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Foreward

The mandate of the BC Transit Corporation, as set out in the BC Transit Act, is:

“to plan, acquire, construct or cause to be constructed public passenger transportation systems and rail systems that support regional growth strategies, official community plans, and the economic development of transit service areas”, [and] “to provide for the maintenance and operation of those systems”.

In the Spring of 2010, BC Transit Corporation launched the Strategic Plan 2030 which highlights the vision, mission and values of the organization, and identifies five major priorities:

- Develop Financial Sustainability
- Support and Shape Livable Communities
- Change the Perception of Transit
- Deliver Operational Excellence
- Strengthen our People and Partnerships

BC Transit upholds the values of safety, customer service, sustainability, integrity, innovation and collaboration across its business. BC Transit strives to achieve the elements of successful transit as gathered from the input of customers, employees, partner local governments, operating company staff, and other stakeholders.

**Elements of successful transit**

- Fast, reliable and accessible
- Easy to use
- Integrated
- Inviting
- Responsive
- Cost-effective
- Positive

To ensure efficiency, safety and accessibility of the transit services provided outside Metro Vancouver, and to promote consistency in the planning and design of bus infrastructure by British Columbia local governments, the BC Transit Infrastructure Design Guidelines (Guidelines) was prepared as a comprehensive document that describes good transit planning and design practices.
The Guidelines were developed through a review of the current available BC Transit documents, the current edition of the TransLink Transit Infrastructure Design Guidelines and other reference documents by the BC Ministry of Transportation and Infrastructure, various North American transit service providers and the Transportation Association of Canada.

Through the distribution of the Guidelines on the Corporation website, BC Transit encourages adoption of these Guidelines by local governments in order to achieve uniformity in the planning and design of transit infrastructure. BC Transit encourages users to provide comments and to share their experiences with these Guidelines. This living document may be revised in the future as needed to better reflect practical applications. Regular updates to the guidelines would enhance the usefulness of the document.
Chapter 1 | Introduction

1.1 Purpose

The purpose of this document is to set in place comprehensive guidelines related to the planning and design of transit infrastructure. Transit infrastructure is defined as all the fixed components in the environment in which transit operates, such as components that are occupied and or used by transit patrons waiting to get on and off of bus vehicles, as well as the roadway used by bus vehicles. BC Transit is taking a proactive approach to publish and make available the guidelines to promote more consistent and uniform practices across British Columbia local governments under BC Transit’s jurisdiction.

The Guidelines incorporate existing practices that are available in various BC Transit documents, as well as best practices identified through the review of other reference documents, including those by TransLink, BC Ministry of Transportation and Infrastructure, various North American transit service providers and the Transportation Association of Canada.

The Guidelines identify the design and operational requirements by the existing BC Transit bus fleet, while taking into consideration the interaction and needs of transit patrons and other road users.

The Guidelines provide general information about transit infrastructure planning to the public, as well as more detailed technical information to transit planners and engineers. It is an objective of BC Transit for the wide distribution of the Guidelines. BC Transit welcomes comments by users of the Guidelines on ways of improving the content to better tailor to practical applications. The Guidelines is a living document that may be updated from time to time.

The following subjects of interest, while relevant to transit planning, are excluded from this document:

- Operational measures (bus routing, schedules, fares, bus fleet operation and maintenance, transit priority measures)
- Community planning strategies
- Education and marketing strategies
- Project funding and investment
1.2 Structure of Document

This document contains two parts. Part 1 (Chapter 2) provides general information about the provision of transit infrastructure, intended for the information of the general public. Part 2 (Chapters 3 to 7, and appendices) contains technical information intended for use by transit planners and engineers. In Part 2, the key principles and considerations are discussed and suggested design dimensions are provided. Working examples of existing and new designs are also provided in Part 2 to illustrate practical applications of the Guidelines.

1.3 How to Use the Document

This document serves a wide audience, from the general public to technical professionals with transit planning and design experience.

**Part 1** (Chapter 2) is intended for people with no or limited transit planning and/or design experience. It focuses on a high level key planning principles related to transit infrastructure. It includes a glossary to define key terms used in the Chapter.

**Part 2** (Chapters 3 to 7 and appendices) is intended for those who are seeking technical guidance on the review and/or design of bus transit facilities. The content includes technical considerations and preferred design dimensions for bus stops, transit exchanges, park-and-ride lots, and passenger pick-up and drop-off locations. Working examples are also provided to demonstrate application of the technical guidelines. Field testing was conducted as part of the Guidelines development to verify key dimensions. Appendix A contains a Bus Stop Request Form which can be used by local governments for requesting modifications to bus stops.
Part 1
Chapter 2
Chapter 2 | Overview of Transit Infrastructure

2.1 Introduction

This Chapter describes the planning of transit infrastructure on a very high level. There are four underlying principles that are considered with regards to the provision of transit infrastructure:

Who

- People of all ages and abilities should be accommodated.

When

- Transit infrastructure is provided to support accessibility to transit services. Transit, rather than the private automobile, should be made available as a travel mode choice in support of environmental sustainability.

Where

- The location of a transit infrastructure should be safe, convenient and accessible.
- Best results may be achieved when transit planning is an underpinning element of overall community planning and land use decisions.

How

- Design of transit infrastructure should be consistent with best practices and available guidelines, as demonstrated in Part 2 of this document.
- Safety and accessibility are prime considerations.
## Glossary

Key terms are used throughout the guidelines. A basic glossary is provided below for the key terms that are used in the current chapter. A detailed glossary is located at the end of this document for a complete list of key terms used throughout the document.

### Table 2.1 Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bus Fleet</strong></td>
<td>The vehicles which are operated by BC Transit. These may include conventional bus, double-deck bus, HandyDart, minibus, low floor bus, community bus, or alternative technology bus.</td>
</tr>
<tr>
<td><strong>Bus Shelter</strong></td>
<td>A building or other structure that provides protection from the weather, and may provide seating and other amenities for the convenience of passengers.</td>
</tr>
<tr>
<td><strong>Bus Stop</strong></td>
<td>An area where passengers wait for, board, alight, and transfer between transit vehicles. It is usually indicated by a bus stop sign and red painting along the road curb, where a road curb is available.</td>
</tr>
<tr>
<td><strong>Bus Stop Sign</strong></td>
<td>In the most basic form, a bus stop sign is a rectangular plate mounted on a pole that contains the bus stop identification number, the words “BUS STOP”, and other information such as a wheelchair accessible decal, if applicable to the bus stop. Where multiple bus routes share the same bus stop, the bus stop sign would also include the numbers and names of the bus routes.</td>
</tr>
<tr>
<td><strong>Curb letdown</strong></td>
<td>Also known as a curb ramp or curb cut. A short ramp cutting through a curb or built up to it to provide continuous and accessible access between the road and a sidewalk or raised concrete/asphalt pad.</td>
</tr>
<tr>
<td><strong>Flag Stop</strong></td>
<td>No designated location or physical signage for the buses to stop. Buses will stop and pick up passengers wherever the bus drivers see a pedestrian who flags or signals the buses to stop.</td>
</tr>
<tr>
<td><strong>Park-and-Ride</strong></td>
<td>An access to transit for passengers who drive private automobiles or ride bicycles to a transit station, park their vehicles, and then ride the transit system to reach their final destinations.</td>
</tr>
<tr>
<td><strong>Passenger Landing Pad</strong></td>
<td>A stable, level, raised and slip-resistant surface to facilitate passenger boarding and alighting.</td>
</tr>
<tr>
<td><strong>Passenger Pick-Up and Drop-Off Facilities</strong></td>
<td>Designated spaces, usually located in the vicinity of a transit station entrance, for taxis or private automobiles to load or unload passengers who are coming from or needing to access the transit station. The spaces are usually enforced with limited parking duration.</td>
</tr>
<tr>
<td><strong>Real-Time Information</strong></td>
<td>The provision of accurate information about the arrival of bus services at a bus stop, through an electronic display located on a pole or under the roof of a shelter.</td>
</tr>
<tr>
<td><strong>Transit Exchange</strong></td>
<td>A focal point for passenger transfers between transit modes (for example, between bus and rail) and/or transit routes.</td>
</tr>
<tr>
<td><strong>Transit Infrastructure</strong></td>
<td>All the fixed components in the environment in which transit operates, such as components that are occupied and or used by transit patrons waiting to get on and off of bus vehicles, as well as the roadway used by bus vehicles.</td>
</tr>
<tr>
<td><strong>Transit Priority Measures</strong></td>
<td>Measures that give transit vehicles priority over other road users, such as exclusive bus lanes.</td>
</tr>
<tr>
<td><strong>Wheelchair Landing Pad</strong></td>
<td>A designated area within the passenger waiting area, located near the front door of the bus, which allows the safe and unobstructed operation of a wheelchair ramp and for the manoeuvre of a person in wheelchair.</td>
</tr>
</tbody>
</table>
2.2 Types of Infrastructure Facilities

The types of infrastructure facilities for transit patrons that are covered in the guidelines include:

- Bus stops
- Transit exchanges

Sections 2.3 and 2.4 below provide a high level description of bus stops and transit exchanges.

2.3 Bus stops

Safety and accessibility are underpinning elements for the implementation of any bus stop. A review of the appropriateness of the location where a bus stop is being planned should be conducted by a qualified transit planner or engineer to ensure that there are no blatant safety risks for both transit patrons and transit operator, and that appropriate accessibility measures are provided to accommodate patrons of all ages and abilities.

While flag stops might be provided in some places, BC Transit does not support the provision of flag stops due to potential safety risks. This type of stop is currently only provided in rural areas at the discretion of the road owner and the transit operator.

Currently, different types of bus stops exist across and within individual jurisdictions where the bus stops have different appearances and number of amenities. The most “basic” stop is identified by a pole-mounted bus stop sign, shown in Figure 2.1.

In the planning process, the next step is to determine the placement of the bus stop (where it is located along a roadway, for example: before an intersection, after an intersection, or mid-block). Placement would be based on engineering principles as discussed in detail in Part 2 (Chapter 3, Section 3.3). Examples of things considered by planners and engineers are:

- How far do transit patrons have to walk to get to a bus stop?
- Can bus operators pull into a bus stop safely, without conflicts with pedestrians at a crosswalk?
- Will the bus be delayed to arrive at a bus stop due to traffic queues that block access to the stop? Will the traffic queues also cause delay with the bus pulling back into traffic?
As a general rule of thumb, bus stops on steep hills are to be discouraged.

The configuration of the bus stop, whether buses would park on the curb lane, in a bus bay, or park at a bus bulge, would require careful design based on engineering considerations. Examples of things considered by planners and engineers are:

- Is there enough distance for the bus to decelerate and accelerate?
- What is the roadway posted speed limit?
- What is the number of travel lane available on the roadway?

These engineering considerations are also discussed in detail in Part 2 (Chapter 3, Section 3.4).

A range of amenities may be considered for implementation at bus stops, including:

- Passenger landing pad
- Wheelchair landing pad
- Curb letdown
- Bus stop sign
- Bus shelter
- Seating
- Bicycle storage
- Lighting
- Real-time schedule information
- Camera
- Telephone
- Newspaper/vending boxes

Chapter 3, Section 3.5.3, contains further considerations for specific amenities.

The extent of passenger amenities to be provided at individual bus stops varies, often depending on the local condition. At the minimum, a bus stop pole/sign, sufficient lighting, a passenger landing pad, a wheelchair landing pad and a curb letdown in the vicinity of the bus stop should be provided, regardless of the land use.

Nonetheless, it is desirable, from a customer service perspective, to provide a consistent level of amenities for a specific land use. The BC Transit Design Guidelines for Accessible Bus Stops provides examples of bus stop layouts in urban and rural locations, as shown in Figure 2.2.
Figure 2.2 Example of Bus Stop Amenities in Urban and Rural Locations
2.4 Transit Exchange

A bus transit exchange is an off-street area, away from the general traffic flow, where passengers can transfer between multiple bus routes. While transfers may also happen at a typical on-street bus stop, a transit exchange is a much bigger area and consists of the start or end stops of the bus routes.

There is no specific sizing for transit exchanges. The size depends on land availability, local conditions, and the number of bus routes served by the facility. The sizing also needs to take into consideration:

- The required lanes or driveways for buses to reach the transit exchange and the individual stops
- The number and type of bus vehicles that use the facility
- Passenger volumes
- Amenities provided for passengers
- Washroom and resting facilities for bus drivers
- In the case of buses laying over, other buses must be able to circulate around these buses without conflict.
When considering changes to transportation infrastructures such as the construction of new roads, sidewalks or the introduction of traffic calming, please contact the BC Transit Regional Transit Manager or the BC Transit Planning department. BC Transit would be happy to support the interpretation and application of these infrastructure guidelines. BC Transit staff support can be reached at by phone at 250-385-2551. BC Transit input at the concept development level will help maximize the effectiveness of transit in your community.

For more specific details and technical guidance on the review and/or design of bus transit facilities, please refer to Part 2 of this document.
Part 2
Chapters 3 - 7
Chapter 3 | Key Planning & Design Considerations

3.1 Planning Process

This chapter focuses on the considerations related to the planning and design of bus stop facilities. Figure 3.1 provides an overview of the discussion in this chapter.

To determine the number and location of bus stops, one has to consider the following:

- The relative spacing between subsequent stops
- Locating bus stops that correspond to passenger demand
- Providing physical facilities that promote safe and efficient operation for the interaction of transit vehicles, transit passengers and other road users

This Section contains discussions related to the relative spacing between subsequent stops and land use areas in relation to ridership. Passenger access and amenities are discussed in Section 3.5.

3.2.1 Stop Spacing Guidelines

The recommended bus stop spacing range for different land use areas is included in Table 3.1. In general, bus stops are spaced closer in central business districts and urban areas where activities are more concentrated. It is noted that there may be special circumstances that require the spacing to deviate from the spacing ranges shown in Table 3.1. Nevertheless, bus stop spacing should be optimized as much as possible to correspond to passenger demand.
Table 3.1 Recommended Bus Stop Spacing

<table>
<thead>
<tr>
<th>Area</th>
<th>Typical Spacing (m)</th>
<th>Spacing Range (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Business Districts</td>
<td>200</td>
<td>200 – 300</td>
</tr>
<tr>
<td>Urban Areas</td>
<td>230</td>
<td>200 – 365</td>
</tr>
<tr>
<td>Suburban Areas</td>
<td>300</td>
<td>200 – 760</td>
</tr>
<tr>
<td>Rural Areas</td>
<td>380</td>
<td>200 – 800</td>
</tr>
</tbody>
</table>

3.2.2 Land Use

Bus stops are generally warranted in areas with concentrated activities that generate high ridership. Such areas typically consist of commercial, service, residential or office land uses.Bus stops may be spaced closer in these areas to correspond to passenger demand.

The spacing between subsequent bus stops in rural areas may vary according to population and development density. In rural areas, towns are typically separated by long stretches of Highway. In such cases, bus stops may be spaced closer within the town area and there may be few or no bus stops along the Highway if very low population density exists.

Alternatively, the bus driver may stop for “flag stops” at a safe location anywhere along a route in a rural area with no designated bus stops. A safe location provides adequate visibility related to bus pull-in and pull-out movements and pedestrian access (for example, a walkable shoulder is available). Flag stops are not recommended in general and are operated at the discretion of the road owner and the transit operator.
3.3 Step 2: How to Determine Placement of Individual Bus Stops?

Having selected the number and location of bus stops along a route, the next step involves deciding far-side, near-side or midblock configuration for individual stops. Subsequently, the physical design of individual stops should be considered in promoting safe and efficient operation for the interaction of transit vehicles, transit passengers and other road users (described in Sections 3.4 and 3.5).

3.3.1 Far-Side, Near-Side and Midblock Configuration

The advantages and disadvantages of the far-side, near-side and midblock configurations are described in this Section.

Far-Side Bus Stop

In general, siting a bus stop on the far-side of an intersection is preferred over the near-side or midblock configuration due to these operational characteristics:

- Buses parked in a far-side position, as opposed to a near-side position, minimize the potential for buses to limit the view of intersection traffic controls (for example, a STOP sign or traffic signal heads) and pedestrians for traffic traveling in the same direction.
- Queues and delays on an approach to a traffic signal or STOP sign, and/or high right-turn traffic volumes on an approach, may potentially cause delays to buses pulling-in and pulling-out of a near-side bus stop.
Advantages of the far-side configuration include:

- Traffic on the curb lane (the right-most travel lane) has minimal interference with buses pulling-in to the bus stop, as opposed to a near-side configuration where bus operation may be affected by delays and queues on the approach to a traffic signal or STOP sign.
- Buses potentially experience reduced delays to re-enter traffic.
- Bus movements would have minimal interference with right-turn vehicles on the near side.
- There is reduced risk of bus passengers stepping in front of the bus to cross the street, as opposed to a near-side configuration.
- The bus stop can also be used by approaching buses from the intersecting street after making a turn onto the street where the stop is located.
- Stopped buses would not obstruct the view of pedestrians that wish to cross the street for other traffic in the same travel direction (pedestrians would be crossing behind rather than in front of the buses).

Disadvantages of the far-side configuration include:

- Reduced through traffic capacity if the volume of boarding and/or alighting is high resulting in long dwell time at the on-line bus stop.
- Increased walking distance to the intersection crosswalk for bus passengers.
- Bus operators have restricted view of passengers approaching from the intersection.
- For a far-side stop sited beyond a channelization island or in an acceleration lane, special consideration should be given to eliminating the potential weaving conflicts between buses approaching the stop area and right-turn traffic from the intersecting street.

This diagram illustrates a potential disadvantage of a far-side bus stop where boarding and alighting activities results in long dwell time at an on-line bus stop. Vehicles traveling on the curb lane (lane closest to the sidewalk) queue behind the bus and need to make a lane change to avoid delays.
Near-Side Bus Stop

Near-side stops may be considered in the context of facilitating passenger transfers between bus stops on two intersecting streets. For example, while a far-side bus stop is provided on a street, a near-side stop may be considered on the intersecting street in the same quadrant as the far-side street bus stop to minimize the need for passengers to cross the intersection (refer to Figure 3.7).

However, there are conditions which make it less ideal for siting a bus-stop on the near-side:

- Traffic queues on the approach are significant to the extent that they will often cause delays to buses pulling-in and pulling-out of the bus stop.
- The curb lane (the right-most lane) does not continue on the far-side of the intersection, where buses are required to merge into traffic after pulling-out of the bus stop.
- The presence of stopped buses limits the view of intersection traffic control for drivers travelling in the same direction. For example, stopped buses may block the view of a STOP sign on an approach and/or pedestrians crossing the road.
- Right-turn traffic volumes on the approach to the intersection are significant, where stopped buses may conflict with right-turn vehicles and weaving manoeuvres occur frequently by the right-turn vehicles.
(a) This diagram illustrates a potential disadvantage of a near-side bus stop where queuing on the approach to an intersection may delay buses from reaching the bus stop.

