Transit Design Guide: Standards & Best Practices

A Resource Manual for Transit System Design
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## STANDARDS & BEST PRACTICES

### Purpose

The document is a collection of standards and best practices for designing transit- supportive roadways and facilities, and for enhancing transit service and operations for bus and rail, improving travel time and reliability, increasing ridership, and minimizing operating costs are all important considerations for Capital Metro and are influenced by factors such as land use, roadway users. Topics addressed include stop spacing, placement, and configuration; designing streets that are well-integrated with transit and create better environments for walking, cycling, and waiting; rail station and park and ride (P&R) design; traffic calming; lanes and boarding techniques; and transit street design.

As a result of regional demographic trends and increased ridership demand, Capital Metro is undertaking several initiatives to improve and expand its service, which necessitate the development of a set of standards and best practices that will provide Capital Metro, consultants, and other cooperating agencies with fundamental guidance on the design of transit systems and the coordination of transit design with the built environment. This manual should not be viewed as an exhaustive list of techniques for improving transit service and operations.


### Current Conditions

Established in 1989, Capital Metro is a regional public transportation provider headquartered in Austin, Texas, which operates bus, paratransit, vanpool, and commuter rail service for Austin and several suburbs in Travis and Williamson counties.

Capital Metro actively partners with the Central Texas planning community and the City of Austin to improve transit-related options for cyclists and first or last mile connections. This section discusses important trends, transportation-related pressures, and current planning initiatives that have contributed to the need for the establishment of transit design guidelines that will provide Capital Metro and other agencies with the means to address the challenges faced by the region.

### Regional Trends

The Central Texas region continues to experience rapid population and economic growth, with over 110 people moving to Austin every day and private sector investment generating a multitude of new jobs. Austin has led the top 25 US Metropolitan areas in population growth and has been consistently one of the top 10 fastest growing metropolitan communities for the last decade, according to U.S. Census data (Austin, 2016). Through this growth has brought many benefits, it has also contributed to a significant increase in traffic congestion, lack of affordable housing supply, and rising income inequality. As the 4th most congested metropolitan area in the United States, Austin is struggling to allocate the pressure on the region’s transportation system, as traffic has grown more than 30 percent faster than the growth in road capacity in the Austin metro area over the past 25 years (Austin, 2016).

Rising housing costs and limited supply have caused many Austin residents to seek more affordable housing in surrounding suburban communities, including Pflugerville, Manor, Buda, Round Rock, and Georgetown. The City of Austin and regional transportation authorities have developed long-term strategies for increasing these mobility and development challenges, which require a “multi-modal system that works seamlessly to provide transportation options, address congestion, and increase mobility throughout the community while supporting and enhancing economic development opportunities within the established ‘preferred centers’” (Austin, 2017). Capital Metro is a valuable partner in these efforts as the agency continues to improve and expand its system to offer an affordable alternative to driving and alleviate mobility challenges the region faces.
Capital Metro is undertaking a system-wide initiative to encourage Transit-Oriented Development (TOD) in providing residents in Greater Austin with an array of affordable, efficient, and sustainable transportation options.

Recognizing the importance of Transit-Oriented Development in connecting people, places, and opportunities in the region, Capital Metro is involved in several initiatives to meet the greater demand on its system.

Another agency initiative, Project Connect, aims to identify and evaluate potential high-capacity transit service corridors.

As a result of regional growth trends and other factors, Capital Metro is undergoing tremendous expansion throughout the system that has created opportunities and challenges regarding the capacity and design needs of its service. In 2015, Capital Metro provided nearly 31 million riders system-wide; launched a five-route frequent MetroBus service on several popular routes, which have shown a 10-25 percent increase in ridership; experienced a 20 percent increase in average daily boardings along both MetroRail corridors combined; and has experienced continued increases in MetroRail ridership to 45,600 average trips per month. MetroRail and MetroRapid ridership; experienced a 20 percent increase in average daily boardings along both MetroRail corridors combined; and has experienced continued increases in MetroRail ridership to 45,600 average trips per month.

The table below shows the services offered by Capital Metro and their function.

<table>
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<th>Route Numbers</th>
<th>Description</th>
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<td>MetroRapid (60-ft)</td>
<td>200-999</td>
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<tr>
<td>MetroRail</td>
<td>500-599</td>
<td>Limited stop commuter rail service</td>
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<td>Senior</td>
<td>490-499 Midday service between senior housing and shopping</td>
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### System Growth
As a result of regional growth trends and other factors, Capital Metro is undergoing tremendous expansion throughout the system that has created opportunities and challenges regarding the capacity and design needs of its service. In 2015, Capital Metro provided nearly 31 million riders system-wide; launched a five-route frequent MetroBus service on several popular routes, which have shown a 10-25 percent increase in ridership; experienced a 20 percent increase in average daily boardings along both MetroRail corridors combined; and has experienced continued increases in MetroRail ridership to 45,600 average trips per month. MetroRail and MetroRapid ridership; experienced a 20 percent increase in average daily boardings along both MetroRail corridors combined; and has experienced continued increases in MetroRail ridership to 45,600 average trips per month.
Transit Vehicle Design (select representations)

Examples of Vehicle Design (source: Capital Metro)

Source: NovaBus (reproduced)

MetroRapid (NovoBus, 40-ft)
Andrew Murphy

MetroBus (Gillig, 40-ft)

MetroRail (Stadler, 134-ft)

Source: Gillig (reproduced)
Source: Stadler (reproduced)

AMurphy: Two(s) touch pads on each center-facing 3-passenger W/C flip-up seats
Bus Stop Design (select representations)

Capital Metro's Local Bus Stop Design (source: Capital Metro)
Service & Operations

Park & Ride Design (select representations)

- Lakeline Station Park & Ride Design (source: Capital Metro)
- Howard Station Park & Ride Design (source: Capital Metro)
- Local and MetroRapid Pole Signs (source: Capital Metro)

Signage (select representations)

- Local Urban Pole Sign
- MetroRapid Urban Pole Sign

Local Routes:
- Routes 1-99 & 301-499

Premium Routes:
- Routes 100-199 & 600-999

Commuter Routes:
- Routes 500-599 & 700-999
Strip Signs (6.25" X 25")

Every Capital Metro bus stop is equipped with a Strip Sign that is usually attached to the bus stop pole. This sign is intended to be read at eye-level and to convey several key pieces including:

• **Location:** At the very top of each Strip Sign is the intersection and the unique Stop ID which assures customers that they are at the correct stop.

• **Next Bus:** This section provides a unique QR code, phone numbers and URLs for customers to use to find out when their next bus is arriving.

• **What to Pay:** This section is an overview of fare levels and which routes are included in each category.

• **Braille:** Capital Metro is committed to providing accessible information wherever possible. Which is why bus stops include Braille for the blind and low-vision community. This information is attached on the bottom half of each sign.

Large Strip Signs (8.75" x 35.375)

For stops with Urban Pole signs, Large Strip Signs are used. These follow the exact design as regular Strip Signs, only difference is their larger size.

Service Guidelines

Service standards provide a framework for the provision, design, and allocation of service. In 2015, Capital Metro revised its Service Guidelines and Standards, which established a set of design criteria including route directness, span, frequency, schedule reliability, and ridership performance. As the provision of a high level of transit mobility that is affordable to passengers and taxpayers often involves trade-offs between the costs and the benefits achieved by providing the service, these service standards provide a formal mechanism for making these trade-offs in an objective and equitable way (SEPTA, 2014). Capital Metro’s standards include the following:

- Routes should be designed to operate as directly as possible to minimize travel time while maintaining access to key destinations and making multi-leg connecting trips efficient.
- Deviations off the primary alignment of a fixed route should be minimized whenever possible and should result in an overall ridership increase.
- Service should be designed to operate in two directions on the same street whenever possible in order to minimize passenger confusion and maximize service effectiveness.

TRB’s TCRP Report 165: Transit Capacity and Quality of Service Manual, 3rd Edition (TCQSM) provides guidance on transit capacity and quality of service issues and the factors influencing both. The manual provides a framework for measuring transit availability, comfort, and convenience, containing quantitative techniques for calculating the capacity and other operational characteristics of transit, including stops, stations, and terminals (TRB, 2013).
Transit-Supportive Roadway Design

Improving bus travel times and travel time reliability are key considerations for transit planning and roadway agencies, as these issues directly impact the cost of providing service, are important for attracting new riders and retaining existing riders, and support sustainable and multi-modal communities. To assist in this process, the 2015 TRB TransIT Manual identifies four main categories of strategies, which are summarized in the diagram below:

- **Bus operations strategies:** Changes made by the transit agency to improve service, such as introducing bus stops, changing bus stop spacing, and changing the way buses operate.
- **Traffic control strategies:** Changes to the way traffic is regulated, for the benefit of transit; examples include changing traffic signal operations to prioritize bus movements and changing traffic regulations to improve traffic flow generally or bus movements specifically (e.g., prohibiting left turns where no left-turn lane is provided, or exempting buses from right-turn-only requirements).
- **Infrastructure and bus lane strategies:** Changes to physical elements of the roadway, such as extending sidewalk space into the parking lane (curb extensions) or constructing bus lanes.
- **Transit-supportive roadway strategies:** Focus on bus mode (including bus rapid transit [BRT] and commuter bus service, many of these categories are potentially applicable to demand-responsive transit, streetcars, and portions of light rail transit systems operating on-street. Some strategies work best when part of a package of strategies, where multiple strategies are implemented at the same time. Some may be considered as “supportive strategies,” that “do not necessarily provide an overall travel time benefit on their own, but help another strategy achieve its maximum benefit” (TRB, 2015)). Various transit-supportive roadway strategies are referred to in this manual. See TRB, 2015 for further guidance, including key benefits, costs, and issues associated with each strategy.

Bus Stop Design

Bus stop design affects many aspects of the transit system and the built environment, such as ridership, public health, and user experience, multi-modal connectivity, and safety. Because riders expend a great deal of time, energy, and patience outside of buses while waiting or transferring (Taylor, Iseki, Miller, & Smart, 2007), enhanced passenger amenities are greatly valued by passengers (Jenks, 1998). Alternatively, lack of adequate design leads to commuters feeling undervalued and thereby view the waiting experience as an impediment to choosing transit (Hess, 2012; Wardman, 2001).

