses which is 1m clearance space, measured out from the kerb. On road testing of articulated buses measured tail swing of 400mm when exiting bus stops on hard steering lock which is comparable to standard buses.

4.3 Traffic calming on articulated bus routes

Many of the same traffic calming design principles apply for articulated bus routes as for standard bus routes. The notable difference is the length of the articulated vehicle.

For speed cushions, international standards recommend no-parking restrictions within 25m of both sides of the speed cushion.[1] This enables articulated buses to line up straight with the gaps between the speed cushions.

Vertical traffic-calming devices like raised safety platforms should be located one bus length away from a sudden change in road gradient. For articulated bus routes this bus length is likely to be 17–18m compared with a standard bus length of 10.0–13.5m.

Other design criteria for raised safety platforms such as height and gradient are the same for articulated buses as for standard buses. This is because the distance between axles tends to be the same as or shorter than those of a standard bus.

Related guidance

For guidance on design criteria for traffic calming on bus routes, or for vertical and horizontal clearance requirements see:

PTDG: General clearance requirements.

5. Bus stop design layout

Because articulated buses are longer than standard buses, existing bus stops will typically need to be lengthened so articulated buses can pull up in line with the footpath.

5.1 Bus stop box and entry and exit tapers

When designing articulated bus stops the bus box should be at least 20m long to accommodate the vehicle. This compares with 15m for a standard bus.

The length of entry and exit tapers also need to be longer than for a standard bus stop. The recommended entry and exit taper lengths depend on several factors, including the width of the adjoining traffic lane, the depth of the parking spaces, the level of front swing over the kerb, the speed at which the manoeuvre is taken and how close to the kerb the bus needs to align.

Tables 1 and 2 summarise high-level advice for entry and exit tapers for kerbside bus stops serving articulated bus based on vehicle tracking. These distances are based on all three doors being aligned with the kerb to enable easy alighting from all doors, including the rearmost door.

If a departure is made from this guidance, be mindful of passengers possibly needing to step down into the road from the rearmost door which may not align with the kerb. Consider whether this is tolerable and whether signage within the bus would be beneficial to warn patrons to mind the step down (as this would be a greater height onto the road surface than onto a footpath). In addition, consider the extent to which the rear of the bus would be positioned in or out of the traffic lane and any associated implications.

Note that bus stops designed for articulated buses can also be efficiently used by standard buses.

Table 1: Entry taper for articulated buses at a kerbside bus stop based on a 3.5m wide traffic lane

	100mm gap between door and kerb	50mm gap between door and kerb
Entry taper length*	20m	30m

* Assuming 3.5m wide traffic lane.

[1] Transport for London. 2005. *Traffic Calming Measures for Bus Routes.* London: Transport for London. https://content.tfl.gov.uk/trafficcalmingmeasuresleaflet-rev-final.pdf

Table 2: Exit taper for articulated buses at a kerbside bus stop based on 2.1m wide parking

	3.0m wide traffic lane	3.5m wide traffic lane	4.0m wide traffic lane
Exit taper length*	15.0m	12.0m	9.0m

* Assuming 2.1m wide parking.

Figure 5 shows the tracking profile of an articulated bus pulling in and out of a kerbside stop, and Figure 6 shows articulated bus stop dimensions.

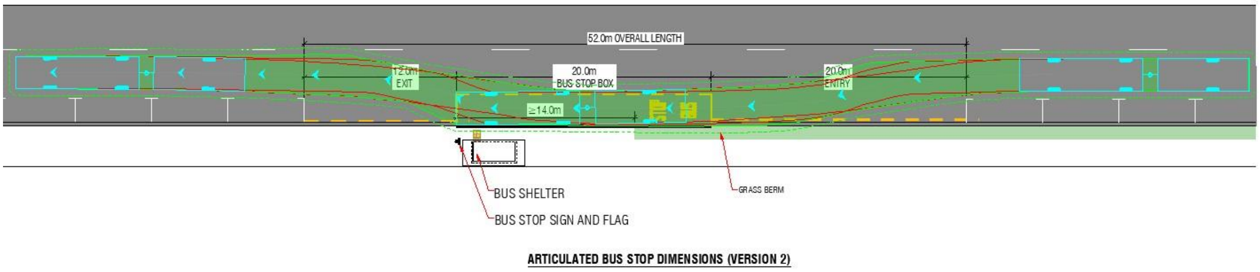

Figure 5: Tracking profile of an articulated bus pulling in and out of a kerbside stop

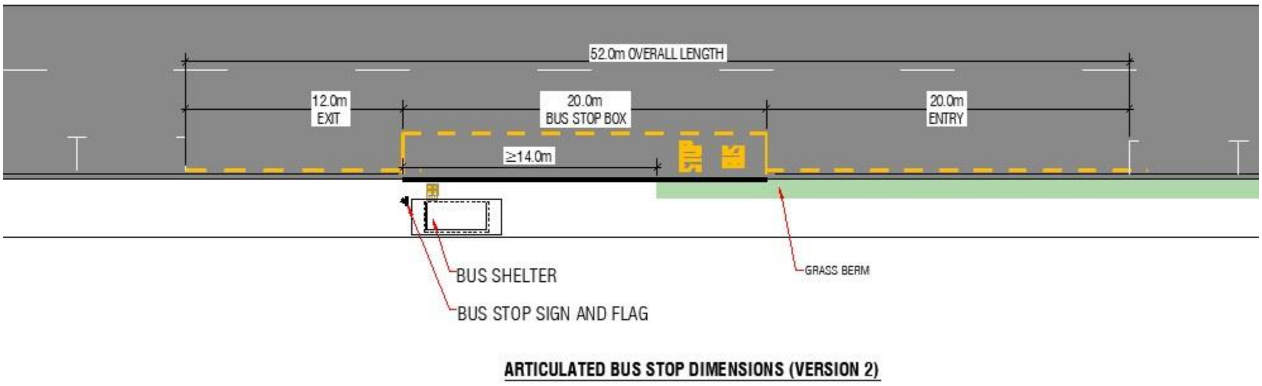

Figure 6: Articulated bus stop layout dimensions

5.2 Hardstand areas

Another important consideration for bus stop design with articulated buses is the length of the hardstand area.

When introducing articulated buses into the fleet, determine whether any hardstand areas need to be lengthened. Standard bus stops typically have a 9–10m long hardstand area, which is the distance between the front and rear doors of a standard bus. The distance between the front and rear doors of an articulated bus is typically 14m if the rear-most door is in front of the rear axle. However, if the rear-most door is behind the rear axle it may be as far back as 17m.

If the hardstand area is the footpath, as it is for many bus stops, the hardstand area would not need to be lengthened.

6. Design at interchanges

Design of bus facilities for articulated buses should minimise or eliminate the need for articulated buses to ever reverse, especially on a public road or at an interchange. This is because a high level of visibility and operational skills are needed to safely reverse an articulated bus. Because of this, a drive-in reverse-out interchange layout is **not** recommended for articulated buses.

For further guidance on layouts, see the relevant Public Transport Design Guidance topics.

PTDG: Interchanges and stations

PTDG: Bus stop

7. Design for layovers

For design and considerations on bus stop layovers, see the relevant Public Transport Design Guidance.

PTDG: Bus layover and driver facilities

The length of the bus box for parking and any associated entry and exit tapers will need to be greater for articulated buses than standard buses. Reverse manoeuvres by articulated buses should be avoided when designing a layover space.

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