(b) This diagram illustrates a potential disadvantage of a near-side bus stop where there is high volume of right turn vehicles at an intersection and a bus with high boarding and alighting activities results in long dwell time which forces the right turn traffic to make a lane change to bypass the stopped bus.

Figure 3.5 Examples of Potential Disadvantages of a Near-Side Bus Stop
Advantages of the near-side configuration include:

- Improved passenger transfers between a near-side stop and a far-side stop on the cross street, if these are in the same quadrant.
- Bus operators have a better view of approaching passengers, particularly those from the cross street.

Disadvantages of the near-side configuration include:

- Potential conflicts with vehicles making right turns.
- Stopped bus may obscure STOP signs, traffic signals, or pedestrians crossing in front of the bus.
- Where the bus stop is sited on the near-side (after reviewing and rejecting the potential for siting a far-side stop), conflicts associated with buses pulling-out of the stop and the risk of rear-end collisions related to approaching traffic slowing or stopping for the merging buses may be introduced.

The near-side configuration is preferred over the midblock configuration.

**Midblock Bus Stop**

Midblock bus stops may be considered when physical or environmental conditions prohibit near-side or far-side stops to be provided. They may also be considered on blocks that are relatively long, where passenger demand exists in between adjacent intersections. Where multiple routes are provided on a far-side stop and a long loading area is needed, the far-side stop may be located further away from the intersection and operate more effectively as a midblock stop.

Advantages of the midblock configuration include:

- In general, more space is available on the sidewalk at a midblock location to accommodate waiting passengers, as opposed to near an intersection where the sidewalk may be shared with passengers accessing the intersection crosswalks.
- The stop location can correspond to particular ridership generator(s) in between adjacent intersections.

Disadvantages of the midblock configuration include:

- Jaywalking may be introduced if there is demand to cross the street near the bus stop and a midblock crossing is not provided.
- Limited passenger transfer efficiency if the connecting bus route is provided at the adjacent intersection rather than at the midblock. Walking distance is increased for passengers making transfers.
- If an on-line stop is provided, it will require removal of on-street parking on the curb lane.

Regardless of the bus stop configuration being selected, there are general considerations related to the safe interaction of buses with other traffic, as described in Section 3.4.
3.3.2 Gradient

Bus stops on steep hills are to be discouraged. However, if unavoidable, bus stops should only be placed at the section of the slope with a gradient less than 8% since it is the maximum grade at a bus stop that wheelchair users can manoeuvre manually.

3.3.3 Bus Stop Placement for Transit Signal Priority

A critical consideration in the selection of bus stop configuration is the application of transit signal priority (TSP) which modifies the normal signal operation process to better accommodate transit vehicles. The application of TSP is increasing, especially along busy transit routes, to accomplish various objectives which may include improved schedule adherence, improved transit efficiency, contribution to enhanced transit information and increased road efficiency.

At its simplest form, TSP includes detection of transit vehicle on an intersection approach which communicates with the intersection signal controller to facilitate priority treatments for transit vehicles that include, for example, “green extension” where the signal green phase is extended to ensure buses can clear the intersection without having to stop, and “early green” where the intersecting road traffic signal goes to red as buses are approaching an intersection and when the buses arrive the signal is at green.

The effectiveness of TSP is maximized with the operation of a far-side bus stop, as opposed to a near-side bus stop.

3.3.4 Route Transfer

Consideration should be given to coordinating bus stop placement with passenger transfer movements. As described earlier in Section 3.3.1, a near-side stop may be considered in the context of facilitating passenger transfers between bus stops on two intersecting streets. For example, while a far-side bus stop is provided on a street, a near-side stop may be considered on the intersecting street in the same quadrant as the far-side bus stop to minimize the need for passengers to cross the intersection.

On two-way routes (bus service provided in both travel directions of a roadway), pedestrian connectivity may be enhanced by placing stops across from each other as much as possible. The provision of a signed and marked crosswalk may be considered to enhance guidance and safety for passengers needing to access from one bus stop to another.
The diagram (left) illustrates a preferred scenario where convenience is provided for a passenger transferring from a westbound route to a northbound route without having to cross the intersection at the crosswalk. The diagram (right) illustrates a less ideal situation where the same passenger would have to cross the intersection at the crosswalk in order to make the transfer.

3.4 Step 3: What are the Considerations in Determining the Bus Stop Type?

Curb-side Considerations

The curb-side area around a bus stop needs to be properly designed in order to ensure that bus movements can be as smooth and efficient as possible. The specific considerations are as follows:

- For an on-line bus stop, the curb lane should be regularly maintained to ensure no potholes are present, and gutter and drains should be flush with the road surface.
- In an urban location, the curb should have a minimum height of 150mm (see Figure 3.8).
- There should be no obstructions within a width of 1m along the landing pad.
- The bus stall length should be long enough for the bus to decelerate, stop and accelerate.
- Adequate overhead clearance should be provided to accommodate double-deck buses.
- Bus stop length, including pull-in and pull-out zones, should be clearly delineated (see Figure 3.8).
- BC Transit bus stops are denoted by curb painted in red (see Figure 3.8).
- The door openings of the bus should be as far away as possible from drainage grates and utility covers.
For high volume locations, a bus pad (a concrete slab installed in the pavement of the curb travel lane at the bus stop) may be considered to improve resistance to rutting and petroleum deterioration. Long-term maintenance costs may be reduced. The pad dimension should be consistent with the dimensions of buses operated at the bus stop.

Advantages of this type include:

- Less cost of implementation compared to the bus bulge and bus bay options.

Disadvantages of this type may include:

- Increased risk of collisions associated with vehicles making lane changes to avoid a stopped bus.
- Depending on the configuration (far-side, near-side or midblock), there is potential to reduce visibility of traffic controls and the supply of on-street parking spaces and/or loading areas may be affected.

**Types of Bus Stop**

Bus stop can be either on-line (on the curb travel lane or as a bus bulge) or off-line (off the mainline in a bus bay). The considerations associated with each bus stop type are described below.

**Bus Stop on the Curb Travel Lane**

The most typical bus stop layout is to provide the stop on the curb travel lane of a roadway. This type is considered when:

- Roadway is multi-lane, or the travel lane has adequate width for approaching vehicles to bypass a stopped bus.

**Bus Bulges**

A bus bulge is a widened piece of sidewalk which protrudes into the parking lane on a road. This type is considered when:

- It is desirable to provide high visibility priority for transit along a corridor.
- On-street parking is provided along a corridor.
- A minimum of two travel lanes in the bus travel direction is provided, such that traffic may use the adjacent lane to bypass a bus that occupies the curb lane.

Advantages of this type include:
- High visibility of transit and transit passengers.
- Relatively smooth transition associated with buses pulling-in and pulling-out of the stop, resulting in better rider comfort.
- Larger passenger landing area that creates opportunity to install a larger bus shelter and more amenities when required.

Disadvantages of this type may include:
- Increased risk of collisions associated with vehicles making lane changes to avoid a stopped bus.
- Increased risk of pedestrians crossing at midblock locations, if there is limited guidance that lead passengers from the bus bulge area to the desired crossing location (for example, a nearby intersection or marked crosswalk).

**Bus Bays**

Bus Bays are a short pull-over zone, adjacent to the main travel lanes, where buses can stop and pick up passengers without interfering with the regular flow of traffic. They are considered when:

- The roadway has high traffic volumes
- Where the roadway is a high speed facility, defined as having posted or prevailing speed of 70 kilometres per hour or higher, bus bays should be provided.
- The roadway has a single travel lane in each direction where passing sight distance is not available for vehicles approaching a stopped bus.
- The bus is scheduled to layover at the stop for an extended period of time.
- Bus service frequency is high such that buses occupying the curb lane would impede traffic flow or increase the risks of rear-end and sideswipe collisions associated with approaching vehicles trying to bypass the bus.

Advantages of this type include:
- Clear definition of the bus stop zone.
- Traffic flow on the mainline is better maintained compared to the curb lane bus stop or bus bulge options. This is ideal for roadways with high traffic volumes.

Disadvantages of this type may include:
- Property and other right-of-way acquisition may be needed.
- Reduced bus efficiency as buses are required to pull-off the roadway and re-enter the adjacent travel lane.

*Figure 3.10 Example of a Bus Bulge*
Sharing of a Bus Stop by Multiple Bus Routes

Where multiple buses are anticipated to use a bus stop, numerous loading areas may be required to ensure that there is adequate curb space for simultaneous bus arrivals. The first bus to arrive occupies the first loading area; the second bus occupies the second loading area, and so on.

Other Traffic Safety Considerations

Regardless of the bus stop configuration selected, there are key considerations for maintaining traffic safety associated with the interaction of buses and other traffic:

- Bus driver’s sight distance on the approach to the bus stop and at the bus stop should not be obscured by trees, shrubs, poles or buildings.
- Adequate sight distances are needed for bus pull-in and pull-out movements.
- Stopped buses should not significantly reduce the visibility of traffic controls for other traffic. For example, the visibility of traffic signals and/or pedestrians at an upcoming crosswalk should be maintained.
- If bike lanes exist, sufficient distance should be given for cyclists to slow or stop safely for buses.
- Stops should not be placed on horizontal curves, if possible, as available sight distance can be limited along a curve.
- Stops should be placed away from access driveways, if possible, as bus pull-in and pull-out movements can potentially conflict with traffic movements at the access driveway and stopped buses can reduce the available sight distance of traffic on the road for vehicles exiting the access driveway.

With regards to the access driveway, the placement of a stop on the near or far-side of an access driveway should be examined on a case-by-case basis as it needs to take various factors into consideration, including:

- Turning movement volumes of the driveway
- The distance between subsequent driveways
- The peak usage of the bus stop compared to the peak usage of the access driveway
- The types of buses that use the bus stop
- The available space to accommodate passenger amenities
Photo shows a vehicle entering an access driveway (white arrow) adjacent to a bus stop. When a bus is stopped for loading/unloading activities, it could block the view of pedestrians on the sidewalk for a vehicle that needs to turn into the driveway. When a vehicle needs to exit the driveway, the stopped bus would block the view of traffic on the road.

3.5 Step 4: How to Optimize Physical Design for Safe Passenger Access and Amenities?

After the selection of the bus stop configuration, the physical design should be considered in promoting safe and efficient operation for the interaction of transit vehicles, transit passengers and other road users. The physical design involves various elements:

- Bus stop visibility
- Passenger access
- Passenger amenities
- Universal access

Section 3.6 contains a maintenance checklist for the elements that are involved, including the suggested frequency of on-site checking.

Design that promotes minimal “perceived barriers” by the general public, particularly vulnerable road users (including the young and the elderly) is fundamental to the design of all transit infrastructure. This must be considered in all design elements.

3.5.1 Bus Stop Visibility

The primary tool for communicating to passengers about the bus stop location is by means of placing a bus stop sign. The bus stop sign also alerts the bus driver to where the bus should be stopped. It is BC Transit’s intent to provide a system icon consistently at all bus stop facilities. Examples of existing bus stop signs are presented in Section 7.2.
In general, the bus stop sign should be positioned to avoid conflict with the bus mirror. The sign should be clearly visible to passengers and the driver, and not be obscured by other objects such as streetlights and trees.

### 3.5.2 Passenger Access

Optimal conditions provided for pedestrian access to the bus stop are key in promoting ridership. These conditions can be classified into several areas:

- Physical characteristics of the routes
- Traffic controls along the routes
- Personal security
- Route transfer

**Physical characteristics of the routes used by passengers**

For convenience, the point of origin and destination to and from the bus stop should be as direct as possible. The path may be along public right-of-way (for example, a sidewalk next to a major street) or private right-of-way (for example, a short-cut route through a residential development).

The optimal conditions involve the path being clear of physical obstacles (for example, fences and barriers) and the ground clear of slippery or unstable materials such as mud and water puddles. Where obstacles do exist, they should be marked by warning strips.

In areas with high snowfall, proactive maintenance to prevent snow and ice accumulation on the ground may be required to avoid slippery conditions unsafe for pedestrian access. Other snow removal considerations include: ensuring the bus stop area is free of collected snow and reviewing the potential to adopt working agreements with nearby properties with regards to snow clearing.

Extreme vertical grades and stairs should be avoided, which may make access difficult for all users (able-bodied and in wheelchairs). Where stairs or extreme grades exist, barrier-free alternative routes should be provided. Both lateral and overhead clearance should be adequate to avoid obstructed travel.

*Routes used by passengers should be clear of slippery materials such as mud and water puddles.*

![Figure 3.13 Example of Unsafe Route Conditions](image)

**Traffic controls along the routes used by passengers**

Where passengers are likely required to cross a street to go to and from the bus stop, the provision of a signed and marked crosswalk may be considered, particularly at midblock locations or where crosswalks are currently not marked at the nearby intersection. The marked crosswalk should be connected to a sidewalk to provide a continuous walking path.
Adequate distance should be maintained between the bus stop and the marked crosswalk, such that adequate sight distance is available between approaching drivers and pedestrians on the crosswalk.

**Personal Security**

Aspects of the built environment can be improved to enhance personal security. Crime Prevention through Environmental Design (CPTED) is an approach to planning and design that reduces opportunities for crime. The physical environment can be designed to reduce the risk of crime and nuisance behaviour associated with public spaces.

Well-cared-for transit facilities improve their desirability. Locations that offer natural surveillance by adjacent land use are desired, such as where neighboring houses look on to the facility or commercial businesses open late.

With regards to lighting, adequate lighting that illuminates directly on waiting and surrounding areas is desired. Where lighting can be coordinated with existing street lights and/or lighting for adjacent land uses, coordination should be considered to maximize visibility of the transit facility. Where existing lighting is not available, installation of new lighting or the use of solar power panels with a bus shelter can be considered to ensure visibility at night-time.

Lighting requirements at bus stops should be no less than the lighting design requirements for the adjacent roadway. Lighting is particularly critical in northern areas with relatively few hours of daylight in winter.

To provide a safe waiting environment during night time at rural or remote bus stops, the provision of solar panels with bus shelters is an important consideration to ensure that light can be provided without access to the electricity supply grid.

With regards to landscaping, low shrubbery or canopied trees should be considered as opposed to bushes or evergreen trees that promote hidden areas.

A public phone may be considered to improve sense of safety for transit passengers. Specific considerations include providing a sign to describe the phone location, limiting communication to outgoing calls only, and posting BC Transit Customer Information Line for real-time information. A public phone may also allow immediate access to emergency services should the need arise.

Regular maintenance of the facility area can prevent a “run-down” appearance and the landscaping from overgrowing and allow observation of the environment conditions for signs of unwanted activities.

**3.5.3 Passenger Amenities**

The amenities to be provided for passengers include an adequate waiting and queuing area, as well as shelter and benches where warranted.

It is important that passengers have sufficient room to queue for the bus without blocking other pedestrians or interfering with other sidewalk activities. The passenger zone typically consists of the following:

- A bus stop pole and sign
- Lighting
- A passenger landing pad
- A wheelchair pad and curb letdown

The extent of passenger amenities to be provided at each bus stop also depends on the local context. Typical layouts of the passenger amenities provided in an urban area versus a rural area are illustrated in Figure 3.14.

(Source: BC Transit Design Guidelines for Accessible Bus Stops)

Figure 3.14 Examples of Bus Stop Amenities (Urban and Rural Locations)

Table 3.2 summarizes the type of amenities that are considered mandatory and those that are considered desirable or to be provided where warranted.

**Table 3.2 Bus Stop Amenities**

<table>
<thead>
<tr>
<th>Amenities</th>
<th>Criteria for Provision</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Regular Stop</td>
</tr>
<tr>
<td>Bus stop pole and strip sign</td>
<td>Mandatory</td>
</tr>
<tr>
<td>System icon</td>
<td>Mandatory</td>
</tr>
<tr>
<td>Route/Schedule information holder</td>
<td>Desirable</td>
</tr>
<tr>
<td>Lighting</td>
<td>Desirable</td>
</tr>
<tr>
<td>Passenger landing pad</td>
<td>Mandatory</td>
</tr>
<tr>
<td>Wheelchair pad</td>
<td>Desirable</td>
</tr>
<tr>
<td>Curb letdown</td>
<td>Desirable</td>
</tr>
<tr>
<td>Garbage Receptacles</td>
<td>Desirable</td>
</tr>
<tr>
<td>Seating</td>
<td>Desirable</td>
</tr>
<tr>
<td>Bus shelter</td>
<td>Desirable</td>
</tr>
<tr>
<td>Telephone</td>
<td>If Warranted</td>
</tr>
<tr>
<td>Real-time information</td>
<td>If Warranted</td>
</tr>
<tr>
<td>Bicycle storage</td>
<td>If Warranted</td>
</tr>
</tbody>
</table>
It is desirable for the passenger zone to be made of a slip resistant, impervious and well drained surface.

The passenger zone should be large enough to accommodate users that are either boarding, alighting, or waiting for a different bus (if multiple routes share a common stop). Depending on the width of sidewalk, the passenger zone may be bounded by the adjacent property line or the boulevard before the property line, the curb face, and lateral limits upstream and downstream of the stop marker.

The required space at a passenger zone depends largely on the expected maximum number of waiting passengers at the bus stop. This may be estimated by the on- and off-loading, the volume of transfer passengers and the scheduled bus frequencies at the stop.

**Passenger Landing Pad**

The passenger landing pad is a surface provided at a bus stop for passenger waiting and loading/unloading activity. Passenger landing pads should be connected to sidewalks that lead to the adjacent intersections, wherever feasible. In areas where a sidewalk does not exist, the passenger landing pad should be raised with connecting ramps on each end to the road shoulder.

**Wheelchair Pad**

A wheelchair pad is added to the passenger landing pad at a bus stop for wheelchair accessibility via mechanical ramp or lift that drops from the bus front door. As such, a wheelchair pad should be provided at all bus stops with an international wheelchair symbol.

A clearance zone that extends in both directions of the ramp/lift area is required to ensure safe and efficient manoeuvres by wheelchair users. The clearance zone may be located within or outside of the bus shelter area.

There must be sufficient room to let the ramp down from the bus front door, which accommodates wheelchair access.

*Figure 3.15 Bus Ramp*
Bus Shelter

Bus shelters are partially enclosed waiting areas that protect waiting passengers from exposure to the weather elements and contain information for passenger convenience, such as route maps, and schedule information. BC Transit is embarking on a program to replace and rebrand its existing and future bus stops. Shelters that can be immediately recognized as “BC Transit” are desirable.

The conditions to be considered for the installation of bus shelters are described below.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Bus shelter is more warranted when</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus service</td>
<td>Frequent services are provided and/or there are a number of transfers at a stop, hence more passenger activities.</td>
</tr>
<tr>
<td>Adjacent land use</td>
<td>Shelter can be made compatible with the adjacent land use (for example, a bus stop in a busy commercial area or modal interface with rail, boat or air transit) and space is available for construction such that the shelter can be sited on level ground and without obstructions by trees, utility poles, etc.</td>
</tr>
<tr>
<td>Passenger demographics</td>
<td>There are relatively high percentages of seniors and/or people with physical disabilities using the bus stop.</td>
</tr>
<tr>
<td>Passenger request</td>
<td>The request is supported by the conditions above.</td>
</tr>
</tbody>
</table>

Provision of bus shelter is more warranted when more than one of the above conditions is met.