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**Design Elements**

Stations and stops play a key role in defining the transit system and the system’s performance. As stated in APTA, 2015, good station or stop design can do the following:

- Attract new riders
- Promote visibility and facile branding of the system
- Provide shelter from the weather
- Ensure safe accessibility for all, including people with disabilities
- Provide passengers with information, including system maps and real-time arrival information
- Provide passengers with a safe and secure environment by including such items as CCTV cameras, a public address system, public and security telephones, lighting and fencing
- Enable passengers to board through multiple doors
- Enable precise boarding at designated stopping points
- Enable level boarding by matching platform height with vehicle floor height and using precision docking
- Enable passengers to pay their fares before boarding using off-board fare payment equipment
- Provide passengers with amenities such as newspaper boxes, signage, waste recycling, special lighting, waiting and bicycle parking
- Provide passengers with an attractive environment, using features such as landscaping and public art
- Create a sense of place within the community, encouraging development and other activities to occur near the station or stop
- Ensure ease of access to users of other modes, including bicyclists, pedestrians and automobile drivers
- Ensure easy connections with other local and intercity modes of transportation

Transit stops are nodes of exchange between all users of the street and great stops must integrate the complex and often conflicting movements of these users. Stops and stations should integrate spatial and temporal strategies to optimize transit streets and simplify rider experience, including signalization, dedicated lanes, and stop location (WACTO, 2016).
Goals
The urban realm and mode choice are strongly linked. Better environments for walking, cycling, and waiting lead to higher active transportation and transit mode shares, as improvements to sidewalks, bus shelters, pedestrian and cycling networks, lighting, and amenities are implemented (NRG Research Group, 2010). Such incremental improvements build off one another and have long-term benefits for transit users and the entire neighborhood (Van Dyck, Deforche, Cardon, & De Bourdeaudhuij, 2009). The effect of the built environment on ridership is often broken down into 5 D’s: density of development, diversity of land uses, design of the environment, destination accessibility, and distance to transit (Ewing & Cervero, 2010). There are seven main goals linked to the built environment that should guide decisions when designing bus stops: safety, thermal comfort, acoustic comfort, wind protection, visual comfort, accessibility, and integration (Zhang, 2012). See Zhang (2012) for more information on these goals.

Wind Protection
- Minimise how much mechanical and thermal bridges on the bus stop. Often building noise and wind may therefore not be significant. Rain and snow may also be a concern.

Visual Comfort
- Surface qualities should be protected by safety and in contact with pedestrian paths at low level space, so that visual scarring is not required.

Accessibility
- The area should be easily accessible by all segments of the population, through and through access lanes.

Amenities
- Amenities such as public art, drinking fountains, and waste bins should be considered as part of the overall planning of the environment.

Traffic Management
- Traffic management techniques focus on reducing nuisance effects of road traffic. This may involve reducing levels of road traffic, managing parking and waiting in the area, and more pleasant urban transport systems.

Pedestrian Infrastructure
- The pedestrian network around a stop is an extension of the broader network. It is important to have high-quality walking environments to offset low riders.

Bike Infrastructure
- Many residents would like to bike if it were to become an option. Adequate bike paths and bike parking must be provided.

Techniques
There are 9 key bus stop design techniques that help achieve the goals outlined in the previous section. Lighting, seating, cover, amenities, information, vegetation, traffic management, pedestrian infrastructure, and bicycle infrastructure (Zhang, 2012). See Zhang (2012) for more information on these techniques.
Stop Placement & Configuration

Determining where to locate stops and stations is one of the chief governing factors of effective transit operation. Bus stop placement involves a balance of customer safety, accessibility, comfort, and operational efficiency. Stop access is described based on lateral placement relative to the curb, and location along the block relative to the nearest intersection.

There are different configurations for stop access, each with its own opportunities, benefits, challenges, and street context (NACTO, 2016). The three main types of stop configuration most applicable to the Capital Metro system are sidewalk stops: near-side, far-side, and mid-block. Typical dimensions for sidewalk stops are shown in the following table’s illustrations, though an additional 20 feet (6.1m) should be provided for articulated buses, plus appropriate transition zones where traffic speeds are higher (NACTO, 2016; TRB Report 19; TSP, 2010 and the Platform Length section of GACTO, 2010) provides further information on design considerations for various stop types.

All bus stops should be fully accessible with a concrete landing and access to sidewalk or pathways. Bus stops should optimally be placed at intersections to maximize pedestrian safety, be compatible with adjacent land use, and minimize adverse impacts on the built and natural environment. Far-side stops are generally preferred over near-side and mid-block stops, though specific riding conditions may determine the placement of a bus stop. This section provides general design guidelines for common stop configurations. See NACTO, 2016; SEPTA, 2012; and TRB, 2010 for more detailed guidance on stop placement, relocation, and additional stop configurations.

### Stop Placement & Configuration

<table>
<thead>
<tr>
<th>Stop Type</th>
<th>Recommended Minimum Distance Between Bus Stops</th>
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</thead>
<tbody>
<tr>
<td>Near-side Stop</td>
<td>50 ft. (15.2m) max.</td>
</tr>
<tr>
<td>Mid-block Stop</td>
<td>100 ft. (30.5m) long x 10 ft. (3.0m) wide max.</td>
</tr>
<tr>
<td>Far-side Stop</td>
<td>150 ft. (45.7m) long x 10 ft. (3.0m) wide max.</td>
</tr>
</tbody>
</table>

### Area Type: Ideal Stop Spacing Range (Min-Max)

<table>
<thead>
<tr>
<th>Area Type</th>
<th>Ideal Stop Spacing Range (Min-Max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suburban and other low-density areas</td>
<td>1,200-2,500 feet</td>
</tr>
<tr>
<td>Low-density areas</td>
<td>800-1,200 feet</td>
</tr>
<tr>
<td>High-density areas</td>
<td>400-800 feet</td>
</tr>
<tr>
<td>Downtown</td>
<td>250 feet max.</td>
</tr>
</tbody>
</table>

### Stop Placement Considerations

- **Near-side Stop**: Stops occur when the bus stops before the intersection. Advantages are that passengers can board and alight closer to intersection crosswalks, which may facilitate better transfers. Near-side stops eliminate the potential of afflicting passengers walking through red light.
- **Far-side Stop**: Stops occur when the bus stops after proceeding through the intersection. These stops are preferred at intersections in which buses make left turns, and intersections with a high volume of right-turning vehicles. Far-side stops are also preferred on corridors with transit signal priority (TSP) and encourage pedestrians to cross behind the bus.
- **Mid-block Stop**: Stops occur when the bus stops in between intersections, usually in a well-defined area. They should be considered when pedestrian crossings are not present. Pedestrian crossings are not present, Capital Metro will work with appropriate entities to address the potential of installing Handeats like flattening handeats because to accommodate this issue. Mid-block stops may be the only option at major intersections with dedicated turn lanes.

### Stop Spacing

The greatest predictor of transit use is proximity (Cervero, 2002; Gutiérrez & García-Palomares, 2011). The closer one lives to a transit stop, the more likely one will take transit (Ulrike, Brennan, Brennan Ramirez, Elliott, & Wandel, 2005). The typical catchment for a bus stop is contained within a 1,200-meter (approximately 1,200 feet) radius around the stop and can be larger for faster forms of transit (Gutiérrez, Cardozo, & García-Palomares, 2011).

Stop spacing is determined by several factors including customer convenience, riderhip demand, and service type. Customer convenience involves a trade-off between proximity to stops and travel time. Closer spaced stops reduce customer walking distance but result in slower transit speeds, reducing operating efficiency, and could be cost-effective. Though few stops further apart increases walking distance, faster, more reliable service is often the result.

Bus stops serving downtown Austin or major activity centers should be spaced more than 800 feet apart. For reference, the average block size in downtown Austin ranges between 333 and 450 feet, so this essentially means a bus stop may occur every other block for local stop services. Regular local stops on arterial streets should be spaced every 800-1,200 feet. In sub- and other low-density areas, stops may be spaced over 1,200 feet apart.

Sufficient riderhip demand is necessary to support the investment of stops. Specific service types such as limited stop, rapid, and express require increased stop spacing over 1,200 feet apart. For reference, the average block size in downtown Austin ranges between 333 and 450 feet, so this essentially means a bus stop may occur every other block for local stop services. Regular local stops on arterial streets should be spaced every 800-1,200 feet. In sub- and other low-density areas, stops may be spaced over 1,200 feet apart.

When existing stop spacing is every block or two, block lengths are reasonably short (e.g., 300-500 feet), and adequate pedestrian infrastructure exists, the stop spacing can be increased up to a three-block spacing without requiring passengers to travel more than one extra block to access a bus stop, and with only a minimal reduction in the area served by the remaining stops.

### Stop Design

- **Ideal Stop Spacing Range (Min-Max)**: 500-1,300 feet

- **Recommended Minimum Distance Between Bus Stops**:
  - Near-side Stop: 250 feet max.
  - Mid-block Stop: 1,000-2,000 feet
  - Far-side Stop: 2,500 feet max.
Sidewalk Stop: Turnout

The bus bay or turnout is a location off-line with respect to the travel lanes, with a specially-curbed pull-out for buses. For lay-bys or inter-modal transfer points, where buses may dwell for extended periods, the bus bay maintains traffic flow, allowing general traffic to pass around a loading bus and interferes less with right-turning vehicles at the intersection. It can be effectively incorporated into a site design where high-volume loading is anticipated, such as an animated complex. Typical dimensions are 110 feet (33.5 m) long by 10 feet (3.0 m) wide (SEPTA, 2012). The “lay-by” configuration should only be applied where sidewalk width is sufficient for the shelter and a pedestrian clear zone is behind it (NACTO, 2016). A variation of the bus bay is the open bus bay, which provides additional maneuverability toward the upstream side of traffic flow. SEPTA, 2012 provides further information on the open bus bay. The bus zone is generally located in a parking and/or loading lane area in the road, with a typical width of 10 feet. The parking lane should be marked in order to identify the loading and maneuvering area for transit vehicles and the bus zone treatment should include painted roadway markings and a sign marking the area as “no stopping” or “no parking” location (SEPTA, 2012). Queue jumps and pre-signals can be used to create “a virtual bus lane when a physical curbside bus lane needs to end due to downstream constraints on the use of the curb space” (TRB, 2015). Further design considerations for curbside stops include the following:

- Stop zone must be 10 feet clear of the crosswalk or curb return whether near- or far- side.
- Stop length must equal the length of the bus, and curbside boarding area should include both the front and back doors.
- Ensure stop amenities do not block accessible boarding area or travel path.

Source: NACTO, 2016

In constrained conditions where the width of the transit lane prevents dedicated bicycle and transit facilities from being provided separately (13 feet or less), place advisory bicycle lanes to the left of the bus stop and place the space of the curb bus pad to either side of the advisory lane, as seams and cracks pose a hazard to bicycle wheels. Shared-lane markings should be positioned to the left side of the bus-bicycle lane (TRB, 2016).
Curb Extension

A curb extension (or "bus bulb") is a modification of the curb and sidewalk to extend the sidewalk or waiting area for passengers and amenities while maintaining a clear pedestrian path on the sidewalk (NACTO, 2016). Curb extensions are most effectively used when travel speeds are lower than 30 mph, where pedestrian volumes are high, or where the sidewalk is narrow and additional waiting space is required (NFTA, 2012). They are best suited for areas with high-density waiting space is required (NFTA, 2012). They are best suited for areas with high-density passenger volumes waiting for a gap in traffic (re-entry delay) when leaving the stop. Bus bulbs increase bus speed and reliability by decreasing the amount of time last when merging into traffic from pull-out stops creates operational delays, thereby reducing dwell time and transit delay waiting for a gap in traffic (entry delay) when merging into traffic from pull-out stops creates operational delays, thereby reducing dwell time and transit delay waiting for a gap in traffic. At stops adjacent to crosswalks, provide at least 10 feet of clear sidewalk space, ahead of the transit vehicle at near-side stops and behind the transit vehicle at far-side stops.

At bus stops, extend the bulb to within two feet of the edge of the travel lane, and can be installed at near-side, far-side, and mid-block stops, at both signalized and unsignalized locations (NACTO, 2016). 

Provide curb extensions for installing curb extensions include.

- Low to moderate traffic volumes (<400-500 vehicles per hour per lane in the same direction).
- Two or more travel lanes in the direction of travel, to allow passing (desirable but not essential).
- Relatively high sidewalk or crosswalk usage, or relatively high passenger volumes waiting on the sidewalk.
- Relatively low right-turning volumes, particularly larger vehicles such as trucks and buses.
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Design considerations for curb extensions include:

- Boarding bulb width must meet accessibility requirements (ADA Std. 810.2.2). With most ramp technology, boarding areas at near-accessible door must be at least 8 feet, along with four-foot clear paths to reach each accessible door (ADA 508.3.1.5 (a) see page 47).
- Boarding area amenities may include shelters, seating, trash bins, planting, utility boxes, wayfinding and route information, which must be placed clear of accessible boarding areas (NACTO, 2016).
- Cross-slopes no greater than two percent should be provided along the accessible paths and landing area.
- Curb extensions are constructed within the area used by the parking lane (TRB, 2013; NACTO, 2016). Boarding areas must be compatible across service types. Center-boarding islands provide greatly enhanced service for bus and rail, especially on streets with high transit ridership or service frequency (NACTO, 2016).
- In-street boarding islands stop the vehicle at the nearest curb and require minimal lateral movement for bus access.
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Other types of bus bulbs include tiered and level boarding stops, which are discussed further in NACTO, 2016. Bicycle lanes behind floating boarding bulbs can be at either street grade or sidewalk grade. TRB, 2013 discusses additional standards for designing curb extensions, including the use of a traffic analysis and Transit Capacity and Quality of Service (TCQSM) model to determine typical level of queuing and vehicle travel time savings and delay expected as a result of buses serving a stop with a curb extension.

Bus Stop Design

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The table below illustrates bus bay dimensions for various vehicle/door configurations cited by the Delaware Valley Regional Planning Commission's (DVRPC), which can be used to design and determine typical level of queuing and vehicle travel time savings and delay expected as a result of buses serving a stop with a curb extension.

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Center island platforms must be either level or near-level boarding and provide an accessible boarding area, typically eight feet wide by five feet long, must be present by left-turn movements. The following diagrams illustrate three potential applications for in-street boarding islands located at intersections:

1. **An accessible boarding area, typically eight feet wide by five feet long, must be provided to permit boarding maneuvers by a person using a wheelchair (ADA Std. 508.2.2) (see page 7).** For low-floor vehicles using drop-plate, near-level boarding can usually be achieved with a 9.5- to 12-inch platform. Higher (10-inch) platforms where drop-plate designs cannot be configured for level boarding, and may be incompatible with some buses.

When a bicycle lane or cycle path requires bicyclists to yield at a crosswalk from the sidewalk onto the island, the BICYCLES YIELD TO PEDESTRIANS sign (the Manual for Uniform Traffic Control Devices (MUTCD R9-6) and yield triangle markings must be installed.

Bicycle signals can enhance clarity of intersection movements and should be considered for far-side and near-side boarding islands to provide a dedicated bicycle and pedestrian thoroughfare.

Traffic signals may permit near-lane moving lane or other traffic rules unique to the intersection. The BICYCLES YIELD TO PEDESTRIANS sign (the Manual for Uniform Traffic Control Devices (MUTCD R9-6) and yield triangle markings must be installed.

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2. **Boarding island stops should include shelters, seating, wayfinding, and passenger information.**

Platform access ramp may have a maximum slope of 1:12 at a crosswalk or other crossing point, at the sidewalk and onto the platform (ADA Std. 508.2.2).

Reflected signage or other visible signal element on the leading (back left) corner of the island (see MUTCD R6-6, 9-6). If loading traffic can be accommodated for level boarding, an island stop may be installed.

An accessible ramp should be placed at the intersection end of the island entering the sidewalk without a crosswalk or at the intersection end, with a regenerative gap to protect pedestrians (at least six feet wide).

Boarding island stops should include shelters, seating, wayfinding, and passenger information when feasible.

Shelters should be located at least 10 feet from crosswalks over the bicycle lane to allow mobility between people bicycles and people exiting the island, loading areas may be included when feasible.

Boarding island extensions can be used for green infrastructure, including rain gardens and other stormwater treatment facilities.

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Amenities
Transit stop amenities improve customer comfort, convenience, and safety. They also have the potential to increase ridership and promote system-wide equity. Stop features that provide added convenience and comfort to the trip and passenger experience include benches, shelters, signage and system information, trash receptacles, public art, bicycle racks and lighting. Collectively, passenger amenities help enhance the visibility of transit in a corridor; raise general awareness of transit as a mobility option, may reflect a visual identity treatment for a locality, and are viewed as a community asset (SEPTA, 2012).

As stated by NACTO, incorporating high-quality transit stop design and amenities “can expand pedestrian capacity and promote transit streets as a desirable ‘place’ in the urban environment. Creating a simple, legible, and pleasant experience at the transit stop grows the capacity of the whole system, and can help transform streets from a basic coverage service to a sought after mobility option” (NACTO, 2016).

The location of passenger amenities should not interfere with normal passenger flow. When considering and placing amenities, it is important to take into account adjacent land uses, programming, non-commuters who may use these items, and microclimatic conditions of the site (Zhang, 2012).

Capital Metro’s service guidelines detail specific requirements that must be met for the provision of certain amenities, such as bus shelters, benches and litter containers. For example, bus stops generating at least 15 boardings per weekday qualify for a bench. Bus stops generating 50 daily boardings qualify for a shelter (though some exceptions exist). All bus stops with shelters or benches should also have a litter container, and bicycle racks may be installed at stops in areas of high demand or in concert with other local entities.

MetroRapid transit station amenities include:
- Cantilever transit shelter with MetroRapid branding
- Real-time arrival display
- Aluminum seating and lean bars
- MetroRapid specific route maps for routes departing from station

Level of Service (LOS) classifications, determined in direct relation to P&R lot capacity, are used by Capital Metro to generate rough order-of-cost estimates for future P&R facilities and specify the types of amenities that should be incorporated into transit facilities to meet safety, security, comfort, and convenience needs. The table below illustrates the stops amenities that are provided for P&R facilities meeting a certain LOS rating. Capital Metro’s service guidelines provide further information.

Examples of Stop Amenities by LOS Rating (source: Capital Metro, 2015)

Public Art
The visual quality of public transit systems has a profound impact on transit riders, the community at large, and the image of a city, with implications for a city’s livability and economy. Capital Metro strives to integrate public art into its transit facilities, redevelopment projects, and vehicles. “High-quality public art and design improve the appearance and safety of a facility, add vibrancy to public spaces, and make patrons feel welcome, often resulting in higher usage of the facility” (APTA, 2013). Other benefits of incorporating art in transit include:
- Encouraging ridership
- Improving perception of transit
- Conveying customer care
- Enhancing community livability
- Improving customer experience
- Enhancing organizational identity
- Decreasing vandalism
- Increasing safety and security

Examples of Stop Design by LOS Rating (source: Capital Metro)

Stop Amenities by LOS Rating Source: Capital Metro (2015)
Signage

Bus stop signage should contain route name, number, direction, and destination. Capital Metro customer service phone number, system logo, and website address. Detailed schedule and route information should be provided at major boarding locations and transfer points. All signage should also contain the unique bus stop ID number and instructions about how to look up real-time information pertaining to buses that serve that particular stop using the mobile app, web functions, or the online trip planner.

Street Furniture

Street furniture enhances the experience of waiting by providing added convenience and comfort for commuters and non-commuters. Examples of street furniture include transit shelters, stop area seating, and bicycle racks. Be able to sit while waiting for the bus significantly reduces commuter stress and doubles the waiting at a stop, leading to an increased catchment area and ridership (Upp, 2019).

Transit Shelters

Shelters protect passengers from weather conditions and should be constructed of durable, architecturally sound, and highly visible areas to deter theft. (SEPTA, 2012). It is important to provide bicycle racks and parking shelters to meet the needs of commuters who use bicycles to access transit and wish to park their bicycles at the point of origin or destination. Security. Bicycle parking should be placed in well-lit and highly visible areas to deter theft (SEPTA, 2012). Capital Metro provides secure bicycle shelters at several of its P&R facilities and rail stations, which include space for 24 bicycles, have gated entry access via key card, and include camera surveillance, maintenance repair stands and air pumps.

Power and Comfort

Shelters should not interfere with pedestrian thorough-paths and should be oriented toward the path that leads to the bus pad. Passengers waiting in the shelter must be able to easily see arriving transit vehicles and must be readily visible to operators if transit vehicles stop only on demand. Include lighting in the shelter, at least 13 ft. (4m) above the waiting area. Ensure the shelter can be seen from outside by using glass or open design for the back wall (SEPTA, 2012). Shelter design, though flexible and context-sensitive design may be allowed in certain circumstances (ex. Mi Jardin Plaza and 38th St/Medical Station).

Seating

Seating should have a variety of seating options, where possible, including benches, leaning rails, and low masonry walls. The amount of seating should match the average number of commuters simultaneously occupying the stop, given that it does not impede access (Tan et al., 2007). It is critical that seating be seamlessly integrated with the surrounding urban landscape; serve non-commuters during non-rush hours; and be sufficiently shielded from vehicular traffic (Zhang, 2012).