Shelters should be located and oriented in the following manner:

- Parallel and facing curb
- Bus driver can easily see passengers that are waiting
- Clear from the passenger landing area or pedestrian path
- Clear of steps between the sidewalk/bus pad and the shelter
- Placed to not obstruct sightlines at intersections or driveways

Some municipalities and transit systems have entered into agreements with advertising companies to obtain shelters at no cost in return for the right to display advertising on the shelters. When used, the same placement criteria as described above must be adhered to.

Other Amenities

Potential options for installation with a shelter include:

- Seating
- Bicycle storage facilities
- Lighting
- Real-time information display
- Camera
- Garbage receptacle
- Telephone
- Newspaper vending boxes

Figure 3.16 Example of a Bus Shelter
In all circumstances, amenities should not obstruct pedestrian flow. In addition, they should be designed to avoid pooling of liquids and be vandalism-proof as much as possible, securely installed (fixed to the ground), and regularly maintained.

**Seating**

Typically, seating space inside a shelter is smaller than standing space to accommodate for more standees. Seating may still be desired where the provision of a bus shelter is not practical. For example, the passenger demographics may warrant seating, or where there is evidence of transit passengers sitting or standing on nearby land structures.

The location of benches may be coordinated with nearby trees for shade and protection from wind or rain. The bench material should have resistance to weathering and vandalism.

Benches should be located way from access driveways. They should have sufficient clearance from the passenger landing pad (especially from the bus rear door).

**Bike Storage Facilities**

The provision of proper bicycle storage facilities at bus stops can result in several benefits. While bike racks and bike storage lockers provide organized storage of bikes, innovations such as bike arcs can be visually appealing. Besides the visual benefits, these provisions can prevent unwanted locking of bicycles to other bus facilities and nearby property.

Safe storage of bikes can deter damage and theft of bikes, which is a major concern as bike prices are high. Not only is this convenient for bicyclists using transit, but it may also encourage more transit users to bike.
Bicycle storage facilities should be visible while not obstructing pedestrian movements and not posing as a safety hazard. Similar to bus shelters, bicycle storage must be designed so that it is durable and not easily subject to vandalism and theft. In addition, providing proper lighting and implementing these facilities close to bus stops is important for the convenience and safety of users. Implementation of a bicycle storage facility should depend on passenger demands, which will typically be higher in suburban areas.

A bike rack facility at the Bourquin transit exchange in the City of Abbotsford

Bike rack facilities and bike lockers at the South Surrey Park-and-Ride Facility (operated by TransLink)

Figure 3.18 Examples of Bike Storage Facilities

3.5.4 Universal Access

While accessibility standards have been integrated into the Guidelines, several design criteria must be implemented to allow bus stop facilities to remain accessible to all users, including people with disabilities.

Where a bus stop is wheelchair accessible, the international wheelchair symbol should be provided. The corresponding bus stop in the other direction should also be accessible. Nearby crosswalks with ramps are recommended for all stops to facilitate access by people with wheel devices, including wheelchairs, baby strollers, etc.

The general provisions of an accessible bus stop are as follows:

- Non-slip finishes are provided.
- Street furniture and signage are kept out of the way of pedestrian access and circulation.
- Hazards are eliminated and dangerous areas are marked clearly where they cannot be eliminated.
- Visual and tactile cues are made through colour and texture contrast.
- The area is well lit for orientation and security.
- Waiting passengers are visible to the bus driver

3.6 Step 5: What Needs to be Included in the Maintenance Checklist?

A maintenance checklist was developed for the elements described in the previous sections, as shown in Table 3.3. The intent is to provide personnel with a list of items that require observation and checking on-site to ensure that maintenance is provided as required. It is noted that certain improvements require co-operation by municipal or other agencies as they may be not be owned or operated by BC Transit.

**Table 3.3 Maintenance Checklist**

<table>
<thead>
<tr>
<th>Element</th>
<th>Preferred Condition</th>
<th>Frequency of on-site check required (Typical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access routes used by passengers</td>
<td>No physical obstacles, clear of materials that create slippery surfaces</td>
<td>Once a year, or as requested by passengers</td>
</tr>
<tr>
<td>Signed and marked crosswalk</td>
<td>Conspicuous sign and pavement markings</td>
<td>Part of regular roadway maintenance</td>
</tr>
<tr>
<td>Lighting</td>
<td>In operation, adequate lighting level</td>
<td>Part of regular roadway maintenance</td>
</tr>
<tr>
<td>Landscaping</td>
<td>Low-level shrubbery or canopied trees</td>
<td>6 months</td>
</tr>
<tr>
<td>Bus stop sign</td>
<td>Good visibility, not obscured by streetlights and trees</td>
<td>6 months</td>
</tr>
<tr>
<td>Bus stop pavement marking (red)</td>
<td>Good visibility</td>
<td>Part of regular roadway maintenance</td>
</tr>
<tr>
<td>Bus shelter and bench</td>
<td>Free of vandalism and weathering effects</td>
<td>6 months</td>
</tr>
<tr>
<td>Garbage receptacles</td>
<td>Free of vandalism, free of pooling of liquids</td>
<td>Monthly, or as requested</td>
</tr>
<tr>
<td>Bus schedules and route maps</td>
<td>Free of vandalism</td>
<td>6 months</td>
</tr>
<tr>
<td>Newspaper vending boxes, advertising displays and public phones</td>
<td>Free of vandalism</td>
<td>6 months</td>
</tr>
<tr>
<td>Curb-side</td>
<td>Free of potholes, no drainage issue</td>
<td>6 months</td>
</tr>
<tr>
<td>Bus pad</td>
<td>Free of cracks in concrete</td>
<td>6 months</td>
</tr>
</tbody>
</table>
Chapter 4  |  Bus Operation Specifications

4.1 Introduction

This chapter provides an overview of the current BC Transit bus fleet, including the types of operating buses and their physical characteristics.

4.2 BC Transit Vehicle Fleet

BC Transit currently operates several types of buses ranging from “conventional” 40-foot buses, to mini-buses, to double-decker buses. All of these vehicles vary in dimensions and performance. In order to allow for interoperability between different buses on any given route, infrastructure must be designed to accommodate all bus models that may use it. There is no one single model in the bus fleet that is the most limiting in all cases. BC Transit has provided the dimensions for all vehicle types. They have been summarized on the following page in Table 4.1.
<table>
<thead>
<tr>
<th>Bus Type</th>
<th>Length (front axle to drive axle)</th>
<th>Wheelbase</th>
<th>Overall (front to rear axle)</th>
<th>Mirror Projection</th>
<th>Track Width</th>
<th>Overhanging Length</th>
<th>Overall Length</th>
<th>Overall Width</th>
<th>Overhanging Width</th>
<th>Height</th>
<th>Overall Track Width</th>
<th>Overall Wheelbase</th>
<th>Overall Track Projection</th>
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<tbody>
<tr>
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<td>12,179</td>
<td>6,291</td>
<td>23,198</td>
<td>1,698</td>
<td>2,085</td>
<td>2,031</td>
<td>2,031</td>
<td>2,031</td>
<td>2,031</td>
<td>1,966</td>
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<td>15,672</td>
<td>1,778</td>
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<tr>
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</tr>
<tr>
<td>Alexander Dennis E-500 (Double-decker)</td>
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<td>1,998</td>
<td>2,500</td>
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<td>1,998</td>
<td>2,500</td>
<td>2,500</td>
<td>2,500</td>
</tr>
</tbody>
</table>

All dimensions in millimeters
4.3 BC Transit Design Vehicle

Based on the bus dimensions shown in Table 4.1, two bus models were considered the “design vehicles”. Each vehicle, and the instances in which they should be used as the Design Vehicle, are described below. Table 4.2 summarizes the parameters that were inputted into AutoTurn for each model in order to generate turning templates and to confirm design vehicle requirements. When specific geometric design guidelines are presented in the subsequent chapters, they will explicitly reference which design vehicle is being used. Two other design requirements, which do not require the development of a Design Vehicle, are also listed below.

**New Flyer Hybrid:** This bus is the most limiting in terms of general manoeuvrability. It is the longest bus, and also sweeps out the largest path while turning. This was confirmed through field testing of several different buses in the fleet. It will be used in determining the sizing requirements for transit exchanges and other infrastructure that involves major turning manoeuvres (such as roundabouts). Due to the dynamic nature of these requirements, depending on the layout of the proposed infrastructure, it is advisable that all new facilities of this type that deviate significantly from the samples provided are checked during the design stage.

**Nova Bus:** This bus has the longest front and rear overhangs. As such, it requires the largest clear zones when pulling in/out of a bus stop, in order to make sure it does not come into contact with any objects on the sidewalk (such as bus stop posts or streetlights). It will therefore be used in determining the clearance requirements at curbside bus stops.

**Vertical Clearance:** The tallest bus in the BC Transit fleet is the Alexander Dennis E-500 (both the hybrid and conventional models). These buses require a vertical clearance greater than 4.30m. Naturally, this design requirement only applies to areas where Double-decker buses operate. In all other cases, the clearance requirement is 3.31m, which is based on the New Flyer Hybrid bus.

**Horizontal Clearance:** The Nova bus, at 2,646 mm excluding mirrors, and 3,192 mm including mirrors, is the widest in the fleet. As such, this model defines the minimum horizontal clearance and some shy distance should be allowed.
### Table 4.2 Input Parameters for AutoTurn

<table>
<thead>
<tr>
<th>Specification</th>
<th>New Flyer Hybrid</th>
<th>Nova Bus</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Length</td>
<td>12,701 mm</td>
<td>12,397 mm</td>
<td>Front bumper to rear bumper</td>
</tr>
<tr>
<td>Front Overhang</td>
<td>2,185 mm</td>
<td>2,979 mm</td>
<td>Front wheel axle to front bumper</td>
</tr>
<tr>
<td>Wheelbase</td>
<td>7,544 mm</td>
<td>6,198 mm</td>
<td>Distance between front and rear wheel axles</td>
</tr>
<tr>
<td>Width</td>
<td>2,591 mm</td>
<td>2,646 mm</td>
<td>Bus body width only (i.e. does not account for mirrors)</td>
</tr>
<tr>
<td>Front Track</td>
<td>2,464 mm</td>
<td>2,563 mm</td>
<td>AutoTurn measures to the outside of the tires, rather than the inside. A tire width of 10” was added to each side.</td>
</tr>
<tr>
<td>Rear Track</td>
<td>2,504 mm</td>
<td>2,512 mm</td>
<td>AutoTurn measures to the outside of the tires, rather than the inside. A double-tire width of 21.8” was added to each side.</td>
</tr>
<tr>
<td>Lock-to-lock time</td>
<td>6 seconds</td>
<td>6 seconds</td>
<td>Standard Assumed Value</td>
</tr>
<tr>
<td>Curb-to-curb Turning Radius</td>
<td>13,400 mm</td>
<td>13,400 mm</td>
<td>Given by BC Transit. Curb-to-curb represents the turning radius of the “outer tire”.</td>
</tr>
<tr>
<td>Steering Lock Angle</td>
<td>37.5°</td>
<td>30.3°</td>
<td>Calculated Value Based on other input parameters</td>
</tr>
</tbody>
</table>

Turning templates of the two BC Transit Bus Models can be found in Appendix C. The Alexander Dennis E-500 is not as critical as the New Flyer and Nova buses in terms of horizontal swept paths. As such, only the New Flyer and Nova buses were selected as the “Design Vehicles” and included in Appendix C.

An articulated bus is not currently operated by BC Transit. While it is longer than the Hybrid bus, it is in fact more manoeuvrable due to the “accordion” in the middle. For design dimensions related to the articulated bus, users of this document are advised to refer to the TransLink Infrastructure Design Guidelines.

The specific design requirements of HandyDART/Minibus type vehicles are not presented in the Guidelines as most facilities that accommodate the design vehicle would be sufficient for the operation of these vehicles. However, for stops where Handy Dart is regularly used, there needs to be a curb letdown nearby since wheel chairs are discharged at the rear rather than the side.
### 4.4 Vehicle Performance

Buses generally have lower acceleration and deceleration rates compared to passenger vehicles. The acceleration and deceleration rates of transit vehicles should be taken into consideration in the design of public road and transit facilities for passenger comfort and safety. This is further discussed in Sections 5.2 and 5.3.

The Canadian Transit Handbook (Canadian Urban Transit Association and Transportation Association of Canada) suggests the desirable rates as shown in Table 4.3. The maximum deceleration rate for emergency situations should only be considered for extreme conditions, such as to avoid a collision.

<table>
<thead>
<tr>
<th>Maximum Rate</th>
<th>Standard Bus (m/s²)</th>
<th>Articulated Bus (m/s²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceleration</td>
<td>0.9</td>
<td>0.7 - 0.9</td>
</tr>
<tr>
<td>Deceleration (normal service)</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Deceleration (emergency condition)</td>
<td>2.7</td>
<td>2.7</td>
</tr>
</tbody>
</table>

### 4.5 Bicycle Racks

It should be noted that the bus turning templates as shown in Appendix C did not take into account the extra length for the bicycle rack as the width of a typical bicycle rack is less than the full width of the bus. As such, adding the extra length onto the template would be overly conservative. However, for on route buses where bicycle racks are used, there needs to be enough room at stops to accommodate the required clearance between buses and to provide access to the rack for loading and unloading. The required clearance between buses equipped with bicycle racks should be 2.5m from the front of the bus to the rear of the next bus to accommodate loading and unloading.
4.6 Visibility Impairment Zones

This section will discuss the impact of operator's visibility impairment zones on the design of transit facilities. It is important to realize that the operators have limited visibility to the side and to the rear of the vehicle and as such some bus movements should be avoided.

Diagrams from the TransLink guidelines are shown below.
4.7 Pavement Widening Values on Curves for Buses

Pavement widening beyond standard widths should be considered when buses are the largest design vehicle for an undivided roadway. A safety hazard may result if the buses fail to slow down significantly to avoid encroaching onto the adjacent travel lanes, etc. The general design principles proposed in the TAC Guidelines, Section 2.1.2.5 should be followed.

4.8 Lateral Sweep of Articulated Bus

BC Transit does not operate articulated buses at the time when this document was prepared. It is noted that the design dimensions of the articulated bus can be found in the TransLink Transit Infrastructure Design Guidelines.
Chapter 5  Roadway Geometric Design

5.1 Introduction

While road design should be prepared in accordance with relevant national, provincial and local standards, considerations for transit operations should be taken into account particularly when a roadway is frequently used by transit vehicles. BC Ministry of Transportation and Infrastructure suggests that specific geometric factors should be considered in the design of a facility where buses represent greater than 7% of the traffic stream.

The incorporation of transit operations criteria will ensure that public safety and transit efficiency can be maintained.

This chapter provides an overview of the specific geometric requirements for transit operations, based on the current BC Transit bus fleet. The design vehicle is the hybrid bus vehicle. Design that meets the requirements by the hybrid bus vehicle will accommodate all other BC transit bus types. The only exception is in the design of vertical clearance where the double-deck bus would govern on roadways or in facilities where this bus type is expected to operate.

Section 5.2 provides a series of diagrams, with associated explanations, on preferred geometric design related to bus operations on public road facilities.

Section 5.3 provides a series of diagrams illustrating design dimensions of bus stop facilities.

5.2 Public Road Facilities

5.2.1 Lane Widths

The widest bus in the BC Transit fleet, the Nova Bus, has a total width of 3,192mm, including mirror protrusions. As such, lane widths must be at least this wide without the bus encroaching into adjacent travel lanes.

The Geometric Design Guide for Canadian Roads (Transportation Association of Canada) provides suggested lane widths for different land uses and road classifications in Section 2.2.2.1. While the suggested lane widths are generally adequate for bus vehicles traveling on a multi-lane roadway, the desired minimum lane width is 3.3m.

Particularly in urban areas, the curb lane may be a shared travel/parking lane. Bus operators must decelerate from the posted or prevailing speed and pass parked vehicles at a comfortable distance while pulling into a bus stop. According to TransLink guidelines, the desirable lane width for a shared travel/parking lane ranges from 5.8 to 6.2m.

A field test was conducted to confirm the width requirement for a bus passing a parked vehicle. The BC Transit Safety Training Officer indicated that bus operators will always slow down to approximately 30 kilometres per hour when passing a parked wide vehicle. This is to reduce likelihood and severity of any bus-pedestrian collisions that may result from a pedestrian entering the street from in front of the parked vehicle.
vehicle. Furthermore, buses will typically pull up to the curb in a slightly angled manner, with the front bumper being a lateral distance of 180mm from the curb, and the rear bumper being a lateral distance of 360mm from the curb.

Based on the field test, the BC Transit suggestion is to provide a 6.5m width where an on-street bus layover is provided to maintain a comfortable distance between the layover bus and a bus (the design vehicle) passing by. The width of 6.5m should also be provided where a single lane is provided and a bus is expected to pass parked vehicles, in order to maintain safe distance from the opposing traffic.

Where a single lane is provided and approaching vehicles are required to wait behind a stopped bus without changing lanes, the lane width should be restricted to no more than 4.8m to avoid drivers from perceiving that a lane change can be made.

Figure 5.1 on the following page shows all these different scenarios.
Figure 5.1 Lane Widths
Other TAC guidelines that are relevant for transit include the following:

- Section 2.2.2.1 suggests that for transit lanes, the lane width should be the same as the adjacent travel lane, or 0.2m less, but the width should be no less than 3.5m.
- Lane widening on roads with a horizontal curve is outlined in Section 2.1.2.5 which may need to be considered where buses operate to minimize the potential for buses to encroach into the opposing travel lane.

The width of shared lanes with bikes is provided in the TAC Guidelines Table 3.4.6.2 according to expected average annual daily traffic in the shared lane, with recommended widths ranging from 4.0m to 4.8m. The BC Transit suggested shared lane width (bike with bus or other high occupancy vehicle in the same lane) is a minimum of 4.5m.

5.2.2 Traffic Circle / Roundabout

For circulatory roadways (around a traffic circle or a roundabout), the left turn movement is usually the critical path for determining the roadway width. The New Flyer Hybrid vehicle requires a lane width of 7.7m for an inner circle diameter of 12m, which is the minimum inner turning diameter. The field test conducted further confirmed the required travel width and circle diameter for the design vehicle to negotiate right turn, through and left turn movements. As a general rule of thumb, the design parameters of circulatory roadways along a bus route are as follows:

- Inner circle must accommodate the bus sweep path by the inner wheels, with diameter no less than 12m
- For a bus to go through or make a right turn, the outer circle diameter must be no less than 26m and the available travel width of no less than 6.9m
- For a bus to make a left or 360° turn, the outer circle diameter must be no less than 28m and the available travel width of no less than 7.7m

5.2.3 Intersections

The specific design considerations related to turning movements by buses are summarized in Table 5.1.