Guidance from SEPTA states that benches should be constructed of durable material, resistant to vandalism and weather from exposure to weather, and AODA compliant in dimension. The recommended minimum length for a Bench is 6 ft. (2.0m) or the equivalent of three seats, whereas leaning rails should be slightly higher than seat height, or about 2.5 ft. (0.8m) high above the stop location surface. It is recommended that benches include arms to aid in seniors, and the disabled, and anti-theft bunding should be considered to prevent unattended seating (SEPTA, 2012).

Bicycle Racks & Parking Shelters

It is important to provide bicycle racks and parking shelters to meet the needs of commuters who use stationary and electric bicycles when waiting for their bus. They also include Corridor Map and Next Bus panels. Temporary wayfinding signs points to the particular stop using the mobile app, texting functions, or the online trip planner. Instructions about how to look up real-time information pertaining to buses that serve that particular stop using the mobile app, web functions, or the online trip planner.

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Bus Stop Signage

Bus stop signage should be illuminated and bus stop fixtures near street lights can provide additional lighting. As defined by SEPTA, “lighting may take several forms in any combination to provide an aesthetic effect that coordinates with the architectural style of adjacent developments can enhance the visual coherence and attractiveness of the setting (Zhang, 2012).” Lower, smaller, less intense, spaced closer together throughout the stop, and usually more visually interesting. Such lighting should be spaced at 30 meters (approximately 98 feet) or more likely to integrate into the surroundings than standard street lights. Pedestrian scale lighting is characterized by lights that are:

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The following guidelines are recommended for effective wayfinding (NACTO, 2016):

- Make sure wayfinding signs are placed at a reasonable distance from the curb or sidewalk, visible through trees, and not obscured by other objects.
- Provide accurate and consistent information, including travel times, distances, and directions.
- Use clear, simple, and consistent symbols and icons.
- Incorporate safety considerations, such as visibility and accessibility.
- Integrate wayfinding with other elements of the urban design, such as streetscapes and public art.
- Test and evaluate wayfinding systems regularly to ensure they are effective and user-friendly.

Wayfinding signage can be extended to vehicles through the use of digital signs and mobile applications. For example, the Capital Metrorapid stations in Austin, Texas, use smart phone applications to provide real-time information to riders. These applications can include maps, schedules, and route details, as well as other relevant information, such as weather and traffic conditions.

Wayfinding signage can also be extended to pedestrians through the use of signs, symbols, and other visual cues. For example, the Capital Metropolitan Transit Authority (CMTA) in Austin, Texas, uses signs to direct pedestrians to the nearest bus stop, as well as other important landmarks, such as parks and bike share stations. These signs are designed to be easily visible and recognizable, even from a distance.

Wayfinding signage can also be used to direct vehicles to permitted turns or other important destinations. For example, the Capital Metrorapid stations in Austin, Texas, use signs to direct vehicles to permitted turns, as well as other important landmarks, such as parks and bike share stations. These signs are designed to be easily visible and recognizable, even from a distance.

Unified wayfinding standards and guidelines should be developed to address a transit agency's facilities, operations, remote signage to direct pedestrians to facilities, and the needs and desires of the various modes the agency has or would like to have. Transit operators should work with service area communities, such as the Downtown Austin Wayfinding Project, which integrates signs, brochures, kiosks, and smartphone applications to facilitate navigation in the downtown area. Capital Metrorapid has developed wayfinding maps for the Metrorapid stations, showing the station, key transit routes, street grid, parks, Austin B-Cycle stations, and key destinations within a half mile walk of the station.
Information Technology
Information plays an important role in the performance of a bus stop and schedule information will ideally be present at every location. (Jain et al., 2001; NACTO, 2016). A variety of media ensure that information is accessible to everyone and tactile wayfinding and audible information should be utilized where possible. Arrival information is best suited for digital display, while transit maps are best presented in print form, especially for those without smart devices (2012). Pedestrian, cycling, and green infrastructure maps for the specific neighborhood increase the sense of ownership of a public space and may be included where possible (Stocrin & Kersaint, 2016).

As updating static information like flags, system maps, and placards require enormous time and financial resources for a transit agency, digital information technology allows for wayfinding information to be presented to transit users in a quick, up-to-date, and easy-to-understand format that is also a cost-effective investment for the agency. In order to be successful, it is important that wayfinding technology balances the provision of detailed information for transit users and cognitive load, which refers to the intellectual pressure placed on a person during decision making situations. Wayfinding should provide the transit user with the minimum amount of information needed to find their way at the right time and place.

ConnectPoint® interactive kiosks used by Dallas Area Rapid Transit’s (DART) provide interactive wayfinding messages, information, and maps in an easy to read and understandable manner. As stated by DART, these kiosks integrate with training and location systems, scheduling systems, and other DART information systems to provide comprehensive information to customers. Touchscreen technology allows for interactive interaction with the information to explore transit options and to create specific routes, including an overview of entire routes, next departure times as well as detailed route mapping for each stop. The kiosks include detailed transit directions for public transportation, cars, bicycling, and walking; texting and email options are also included for easy transfer to a mobile device. The kiosk also has the ability to push out route deviations as they happen, generate revenue via location-based advertising and leverages smartphone applications, and smartpens. projectactionx.org provides more detailed information on these and other disability-specific wayfinding strategies.

For those with disabilities (including visual impairment), there are several wayfinding technologies that allow users to navigate and access transit facilities. These include tactile maps, detectable warnings and directional texture, infrared talking signs, GPS, smartphone applications, and smartpens. projectactionx.org provides more detailed information on these and other disability-specific wayfinding strategies.

Fares & Boarding
Fare collection and boarding can be time-consuming, accounting for half to a third of vehicle revenue time. Strategies that streamline fare collection and allow for multi-door boarding can dramatically speed up passenger boarding time, reducing dwell time and total running time (NACTO, 2014). Same-level bus boarding plus pre-boarding fare payment results in reduced dwell time of a stop. Comment fare payment methods including cash payment, ticket vending, Radio Frequency (RFID) card, and mobile application. Cash fares are paid to the driver upon boarding and, in systems using proof-of-payment (PoP) fare control, riders paying cash receive a PoP ticket from the driver showing that the fare was paid. It is common for drivers, particularly on local transit service, to both operate the vehicle and collect fares, slowing bus operations. “Pay-on-boarding fare collection is a time-consuming act, typically accounting for about half of passenger dwell time. Total dwell time may be 20-25 percent of vehicle revenue time” (NACTO, 2016).

Advertising
Capital Metro Transit Advertising, 2019 contains detailed information and rates for the agency’s advertising services. Transit advertising has a number of benefits (Federated Transportation Services):

- Reaching Audience: Transit advertising brings an agency’s message to the busiest and most desirable areas— including many areas where billboards are not used.
- Timing: Consumers see advertising at the best possible time—when they are not at work, home, or school. Transit ads reach people when they’re most ready to respond or make a purchase, such as when they’re traveling or shopping.
- Value: Transit advertising typically costs less than television, radio, billboards, and newspapers. An agency will reach the largest audience typically for the least cost.
- Creative Exposure Ads will be seen 12-15 hours a day and allow an agency to engage a captive audience of motorists and pedestrians in passing, at stops, or paused in traffic.
- Get Noticed: With their bold text and larger-than-life graphics, transit ads are naturally appropriate to support an agency’s products.

Ticket vending machines may be on/off-board, acting as a proof-of-payment (and fare collection) device. Ticket vending machines may be on/off-board, acting as a proof-of-payment (and fare collection) device. They may be located at the entrance to an off-board ticketing area or on the vehicle itself. Ticket vending machines may be on/off-board, acting as a proof-of-payment (and fare collection) device. They may be located at the entrance to an off-board ticketing area or on the vehicle itself. Ticket vending machines may be on/off-board, acting as a proof-of-payment (and fare collection) device. They may be located at the entrance to an off-board ticketing area or on the vehicle itself. Ticket vending machines may be on/off-board, acting as a proof-of-payment (and fare collection) device. They may be located at the entrance to an off-board ticketing area or on the vehicle itself. Ticket vending machines may be on/off-board, acting as a proof-of-payment (and fare collection) device. They may be located at the entrance to an off-board ticketing area or on the vehicle itself. Ticket vending machines may be on/off-board, acting as a proof-of-payment (and fare collection) device. They may be located at the entrance to an off-board ticketing area or on the vehicle itself.
For transit stations, modal conflicts differ depending on station size and transit services provided. Pedestrians and bicyclists may conflict with buses at access points to on-site bus bays or along on-street bus stops. Where passenger car parking garages or lots are provided, car/bike and car/pedestrian conflicts are typical. On station sites and at approaches, conflicts between pedestrians and bicyclists can occur because these users frequently share the same facilities, including sidewalks, pathways, and crosswalks. To address potential inter-modal conflicts through station design, retrofits, and pedestrian and bicyclist trip generators and catchment zones in the station's service area should be identified. Desire lines and travel routes for each catchment zone can be evaluated for safety, comfort, and convenience (FHWA, 2016).

In order to mitigate these conflicts, improve user safety, and increase multi-modal transit access, the following design principles should be applied: pedestrians and bicyclists seek the most direct possible route; bicycle parking options should be secure and convenient; and infrastructure improvements should address on-site, off-site, and approach roadway through agency and inter-jurisdictional coordination. Conflicts between vulnerable road users, such as pedestrians, and transit buses should be reduced through the separation of modes and within transit stations. Preferred dimensions range due to high volumes of pedestrians and bicyclists in the vicinity of the station. Where management of at-grade conflicts is infeasible, designing retrofits that prioritize direct and convenient pedestrian and bicycle movements to and from the station entrance can often address conflicts at and around transit stations. Separating transportation modes makes it easier for the station staff and at the station itself should be considered due to high volumes of pedestrians and bicyclists in the vicinity of the station. Where separation is not feasible, sidewalks should be wide enough to accommodate both bicyclists and pedestrians safely. Sidewalk width should accommodate peak period boarding and alighting volumes on a site-specific basis. Preferred dimensions range from 10- to 30-feet wide (FHWA, 2016).

Design strategies to improve access to transit stations include:

- Provide street crossing improvements on all legs of intersections near the station.
- Provide content-appropriate mid-block crossings, if necessary, to accommodate direct pedestrian and bicycle movements to and from the station entrance. These are particularly important where local or regional bus connections stop on- and not within the station site itself.
- Reduce pedestrian crossing distances by installing pedestrian crossings across islands or curb extensions.
- Tighten curbs reduce to vehicle turning speeds or provide slip lanes and crossing islands to accommodate bus turning maneuvers.
- Provide bicycle and pedestrian accommodations and wayfinding across station surface parking areas and sidewalks from accessible parking and loading to accessible station entrances are as direct as possible.
- Provide designated crossing at bus loading, pick-up and drop-off areas, and motor vehicle access points.
- Align grade-separated crossing structures with pedestrian and bicycle desire lines where management of at-grade conflicts is infeasible.
- Enhance pedestrian crossings such as raised crosswalks, mitigation of poor sight distances, and sensor-controlled crossing signals.
- Install new sidewalks along well-worn tracks on grass (goat paths) that enter or cross public areas.
- Provide direct bicycle connections to the station via separated bicycle lanes or shared bus stop paths along desire lines that are not severed by streets.
- Ensure that nearby paths and trails are linked to the station and that wayfinding signs are provided.
- Provide bicycle channels-flat ramps parallel to the roads on which bicyclists make it easier to navigate across a bus stop. Transitions should be made between bicycle lanes and pedestrian sidewalks in a manner that clearly delineates the travel path for each mode, maximizes predictability between users, and provides convenient and accessible access to and from transit facilities can help mitigate transit conflicts.

Transit conflicts include conflicts between transit vehicles, such as buses and trains, and vulnerable road users, such as pedestrians, bicyclists, and pedestrians accessing bus stops. Examples include: “a bus accessing a stop by crossing a standard bicycle lane, a bicyclist traveling across or along retail travel, or a pedestrian or bicyclist passing a bus stop with waiting passengers. Conflicts also occur between pedestrians and motor vehicles when accessing or departing from a bus stop” (FHWA, 2016). Design strategies that clearly delineate the travel path for each mode, maximizes predictability between users, and provides convenient and accessible access to and from transit facilities can help mitigate transit conflicts.

Conflicts between buses and bicyclists (i.e., bus-bus lane/leapfrogging) can be addressed by locating bicycle facilities on the other side of a one-way street, or a floating bus stop can be implemented to improve bicyclist’s comfort and bus operation. Design considerations for mitigating bus-bicycle conflicts include:

- Provide clear indication of the purpose and operation of the floating stop for bus and bicycle users.
- Provide adequate ripers for bicycles to transition from bicycle lane to behind the bus.
- Provide stop passengers amenities such as shelters, benches, and trash barrels outside of bicycle travel.
- Maintain accessible pedestrian access to stop amenities, sidewalk, and boarding areas.
- Provide separate bicycle facility behind the boarding area.
- Provide clearly marked crossover from the island to the adjacent sidewalk.
- Consider a raised crossover across the bicycle facility.
- Consider yield or stop lines and FIELD (STOPOUT) HERE FOR PEDESTRIANS (R-10) signs to alert bicyclists of the pedestrian crossover (NCDOT 2010, Sec. 2.1.1).

Source: FHWA, 2016.
Rail track and bicycle conflicts are possible in certain situations. Tracks often contain a gap, called the flangeway, which can be a hazard for bicycle riders. Trails may be slippery in wet conditions, causing bicyclists to lose control. Design considerations for mitigating track-bicycle conflicts include:

- Consider using the best track surface material for safe bicycle travel especially when the surface may be regularly wet and consider reducing the flangeway or using a flangeway filler product.
- Provide pavement markings such as bicycle lane lines, bicycle symbols, and green-colored pavement surfaces to direct bicyclists to cross the tracks at the appropriate angle and prevent illegal parking by motorists.
- Provide advance warning signs to alert bicyclists of the tracks ahead.

Source: FHWA, 2016

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Source: FHWA, 2016

Bus stop placement is an important factor in reducing conflicts between roadway users. As discussed previously, bus stops should be located at appropriate distances depending on the context of the area. "Bus stops should be lined up in the order from north to south on the side of the road. A bike lane between the bus stops and the bike riders will be very useful." (FHWA, 2016)

Neighborhood Transit Streets

Neighborhood transit streets are important multimodal routes and urban living spaces. These streets, including both mixed-use main streets and residential streets, are generally no wider than one lane in each direction with moderate pedestrian and bicycle traffic and low-speed vehicular traffic (≤25 mph). Successful neighborhood transit streets are lively, serving as the nexus of neighborhood life, and provide all-week transit service to neighborhood destinations and beyond. Main streets have moderate or high amounts of walking and congregating on sidewalks or public spaces (NACTO, 2016).

Challenges to neighborhood transit streets include limited parking; vehicles double-parking and loading frequently blocking the travel lane; transit delay and operational difficulties encountered by bus and automobile vehicles waiting to turn, particularly at small intersections; potential conflicts between buses and bicycles at pull-out stops; and difficulties caused by buses and vehicles waiting to turn, particularly at small intersections. "Neighborhood transit streets are desirable bicycle routes and have moderate to high amounts of walking and congregating on sidewalks and in public spaces, quality pedestrian and bicycle infrastructure and clustered local destinations enhance access and capacity for multi-modal users along the corridor. Further guidance on integrating bicycle lanes with neighborhood transit streets is presented in NACTO, 2016."

Design treatments for neighborhood transit streets include small improvements that make service more reliable and improve station and stop quality without dramatic changes to the street section. Design considerations include:

- Curbside management to improve transit and general traffic conditions. Designating space for deliveries and managing delivery times relieves common sources of delays.
- Upgrading bicycle facilities can draw more spending, while cutting vehicle parking needs.
- Neighboring streets can benefit from increased street legibility by better organizing traffic flows, such as with left turn lanes where space permits.
- Sidewalks should be widened where pedestrian volumes or density of destinations merits.

Source: NACTO, 2016.
There are several constraints to designing high-quality transit corridor streets, as they have often been designed as highway-like arterials, with minimal or substandard pedestrian and bicyclist facilities and dangerously high motor vehicle speeds. Buildings or long corridors have been designed to face away from the street or with setbacks and parking lots, though density in the transit-shed may be high (NACTO, 2016). Further planning design challenges include:

- One-way corridor streets are not very bicycle or pedestrian friendly, which can discourage the development of attractions like restaurants and shops.
- Wider streets or streets with heavier or faster traffic can create hostile pedestrian environments.
- One-way streets may have low street legibility, creating confusion about where different street users should be, and may encourage speeding, especially where or when traffic is lighter.

Two-way corridors require more complex signal planning and progressions.
- On-street parking is often a low priority, though driveways may be frequent depending on land use context.

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Increasing total street capacity transit lanes, while limiting conflicts with mixed traffic, bicyclists, and pedestrians:

Transit Priority Lanes are flexible, operating either full time or only during peak times on daylight hours and may be dedicated to bus use only, allow designated vehicles (e.g., taxis, bicyclists) to use the lane, or allow other vehicles to enter the lane to make right turns or to pick up and drop off passengers. Full-time lanes benefit barrier performance and visibility, while peak-period lanes may be appropriate in specific contexts. Dedicated lanes are typically considered for urban streets with relatively high bus and general traffic volumes, where many buses and their passengers are subject to delays; in corridors with I-80 or other frequent bus service, where maximizing bus speeds and reliability is a priority; or on shorter stretches of roadway, allowing buses to bypass a bottleneck, or to move to the front of a queue (TRB, 2015). There are a variety of configurations for Transit Priority Lanes, including offset, curbside, rail lane, contraflow, and shared bus-bicycle lanes. These are discussed further in NACTO, 2016. General design considerations for designated lanes include the following:

- Manage or prohibit turns across transit facilities to reduce transit delays and minimize conflicts with pedestrians, bicyclists, and other traffic lanes (TRB, 2013) for strategies.
- Incorporate markings, signage, and enforcement to ensure that the lane is available for buses. Strategies may include automated electronic enforcement, including license-plate readers or video.
- Decisions involving converting a lane to bus use should consider whether existing traffic might choose to use a parallel route in the future, thereby reducing the overall impact to roadway operations.
- In situations where the number of buses proposed to use the lane initially is relatively low (even after rerouting other bus routes to the new facility), and the policy environment is less supportive of transit, it may be necessary to allow designated vehicles to use the lane, to give a greater appearance of being used to build support for the lane’s travel time and reliability.

The width of vehicle lanes affects street safety and travel speeds. Slower travel speeds and increased street safety for all users are often a result of narrower lanes, while wider mixed-traffic lanes increase the lane’s number and severity of total crashes involving transit vehicles. Providing safe pedestrian linkages across transit lanes is an important consideration in choosing an appropriate lane width. As buses are among the largest vehicles operating on city streets, with mirror widths often exceeding available lane space, adjacent lanes in a street section should be able to accommodate additional infrastructure. These controls include designing appropriate lane widths for transit vehicles, provision of adequate buffer space to ensure the safety of vulnerable users during bus operations, design speed, turning radii, and limiting obstructions.

Lane Width & Buffers

Design Control

Transit design controls are important for balancing multiple travel modes and providing a safe and vibrant street. These controls include designing appropriate lane widths for vehicles operating on city streets, with mirror widths often exceeding available lane space (e.g., taxis, bicycles) to share the lane, or allow other vehicles to enter the lane to make it visually narrower. Parking buffers or wider curbside lanes can provide additional maneuvering space and variance for buses to avoid wide trucks and other vehicles operating on city streets, with mirror widths often exceeding available lane space. In situations where the number of buses proposed to use the lane initially is relatively low (even after rerouting other bus routes to the new facility), and the policy environment is less supportive of transit, it may be necessary to allow designated vehicles to use the lane, to give a greater appearance of being used to build support for the lane’s travel time and reliability.

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Intersection Design for Bus Turns (source: Tri-Met)

Rail paths should be kept clear from all but the briefest obstructions. Design “T” intersections to give bus operators an unobstructed view of traffic and ensure that vertical obstructions are at least nine feet (2.7m) and preferably 12 feet high. Horizontal obstructions, such as sidewalk furniture and transit stop signs, should be made under special circumstances, such as the following:

- Accessibility
- Pedestrian movements.

When designing transit-supportive roadways, it is important to ensure that obstructions to transit vehicles are mitigated. As buses often travel in the curb traffic lane and make frequent stops to drop and pick up passengers, utility poles, signs, and other physical obstructions must be set back far enough from the curb to allow safe access for bus 167 from curbed roadway sections and provide motorist clearances (TriMet). In-street stop design requires consideration of horizontal and vertical clearances for both passengers and vehicles. SDPTF, 2012 and TriMet provide the following bus clearance requirements:

- Horizontal obstructions, such as sidewalk furniture and transit stop signs, should be set back at least two feet (0.6m) from the curb to avoid collision with bus mirrors; benches facing the street should be at least three feet back from the roadway edge.
- Ensure that vertical obstructions are at least nine feet high (2.7m) and preferably 12 feet (3.7m) or more above the loading surface.
- Design “T” intersections to give bus operators an unobstructed view of traffic and pedestrian movements.
- Rail paths should be kept clear from all but the briefest obstructions.