<table>
<thead>
<tr>
<th>Table 5.1 Design Considerations for Bus Turning Movements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entry Lane</strong></td>
</tr>
<tr>
<td>Left Turn</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Right Turn</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
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<td></td>
</tr>
</tbody>
</table>
Figures 5.2 and 5.3 illustrate the vehicle paths of the TransLink hybrid bus vehicle making typical left- and right-turning movements at an intersection. The dimensions shown will keep the bus within its own right-of-way while completing the turns, without encroaching into other travel lanes.

The suggested dimensions are to be considered against site-specific conditions. Often there will be tradeoffs between right-of-ways and other limits in the physical environment, provisions for various traffic modes, etc, but nonetheless safety should be the foremost consideration. Where frequency of bus turning movements is relatively high, it is desirable for the design to meet or exceed the suggested dimensions.

**One Receiving Lane**

(Source: TransLink Transit Infrastructure Design Guidelines)

Figure 5.2 Bus Turning Left at Intersection

**Two Receiving Lane**

(Source: TransLink Transit Infrastructure Design Guidelines)

Figure 5.2 Bus Turning Left at Intersection
One Entry Lane

![Diagram of a bus turning right at an intersection with one entry lane.]

<table>
<thead>
<tr>
<th>Receiving Lane Width</th>
<th>Corner Radius</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0m</td>
<td>15.9m</td>
</tr>
<tr>
<td>5.4m</td>
<td>13.0m</td>
</tr>
<tr>
<td>5.8m</td>
<td>11.5m</td>
</tr>
<tr>
<td>6.2m</td>
<td>9.9m</td>
</tr>
<tr>
<td>6.6m</td>
<td>8.9m</td>
</tr>
<tr>
<td>7.2m</td>
<td>8.0m</td>
</tr>
</tbody>
</table>

Two Entry Lane

![Diagram of a bus turning right at an intersection with two entry lanes.]

<table>
<thead>
<tr>
<th>Receiving Lane Width, W2</th>
<th>Minimum Corner Radius, R</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0m</td>
<td>17.7m</td>
</tr>
<tr>
<td>5.4m</td>
<td>14.6m</td>
</tr>
<tr>
<td>5.6m</td>
<td>12.8m</td>
</tr>
<tr>
<td>6.2m</td>
<td>12.0m</td>
</tr>
<tr>
<td>6.8m</td>
<td>11.7m</td>
</tr>
<tr>
<td>7.2m</td>
<td>10.9m</td>
</tr>
</tbody>
</table>

Note:
1. Corner radius may be interpolated between values shown.
2. Actual corner radius should be larger than minimum from table.

(Source: TransLink Transit Infrastructure Design Guidelines)

Figure 5.3 Bus Turning Right at Intersection
5.2.4 Road Alignment

In general, road alignment elements should be designed in accordance with the TAC Guidelines and other relevant jurisdiction standards. Given the lower acceleration and deceleration capacities of bus vehicles, the use of minimum geometric design standards should be avoided, wherever possible. This would ensure that a satisfactory level of bus performance and passenger comfort is achieved.

5.2.5 Horizontal and Vertical Clearance

Where buses represent greater than 7% of the traffic stream, BC Ministry of Transportation and Infrastructure suggests that at least 0.6m lateral clearance should be provided to adjacent traffic barriers along exclusive bus lanes or lanes heavily used by buses. The desired lateral clearance is 1.2m. The minimum lateral clearance should be provided except for temporary conditions such as during construction or rehabilitation work on the roadway facility.

The vertical clearance provided is governed by the tallest vehicle anticipated to operate on a facility. Therefore, the vertical clearance needs to accommodate the double-deck bus where they are expected to operate.

5.2.6 Maximum Gradient

According to the TAC guidelines, the gradient for roadways with design speed of 50 kilometres per hour or lower ranges from 7 to 12%. The maximum gradient for roadways with design speed of 100 kilometres per hour is 5%. Accordingly, the maximum gradient of roadways with design speeds in-between these ranges will be 5% to 12%.

Where bus traffic constitutes greater than 7% of the traffic stream, BC Ministry of Transportation and Infrastructure suggests that the maximum grades should not exceed 10%, with a preferred maximum grade of 6%.

Based on the above, the suggested maximum gradient for roadways designed for buses is 12%, but the BC Ministry of Transportation and Infrastructure guidance should be followed where bus traffic constitutes greater than 7% of the traffic stream.

TransLink guidelines suggest that for sustained gradients longer than 800 m, the maximum grade is preferably no more than 8%. The BC Transit guidelines concur with this requirement.

5.2.7 Grade Change Points Without Vertical Curves

On roadway alignment with changes in road grades where no vertical curve is provided, the transition at the grade change point should be no more than the permissible breakover, approach and departure angles of the Transit Design Vehicle. The provision of appropriate grade change points will prevent the underside or the front/rear bumpers of the bus from contacting the pavement. Maximum changes in road grades at break-over, approach and departure points for low-floor Standard and Articulated Buses are shown in Table 5.2. These are absolute maximum values, which should not be exceeded in any road design.
### Table 5.2 Maximum Changes in Road Grades for Low-Floor Buses

<table>
<thead>
<tr>
<th>Type</th>
<th>Breakover Between 1st and 2nd Axle</th>
<th>Breakover Between 2nd and 3rd Axle</th>
<th>Approach Between Front Bumper and 1st Axle</th>
<th>Departure Between Rear Axle and Rear Bumper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-Floor Standard Bus</td>
<td>14.6%</td>
<td>-</td>
<td>15.8%</td>
<td>15.8%</td>
</tr>
<tr>
<td>Low-Floor Articulated Bus</td>
<td>18.5%</td>
<td>14.0%</td>
<td>15.8%</td>
<td>15.8%</td>
</tr>
</tbody>
</table>

![Image of bus with grade changes](image-url)

(i) Breakover Angle

Maximum Grade Change (14.6%)

(ii) Approach Angle

Maximum Grade Change (15.8%)

(iii) Departure Angle

Maximum Grade Change (15.8%)

Figure 5.4 Grade Change Points for Design Vehicle
5.2.8 Sight Distances

The TAC Guidelines provide sight distance requirements generally for automobiles and trucks. As the acceleration and deceleration capability of transit buses is different from other vehicles, and there is a need to maintain a high level of passenger comfort and safety wherever possible, sight distance requirements specifically for transit buses are provided in this Section to assist in the design of roadways for bus operation.

Stopping Sight Distance

The minimum sight distance criterion for transit buses (and other vehicles) approaching an intersection or travelling along a roadway is the ‘Stopping Sight Distance’. The minimum Stopping Sight Distance for transit buses is the sum of (i) the perception and reaction distance and (ii) the braking distance:

- **Perception and Reaction Distance** is the distance travelled at the operating speed (or posted speed limit) during the operator’s perception of an incident and the subsequent brake reaction time. This corresponds to the time elapsed from the instant an object for which the bus operator decides to stop comes into view, to the instant the operator contacts the brake pedal. Perception and reaction time is typically taken to be 2.5 seconds for design purposes.

- **Braking Distance** is the distance travelled from the time that braking begins to the time the transit bus comes to a stop. The minimum braking distance for transit buses may be calculated from the bus deceleration rates indicated in Section 4.4. The maximum deceleration rate for Standard and Articulated Buses in Service Conditions is 1.1 m/s²; this rate is for normal operations where reasonable passenger comfort and safety is maintained. In Emergency Conditions, such as collision avoidance, the maximum deceleration rate for transit buses is 2.7 m/s².

The following Table 5.3 gives the minimum Stopping Sight Distance for transit buses in Service and Emergency Stopping Conditions.

*Table 5.3 Transit Bus Stopping Sight Distance*

<table>
<thead>
<tr>
<th>Initial Operating Speed (km/h)</th>
<th>Perception and Reaction Time (sec)</th>
<th>Service conditions</th>
<th>Emergency Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Perception and Reaction Distance (m)</td>
<td>Brake Distance (m)</td>
<td>Minimum Stopping Sight Distance (m)</td>
</tr>
<tr>
<td>40</td>
<td>2.5</td>
<td>28</td>
<td>56</td>
</tr>
<tr>
<td>50</td>
<td>2.5</td>
<td>35</td>
<td>88</td>
</tr>
<tr>
<td>60</td>
<td>2.5</td>
<td>42</td>
<td>126</td>
</tr>
<tr>
<td>70</td>
<td>2.5</td>
<td>49</td>
<td>172</td>
</tr>
<tr>
<td>80</td>
<td>2.5</td>
<td>56</td>
<td>225</td>
</tr>
<tr>
<td>90</td>
<td>2.5</td>
<td>63</td>
<td>284</td>
</tr>
</tbody>
</table>
To maintain reasonable passenger comfort and safety during deceleration, the minimum Stopping Sight Distance for Service Conditions should be provided whenever possible. Higher deceleration rates (such as the emergency deceleration rate) should only be used if and when the operator is in an extreme situation, and should not be used for design purposes.

**Decision Sight Distance**

In the relatively complex situations that bus operators and other vehicle drivers often encounter, evasive manoeuvres may be required. Situations can arise that require longer perception and reaction times and more complex operator’s action than a straightforward decision to stop. In these circumstances, it is desirable to provide ‘Decision Sight Distance’, a longer measure than the Stopping Sight Distance. As recommended in the TAC Guidelines, Section 2.3.4, ‘Decision Sight Distance’ allows for a greater margin of error in reacting to unexpected circumstances and enhances safety in such complex situations.

Table 1.2.5.6 of the TAC Guidelines provides the recommended Decision Sight Distance for a range of design speeds, depending on the type of manoeuvre. Further research may be required to determine the Decision Sight Distance applicable to transit buses, particularly due to the fact that the height of the bus operator’s eye (1.80 m) is substantially higher than that of a passenger car driver (1.05 m) and the deceleration and acceleration rates of buses are significantly lower than those of a passenger car. The provision of Decision Sight Distance is desirable wherever feasible. If it is not possible to provide the Decision Sight Distance because of horizontal and/or vertical curvature, special attention should be given to the use of traffic control devices for providing advance warning of the conditions to be encountered. Figure 5.5 illustrates the requirements of Stopping and Decision Sight Distances as per the TAC Guidelines together with the specific Stopping Sight Distance for transit buses in Service and Emergency Conditions.
Figure 5.5 Stopping and Decision Sight Distances

(Source: Adapted from TAC Geometric Design Guide for Canadian Roads)

Figure 5.5 Stopping and Decision Sight Distances
Crossing Sight Distance

The required sight distance for transit buses to make a crossing manoeuvre from a stop control is a function of the time it takes for a stopped bus to clear the intersection and the distance that another vehicle would travel along the major roadway at the design speed during the same period of time. The required crossing time depends upon the perception and reaction time of the bus operator, the bus acceleration time, the width of the major roadway, the length of the bus, and the speed of the approaching vehicle on the major roadway.

Figure 5.6 illustrates the distance travelled by a transit bus during the acceleration time. The minimum Crossing Sight Distance along the major roadway from an intersection can be calculated, as shown in Figure 5.7, based on (i) the design speed of the major roadway, $V$, (ii) the perception and reaction time of the crossing driver on the major roadway, $j$, and (iii) the acceleration time for the bus to cross the major roadway, $t$.

Sight triangles are used, for example, to determine building setbacks at intersections or to determine whether existing obstructions such as parking zones, advertising signs, trees, etc., are to be removed or relocated. The required ‘sight triangle’ at the intersection for the crossing manoeuvre depends on the minimum Crossing Sight Distance for the bus on the stop approach and the approaching vehicle on the major roadway.
Figure 5.6 Acceleration Time for Stopped Bus

(Source: Adapted from TAC Geometric Design Guide for Canadian Roads)

Figure 5.6 Acceleration Time for Stopped Bus
Turning Sight Distance

A vehicle approaching from the right of a left-turning bus, at the instant the turning manoeuvre begins, should be sufficiently far away so that the turning bus can accelerate to a speed which does not significantly interfere with the approaching vehicle. To determine the required ‘Turning Sight Distance’, it is assumed (as per the TAC Guidelines) that (i) the approaching vehicle will slow to a speed of 85% of the design speed at the intersection, and (ii) there should be always a gap of at least 2 seconds between the turning bus and the approaching vehicle. Due to the acceleration characteristics of transit buses, the requirement for transit buses making right or left turns is generally greater than other vehicles.

Figure 5.8 shows the Turning Sight Distance requirements for transit buses from a stop control on a minor road. An average acceleration rate of 0.9 m/s² for transit buses (instead of 1.9 m/s² used for passenger cars) is assumed for both left and right turning movements.
Figure 5.8 Turning Sight Distance for Stopped Buses

Note:
(1) Sight distance to a vehicle approaching from the right for a passenger car (or bus) turning left, or for a passenger car (or bus) turning right to a vehicle approaching from the left.

(Source: Adapted from TAC Geometric Design Guide for Canadian Roads)

Figure 5.8 Turning Sight Distance for Stopped Buses
**Merging Sight Distance**

A bus merging back onto the adjacent travel lane from a bus stop should have the required ‘Merging Sight Distance’ for the vehicle approaching from behind. It is assumed that the approaching vehicle driver would not perceive the movement of the bus until the latter is set into motion. Once perceived, the driver of the approaching vehicle would apply the brake to a complete stop, if necessary, to avoid contacting the bus.

The minimum Merging Sight Distance for a transit bus to merge onto the adjacent travel lane is the sum of (i) the minimum Stopping Sight Distance of the approaching vehicle in the travel lane, (ii) the distance travelled by the same approaching vehicle at the design speed during the 2.5 seconds of perception and reaction time required by the bus operator, and (iii) the length of the bus. The minimum Merging Sight Distance for transit buses may be used to determine the location of bus stops and other transit facilities, especially on roadways with horizontal curvature and other obstructions such as buildings and trees.

Figure 5.9 illustrates the minimum Merging Sight Distance for transit buses when leaving a bus stop for a range of vehicle speeds on a through traffic roadway.

![Merging Sight Distance Diagram](image)

**Figure 5.9 Merging Sight Distance for Stopped Buses**

<table>
<thead>
<tr>
<th>Design Speed (km/h)</th>
<th>S.S.D. (m)</th>
<th>V (m)</th>
<th>L* (m)</th>
<th>M.S.D. (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>45</td>
<td>30</td>
<td>12</td>
<td>87</td>
</tr>
<tr>
<td>60</td>
<td>66</td>
<td>35</td>
<td>12</td>
<td>112</td>
</tr>
<tr>
<td>60</td>
<td>85</td>
<td>40</td>
<td>12</td>
<td>137</td>
</tr>
<tr>
<td>70</td>
<td>110</td>
<td>50</td>
<td>12</td>
<td>172</td>
</tr>
<tr>
<td>80</td>
<td>140</td>
<td>55</td>
<td>12</td>
<td>207</td>
</tr>
<tr>
<td>90</td>
<td>170</td>
<td>60</td>
<td>12</td>
<td>242</td>
</tr>
</tbody>
</table>

*Note: *Assume Standard Bus

Source: Adapted from TAC Geometric Design Guide for Canadian Roads
5.2.9 Pedestrian Sight Lines

As noted in Section 4.6, there are visibility impairment zones, or blind spots, on both sides of the bus where the operator cannot see pedestrians. Pedestrians boarding or alighting from transit buses, as well as other pedestrians walking near bus facilities, may be unaware of the restricted visibility of the bus operators.

Adequate pedestrian sight lines should be provided for bus operators wherever there is any potential conflict between buses and pedestrians. This is particularly critical for the right-turning bus movement at an intersection, within a transit exchange, or where a merging movement to the right has to be made within a short distance.

5.2.10 Traffic Calming Measures

Traffic calming measures are often installed in residential neighborhoods to reduce vehicle speeds and volume, among other reasons which may include:

- Reducing truck traffic
- Discouraging through traffic
- Improving safety for non-motorized users (pedestrians and cyclists)
- Reducing collisions
- Reducing noise and air pollution

Most traffic calming measures are in the form of physical measures such as traffic circles, speed humps, curb extensions, raised crosswalks, and diverter. In general, physical traffic calming measures should be avoided on bus routes; however, if these measures are to be installed along bus routes, special design considerations must be given to accommodate the physical dimensions required by bus operation and bus vehicle operational capabilities.
Table 5.4 below describes the impacts that the traffic calming measures may have on passenger safety and bus operational efficiency.

**Table 5.4 Impact of Traffic Calming Measures**

<table>
<thead>
<tr>
<th>Traffic calming measure</th>
<th>Impact on passenger safety</th>
<th>Impact on bus operational efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic circle</td>
<td>No adverse impact, but avoid a series of traffic circles to minimize side-to-side movement</td>
<td>The circulatory roadway width that provides traffic calming for passenger vehicles may result in buses having difficulty going through the traffic circle</td>
</tr>
<tr>
<td>Speed hump</td>
<td>Shorter ramps result in greater passenger discomfort, A speed hump should not be installed immediately before or after a bus stop for passenger safety</td>
<td>Buses need to reduce speeds significantly to travel over a speed hump, May cause damage to the suspension of the bus vehicle, A series of speed humps should be avoided along a bus route</td>
</tr>
<tr>
<td>Curb extensions</td>
<td>No adverse impact</td>
<td>The corner radii may impact bus right-turning movement</td>
</tr>
<tr>
<td>Raised intersection</td>
<td>A raised intersection should not be installed immediately before or after a bus stop for passenger safety</td>
<td>A series of raised intersections should be avoided along a bus route</td>
</tr>
<tr>
<td>Diverter</td>
<td>No adverse impact</td>
<td>Room must accommodate bus manoeuvre, and without obstruction by parked vehicles</td>
</tr>
</tbody>
</table>
5.3 Bus Stop Facilities

This Section provides a series of diagrams illustrating design dimensions of bus stop facilities; the requirements for which are based on the Nova Bus.

5.3.1 Curbside Clearance Zone

The placement of the bus stop sign is very important to the overall operation as it signals to the driver where to safely stop the bus and provides a consistent message to transit passengers with regards to where to wait for a bus. The bus stop sign is typically installed adjacent to the right front bumper where the bus would come to a full stop. However, there should be a minimum of 0.30m from the face of the curb, in order to avoid conflict between the sign post and the bus. Note that this Clearance Zone requirement applies not only to bus stops, but to all curbside facilities (such as newspaper boxes). The rationale behind this 0.30m requirement is based on the following two considerations:

Curbside Sweep

The Nova Bus has the longest front and rear overhangs of any bus in the BC Transit fleet. As such, it will have the greatest sweep as it pulls out of a bus stop. At the extreme, the Nova Bus sweeps an additional 0.40m from its at-rest position. However, if a 0.18m clearance between the curb and the bus wheel is assumed, this results in a 0.22m curbside sweep. This is shown in Figure 5.10. Allowing for the 0.18m clearance is considered to err on the side of caution, as generally, according to the Safety Training Officer, the rear of the buses will more typically be 0.36m away from the curb face.