Aside from recommended clearances, strategies for reducing the occurrence of obstructions include dedicating transit lanes and pavement coloring. Dedicated transit lanes can reduce double parking and other obstructions. TRB, 2011 cites a recent study that found “red colored pavement significantly reduced the occurrence of obstructions farther roadway areas legally or illegally entering the lane for interurban bus lanes.” In addition, the same study found that the bus driver used red lanes 52 percent more often than non-red lanes, indicating a greater degree of bus driver confidence in red colored lanes being undisturbed (Safran et al., 2014).

Red transit lanes enhance motorist and pedestrian awareness of curbside transit lanes and transit vehicles (NACTO, 2016). NACTO provides detailed clear area recommendations for specific stop typologies and configurations. The following charts provide the distance, lane width, and clearance requirements. Driveway placement and design should consider the effect of the bus stop on sight lines, for entering and leaving the ROW. Trifold guidance states that “adequate distance between bus stops and driveways is important to prevent buses from blocking driveway traffic or sight lines. In constrained situations, buses may stop if it neveres except where this would block property access or severely restrict sight distances.”

Turn Radii

Designing turn geometries for transit routes can be challenging, as a result of tight corner curb returns and because the bus and train vehicles in the Capital Metro fleet have turning radii. Often, buses must encroach on adjacent or oncoming travel lanes when turning, which causes delays in bus operations and adds to potential conflicts with other road users. Properly designed corner curbs and radii help minimize conflicts among buses, cars, pedestrians, and bicyclists at intersections. Improvements in bus operating speed and a reduction of travel time are additional benefits.

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There are several methods transit agencies can assess speed and reliability for transit and other vehicles. Automatic vehicle location (AVL) and automatic passenger counter (APC) equipment can be installed on buses to identify where and when speed and reliability problems occur; quantify the magnitude of the problem; and, quantitatively how many passengers are affected by the problem. Bluetooth-enabled, global positioning system (GPS) data, or traditional speed tests can be used to compare typical speeds and travel delay in the private sector and transit sector before and after transit enhancement projects (TRB, 2013). Additional techniques to improve design speed include:

- Align the design speed with target speed by implementing traffic-calming measures, including narrower lane widths, roadway landscaping, speed cushions, and curb extensions.
- In selecting the design speed basis for such values as signal progression speed, lane width, and transition taper lengths, designers can choose a speed lower than the speed limit unless the limit can be lowered locally to the desired design speed.
- Reducing speeds to under 19 mph increases driver reaction time and minimizes accident severity (TRB, 2015). This is especially important on transitways, where passengers are often carried by transit operators for whom accident severity is of greatest concern.
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- Enforcement cameras have proven highly effective at reducing speeds and improving travel times, on-time performance, bus driver utilization, and reliability (TRB, 2015).
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- Lane Markings & Color

Red colored pavement may be used to improve the conspicuity of the bus lane, visually enforcing dedicated transit space and thereby reducing the number of non-authorized vehicle incursions. Red colored pavement can be installed anywhere a roadway lane is reserved exclusively or primarily for buses; and can be applied safely at the start of a lane leg, at grade crossing transitions away from the bus lane; only in the sections where only buses are permitted (leg i.e., indicate where vehicles may enter the lane to make right turn); or for the full length of the lane, including sections where other vehicles are permitted by law to briefly enter the lane e.g., to enter or cross the lane to make a right turn, to stop to immediately pick up or drop off passengers); however, it should be applied consistently within a jurisdiction (TRB, 2015). Red carpet treatments can reduce vehicle incursions by 30-50 percent - particularly for interior bus lanes-improving travel times, on-time performance, bus driver utilization, and reliability (TRB, 2015).

Markings & Signage

Lane elements such as the use of solar and marking material, as well as regulatory signage and signals, contribute to pedestrian safety, and the success of a transit system. Colored pavement can enhance the visibility of the lane, reducing vehicle incursions and improving on-time performance, in addition to other benefits. Signs and signals enable required or prohibited vehicle movements, enhance overhead and other regulatory signage, and alert other street users of approaching transit vehicles.

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Queues may jump to be used for shared right-turn, short bus, and shoulder bus lanes to allow buses to bypass any queues of vehicles that might exist at an intersection. The application of queue jumps has the potential to significantly reduce bus travel time. Constraints to using queue jumps may include, but are not limited to, available ROW; the cost of extending or constructing a queue jump lane, and the need for a sufficiently long lane to allow buses unimpeded access across the lane. AASHTO (2011) recommends that “1.5 to 2 times the average peak period queue length be used in design turn lane storage lengths, which approximate 85th and 95th percentile queues, respectively.” However, a traffic analysis is recommended to determine queue length percentiles as an input for determining required, as well as the probability that an arriving bus would not be able to access the queue jump lane (TRB, 2011).

Separation Elements
Vertical separation elements can be used to increase separation and prevent penetration of transitways by unauthorized vehicles. The level and application of separation elements and must be adequately anchored to absorb forces from vehicle impact when they encroach upon a transit lane, and are typically reserved for high-speed streets removed from pedestrian areas like crosswalks, where transverse lines would be dangerous to enter. Bollards, concrete domes, round traffic buttons, or easy-to-install plastic “armadillos” provide visual and physical lane delineation and should be set 30–42 inches in height to achieve full visibility (City & County of San Francisco, Planning Department, 2010). There are many types of bollards ranging in cost and design and design speeds; contextual characteristics, and urban design guidance should be assessed to determine appropriate bollard design and styling. As stated by NACTO, “bollards must be visible and effective for near retro-reflection or face lighting elements and must be adequately anchored to absorb forces from vehicle impact when fixed. Bollards may be applied for full block segments or at specific locations where warning is desired.”

Planting strips can be used to complement the on-streetcape and provide vertical and horizontal separation, though require additional space and maintenance. Plants should not block sightlines, impede the running way, or encroach on intersections in order to ensure pedestrian access and safe interactions with vehicles. Rerouting may be used as a low-maintenance alternative to planting strip and and buses and connected planters assist with stormwater management (NACTO, 2010).

Sustainable Design
Capital Metro is committed to incorporating sustainability best practices throughout the design and operation of its facilities, as is referenced throughout this document. Electric vehicles, low-impact development (LID), green building design, transit-supportive land use, climate resilience, and sustainable infrastructure rating tools are some examples of applicable principles that are applicable to transit system design.

Integrating green infrastructure within transit design has many benefits, including improved water quality, stormwater detention, traffic calming, and enhanced comfort for waiting riders. At stations and terminals, an enhanced landscape can improve aesthetic appearance, user comfort, and ecological performance, improving the natural ecosystem and reducing harmful pollutants. Tree canopy and green features “can improve transit experience for waiting riders, increasing comfort and reducing perceived wait time,” and bioswale facilities can “prevent large amounts of pollution from entering the watershed where vehicles leave oil and other pollutants on the road surface” (NACTO, 2016). Examples of green infrastructure include bioswales, flow-through planters, pervious strips, tree canopies, and permeable surfaces.

“bollards must be readily visible and include either retro-reflective surface or lighting to ensure pedestrian access and safe interactions with vehicles. Xeriscaping may be used as a low-maintenance alternative to planting strip and and buses and connected planters assist with stormwater management (NACTO, 2010).”

Some considerations for integrating green infrastructure into sidewalks, medians, curbs, and other features include the following:

- Select appropriate plantings; in dry climates, drought-resistant landscaping (biovore) reduces water and maintenance requirements. The planter should drain within 24 hours, especially near transit stops, where pooling can degrade transit access.
- Chose green infrastructure based on pedestrian volume and the intensity of use on a sidewalk.
- As required, install a protected pipe at the base of the facility to collect the treated runoff.
- Ensure that pavement is permeable with a minimum and maximum criteria. The engineer’s soil mixture should be designed to pass five–10 inches of red water per hour. Source: NACTO, 2010.
An example of LID, green guideways can be used to complement transit investments cost-effectively, creating an attractive human and natural environment by providing large planted areas along and between transit guideways. Benefits of planted guideways include the noise dampening-effects of soil on transit vehicles, substantially improved stormwater infiltration and retention provided by a large permeable surface. Green-guideways can support rain gardens and other higher biomass or high absorption areas, enhanced public spaces along the green provided by large areas of green space (NACTO, 2016). The green guideways can be used for stormwater management and can be used for both center- and side-running fully separated bus or rail guideways. Design considerations for green guideways include:

- Continuous green space should be provided between tracks and adjacent road beds. Green space should be discontinued at intersections and pedestrian crossings and accessible paths for pedestrians through the guideway should be provided.
- For buses, grass can be planted between and adjacent to concrete running paths or guideways for bus wheels. For rail, tracks can be completely set within a surface covered with grass or other low maintenance, low-lying, non-trailing plants such as sedum, but rail or concrete bus guideways should be anchored on solid material under the surface. Tracks should be installed in a noise absorber. Filled with a porous base layer, covered with an anti-nit membrane, and covered with a porous paving that is then planted.
- Plant types should be chosen based on durability, geographic and location-specific climate conditions, and water absorption capacity.

Green guideways can be designed as swales that drain stormwater from the street. Such swales can be designed for central- or side-running fully separated bus or rail guideways. These swales can be designed to be low maintenance. The swales can be used for both center- and side-running fully separated bus or rail guideways. Design considerations for green guideways include:

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Platform Configurations

Near-Level Boarding

Platform boards shall be provided and properly aligned with the roadway in the mid-block to be level or, if curbs are also to be provided, near-zero curb level. The curb height should be eight to 11 inches, and the platform height at least eight inches. The curb height may be reduced to four to six inches in areas with minimal pedestrian traffic.

Mid-Level Boarding

Mid-level platforms are designed so that the level of the platform is at the curb height at near-side, or near-transit vehicle level at far-side. This same level is matched to the floor height of transit vehicles (typically level boarding platforms have a platform height that matches the floor height of transit vehicles (typically one to two feet above curb level). Near-level platforms allow an operator to either load from the sidewalk or curb level, with vehicles turning to board, allowing the sidewalk and platforms to be continuous throughout the day.