A clear zone prevents pedestrians from becoming “pinched” between the rear of the bus and structures such as a tree or power pole. Since the curb side sweep is 0.22m, an additional clearance of at least 0.5m is recommended. A clear zone of 0.75m is therefore suggested and is shown in Figure 5.10.
**Mirror Protrusion**

The right mirror protrudes 254mm from the edge of the Nova Bus. It is acceptable for this mirror to protrude over the sidewalk as it pulls into a stop, provided there is no object that it could collide with. Clearance should be allowed for the worst case where the front of the bus pulls up immediately adjacent to the curb, rather than allowing for the more typical gap of 180mm.

Based on the above considerations, the mirror protrusion is the governing factor for the front half of the bus, while curb sweep/pinch points are predominant factors for the rear half.

---

**5.3.2 Concrete Bus Pads**

Buses, being heavy vehicles, are prone to cause deformation in asphalt pavement, especially in locations where they start, stop or turn. Bus stops, in particular, are susceptible these types of pavement damage. In order to minimize pavement wear, a concrete bus pad should be considered for all high bus volume locations. Although concrete bus pads are more expensive to construct than normal asphalt paving, they will reduce long term maintenance costs and aid in the retention of roadway surface shape, drainage and skid resistance.

Concrete bus pads should be a minimum of 3m wide, stretching across the entire lane or bay over which a bus would stop. They should be long enough to cover the entire wheelbase of a bus. For a single bus, this would be approximately 15m. In the case of a multi-stop bay, the concrete area should span from the front wheel of the first bus to the rear wheel of the last bus, including pull-in/pull-out zones.

In terms of pavement structure, the concrete bus pad thicknesses should be designed as follows:

- Portland Cement Concrete: 225mm
- Base Course: 150mm
- Sub base Course: 300mm
5.3.3 Far-side, Near-side and Midblock Configuration

**Far-side bus stop**

The suggested dimensions are based on a cross section of 15m on the roadway which the bus is approaching from on the left and right turns, and the receiving lane width of 3.7m.

![Diagram of Far-Side Bus Stop Configuration](image)

<table>
<thead>
<tr>
<th>Approach Movement</th>
<th>X (minimum)</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td>15.9m</td>
<td>Field tested by BC Transit</td>
</tr>
<tr>
<td>Through</td>
<td>6m</td>
<td>Suggested by TransLink</td>
</tr>
<tr>
<td>Right</td>
<td>12.3m</td>
<td>Field tested by BC Transit</td>
</tr>
</tbody>
</table>

*Figure 5.11 Far-Side Bus Stop Configuration*

As mentioned in Section 3.3.1, if a far-side stop has to be sited beyond a channelization island or in an acceleration lane, special consideration should be given to eliminate potential weaving conflicts between buses approaching the stop area and right-turn traffic from the cross street. Site-specific review will be required to determine the appropriate bus stop location that will minimize traffic conflicts and maintain reasonable walking distance for passengers going to and from the bus stop.
5.3.4 Other Bus Stop Configurations

Bus bay

It is noted that on a typical urban arterial road, operators slow down from the posted speed to about 30 km/h when entering and exiting a bus bay. On exit, bus operators typically accelerate after they have merged back into an adjacent travel lane, rather than accelerating along the taper of the bus bay.

It is suggested that TransLink guidelines be followed in the design of a typical bus bay sited on the far-side, near-side and midblock in an urban environment. The dimensions for the TransLink “Standard Bus” were found to be adequate for the BC Transit design vehicle.
**Bus Bay Type I**
(Corner) - Far-side

(i) Standard (Open-end)
Speed Limit ≤ 50 km/h

(ii) Full Bay (With Heavy Right Turn Volume)
(Also applies at Mid-Block Locations)
Speed Limit ≤ 50 km/h

* Dimensions are measured from property line

**Bus Bay Type I**
(Corner) - Near-side

**Bus Bay Type II**
(Mid-block)
In a highway environment, BC Transit adopts the BC Ministry of Transportation and Infrastructure guidelines on pullouts for bus bay design.
For bus bay design, maintenance would be made easier if the transition was a curve rather than a point between the taper and the bay area (note: the TransLink Design Guidelines diagrams above show a point). BC Transit bus bays should provide a curve in the transition area (please refer to Figure 6.4).

Note: Minimum Pullout width is 4.0 m. This is a shoulder widening. Parking should be prohibited in the pullout area. The minimum width is to avoid pavement degradation by off-tracking or wide vehicles. Pavement design should be as per travel lanes.

<table>
<thead>
<tr>
<th>Reference Speed km/h</th>
<th>T1 m and (Ratio)</th>
<th>Minimum PL (m)</th>
<th>Desirable PL (m)</th>
<th>Maximum PL (m)</th>
<th>T2 m and Ratio (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>30 (7.5:1)</td>
<td>30</td>
<td>70</td>
<td>200</td>
<td>30 (7.5:1)</td>
</tr>
<tr>
<td>60</td>
<td>40 (10:1)</td>
<td>45</td>
<td>120</td>
<td>300</td>
<td>40 (10:1)</td>
</tr>
<tr>
<td>70</td>
<td>50 (12.5:1)</td>
<td>65</td>
<td>190</td>
<td>500</td>
<td>50 (12.5:1)</td>
</tr>
<tr>
<td>80</td>
<td>60 (15:1)</td>
<td>85</td>
<td>270</td>
<td>600</td>
<td>60 (15:1)</td>
</tr>
</tbody>
</table>

Note: Use the ratio if Pullout width is other than 4.0 m. Maximum width is 4.0 m. This is a shoulder widening. The minimum width is to avoid pavement degradation by off-tracking or wide vehicles. Pavement design should be as per travel lanes.

(Source: BC MoT Supplement to TAC Geometric Design Guide)

Figure 5.15 Typical Pullout Lengths (Provincial)
Bus bulge

It is suggested that the TransLink guidelines be followed in the design of typical bus bulge.

Field Observations

<table>
<thead>
<tr>
<th>Width of Curb Lane</th>
<th>Distance Between Bus ID and End of Parked Car L (m)</th>
<th>Depth of Bus Bulge D (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5</td>
<td>3.0</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td>7.0</td>
<td>2.3</td>
</tr>
<tr>
<td>5.6</td>
<td>5.0</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>7.0</td>
<td>1.9</td>
</tr>
<tr>
<td>5.7</td>
<td>5.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>7.0</td>
<td>1.9</td>
</tr>
</tbody>
</table>

(Source: TransLink Transit Infrastructure Design Guidelines 2003 Figure 3.4.3)

Figure 5.16 Bus Bulge Configuration
Bus stop between access driveways

![Diagram of bus stop between access driveways]

Figure 5.17 Configuration of Bus Stop Between Access Driveways

Bus stop in bike lanes

The minimum design requirements for a bus stop located adjacent to a bike lane are presented below. The dimensions are taken from the TransLink Transit Infrastructure Design Guidelines.

The key design considerations for the design of bus stops where a bike lane is present are as follows:

- On roadways with posted speed of 60 km/h or higher, a bus bay needs to be located 4m further downstream than for a normal bus bay.

- On roadways with posted speed less than 60 km/h, a longer bus pull-in distance should be provided for a midblock bus stop. The bus zone (marked by the Bus Zone sign) needs to be extended to at least 34m upstream. The location of far-side and near-side stops remains the same as in the situation of no bike lane (as shown in Section 5.3.2).

- In any situation where a bus at the stop may encroach into the bike lane, the location of the bus stop should be examined in more detail to ensure that the cyclist from behind is either able to pass the stopped bus safely, or to make other decisions in a safe and timely manner such as stopping behind the bus or making a lane change into the adjacent travel lane.
**Bus Stop in Bike Lane (With Bus Bay)**

Posted Speed Limit $\geq 60$ km/h

![Bus Stop in Bike Lane](image)

**Bus Stop in Parking Lane (Far side)**

Posted Speed Limit $< 60$ km/h

![Bus Stop in Parking Lane](image)

**Bus Stop in Parking Lane (Mid-block)**

Posted Speed Limit $< 60$ km/h

![Bus Stop in Parking Lane](image)

(Source: TransLink Transit Infrastructure Design Guidelines 2003 Figure 3.4.5)

Figure 5.18 Bus Stop in Bike Lanes
5.3.5 Marked Crosswalks

It is preferable to site a bus stop on the far-side of a crosswalk to maximize the available sight distance between approaching vehicles and pedestrians at the crosswalk. The distance between the rear of the bus and the crosswalk should be at least 2m.

If a near-side stop is provided, the minimum distance between the intersection crosswalk and the bus stop should be 4.5m. For a midblock crosswalk provided in front of a bus stop, the minimum distance between the front of the bus and the crosswalk should be increased to 10m.

5.3.6 Passenger Amenities

Requirements

Passenger landing pad

All bus stops should have a firm, even, and slip resistant surface for passengers to step on/from the bus. For the BC Transit design vehicle, a passenger landing pad length of 9m and cross slope of 2% is recommended. Passenger landing pads may contain amenities such as shelters or newspaper boxes, but these must not act as obstacles preventing riders from accessing the bus doors. Furthermore, for accessibility, a clear minimum width of 2.1m is necessary to accommodate wheelchair ramp deployment from the bus and allow for wheelchair movement after clearing the ramp.

In urban areas, the sidewalk may extend all the way to the curb. In this case, the sidewalk already acts as a passenger landing pad, and no major modifications are necessary. The passenger landing pad should be at least 3m wide, if possible, unless a property line or a building prevents it from being extended this far. If any further amenities, such as bus shelters are to be added, a minimum sidewalk width of 1.5m should still be maintained.

In more suburban areas, there will likely be a sidewalk, but it will be separated from the curb or edge of road by a grass boulevard. In this case, the grass boulevard should be replaced with a landing pad that extends from the curb or edge of road to the sidewalk. An example of this configuration is shown below. If the grass boulevard is wider than 3m (the required width of the landing pad), then a 1.5m wide pathway may be installed to provide a connecting path between the passenger landing pad and the sidewalk.

![Figure 5.19 Passenger Landing Pad](image-url)
In more rural areas, bus stops may be placed on a road that features a gravel shoulder, rather than a sidewalk. In this case, a passenger landing pad should be provided at the site of the bus stop, instead of having passengers queue on the road shoulder. It is preferred that the bus stop (curb) be built at an elevation of 150mm above the road surface, to minimize the “step-up” distances required for passengers to board or alight from the bus. A ramp (maximum slope of 8%) should be provided at each end of the pad for access to a safe location away from the travel lane(s).

In rural areas, site-specific reviews may be warranted to identify amenities such as crosswalks, pedestrian pathways, lighting and roadside treatments for enhancing the safety and convenience of pedestrian access to/from a bus stop.

### Wheelchair pad

A wheelchair pad is a designated area within the passenger waiting area, located near to where the front door of the bus will be located once the bus stops. The wheelchair pad is an obstruction-free area that allows space for the bus to deploy its ramp or lift, and to allow the wheelchair to manoeuvre as needed in order to move between the sidewalk and the bus (or vice versa).

Depending on site-specific conditions, the wheelchair pad may be located outside of the bus shelter, within the shelter with the sidewalk behind the shelter, or within the shelter with the sidewalk in front of the shelter. The minimum clearance area for the wheelchair pad is 1,980mm by 2,134mm, as shown in the figure below for a wheelchair pad that is located within the shelter.

Should the wheelchair pad be located outside of the bus shelter, the physical ground conditions on the edge of the sidewalk area may require attention in maintaining safety for wheelchair manoeuvre. For example, if a downward slope exists beyond the sidewalk area, a projecting curb or handrail should be installed on the edge of the sidewalk area to mitigate the potential hazard of wheelchair users encroaching into the slope. Where a fixed object such as a wall or fence exists on the edge of the sidewalk area, the wheelchair pad clearance width may be increased up to 3m to mitigate potential hazard of wheelchair users rolling into the hard surfaces.
Figure 5.20 Wheelchair Pad (BC Transit)
The suggested dimensions for accommodating wheelchair pads, as shown in the TransLink Transit Infrastructure Design Guidelines, are also included below for reference. When the wheelchair pad is located outside of the shelter (Option 2), BC Transit suggests a minimum distance of 1.2m between the (long) edge of the ramp area and the (short) edge of the shelter to provide room for the manoeuvre of a wheelchair.

(Source: TransLink Transit Infrastructure Design Guidelines 2003 Figure 3.5.2.1)

Figure 5.21 Wheelchair Pad (TransLink)
Bus shelter

While shelters are available in various configurations, the BC Transit preferred design is as follows:

- Dimensions are 1.2m W x 2.4m H to 4.0m L for enclosed shelters, or 2.0m W x 2.4m H x 4.0m L for open shelters or canopies
- Four sided shelters require an opening that has a minimum width of 800mm
- Glass panels are not preferred by BC Transit due to high maintenance costs, but if used, they should be marked with a contrasting horizontal stripe of minimum width of 75mm located approximately 140-160cm above ground level
- Sides are transparent
- Seating is oriented to view oncoming transit, pedestrians and adjacent buildings
- Lit shelters are preferred, as down lighting improves shelter safety and visibility

Offset of the shelter from the curb will be influenced by a number of factors. Factors to be considered include avoidance of conflict with mirror projections, provision of pedestrian and wheelchair landing pads (see Figures 5.20 and 5.21) and provision of sufficient space for pedestrians and wheelchairs passing in front of or behind the shelter. See section 6.2.4 for effective walkway widths required for pedestrians and wheelchairs.

5.3.7 Universal Access Requirements

Existing accessibility guidelines are available from the BC Transit Design Guidelines for Accessible Bus Stops. The document provides design criteria and evaluation considerations for the provision of:

- Shelter
- Access and circulation
- Seating
- Rural transit stops
- Curb cuts (or curb ramps)
- Walkways
- Ramps and stairs
- Tactile surface (pavement)

According to the accessibility guidelines, the necessary minimum infrastructure requirements for an accessible stop are summarized below.

<table>
<thead>
<tr>
<th>Amenity to be provided</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete barrier curb</td>
<td>150mm high, without indentation for a catch basin</td>
</tr>
<tr>
<td>Wheelchair pad</td>
<td>Minimum 2.1m x 1.98m</td>
</tr>
<tr>
<td>One or two paved connections from transit stop waiting pad to the sidewalk</td>
<td>1.5m wide</td>
</tr>
<tr>
<td>Accessible ramps on either side</td>
<td>Maximum slope 12:1 (8%), minimum 1.2m wide</td>
</tr>
<tr>
<td>Street furniture or other such objects</td>
<td>Minimum clear width of 1.5m and clear headroom of 2.0m, kept clear of transit loading and unloading areas</td>
</tr>
<tr>
<td>Bench</td>
<td>Only to be provided where sidewalk width is greater than 2m, and where a fire hydrant is located more than 6m away</td>
</tr>
</tbody>
</table>

In areas where no sidewalk is present, it is suggested that an elevated concrete or asphalt pad be installed on the shoulder of the road, with a connecting ramp at each end.
Chapter 6  |  Off-Street Facilities

6.1 Introduction

Off-street transit facilities are located on sites that are fully separated from the general traffic flow, and allow for a greater degree of passenger transfer movement (both bus-to-bus and intermodal) to take place than what would be possible at a typical curb-side facility. Three types of off-street facilities exist:

- Transit Exchange
- Park-and-Ride Lot
- Passenger Pick-Up and Drop-Off Facility (also known as a Kiss-and-Ride Facility)

6.2 Transit Exchange

A transit exchange can be designed to facilitate passenger transfers between various modes of transportation, such as bus, train or marine transit.

Bus transit exchanges, or bus loops, facilitate passenger transfers between multiple bus routes by the converging of various bus routes at a single location. The discussion below focuses on bus transit exchanges.

6.2.1 Location Considerations

A bus transit exchange should be sited at a location that maximizes transfer opportunity, while minimizing any “detouring” that buses need to take from their assigned route in order to serve the transit exchange. A bus transit exchange is therefore often placed at the end of a route.

Major trip generators, such as shopping centres or institutional facilities, are also considered appropriate locations for a bus transit exchange. The presence of a transit exchange will allow riders to access the trip generator from different service areas, and will therefore serve not only as an exchange but also as a “hub” of concentrated activities.

Another candidate location for a bus transit exchange is where multiple bus routes pass by in the vicinity and there is a high demand for transfer movements between the routes.

6.2.2 Design Considerations

Once the general area within which a bus transit exchange may be sited has been identified, evaluation and conceptual design of the potential sites must take into account a number of considerations, as follows:
- Bus access (to and from the adjacent roadways)
- Bus circulation within the transit exchange
- Anticipated vehicle use, with respect to the type and number of buses
- Bus layover space (for a driver’s break time at the end of a route, or as a mid-route timing point)
- Pedestrian access routes to and from the transit exchange
- Passenger amenities (shelters, payphones, newspaper stands, etc.)
- Bike racks and/or lockers
- Wheelchair accessibility within the transit exchange, and in the surrounding area
- Measures to reduce bus-auto-pedestrian conflict
- Bus operator restrooms
- Integration with nearby parking or drop-off zones
- Signage within the layout to direct users to the appropriate bay

Also, note that as with curbside stops, all facilities should be a minimum of 0.3m away from the curb face, in order to provide sufficient clearance for bus mirrors, with additional clearance where pinch points may occur.

The exact layout of a bus transit exchange depends on candidate site dimensions and the ability for bus vehicles to access to and from the local road network.

Passenger platforms vary in size and configuration depending on the number and types of buses, as well as expected passenger volumes and profile. The two most common transit exchange configurations are the parallel loading platform and the sawtooth loading platform.

A combination of these configurations is often used in actual design. Depending on available space, bus transit exchanges may feature either a single large platform where individual bus bays are sited around the platform edge, or multiple platforms that service one (or more) bus routes each.

**Parallel Loading Platform**

A parallel loading platform typically consists of multiple bus stops aligned with one after another along the curb, with some spacing in between to accommodate bus pull-in and pull-out movements.

Parallel loading platforms generally require a longer platform length compared to a sawtooth layout for the same number of bus bays being accommodated. A parallel loading platform requires a minimum of 6.5m right-of-way between the platform and the edge of the bus transit exchange in order to allow a bus to pass another bus that is stopped along the curb. Individual bus stops should be spaced with a distance of 30.5m, comprised of a 18m pull-in zone and a length of 12.5m for the bus. In order to minimize space requirements, the pull-out zone is assumed to share road space with the pull-in zone of the subsequent stop. These dimensions are similar to those discussed for Midblock Stops in Section 5.3.3. The New Flyer Hybrid bus is used to calculate spacing requirements (and therefore area requirements) for each sample configuration. This layout is meant to be an example only; in reality, transit exchange layouts will be determined by considerations discussed at the beginning of this section.
Figure 6.2 Parallel Loading Platform
Sawtooth Loading Platform

Sawtooth loading platforms are characterized by the jagged edges of the pedestrian platform area, which allow buses to pull-in at an angle. Sawtooth loading platforms generally require a shorter platform length compared to a parallel loading layout for the same number of bus bays being accommodated.

![Figure 6.3 Example of Sawtooth Loading Platform](image)

The “teeth” of the platform should protrude 1.3m from the rest of the platform, and must be tapered over a 14m pull-in/stopping zone and a 6m pull out zone. It is preferred that all “jagged” edges be rounded with a radius of 8m (6m is considered a minimum), as shown in Figure 6.4. This provides easier access for both bus drivers and street-cleaning vehicles. Figure 6.4 provides an example of how this curve requirement can be incorporated into the design.
Figure 6.4 Sawtooth Loading Platform Reference Points
Sawtooth platforms can be used as both curb-side stops, and as part of an island platform at a bus transit exchange. Depending on which set-up is being considered, there are several key layout dimensions to consider.

i. Curbside sawtooth stop

A minimum platform “clear-width” of 2.75m (excluding the “teeth”) should be provided for the length of the platform. Additionally, the roadway space for buses to park should be at least 4.75m from the tip of the teeth (i.e. 6.05m including teeth width) to the nearest travel lane. This allows buses to safely pull in and out of their stops without interfering with traffic. At either end of the bus layover space, there should be a taper to and from the adjacent travel lane. A 1:6 taper ratio is recommended.

Based on all these criteria, a rough approximation of the area required for this type of bus stop is as follows:

- Width of land: 8.8m measured from the left edge of nearest travel lane
- Length: 77m (including tapers) for a single bus stop, plus an additional 20m for each additional bus stop

Note that calculating an area using these values would include two triangular wedges of land at either end (where the tapers are located) that is not actually required for use. Depending on the nature of existing site conditions, it may be possible to reduce the total land area required by excluding these sites.

A sample drawing of a 4-bay curbside sawtooth stop is shown in Figure 6.5, and uses the New Flyer Hybrid Bus as a design vehicle,
Figure 6.5 Multi-bay Curbside Sawtooth Stop
ii. Island platform at transit exchange

An island platform may feature sawtooth bus stops on both sides of the island. This setup is typically used at a major transit exchange, which is assumed to be off-road with prohibited access by general traffic. The two major design considerations for an island platform are the accommodation of pedestrians (ensuring the platform is large enough to handle expected pedestrian volumes), and making sure buses have sufficient circulation space to move around the exchange.

Island platforms should be at least 5.5m wide (excluding the “teeth”) to allow for pedestrian circulation. A greater width would be required to accommodate the placement of amenities on the platform such as benches and landscaping. Transit exchanges where higher passenger volumes are anticipated should also be designed with wider platforms to ensure that sufficient queuing and circulation space is provided.

In terms of road space, a minimum of 9.75m (from the tip of the “teeth”) is required to allow effective bus circulation, as well as provide layover space for buses. Buses will be required to make a 180-degree turn around the end of the island platform. In order to accommodate the bus sweep path, there needs to be both sufficient width of the transit exchange, as well as a minimum distance from the stops closest to the end of the 180-degree turn area. There is some degree of trade-off between these two parameters; a narrower platform will require more space past the end of the platform for the bus to make a turn, while a wider platform will require less space for the bus to make a turn. There is no specific formula for this tradeoff for design purposes, or “rule-of-thumb” about land requirements. The area required for any given number of bus bays will depend on the shape of the site available, and thus, general site constraints should be considered prior to determining an overall exchange layout.

Two sample bus loop designs are shown below for illustrative purpose only. One features a 4-bay wide sawtooth platform setup, the other features a 4-bay parallel platform setup. These examples will be used to illustrate some of the key elements related to sawtooth platform design. In both of these examples, it is assumed that all buses enter and exit the loop in a clockwise manner. The vehicle sweep paths are based on the New Flyer Hybrid bus.
Figure 6.6 Platform Size Requirements (For Illustrative Purpose Only)
Other Considerations in Transit Exchange Design

Several further design considerations that apply to both sawtooth and parallel island platforms are presented, in order to provide tips to accommodate common issues that arise in transit exchange design.

- In conducting a sweep path analysis, designers should design for some buffer at the edge of the bus loop. Drivers will not always execute the turn in exactly the manner shown in the sweep path analysis, therefore, giving them a buffer zone provides some degree of “forgiveness”. The exact amount of room that should be provided depends on the site conditions at the end of a transit exchange, and the severity of the consequences if the bus exceeds them. For example, if the transit exchange has a large gravel shoulder (with no major obstructions) adjacent to it, then if the occasional bus drives on the gravel shoulder a bit, from an operation perspective, this is not hugely problematic. Conversely, if there was a major vertical surface, such as a fence/wall at the edge of the site, more buffer room (up to 2 meters, depending on conditions) should be provided. This gives for some extra room for the bus’ left mirror, and a bike rack. The additional buffer space also reflects the severity of the consequences of an improperly executed turn; unlike a gravel shoulder, in this case, the bus would have to reverse, and then try the turn again. This can pose both a safety concern, and also impede efficient transit exchange operations.

- In instances where there is very limited space, a strategy which can be considered is the painting of a guiding line on the pavement to guide bus drivers as they make the turn. The guiding line could be in the form of a single dashed line delineating the outer front wheel sweep path.

- In extreme cases, which involve exceptionally complicated manoeuvres, the layout should be field tested. This can be done at a bus depot, using traffic pylons to provide a layout of the proposed design.

- If a bus transit exchange is also intended to act as either a timing point or a terminus loop, and multiple routes are scheduled to arrive at the same bay, provisions for layover space must be included. This would typically be provided around the outer edges of the loop, and may require additional land area for the bus loop, beyond what is shown in the above drawings.
6.2.3 Bus-Pedestrian Conflicts within a Transit Exchange

Bus transit exchanges should be designed to minimize movement conflicts and collision risks between buses and pedestrians. Painted crosswalks, handrails and/or wayfinding signage can be provided to guide pedestrians and direct them to paths that enhance their visibility to bus drivers.

Painted crosswalks should be provided behind where a bus would stop, before a point where bus turning manoeuvre begins, or at a point that is after the bus turning manoeuvre. These potential locations are shown in Figure 6.6. Curb extensions may be used to enhance the visibility of pedestrians at a crosswalk placed in front of a bus stop.

Crosswalks should be located in a manner that prevents pedestrians from having their back facing oncoming buses. The placement of facilities on or around the platform area should maximize available sight distance between bus drivers and pedestrians. For example, consideration should be given to site a building away from the top platform edge as shown in Figure 6.7 to maximize available sight distance of the pedestrian crosswalk for bus drivers making the turning manoeuvre around the upper part of the transit exchange.

The use of handrails to funnel pedestrians to use a specific path and/or crosswalk(s) is desirable where there are potential shortcut routes, especially if pedestrian visibility is limited on the shortcut routes.
Figure 6.7 Pedestrian Crossing Within a Transit Exchange

Preferred Pedestrian Crossing Locations
(At Beginning or End of Curved Sections or Behind Stopped Buses)

(Source: TransLink Transit Infrastructure Design Guidelines)
6.2.4 Passenger Access, Boarding and Alighting Activities

Pedestrian access both within a bus transit exchange and to the surrounding area are important considerations in the design process of the facility. Walkways to surrounding areas should be as direct as possible, and walkways should be wide enough to properly accommodate the expected pedestrian flows.

The Highway Capacity Manual (Transportation Research Board) describes the relationship between effective walkway width (the walkway width available to pedestrians after discounting lateral restrictions such as a grass boulevard, trees, and other fixed objects) and passenger flow rates on the basis of Level of Service (LOS). The relationship is shown in Figure 6.8. Maximum capacity for a walkway is considered to be 80 pedestrians per minute per metre, which corresponds to LOS E. Generally, a LOS C is recommended for design purposes. Using Figure 6.8, the required walkway width can be determined based on the expected pedestrian flow rate, if it is known.

(Source: Highway Capacity Manual, Transportation Research Board)

Figure 6.8 Relationships Between Pedestrian Flow Rate and Effective Walkway Width

Effective walkway width may be lower than the total width, depending on what is located adjacent to the walkway. Effective walkway widths are shown in Figure 6.9.
According to TAC, the suggested minimum effective walkway width (WE) is 2m to accommodate persons in wheelchairs. An effective walking width of up to 2.4m is suggested in commercial areas with higher pedestrian volumes.

If pedestrian flows are even in both directions and are anticipated to be heavy, the provision of a directional line or a physical barrier may be considered to improve passenger flow.

If a particular route is expected to have heavy boarding and alighting activities, it may be necessary to provide separate unloading and loading areas to minimize pedestrian conflicts and reduce dwell times.

The sidewalk adjacent to a bus bay should be of sufficient width to accommodate waiting passengers and permit pedestrians to pass freely on the sidewalk. A minimum sidewalk width of 3.0m is suggested.
6.2.5 Loading Area Estimation

A suggested methodology for estimating the number of loading areas is included in this subsection. The source of reference is the Transit Capacity and Quality of Service Manual – 2nd Edition (Transportation Research Board). It should be noted that the methodology generally refers to linear stops (as in parallel loading) as opposed to a sawtooth or other loading configuration.

According to the Transit Capacity and Quality of Service Manual - 2nd Edition, the capacity of a linear loading area in buses per hour is:

$$Bl = \frac{3,600 \times (g/C)}{tc} + td \times (g/C) + Z \times cv \times td$$

Where:

- $Bl$ = Loading area bus capacity (bus/hour)
- $3,600$ = Number of seconds in 1 hour
- $g/C$ = Green time ratio (the ratio of effective green time to total traffic signal cycle length, equals 1.0 for unsignalized streets and bus facilities)
- $tc$ = Clearance time (seconds)
- $td$ = Average (mean) dwell time (seconds)
- $Z$ = Standard normal variable corresponding to a desired failure rate (assume to equal $(1 – \text{failure rate})$, where failure rate is 0.25)
- $cv$ = Coefficient of variation of dwell times (assume 0.6)

The resulting capacity ($Bl$) is then compared to the desired provision of buses per hour (typically derived from the arrival headway). If the resulting capacity is less than the desired provision of buses per hour, additional loading area (in the form of extra storage length) must be provided for the route.

The site characteristics and desired access and circulation pattern will determine the arrangement of the various loading areas, given the various lengths that may be required. Nonetheless, there are circumstances that warrant the provision of additional loading areas, such as layover space for routes that terminate at the transit exchange and/or vehicles that may be stored overnight at the facility.

In a transit exchange, linear stops are typically separated by the required pull-in zone as shown in Figure 6.1. Therefore, the desired length of loading area for each route can be provided and separated by the required pull-in zone. However, when multiple stops are arranged in a linear manner without the pull-in zone, the efficiency may be reduced due to the following reasons:

- A bus arriving will generally stop at the front loading area and as such the rear loading areas will be used less often.
- The dwell time of buses using the rear loading areas will be longer compared to the front loading area because passengers may be waiting near the front and would need time to walk to the buses towards the rear.
- Sometimes buses stopped behind the bus in front may not be able to leave the loading area until the bus in front departs. This depends on the available gap between the buses.
To account for reduced efficiency, the Transit Capacity and Quality of Service Manual - 2nd Edition suggests the application of a factor that represents the equivalent efficiency:

\[ Bs = \text{Nel}Bl \]

Where:

- **Bs** = Bus stop bus capacity (bus/hour)
- **Bl** = Loading area bus capacity (bus/hour), as calculated from the previous formula
- **Nel** = Estimated capacities as shown in Exhibit 4-14 of the Transit Capacity and Quality of Service Manual - 2nd Edition (reproduced below)

<table>
<thead>
<tr>
<th>Dwell Time (s)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<td>g/C</td>
<td>g/C</td>
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<td>20</td>
<td>26</td>
<td>35</td>
<td>37</td>
</tr>
</tbody>
</table>

Note: Assumes 10-second clearance time, 25% failure rate, 60% coefficient of variation of dwell times, and random bus arrivals. To obtain the vehicle capacity of non-linear on-line bus stops, multiply the one-loading area values by the number of loading areas provided.

### 6.3 Park-and-Ride Lot

A park-and-ride lot is a facility where transit passengers can park their private automobiles and continue travelling to their destination via the use of transit. A park-and-ride lot generally features ample supply of parking and may contain other amenities such as bicycle racks, lockers, and public telephones, etc.

#### 6.3.1 Location Considerations

A park-and-ride lot is commonly sited in a suburban area and adjacent to a transit exchange with transit connections to regional centres of employment and other activities. A suitable location would meet the physical size requirement for siting the park-and-ride lot, based on the anticipated demand (further described in Section 5.3.2.2), and the required footprint of the transit exchange. It would be well integrated with adjacent land uses to facilitate pedestrian trips in the vicinity and increase the prominence of transit within the community.
6.3.2 Design Considerations

To support transit ridership, a park-and-ride facility should meet the design requirements of automobiles, transit vehicles, pedestrians, and cyclists. The integration and balance of these provisions are important to the success of the facility.

Once a general location is selected for siting the park-and-ride lot and the transit exchange, specific considerations are given to adjacent road network traffic operations, the design of the park-and-ride lot, and the interaction between various traffic modes. These considerations are described in Sections 6.3.2.1 to 6.3.2.3. Refer to Section 6.2 for the design of a transit exchange.

6.3.2.1 Adjacent Road Network Traffic Operations

The surrounding street traffic conditions may determine where it is most appropriate to locate the access driveway(s) of the facility. Access points should be located away from any bottleneck that would result in delay for vehicles entering and exiting the facility. Access points along exclusive turn lanes are not preferred due to potential conflicts associated with vehicles slowing to turn into the facility or exiting vehicles crossing traffic lanes to merge into the traffic stream.

The placement of driveways in the middle of a vertical crest curve is not preferred as sight distance may be limited for the exiting vehicles, resulting in increased risk of angle or crossing type collisions.

6.3.2.2 Design of the Park-and-Ride Lot

The elements related to the design of the park-and-ride lot include:

- Number of access driveways, driveway geometry and traffic control
- Parking supply
- Parking stall type, dimensions and configuration
- Site circulation
- Site security
- Paving requirements

**Access Driveways**

The number of access driveways provided should be determined based on a balance on the peak arrival/departure volumes and the adjacent road network geometry and traffic conditions.

Where traffic volume is relatively high on the adjacent street, it may be more appropriate to provide multiple access driveways to minimize delays for vehicles exiting the park-and-ride lot and the associated queue lengths. At the same time, the locations of the driveways need to be considered in the context of the surrounding road network to ensure that entering/exiting traffic will distribute among the driveways (i.e. driveway locations are convenient to/from the adjacent streets) and traffic operations conditions can be maintained (as described in Section 6.3.2.1).

The anticipated traffic volumes and movements at individual driveways will be used as input into the geometric design, including the number of lanes and traffic control with the intersecting public road. Typically, the access driveway is 8.5m wide for a 2-lane access and 11.0m wide for a 3-lane access. Simulation software can be used to
assess the appropriate traffic control needed at the driveway intersection.

The design should also consider the available storage length (magazine length) for the anticipated queue in the exiting direction.

**Parking Supply**

In the planning of park-and-ride facilities, the longer term need rather than the immediate need is often considered. The trip generation, and associated parking demand generated, can be estimated with the use of a forecasting model which considers land use, population growth, demographic, social and economics trends, auto and transit travel network, and future increase in transit ridership.

The Trip Generation Manual (Institute of Transportation Engineers) Land Use 090 provides data for Park-and-Ride Lot with Bus Service which can be used as a reference on the relationship between vehicle trip ends and the number of parking spaces provided. In the early planning stages, surveys of similar facilities may also add value in identifying trip patterns and parking utilization.

As a general rule, the number of handicapped stall to be provided is 5% of the number of regular stalls being provided.

**Parking Stall Dimensions and Configuration**

The right angle parking configuration provides more flexibility than the angle parking configuration as it allows for two-way traffic between the aisles and two-way traffic is generally easier for drivers to comprehend and follow.

Right angle parking stalls are typically 2.6m wide by 5.3m long. Handicapped stalls are typically 3.7m wide by 5.3m long. An aisle is typically 7.0m wide for right angle parking configuration.

**Site Circulation**

The configuration of parking spaces within the park-and-ride lot should be as simple as possible to minimize the time needed to locate a parking space. A single, continuous path from the street to a parking space is ideal. Guidance that is clearly visible at the major access points (signage, for example) as well as guidance within the lot (pavement arrows and STOP signs, for example) can be provided to control site circulation.

Design that minimizes inbound vehicles from backing up at the entrance(s) onto the public street is preferred.
**Site Security**

A safe and secure environment, both for pedestrians and parked vehicles, is important. Potential measures to eliminate unauthorized activities include:

- Provide natural surveillance if possible
- Adopt an enforcement policy
- Post signage to indicate the enforcement policy
- Co-ordinate with local police force for police drive-throughs
- Provide adequate illumination
- Carry out on-site security patrol
- Carry out remote surveillance
- Provide fencing and pathway bollards to control access by pedestrian and vehicle

**Paving Requirements**

Pavement design for individual Park-and-Ride facilities is subject to local bylaws and other requirements. The general considerations related to paving include:

- Expected traffic volume and bearing weights
- Local geotechnical conditions
- Local weather conditions
- Properties of paving materials chosen

**6.3.2.3 Interaction between Traffic Modes**

There are key considerations related to the interaction of the various traffic modes that may be present in the Park-and-Ride lot and the transit exchange. These include:

- Providing safe pedestrian connections between the parking lot and the transit exchange. For example:

  - Wayfinding can be provided to direct pedestrians to follow desired paths through the parking lot rather than cutting through parked vehicles.
  - Maintaining a reasonable walking distance for pedestrians (300 metres or less, equivalent to travel time of 5 minutes or less) will also help to reduce this undesired behavior.
  - Pedestrian/vehicle conflicts can be minimized through the provision of marked crosswalks and appropriate signage where pedestrians are expected to cross in the way of traffic.
  - Raised pedestrian pathways can further enhance the visibility of pedestrians but may not always be feasible for implementation.
  - Providing separate access for transit vehicles and automobile traffic to minimize conflicts.
  - Providing separate access and secured/protected storage for bicycle traffic.

**6.4 Passenger-Pick-Up and Drop-Off Facilities**

Passenger pick-up and drop-off (PPUDO) facilities, also known as drop-and-rides or kiss-and-rides, are short-term parking areas that allow passengers to be picked up or dropped off at a transit facility by private automobiles.

PPUDO facilities may consist of either a designated series of parking stalls or a pull-up zone alongside a designated pedestrian area. Generally, they are enforced with limited parking duration (usually 5 to 10 minutes) according to typical observed times required for drop-off and pick-up.
6.4.1 Location Considerations

PPUDO facilities are typically included as part of a dedicated park-and-ride facility. The specific considerations related to the PPUDO facility location are as follows:

The PPUDO facility should be easily accessible from the adjacent road network and its operation should not create conflicts with adjacent road traffic. For example, high turnover is expected at the PPUDO facility during specific periods (typically in the morning for drop-off and in the late afternoon for pick-up) and the design needs to take into account the surge to avoid queues from encroaching back into the adjacent road.

Conversely, the access points should be located away from any bottleneck that would result in delay for vehicles entering and exiting the facility.