Near-Side Stop

Near-Side Stop (source: NACTO, 2016)

Pull-Out Stop (source: NACTO, 2016)

Near-Level Boarding

Mid-Block 35 55 80 115
Near-Side 35 55 80 115
Stop Position 40' Bus 60' Bus 2 x 40' Bus 2 x 60' Bus

Pull-Out Stop (source: NACTO, 2016)

In-Lane Stop (source: NACTO, 2016)

Mid-Level Boarding

Far-Side 90 100 125 165
Near-Side 100 120 145 185

62

63

Platform Width

From the curb's edge, the width of the boarding platform runs perpendicular to lane and accommodates ADA-required boarding space for ramps and bridge plates, shelter and amenities; and clearance zones for pedestrians to traverse safely. The interface for boarding and alighting width must be adequate to traverse planned capacity and desired amenities to enhance rider experience and the transit system brand, and may extend into the pedestrian zone of the sidewalk generally when both pedestrian volumes and the number of transit passengers are relatively low, though only with careful consideration for capacity and access on the boarding platform from the pedestrian zone through platform, boarding pads, islands, or median platforms can provide additional space from amenities and highlights great transit service (NACTO, 2016).

Design considerations for platform width include:

- The platform must receive deployed ramps or bridge plates to provide easy boarding.
- Minimum width is eight feet from platform edge for a platform boarding passengers from one direction.
- Platforms serving two directions should be 12 feet wide minimum to accommodate additional passengers.
- Install 1' wide detectable warning strip along front of boarding pads.
- All boards should be equipped with two 18-inch-wide ramps along the edge of the boarding pad and slope towards the curb.
- Minimum width is eight feet from platform edge for a platform boarding passengers from one direction.
Tactile, visual, and audible design elements should be employed together to guide people of all abilities through the street environment by consistently using detectable surfaces, color contrast, audible warnings, or other methods to assist all users, enhance safety and accessibility. Signalized crossings may include accessible pedestrian signals (APS), which utilize audible cues to inform pedestrians of signal phases, including announcements or rapid percussive tones (NACTO, 2016). Universal street design considerations include:

- Detectable warning strips may be used to indicate door locations at sidewalks-level stops and must be at least 2½ inches wide and should be applied at curb ramps for their entire width or at any location where pedestrians cross into another modal zone (i.e., bicycle lanes or vehicle lanes) along a flush transition (DOT §504 §406.8). Detectable warning strips should be visually contrasted with adjacent surfaces to help pedestrians that are crossing into a new modal zone (such as a transitway, bicycleway, or vehicle lane) to decode the area.

- Where passengers using wheelchairs are directed to specified doors, ensure the accessible doors are clearly communicated throughout the boarding platform using signs and markings.

- Use color consistently to delineate modal zones and edges; for instance, transit lanes may be red and bike zones or crosswalks may be green (trench cats for bicycle lanes also is an option). Color repetition reinforces legibility, and should be employed at conflicts and transition zones.

- Higher illumination lighting around transit stops should be gradual rather than sudden to avoid creation of visual shadows as driver and pedestrian eye adjust.

- Stops and stations with real time arrival information should include audible announcements or rapid percussive tones (APS), which utilize audible cues to inform pedestrians of signal phases, including announcements or rapid percussive tones (NACTO, 2016). Universal street design considerations include:

  - Pedestrian Access
  
  For pedestrian access to stops, a minimum four-foot-wide clear pedestrian travel path should be provided to connect the bus stop waiting area and loading area to adjacent areas. The pedestrian travel path should be wider on or near the light rail platform for easy deployment and usage.
As specified by SEPTA, “a reinforced concrete pad is recommended for bus stop areas, particularly in P&R or depot situations, where multiple routes and heavier loads can be expected. A concrete pad can be incorporated or retrofitted into the roadway design to provide a heavy-duty surface that will handle constant heavy vehicle stress; however, local conditions must be evaluated to determine the best design for a particular site” (SEPTA, 2012). The seam of the concrete bus pad should be placed on either side of a bicycle lane (if present), as seams and cracks prove a hazard to bicycle wheels, and stop amenities should not block bus stop signage or walking path (NACTO, 2016). At a minimum:

- Ensure that the cross-slope of the bus pad does not exceed two percent.
- Where possible, construct the bus pad of concrete at least 12 inches in depth. In uncured shoulder areas, an asphalt bus pad is acceptable.
- For most buses, locate bus pads at least one foot from the bus stop sign. For buses with rear door lifts, locate the landing 23.5 feet from the bus stop sign. (SEPTA, 2012)

Pavement Materials

The choice of appropriate pavement materials is important for minimizing roadway damage caused by transit vehicles. Asphalt is the most common street material, but is more expensive than asphalt, whereas concrete is more durable, stronger, and longer lasting. Concrete bus pads are also recommended for locations where buses brake, including stops, signs, and traffic signals. Rail should be embedded in concrete, where feasible, to avoid track shifting and service interruptions due to resurfacing and other maintenance.

Continuous bus pads from the front to the rear door areas are appropriate at bus stops that have a high number of passenger loadings and unloadings, whereas such pads could improve the connections to the adjacent sidewalk system, or where landscaped buffers are located between the sidewalk and the street (SEPTA, 2012).

Traffic Calming & Shared Space

Traffic calming is one traffic management strategy that can be used to make the area surrounding bus stops safer for commuters. As defined by the Institute of Transportation Engineers, “traffic calming involves changes in street alignment, installation of barriers, and other physical measures to reduce traffic speeds and/or cut through volumes. In the interest of street safety, livability, and other public purposes. “Many of these strategies focus on reducing the speed of vehicles that are in close proximity to pedestrians to around 30 kph (Hamilton-Baillie, 2004; Hamilton-Baillie & Jones, 2005; Kaparias et al., 2012), which significantly reduces the risk of fatal accidents and allows pedestrian to feel less fear to be able to cross the street. Traffic calming elements such as chokers, raised (or box) and bicycle bypasses are already popular in many major European cities (e.g. Hong Kong, 2006). The description and application of some of these elements are described in the following table.

Traffic calming measures can be designed to slow general traffic while having little negative impact on transit vehicle operation (NACTO, 2016). Where traffic cannot be slowed down, physical separation and crossing lights greatly increase the comfort of pedestrians (Tan et al., 2017). Thus, and checks below 6 meter (approximately 20 feet) are recommended because they not only provide visual and acoustic separation, but they also add to the attractiveness and contribute to the natural comfort of the setting (Fukahori & Kubota, 2013). See Ite.org and trafficcalming.org for further information or traffic calming strategies, including design considerations, effectiveness, and typical implementation costs.

Shared space, another strategy for creating a more pedestrian-friendly environment, is a design concept for public spaces that encourages the separation between modes of transport by removing ground markings for traffic. Though the removal of these markings, which were painted in the name of safety, may seem counter intuitive, the result is more eye contact, slower speeds, and heightened awareness. The implementation of shared space is a region in that has never had such urban features may be a challenge, as people’s familiarity with shared spaces largely determines their success (Kaparias, Bell, Miri, Chan, & Mount, 2012). Therefore, considerable work from all parties involved in the implementation of shared spaces is important, including the provision of adequate driver education to ensure the safety of pedestrians in these areas and heightened driver awareness (Zhang, 2012).
### Traffic Calming Measures

<table>
<thead>
<tr>
<th>Technique</th>
<th>Description</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicane</td>
<td>A series of narrowings or curb extensions that alternate from one side of the street to the other forming S-shaped curves.</td>
<td>• Appropriate for mid-block locations only&lt;br&gt;• Most effective with equivalent volumes on both approaches&lt;br&gt;• Typically used on residential streets&lt;br&gt;• Can serve to improve visual interest</td>
</tr>
<tr>
<td>Choker</td>
<td>Curb extensions at mid-block or intersection corners that narrow a street by extending the sidewalk or widening the planting strip.</td>
<td>• Local and collector streets&lt;br&gt;• Pedestrian crossings&lt;br&gt;• Main roads through small communities&lt;br&gt;• Work well with speed humps, speed tables, raised intersections, and raised median islands</td>
</tr>
<tr>
<td>Center Island Narrowing</td>
<td>Raised islands located along the centerline of a street and narrow the travel lanes at that location.</td>
<td>• Applicable for multiple block locations only&lt;br&gt;• Most effective with equivalent volumes on both approaches&lt;br&gt;• Most effective where mid-block curb extensions are also used&lt;br&gt;• Can be used in the pedestrian environment</td>
</tr>
<tr>
<td>Speed Hump</td>
<td>Rounded raised areas of pavement typically 12 to 14 feet in length. Often placed in a series (typically spaced 300 to 600 feet apart).</td>
<td>• Residential streets&lt;br&gt;• Not typically used on major roads, bus routes, or primary emergency response routes&lt;br&gt;• Mid-block placement, not at an intersection&lt;br&gt;• Not on grades greater than eight percent&lt;br&gt;• Work well with curb extensions</td>
</tr>
<tr>
<td>Speed Table</td>
<td>Long raised speed humps with a flat section in the middle. Such humps are usually placed with their long axis at right angles to the street and typically spaced 600 to 1000 feet apart.</td>
<td>• Local and collector streets&lt;br&gt;• Work well in combination with brick or other textured materials, curb extensions, and curb radius reductions&lt;br&gt;• Can include a crosswalk</td>
</tr>
<tr>
<td>Raised Intersection</td>
<td>Flat raised areas covering entire intersections, with ramps on all approaches and often with brick or other textured materials on the flat sections and curbs.</td>
<td>• Local and collector streets&lt;br&gt;• Work well with curb extensions and brick or other textured materials&lt;br&gt;• Often part of an area-wide traffic calming scheme involving both intersecting streets&lt;br&gt;• Can include a crosswalk or median on-street parking</td>
</tr>
<tr>
<td>Neighborhood Traffic Circle</td>
<td>Raised islands, placed in intersections, around which traffic circulates. Motorists yield to motorists already in the intersection.</td>
<td>• Intersections of local or collector streets&lt;br&gt;• Can be used as an alternative to signalized intersections&lt;br&gt;• Typically used at intersections with high volumes of larger trucks and buses turning left&lt;br&gt;• Can help to improve visual quality and pedestrian safety</td>
</tr>
</tbody>
</table>

Source: Institute of Transportation Engineers; Traffic Calming.org
Bus & Bicycle Interactions

Well-designed transit streets provide diverse mobility options, including walking and bicycling, which complement strong transit ridership and create an inviting streetscape. Streets used by transit vehicles often make desirable corridors for bicycle traffic, as these roadways often provide direct access to destinations, with relatively few stops required. Accommodating both bicycle and bus traffic on streets and at bus stops can be challenging, as the need to serve bicycle traffic may constrain the options available for implementing transit-supportive roadway strategies due to limited ROW to allocate to direct bicycle traffic to preferred doors. Where bicycles are allowed on transit vehicles, level-boarding platforms should be provided, along with signage and markings to direct bicyclists to preferred doors. Short- and long-term bicycle parking and access to destinations should be considered near stations and stops, yet parked bicycles should not impede access paths to and from transit vehicles or along walking routes.