The PPUDO facility (the drop-off spaces at the least) should be sited close to the transit exchange entrance. This will provide convenience for the dropped-off transit passengers. However, conflicts between transit vehicles and PPUDO activities should be avoided.

Pick-up spaces may be located separately and be slightly farther away; however, they should not require passengers to cross more than one street. Otherwise, the passengers will likely be picked-up at locations that are considered more convenient and closer to the transit exchange.

6.4.2 Capacity Provisions

High-capacity express bus service will likely attract more drop-and-ride passengers than local or other low-capacity bus service.

Various capacity provisions for PPUDO facilities are currently adopted by agencies, for example:

- The King County (State of Washington) Metro Transportation Facility Design Guidelines suggests that as much as 10 percent of vehicles accessing the park-and-ride facility will be for drop-and-ride purposes. The King County guidelines recommend that space for drop-and-ride vehicles should be provided for approximately 1 to 1.5 percent of the park-and-ride lot’s capacity. The same guidance is included in the Park-and-Ride Planning and Design Guidelines (Parsons Brinckerhoff Inc.)

- TransLink’s South Surrey Park-and-Ride Expansion project assumed kiss-and-ride demand to be 15 percent of the park-and-ride demand (source: 2009 ITE Quad Conference presentation entitled “Building Up Transit Ridership: South Surrey Park & Ride Expansion” by the Coast Mountain Bus Company). The number of kiss-and-ride stalls provided is 16 while the total number of stalls built was 451. Based on this information, kiss-and-ride stalls represent 3.5 percent of the park-and-ride lot’s capacity.
Chapter 7  Signing, Pavement Markings & Lighting

7.1 Design Standards

The design and placement of signs and pavement markings for transit operations should be in accordance with the Manual of Uniform Traffic Control Devices for Canada (Transportation Association of Canada) and other relevant jurisdiction standards.

Consistent and concise signing and pavement markings will reduce confusion for passengers and the general public. Regular maintenance will ensure that signs and pavement markings are conspicuous during daytime and nighttime conditions.

7.2 Bus Stop Signs

BC Transit is currently developing a new set of signage standards for its corporate branding. The draft versions of the standards are shown below.

General Sign Standards

- Pantone® 282 C
  - CMYK: 100-68-0-54

- Pantone® 354 C
  - CMYK: 80-0-90-0

- Font
  - Helvetica Neue

Figure 7.1 General Sign Standards
Strip Sign (Draft Design: Approval Pending)

Size: 4.5” wide by 30” tall

Reflective Grade: Diamond

- Required Information
- Stop ID Number
- Words “Bus Stop”
- Universal Symbol
- BC Transit Logo
- BC Transit Website
- Municipal System Phone No.
- Funding Partners
  - Provincial
  - Municipal System(s)
- Wheelchair accessible decal (only on stops that meet accessible criteria)
Flag Sign (Draft Design: Approval Pending)

Size: 16” wide
Variable heights

Reflective Grade: Hi-Intensity (HI)

Required Information
- Stop ID Number
- Universal Symbol
- BC Transit Logo
- Bus Number(s)
- Route Name(s)
- BC Transit Website
- Municipal System Phone No.
- Funding Partners
  - Provincial
  - Municipal System(s)
- Wheelchair accessible decal
  (only on stops that meet accessible criteria)
7.3 Other Signs

**Park & Ride Sign** (Draft Design: Approval Pending)

![Park & Ride Sign](image)

**Size:** 8’ wide x 4’ high

**Reflective Grade:** Hi-Intensity (HI)

**Required Information**

- On white area:
  - BC Transit Logo
  - Tag Line (Linking Communities, Businesses & Lifestyles)

- On blue area:
  - Universal Symbol
  - “Park & Ride”
  - Location (address)
  - Funding Partners
    - Provincial
    - Municipal System(s)

*Figure 7.4 Park and Ride Sign*
**Building Sign** (Draft Design: Approval Pending)

**Size:** 6’ wide x 4’ high

**Reflective Grade:** Hi-Intensity (HI)

**Required Information**

On white area:
- BC Transit Logo
- Tag Line (Linking Communities, Businesses & Lifestyles)

On blue area:
- Location (address)
- Funding Partners
- Provincial
- Municipal System(s)

*Figure 7.5 Building Sign*
7.4 Transit Shelters

**Transit Shelters**
(Draft Design: Approval Pending)

**Size:** varies

**Reflective Grade:** to be determined

**Required Information**
- BC Transit Logo

To be confirmed:
- Location (address)
- Funding Partners
  - Provincial
  - Municipal System(s)

7.5 Lighting

Lighting at bus stops and other transit facilities can improve passenger visibility, promote personal security and deter unwanted activities. The lighting level at transit facilities should be no less than the adjacent street lighting. Supplemental lighting may be required for specific situations, such as at:

- Isolated bus stops
- Transit exchanges (above-ground and underground)
- Park-and-ride lots

TransLink’s Universally Accessible Bus Stop Design Guidelines indicates that lighting level of 20 – 50 lux should be provided at all ground level bus stops, based on a review of various guidelines. The TransLink recommendation is now a lighting level of 50 lux at transit exchanges and bus stops.
This chapter provides examples of projects that the Project Consultant has been involved with. The intent is to provide a background on the planning of various facilities, to highlight considerations in the design process, and to provide references for future BC Transit projects.

8.1 Bus Lane

Project # 1

Highway 99 Transit Lane Project, Richmond, B.C.

Overview

The main feature of this project is to design a 4.0m wide and 3.0 km long dedicated bus lane along the shoulder of Highway 99 between the northbound off-ramp to Highway 91 and the south approach at the intersection of Bridgeport Road and Highway 99 northbound off-ramp. The detailed design includes widening the existing shoulder for at-grade bus operation with signalized metering at on-ramps.

Key Design Elements

To optimize the design, weaving and ramp operations for the current and future horizon years, as well as collision history, were analyzed. The proposed design also includes recommendation of the location of bus check-in and check-out detectors, ramp and bus signals, advance warning flashers and intersection detectors.

Stop Bar Locations

The existing on-ramps located along Highway 99 within the project limits were designed as a parallel lane entrance, as shown in the figure below. The driver entering on a parallel lane is intended to accelerate to close to through traffic speed on the parallel section of the terminal before making a lane change into the adjacent through lane. The length of acceleration lane (La) excluding the taper length (Lt) is the distance required to accelerate from speeds as controlled by the ramp to speeds required to safely merge with through traffic. The length of acceleration lane (La) is measured to the beginning of the taper (Lt).

Stop Bar Locations

The existing on-ramps located along Highway 99 within the project limits were designed as a parallel lane entrance, as shown in the figure below. The driver entering on a parallel lane is intended to accelerate to close to through traffic speed on the parallel section of the terminal before making a lane change into the adjacent through lane. The length of acceleration lane (La) excluding the taper length (Lt) is the distance required to accelerate from speeds as controlled by the ramp to speeds required to safely merge with through traffic. The length of acceleration lane (La) is measured to the beginning of the taper (Lt).
Parallel Lane Entrance

Since the ramps are proposed to be metered in this project, the location of stop bars must take into consideration providing available queue storage space on the ramp, and allowing vehicles sufficient distance to accelerate to freeway speeds at stop condition and merge safely with freeway traffic. Table 2.4.6.5 in the Transportation Association of Canada (TAC) Geometric Design Guide for Canadian Roads (as shown below) provides design domain for lengths of acceleration lanes.

### Design Length for Acceleration

The posted speed limit along Highway 99 is 90 km/hr. Under this criteria, the design domain for length of acceleration lane under stop condition ranges from 215m to 325m. Section 2.4.6.4 of the TAC Geometric Design Guide states that longer entrance terminals (i.e. the higher values of the design domain in the above table) are desirable on higher volume roads to enable entering traffic to merge with through traffic safely and conveniently. Based on this guideline, it is proposed that the stop bar location at the Highway 91 eastbound on-ramp will be located 215m upstream from the beginning of taper due to its low volumes. For the Highway 91 westbound on-ramp, the stop bar is located 325m upstream from the beginning of taper. For the Shell Road on-ramp, since the existing acceleration lane exceeds the 325m upper domain, the stop bar is proposed to locate at 10m upstream from the beginning of the gore nose to maximize storage space.

<table>
<thead>
<tr>
<th>Speed of Roadway (km/h)</th>
<th>Length of Taper (m) Lt</th>
<th>Length of Acceleration Lane Excluding Taper (m) La</th>
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<tr>
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<td>Stop Condition 20 30 40 50 60 70 80</td>
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<td>105-130</td>
<td>100 550-885 540-880 510-870 500-850 470-820 400-745 340-655 300-550</td>
</tr>
</tbody>
</table>

### Notes:
The selection of ramp design speed as discussed in Subsection 2.4.6.2 should be referred. The acceleration distance curves in 1994 AASHTO are used in developing the design domain.
Vehicular Clearance Periods

The vehicular clearance period is the sum of the yellow and red time at the end of a green interval, which allows motorists approaching an intersection at the end of this interval time to either stop or enter and clear the intersection before a conflicting traffic stream enters the intersection. For this project, using the same guideline as for a signalized intersection, the vehicular clearance period is the clearance time which allows ramp vehicles approaching the intersection of the bus lane and the ramp entrance lane to either stop at the ramp signal or enter and completely clear from the intersection before a bus arrives at the advanced warning sign.

The vehicular clearance periods are calculated using the following equation:

\[ I = T_{pr} + \frac{V_a}{2} + \frac{D_c}{2} - \frac{D_b}{2} \]

Where:
- \( I \) = perception / reaction time (s).
- \( V_a \) = approach speed (m/s)
- \( f \) = friction factor on wet pavement (varies depending on speed)
- \( AG \) = approach grade (m/100m), positive if approached traffic is climbing: negative if approach traffic is descending
- \( g \) = 9.81 m/s\(^2\)
- \( D_c \) = clearance distance (m)
- \( V_c \) = clearance speed (m/s)
- \( D_b \) = conflict distance (m)
- \( V_b \) = conflict speed (m/s)

The following assumptions were incorporated into the above equation to determine the vehicular clearance periods in this project:

- A perception/reaction time of 1.0 second
- An approach speed on the ramps of 50 km/hr
- A friction factor of 0.36 under the posted speed limit at 50 km/hr
- Approach gradients of -3.7% for the Highway 91 eastbound on-ramp, -5.2% for the Highway 91 westbound on-ramp, and 0% for the Shell Road on-ramp
- Clearance distances for the on-ramps are illustrated on the following page. As shown on the following page, the clearance distance is measured from the location of the stop bar to the point at the intersection where on-ramp vehicles are completely clear from the bus traveling path and the body of on-ramp vehicle is completely inside the downstream accelerating lane.
On-ramp Clearance Distances

- **Highway 91 EB On-ramp**
  - Clearance Distance = 80 m

- **Highway 91 WB On-ramp**
  - Clearance Distance = 90 m

- **Shell Road On-ramp**
  - Clearance Distance = 85 m

- A clearance speed of 50 km/hr is assumed to be the same as the approach speed
- Conflict distances between the on-ramp vehicle path and the bus path is small and assumed to be zero
Based on these assumptions, the vehicular clearance periods are 9.0 seconds for the Highway 91 eastbound on-ramp, 9.8 seconds for the Highway 91 westbound on-ramp, and 9.1 seconds for the Shell Road on-ramp. According to MoT Electrical & Traffic Engineering Design Guidelines Clause 4.2.5.4, the maximum allowable yellow time is 5.0 seconds. It is proposed to provide only 3.0 seconds of yellow time to reduce the window of opportunities for vehicles to run through a yellow light.

**Advanced Warning Sign**

The advanced warning sign locations for the on-ramps and bus lane were determined based on MoT Electrical & Traffic Engineering Design Guidelines Clause 402.6.8. Using the grade % and approach speeds assumptions stated above, the advanced warning sign locations for the on-ramps were calculated to be: 45m for the Highway 91 eastbound on-ramp, 46m for the Highway 91 westbound on-ramp, and 41m for the Shell Road on-ramp. The location of the advanced warning sign for the on-ramps is measured upstream from the stop bar location.

The advanced warning sign locations on the bus lane were determined based on the assumptions that the traveling speed of buses is at 90 km/hr and the grade % of the bus lane is at 0%. Based on these assumptions, advanced warning signs should be located 131m upstream from the beginning of the gore nose.

**Bus Check-In and Check-out Detector Locations**

The bus check-in detector locations are based on the vehicular clearance periods and advanced warning sign locations calculated in the above sections. The basic idea is that the time it takes a bus to travel from the check-in detector location to the advanced warning sign should allow for on-ramp vehicles to enter and clear the intersection. If by the time a bus arrives at the advanced warning sign and there are vehicles traveling inside the intersection, the advanced warning sign will start flashing and the distance between the sign and the beginning of the gore nose should allow for buses to come to a complete stop before entering the intersection.

The check-in detector location should be measured from the farthest point on the upstream approach lane just before the bus enters the intersection, and the check-out detector should be located at the middle of the intersection. The distances should include the clearance interval periods plus the advanced warning sign distances. It is noted that the check-in detector for the Highway 91 westbound on-ramp will be located upstream of the Highway 91 eastbound on-ramp intersection due to the short distance between the two ramps.

When an approaching bus reaches the check-out detectors and if there is not another bus activating the upstream check-in detectors, the on-ramp signal will switch to green immediately. In the case when there is more than one bus approaching at a time, the on-ramp signal will switch to green after the last approaching bus reaches the check-out detectors.

**Intersection Detectors**

Due to the heavy through volumes on Highway 99 during peak periods, it is possible that the intersection of the bus lane and the on-ramp lane could be blocked by on-ramp vehicles trying to merge with through traffic. It is proposed that detectors should be placed at the intersections to detect the presence of vehicles.
A bus signal is proposed to be installed on the bus lane in conjunction with the advanced warning sign. The bus signal should be located upstream from the intersection just before buses enter the intersection. The detection of vehicles in the intersection can trigger the advanced warning sign and the bus signal to warn bus drivers about possible downstream conflicts, and also trigger the ramp signal to stop releasing vehicles to the intersection. The detectors would need to be able to detect stopping vehicles from traveling vehicles.

**Ramp and Bus Signals Display**

Signals at both the on-ramp and the bus lane were also suggested in this project in order to improve safety at the intersection. The signal at the on-ramp is a standard signal head with red, amber, and green displays. For the bus lane, it is proposed to install a customized advanced warning sign and a flashing red signal at the intersection, as illustrated below.

<table>
<thead>
<tr>
<th>Displays</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="When Flashing Buses Prepare to Stop" /></td>
<td>When flashing, to inform bus drivers that they must come to a complete stop before entering the intersection. After having caused the bus to stop, the bus drivers can approach the intersection safely with caution.</td>
</tr>
<tr>
<td><img src="image" alt="Flashing Red Signal" /></td>
<td>When flashing, to inform bus drivers that they may have to come to a complete stop before entering the intersection.</td>
</tr>
</tbody>
</table>
8.2 Transit Exchange

Project # 2

Capilano College Transit Exchange, North Vancouver, B.C.

Overview

The task assigned is to develop various conceptual and functional layouts of the proposed temporarily transit exchange at Capilano College. The candidate site for the proposed transit exchange was a parking lot on Monashee Drive.

Project Images

Before

Now

Key Design Elements

Various conceptual and functional layouts of the proposed transit exchange were developed and evaluated by going through the design considerations as listed in Sections 6.2.2 and 6.2.3 of this manual. Since this proposed transit exchange is located inside the campus area where high pedestrian activity is anticipated, particular design considerations were given to site the bus platforms where available sight distance of the pedestrian crosswalk for bus drivers making the turning manoeuvre around the upper part of the transit exchange will be maximized.

Where there are potential shortcut routes with limited visibility, handrails were installed to funnel pedestrians to use specific path and/or crosswalk(s).

Swept path analysis of each layout was conducted by the software Autoturn and were then confirmed by a field test. In general, 3 key conceptual layouts were developed and they are illustrated on the following page.
Conceptual Layout
Option 1

Conceptual Layout
Option 2
Option 1 was eventually selected by TransLink for further development of the preferred layout. After conducting the field test, the drop-off bay at the entrance of the loop was removed. Although the spare layover bay at the bus loop exit (with the widening of the exit driveway to 10 m) has been tested to be adequate for the swept paths, it may create some sight distance issues between the pedestrian crossing and the exiting buses. Moreover, according to the Motor Vehicle Act, vehicles are prohibited to park within 6 m of the approach side of a crosswalk or stop sign. As such, the spare layover position was also removed. The transit exchange was constructed in November 2008 and is now in operation.
Project # 3

Review of Transit Exchange Operations at Brighouse Station, Canada Line, Richmond, B.C.

Overview

A review of Coast Mountain Bus Company’s requirements was conducted and alternate arrangements were identified with attempts to minimize the number of buses stopping on No.3 Road northbound and to maximize the number of buses that would be using the new bus mall.

Bus Mall Location
Key Design Elements

The proposed future bus services were reviewed and the information was used to estimate the layover bus requirements. Bus routing options were assessed to determine the impact of access and egress on each bus route that terminates at the station. Upon consultation with TransLink’s Planners, the following guiding principles were used in re-assigning the routing and bus bay location:

i. Drop-off and pick-up location for the Handy Dart should be located as close to the station entrance as possible

ii. Stops for the local routes should also be located near the station entrance, since they will have the most transfers to/from the Canada Line

iii. Stops for the regional routes could be located a bit further from the station entrance since they will have less Canada Line activity

iv. Bus routes with higher passenger loading should be assigned to bays where a larger area for passenger queuing is available

v. Bus routes which are going to the same destination and serving corridors that are often parallel or intersect with each other would have their stops either sharing the same bay or locating close to each other so that customers may be able to choose between two or more of them for their trip

vi. Bus travelling time and delays to the designated stop should be minimized

vii. Unnecessary routing inside the mall should be eliminated

viii. The distance between the drop-off and the layover position of each terminating route should be minimized;

ix. Dedicated drop-off and pick-up positions for the terminating routes should be provided

x. Bus layovers on side streets should be kept to the minimum.

The proposed number of bus storage units at each bus bay was reviewed to ensure adequate operation during peak hour passengers loading. The required bus bay lengths were subsequently identified using the formula as discussed in Section 6.2.5 of this manual. In estimating the bus bay lengths, an average bus clearance time of 10 seconds was assumed for a bus to start up and travel its own length when departing from the bus bay. Apart from the above assumptions, a 25% failure rate, 60% coefficient of variation of dwell times and random bus arrivals were also assumed in the assessment.
<table>
<thead>
<tr>
<th>Bus Bay</th>
<th>1</th>
<th>2</th>
<th>3B</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Buses per Hour</td>
<td>39</td>
<td>20</td>
<td>12.5</td>
<td>4</td>
<td>7</td>
<td>19.5</td>
<td>19</td>
<td>34</td>
</tr>
<tr>
<td>Green Time Ratio</td>
<td>0.6</td>
<td>0.6</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>0.6</td>
</tr>
<tr>
<td>Average Arrival Headway (s)</td>
<td>55</td>
<td>108</td>
<td>288</td>
<td>900</td>
<td>514</td>
<td>185</td>
<td>189</td>
<td>64</td>
</tr>
<tr>
<td>Average Dwell Time per Bus (s)</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Assumed Clearance Time (s)</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>No. of Bus Storage Unit* (raw)</td>
<td>1.5</td>
<td>0.7</td>
<td>0.4</td>
<td>0.1</td>
<td>0.2</td>
<td>0.6</td>
<td>0.6</td>
<td>1.3</td>
</tr>
<tr>
<td>No. of Bus Storage Unit* (rounded)</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: *Assumes 25% failure rate, 60% coefficient of variation of dwell times and random bus arrivals
Overview

A review was conducted for the proposed crosswalks in the vicinity of the Bridgeport bus loop. The potential issues related to pedestrian safety and bus operation were identified. Potential improvements to the design and other mitigating measures were identified.

Original and Final Crosswalk Layout Designs

Key Design Elements

The review involved identifying pedestrian desire lines, potential conflict points between pedestrian and bus movements, and potential signage and physical measures to be installed to funnel pedestrians to cross at the designated location. The guidelines as stated in Section 6.2.3 of this manual were followed.

Originally, the bus loop was to provide with two crosswalks for pedestrians access to/from the Great Canadian Way. The two crosswalks of concern are located at the northeast and southeast of the Bridgeport bus loop. Issues with regard to the original locations of the two proposed crosswalks were identified as follows:

i. The diagonal orientation of the SE crosswalk may increase pedestrian exposure to the bus traffic

ii. The rear of an articulated bus entering the bus terminus from Great Canadian Way may block the sidewalk crossing, the bike lane and a portion of the travel lane on Great Canadian Way when yielding to a crossing pedestrian at the SE crosswalk
iii. When pedestrians cross from the SE sidewalk to the island platform, they may not be able to see an approaching bus turning left from Great Canadian Way NB into the terminus driveway

iv. The rear of an articulated bus stopping at the passing lane beside Bay #13 may block the NE crosswalk

v. Pedestrians crossing at the NE crosswalk may not be able to notice a right-turning on-coming bus to the driveway beside Bay #13 while Bay #12 is occupied

These potential issues are illustrated in the figure below.
Taking into account the above concerns, the following measures were suggested to TransLink for their consideration:

i. Eliminate the NE crosswalk and provide only one crosswalk to facilitate pedestrian access to and from the western sidewalk of Great Canadian Way

ii. Relocate and re-arrange the orientation of the new crosswalk to be perpendicular to the bus travelling direction in front of Bay #13

iii. Moving Bay #13 slightly to the north and install a bulge in front of Bay #13 such that the bus drivers coming out from the passing lane beside Bay #13 would be able to see the pedestrians using the crosswalk

iv. Install fencing and signage to regulate pedestrians to cross at the designated crossing location

v. Install appropriate signs to warn pedestrians of the bus movement in vicinity of the crosswalk

vi. Install appropriate signs to warn bus drivers of pedestrians crossing the sidewalk at the entrance and exit of the bus loop

vii. Install pedestrian guide signs along the sidewalk on Great Canadian Way and inside the terminus to direct transit passengers to the nearest crosswalk when accessing the bus loop and Canada Line

viii. Discourage jaywalking inside the terminus with TransLink Patrol Team enforcement during the initial opening of the station and the bus loop.

The Bridgeport Transit Exchange was opened in September 2009. Images of the pedestrian crosswalk and its associated signage provided are shown below.
8.3 Park-and-Ride Facility

Project # 5

Maple Meadow West Coast Express Park-and-Ride

Overview

The objectives of this assignment was to review the existing park-and-ride lot on the north side of the Maple Meadow West Coast Express station and to develop a new conceptual layout that could accommodate more parking stalls as well as to improve the circulation of the current drop-off and pick-up bays.

Existing Park-and-Ride Lot

An aerial photo of the existing park-and-ride lot is shown below.
**Key Design Elements**

No design standard was available from either West Coast Express or District of Maple Ridge for the dimensions and spacing of parking lanes. The existing parking stalls provided on-site have dimensions of 4.5m x 2.5m which is considered to be sub-standard when compared to the current standard of 5.5m x 2.6m.

Five handicapped parking stalls are currently provided and a loading/unloading bay was dedicated to the HandyDART vehicle.

Surveys were conducted in March and July 2008 with respect to the pick-up and drop-off demand at this station. During the busiest time of the day (in the afternoon when the 2 longest trains arrive), approximately 5 cars were observed waiting for approximately 5-8 minutes each. The results observed in March were similar to those observed in July 2008. A factor of 1.6 was further applied to forecast the future ridership demand using this station. As such, a total of 8 pick-up and drop-off spaces were recommended to be provided.

A conceptual layout was then prepared to provide additional 44 parking stalls and 8 pick-up and drop-off bays. Signage and pavement markings are proposed and vehicle swept path analyses were conducted as shown in the following drawings.
Note: The design of extended parking lot stalls are based on the existing parking stall dimension of 4.5 x 2.5 m which was shown in the Drawing No. 702 MW-C-181 dated March 31, 1995 provided by West Coast Express. This dimension has not been verified on-site and does not meet the TransLink Infrastructure Design Guidelines which states that the parking stall should be 5.5 x 2.6 m.
Note: The design of extended parking lot stalls are based on the existing parking stall dimension of 4.5 x 2.5 m which was shown in the Drawing No. 702 MW-C-181 dated March 31, 1995 provided by West Coast Express. This dimension has not been verified on-site and does not meet the TransLink Infrastructure Design Guidelines which states that the parking stall should be 5.5 x 2.6 m.
Appendix A

Bus Stop Request Form
<table>
<thead>
<tr>
<th>Date</th>
<th></th>
</tr>
</thead>
</table>

**Transportation Engineering Comments**

**Description of Requested Improvements**

<table>
<thead>
<tr>
<th>Date</th>
<th></th>
</tr>
</thead>
</table>

**Sketch Drawings of Requested Improvements**

<table>
<thead>
<tr>
<th>Design Drawings by:</th>
<th></th>
</tr>
</thead>
</table>

**Stop Type:**

<table>
<thead>
<tr>
<th>Right Turn</th>
<th>Left Turn</th>
<th>Straight</th>
<th>Fully Accessible</th>
<th>Accessible With Caution</th>
<th>Not Accessible</th>
</tr>
</thead>
</table>

**Bus Approach:**

<table>
<thead>
<tr>
<th>Jurisdiction:</th>
<th></th>
</tr>
</thead>
</table>

**Directions of Travel:**

<table>
<thead>
<tr>
<th>Prepared By:</th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Nearest Intersection:</th>
<th>Routes Affected:</th>
<th>Nearest Upstream Stop:</th>
<th>Nearest Downstream Stop:</th>
<th>Date:</th>
</tr>
</thead>
</table>

**BC Transit Bus Stop Geometric Change Request Form**
Appendix B
Design Checklist for Bus Stop Facilities
The following serves as a checklist of the design aspects of a bus stop. The Section(s) which more detailed information can be found is also noted. This checklist can be referred to at the onset of design and/or towards the end of the design process to ensure that all aspects have been considered.

<table>
<thead>
<tr>
<th>Design Aspect</th>
<th>Relevant Section(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Far-side, near-side or midblock configuration</td>
<td>3.3.1</td>
</tr>
<tr>
<td>- Advantages and disadvantages</td>
<td></td>
</tr>
<tr>
<td>Bus stop visibility</td>
<td>3.5.1, 7.2, 7.3</td>
</tr>
<tr>
<td>- Signing</td>
<td></td>
</tr>
<tr>
<td>Passenger access</td>
<td>3.3.3, 3.5.2</td>
</tr>
<tr>
<td>- Route characteristics</td>
<td></td>
</tr>
<tr>
<td>- Traffic controls</td>
<td></td>
</tr>
<tr>
<td>- Personal security</td>
<td></td>
</tr>
<tr>
<td>- Route transfer</td>
<td></td>
</tr>
<tr>
<td>Passenger amenities</td>
<td>3.5.3, 5.3.6, 7.4</td>
</tr>
<tr>
<td>- Passenger landing pad</td>
<td></td>
</tr>
<tr>
<td>- Wheelchair pad</td>
<td></td>
</tr>
<tr>
<td>- Bus shelter</td>
<td></td>
</tr>
<tr>
<td>- Miscellaneous amenities</td>
<td></td>
</tr>
<tr>
<td>Universal access</td>
<td>3.5.4, 5.3.7</td>
</tr>
<tr>
<td>- Minimum requirements</td>
<td></td>
</tr>
<tr>
<td>Pedestrian safety</td>
<td>5.3.5</td>
</tr>
<tr>
<td>- Interaction with pedestrian crosswalks</td>
<td></td>
</tr>
<tr>
<td>Bus stop layouts / dimensions</td>
<td>5.3.1 to 5.3.4</td>
</tr>
<tr>
<td>- Curb side stop</td>
<td></td>
</tr>
<tr>
<td>- Bus bay</td>
<td></td>
</tr>
<tr>
<td>- Bus bulge</td>
<td></td>
</tr>
<tr>
<td>- Multi-position stop</td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>3.6</td>
</tr>
<tr>
<td>- Preferred conditions</td>
<td></td>
</tr>
<tr>
<td>- Frequency of on-site checking</td>
<td></td>
</tr>
</tbody>
</table>
Appendix C
BC Transit Bus Turning Templates
BC Transit - New Flyer Hybrid
Custom

126 | BC Transit
BC Transit - Nova Bus

STEERING LOCK ANGLE = 30.3 deg.
ACHIEVED STEERING ANGLE:
30 deg. SWEEP ANGLE: 18.8 deg.
60 deg. SWEEP ANGLE: 29.8 deg.
90 deg. SWEEP ANGLE: 28.5 deg.
120 deg. SWEEP ANGLE: 29.6 deg.
150 deg. SWEEP ANGLE: 30.1 deg.
180 deg. SWEEP ANGLE: 30.3 deg.
References

Accessible Bus Stop Design Guidance
Transport for London, 2006

Design Guidelines for Accessible Bus Stops
BC Transit

Bus Pre-signal Assessment and Design Guidance
Transport for London, 2005

Bus Priority at Traffic Signals Keeps London’s Buses Moving
Transport for London, 2006

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http://www.honolulu.gov/dts/transit_glossary.htm#d

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Passenger Facilities
Sound Transit, 2007

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Ian Fisher and Tom Parkinson, 2006

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Department of Infrastructure, State of Victoria, 2006

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Department of Infrastructure, State of Victoria, 2007

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Easter Seals Project ACTION
Traffic Calming Measures for Bus Routes
Transport for London, 2005

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Transit Design Manual
PalmTran, 2004

Transit Facilities
BC Ministry of Transportation and Infrastructure, 2009

Transit Facilities Design Manual
SunLine Transit Agency, 2006

Transit Friendly Design Guide
Calgary Transit, 2006

Transit Infrastructure Design Guidelines
TransLink, 2002

Transit Stop Installation Checklist
BC Transit

Universally Accessible Bus Stop Design Guidelines
TransLink, 2007

Urban Design Framework
Portland Mall Revitalization, 2005
<table>
<thead>
<tr>
<th>Glossary</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Articulated Bus</td>
<td>Segmented bus that has rear portion flexibility, but is permanently connected to a forward portion and has no interior barrier to hinder passenger movement between the two portions.</td>
</tr>
<tr>
<td>Bus Bay</td>
<td>One type of bus stop where a bus pulls off from the roadway to a designated area (which typically consists of tapers and a loading area), stops to pick-up and drop-off passengers, before re-entering the roadway.</td>
</tr>
<tr>
<td>Bus Bulge</td>
<td>One type of bus stop where a widened piece of sidewalk extends into the parking lane on a roadway and is used as the passenger zone.</td>
</tr>
<tr>
<td>Bus Fleet</td>
<td>The vehicles which are operated by BC Transit. These may include conventional bus, double-deck bus, HandyDart, minibus, low floor bus, community bus, or alternative technology bus.</td>
</tr>
<tr>
<td>Bus Pad</td>
<td>An overlay of concrete above the area occupied by bus vehicles stopping at a transit facility to minimize pavement wear.</td>
</tr>
<tr>
<td>Bus Shelter</td>
<td>A building or other structure that provides protection from the weather, and may provide seating and other amenities for the convenience of passengers.</td>
</tr>
<tr>
<td>Bus Stop</td>
<td>An area where passengers wait for, board, alight, and transfer between transit vehicles. It is usually indicated by a bus stop sign and red painting along the road curb, where a road curb is available.</td>
</tr>
<tr>
<td>Bus Stop Sign</td>
<td>In the most basic form, a bus stop sign is a rectangular plate mounted on a pole that contains the bus stop identification number, the words &quot;BUS STOP&quot;, and other information such as a wheelchair accessible decal, if applicable to the bus stop. Where multiple bus routes share the same bus stop, the bus stop sign would also include the numbers and names of the bus routes.</td>
</tr>
<tr>
<td>Bus Sweep Path</td>
<td>The horizontal distance taken up by a bus vehicle when it turns. The width increases when a bus begins to turn and decreases as the bus completes the turn.</td>
</tr>
<tr>
<td>Crime Prevention through Environmental Design</td>
<td>Commonly known as CPTED, is a proactive crime prevention strategy through proper design and effective use of the built environment which can lead to a reduction in the occurrence and fear of crime.</td>
</tr>
<tr>
<td>Curb letdown</td>
<td>Also known as a curb ramp or curb cut. A short ramp cutting through a curb or built up to it to provide continuous and accessible access between the road and a sidewalk or raised concrete/asphalt pad.</td>
</tr>
<tr>
<td>Detector</td>
<td>A device used for indicating the presence or passage of vehicles.</td>
</tr>
<tr>
<td>Dwell Time</td>
<td>The scheduled time a vehicle or train is allowed to discharge and take on passengers at a stop, including opening and closing doors.</td>
</tr>
<tr>
<td>Far-Side Bus Stop</td>
<td>A bus stop situated after an intersection, in the direction of bus travel.</td>
</tr>
<tr>
<td>Flag Stop</td>
<td>No designated location or physical signage for the buses to stop. Buses will stop and pick up passengers wherever the bus drivers see a pedestrian who flags or signals the buses to stop.</td>
</tr>
<tr>
<td>Hybrid Bus</td>
<td>A hybrid electric bus combines a conventional internal combustion engine propulsion system with an electric propulsion system.</td>
</tr>
<tr>
<td>Layover</td>
<td>Layover may either be recovery time for the schedule to ensure on-time departure for the next trip, or break time between trips for bus drivers. Regardless of the situation, layover space is required for parking the bus vehicles.</td>
</tr>
<tr>
<td>Midblock Bus Stop</td>
<td>A bus stop situated midway between two adjacent intersections.</td>
</tr>
<tr>
<td>Near-Side Bus Stop</td>
<td>A bus stop situated before an intersection, in the direction of bus travel.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>On-Line Bus Stop</td>
<td>A bus stop where bus vehicles stop on the curb travel lane to load and unload passengers.</td>
</tr>
<tr>
<td>Parallel Loading</td>
<td>A type of platform configuration characterized by an area running parallel to the roadway.</td>
</tr>
<tr>
<td>Park-and-Ride</td>
<td>An access to transit for passengers who drive private automobiles or ride bicycles to a transit station, park their vehicles, and then ride the transit system to reach their final destinations.</td>
</tr>
<tr>
<td>Passenger Landing Pad</td>
<td>A stable, level, raised and slip-resistant surface to facilitate passenger boarding and alighting.</td>
</tr>
<tr>
<td>Passenger Pick-Up and Drop-Off Facilities</td>
<td>Designated spaces, usually located in the vicinity of a transit station entrance, for taxis or private automobiles to load or unload passengers who are coming from or needing to access the transit station. The spaces are usually enforced with limited parking duration.</td>
</tr>
<tr>
<td>Passenger Zone</td>
<td>The area which passengers use to wait for, board and alight buses. The area may be bounded by the road curb, adjacent property lines or boulevards. The passenger zone consists of a variety of amenities, such as the passenger landing pad, wheelchair pad, and bus shelter, etc.</td>
</tr>
<tr>
<td>Pull-In and Pull-Out Zones</td>
<td>Pull-in zone is the area occupied by a bus vehicle as it decelerates to come to a stop at a bus stop. Pull-out zone is the area occupied by a bus vehicle as it accelerates from a stopped position at a bus stop.</td>
</tr>
<tr>
<td>Real-Time Information</td>
<td>The provision of accurate information about the arrival of bus services at a bus stop, through an electronic display located on a pole or under the roof of a shelter.</td>
</tr>
<tr>
<td>Sawtooth Loading</td>
<td>A type of platform configuration characterized by jagged edges which allow buses to pull-in at an angle.</td>
</tr>
<tr>
<td>Sight Distance</td>
<td>Sight distance is the length of roadway ahead that is visible to the driver.</td>
</tr>
<tr>
<td>Sight Line</td>
<td>A line of sight from the eye to a perceived object. In transportation sight line typically refers to the ability for a road user to detect an object or another road user.</td>
</tr>
<tr>
<td>Timing Point</td>
<td>A location, usually a bus stop, where a bus vehicle reaches at an agreed time.</td>
</tr>
<tr>
<td>Traffic Calming</td>
<td>According to the Transportation Association of Canada, traffic calming involves altering of motorist behaviour on a street or on a street network. It also includes traffic management, which involves changing traffic routes or flows within a neighbourhood.</td>
</tr>
<tr>
<td>Transit Exchange</td>
<td>A focal point for passenger transfers between transit modes (for example, between bus and rail) and/or transit routes.</td>
</tr>
<tr>
<td>Transit Infrastructure</td>
<td>All the fixed components in the environment in which transit operates, such as components that are occupied and or used by transit patrons waiting to get on and off of bus vehicles, as well as the roadway used by bus vehicles.</td>
</tr>
<tr>
<td>Transit Priority Measures</td>
<td>Measures that give transit vehicles priority over other road users, such as exclusive bus lanes.</td>
</tr>
<tr>
<td>Transit Signal Priority</td>
<td>The alteration of normal signal phasing or sequence to provide preferential treatment for transit vehicles.</td>
</tr>
<tr>
<td>Universal Access</td>
<td>The ability of all people (including people with disabilities and other mobility challenges) to have equal opportunity to access transit service.</td>
</tr>
<tr>
<td>Visibility Impairment Zones</td>
<td>Areas where a “blind spot” occurs for bus drivers on both sides of a bus vehicle, which are outside of drivers’ direct line of sight and the areas visible through the bus side mirrors.</td>
</tr>
<tr>
<td>Wheelchair Landing Pad</td>
<td>A designated area within the passenger waiting area, located near the front door of the bus, which allows the safe and unobstructed operation of a wheelchair ramp and for the manoeuvre of a person in wheelchair.</td>
</tr>
</tbody>
</table>
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B
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