The interactions between transit and bicycle facilities should not impede access paths to and from transit vehicles or along walking routes. Where space permits, an option for preventing bicycle-vehicle conflicts at bus stops is to divert the bicycle lane around the bus stop, either at its original grade or by raising the bicycle lane to sidewalk level in the vicinity of the bus stop.

Bus & Bicycle Facility Design

The following table illustrates a number of design configurations for bicycle and bus interactions. Consideration in the bus zone should also be given to the loading and unloading of bicycles from the front of bus rack, which adds an additional six feet (1.8m) to the loading area width (HSTP, 2012). Where bicycles are allowed on transit vehicles, level-boarding platforms should be provided, along with signage and markings to direct bicyclists to preferred doors. Short- and long-term bicycle parking and access to destinations should be considered near stations and stops, yet parked bicycles should not impede access paths to and from transit vehicles or along walking routes.

To prevent developing separate bus and bicycle facilities, this is not the preferred option when others are available due to potential bus and bicycle conflicts. Although buses need to pull into the bicycle lane at bus stops, sufficient space is needed to avoid conflicts arising from pedestrians crossing the bicycle lane or queuing in the street and the bicycle lane on the left side of the street. On one-way streets, an additional option for ensuring separation between bus and bicycle facilities is to locate the bus lane on the right side of the street and the bicycle lane on the left side. This treatment can be an effective way to minimize conflicts and delays between bus and bicycle traffic. Bicycle parking can be provided along the bus lane at bus stops, allowing bicyclists the option of accessing bicycle storage facilities (NACTO, 2016). See NACTO, 2012 and NACTO, 2016 for further information on bicycle facility design and coordination with transit.

<table>
<thead>
<tr>
<th>Description</th>
<th>Diagram</th>
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<tbody>
<tr>
<td>Bicycle &amp; Bus, Bicycle Lane</td>
<td><img src="image1" alt="Diagram of Bicycle &amp; Bus, Bicycle Lane" /></td>
</tr>
<tr>
<td>Diverted Bicycle Lane at Bus Stops</td>
<td><img src="image2" alt="Diagram of Diverted Bicycle Lane at Bus Stops" /></td>
</tr>
<tr>
<td>Shared Bus &amp; Bicycle Lane</td>
<td><img src="image3" alt="Diagram of Shared Bus &amp; Bicycle Lane" /></td>
</tr>
<tr>
<td>Left-Side Bicycle Lane</td>
<td><img src="image4" alt="Diagram of Left-Side Bicycle Lane" /></td>
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<tr>
<td>Right-Side Bicycle Lane</td>
<td><img src="image5" alt="Diagram of Right-Side Bicycle Lane" /></td>
</tr>
<tr>
<td>Bicycle Lane at Bus Stops</td>
<td><img src="image6" alt="Diagram of Bicycle Lane at Bus Stops" /></td>
</tr>
<tr>
<td>Bicycle-Ramp Entry</td>
<td><img src="image7" alt="Diagram of Bicycle-Ramp Entry" /></td>
</tr>
<tr>
<td>Bicycle Box</td>
<td><img src="image8" alt="Diagram of Bicycle Box" /></td>
</tr>
<tr>
<td>Bicycle Lane Capital Section</td>
<td><img src="image9" alt="Diagram of Bicycle Lane Capital Section" /></td>
</tr>
<tr>
<td>Bicycle Box Capital Section</td>
<td><img src="image10" alt="Diagram of Bicycle Box Capital Section" /></td>
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</tbody>
</table>

*Note: Diagrams illustrate a number of design configurations for bicycle and bus interactions. See NACTO, 2016 for further information on bicycle facility design and coordination with transit.*
Cured platform and boarding trains across active tracks is to be avoided in order to provide the conductor with a full view of passengers and to allow full passenger view of oncoming trains and safe crossings. Platform Design section for further information on platform dimensions, as applicable.

Min. Standard Platform Dimensions

<table>
<thead>
<tr>
<th>Standard</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor Height</td>
<td>2' 11&quot;</td>
</tr>
<tr>
<td>Platform Length</td>
<td>405 Lin. Ft</td>
</tr>
<tr>
<td>Support Material</td>
<td>Poured Concrete 1 percent</td>
</tr>
<tr>
<td>Minimum Support</td>
<td>3&quot; wide precast along trackside edge.</td>
</tr>
<tr>
<td>Slope</td>
<td>Reinforced concrete 1 percent</td>
</tr>
<tr>
<td>Tactile Warning</td>
<td>2' wide precast along trackside edge.</td>
</tr>
</tbody>
</table>

Source: Capital Metro; Metra, 2007

Minimum Internal Platform Length

| Projected Peak Train Boarding or Alighting Diesel Lines Electric Lines |
|--------------------------|--------------------------|
| Period | Minimum | Maximum |
| 1 to 175 | 380 Lin. Ft. | 465 Lin. Ft. |
| 211 to 245 | 550 Lin. Ft. | 550 Lin. Ft. |
| 246 to 316 | 635 Lin. Ft. | 635 Lin. Ft. |
| 316 to 350 | 805 Lin. Ft. | 635 Lin. Ft. |
| 351+ | 890 Lin. Ft. | 635 Lin. Ft. |

Source: Capital Metro; Metra, 2007

Provision for moving sidewalks should be made where the circulation path differs from that of the general public. Stairs made of smooth materials and with a minimum gradient of 1:20 (five percent) should be provided in addition to ramps and should conform to all applicable accessibility requirements (Metra, 2007). See Metra, 2007 for ASD design specifications for ramps and stairs.

Crossings

Capital Metro recognizes the importance of coordinating with regional and municipal agencies to provide a safe pedestrian network that approaches pedestrian crossings along its rail tracks in a consistent, appropriate, and context-sensitive manner. Crossings are to be designed and constructed to accommodate all modes of pedestrian movement, including those who are visually-impaired or otherwise impaired. Ramps and sidewalks should be provided where the circulation path differs from that of the general public. Crossings should ensure that the safety needs called for on-the-ground. Completing the pedestrian network with infrastructure that meets safe crossing standards in a way that can be replicated throughout the service area. Crossings is needed when requiring infrastructure improvements although accepted in the industry, may not be needed to appropriately respond to the safety needs called for on-the-ground. Completing the pedestrian network with an appropriate level of crossing infrastructure establishes safety mechanisms and encourages pedestrian paths that otherwise would not exist at all.

Pedestrian safety at railroad crossings can be improved by selectively using passive and/or active devices. Passive devices include fencing, swing gates, channelization, pedestrian barriers, fixed message signs, and pavement markings/labeling. Active devices include flashers, automated pedestrian gates, pedestrian signals, audible active warning devices, and variable message signs. A combination of audible and visual devices should be used to serve the accessibility needs of hearing-impaired and visually-impaired pedestrians.” (FHWA, PEDSAFE 2000).
Recommended minimum distance between all platforms

<table>
<thead>
<tr>
<th>All Routes</th>
<th>Heavy Rail Operating Environment</th>
<th>Single Track</th>
<th>Dual Track</th>
<th>Multi-Track</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 feet</td>
<td>250 feet</td>
<td>250 feet</td>
<td>250 feet</td>
<td>250 feet</td>
</tr>
<tr>
<td>360 feet</td>
<td>300 feet</td>
<td>300 feet</td>
<td>300 feet</td>
<td>300 feet</td>
</tr>
</tbody>
</table>

Shelters

Single shelters should be located as close as possible to the middle of the platform, whereas multiple shelters should be located opposite the loading doors. Shelters should be located at least 30 feet away from a platform access point, where possible (Metra, 2007).

Benches and seating units should have individual seats separated by dividers and should be constructed in a durable, weather-resistant, and vandal-resistant manner. The seating should run along the back of the shelter, for two-thirds of its length, and should be anchored in a secure, tamper-resistant manner to the floor or wall (Metra, 2007).

Source: SEPTA, 2012

<table>
<thead>
<tr>
<th>Area Type</th>
<th>Ideal Stop Spacing Range (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suburban and other low-density areas beyond first generation densities between 1,000 and 10,000 per square mile</td>
<td>1,320 feet</td>
</tr>
<tr>
<td>Densities between 1,100 and 1,300 per square mile</td>
<td>1,250 feet</td>
</tr>
<tr>
<td>Densities between 1,300 and 1,500 per square mile</td>
<td>1,180 feet</td>
</tr>
</tbody>
</table>

Circulation Paths

The station area should include a circulation path for the general public that complies with the minimum accessibility requirements displayed in the following table.

Circulation Path Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Commentary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right of Way</td>
<td>No limits</td>
</tr>
<tr>
<td>Line of Sight</td>
<td>At least 180°</td>
</tr>
<tr>
<td>Curb Cutout</td>
<td>No limits</td>
</tr>
<tr>
<td>Crosswalks</td>
<td>Width should be at least 5 feet and be located at right angles to the throughway</td>
</tr>
<tr>
<td>Passing Spaces</td>
<td>Required at 200’ intervals if route is less than 60” wide 60” x 60” floor space</td>
</tr>
<tr>
<td>Turning Widths</td>
<td>36” for 900 turn with no additional turn for 48”</td>
</tr>
<tr>
<td>Clear Width</td>
<td>36” Minimum</td>
</tr>
</tbody>
</table>

Passing Space

Passing spaces shall be provided at least on one side of the platform location the passenger is boarding. When space permits, passing spaces shall be provided on both sides of the platform location the passenger is boarding. When space permits, passing spaces shall be provided on both sides of the platform location the passenger is boarding.
Park & Ride Design

Park & Rides (P&R) are specialized parking lots generally located on the suburban fringe of urbanized areas outside of the “tip of congestion” on major commuter corridors. P&Rs are an important component of the transit system, concentrating transit demand and enabling transit services that would otherwise not be cost-effective, and are designed to transfer commuters from low-occupancy modes (personal cars) to high-occupancy modes (trail, bus, van- and car-pool (TAMU, Mobility). This section provides general guidance on P&R location, accessibility, parking, and landscaping. Capital Metro is in the process of developing P&R design guidelines. For further information on P&R design, see附件section Capital Metro's service guidelines, Sound Transit, 2007, and FDOT, 2012 for additional information.

Location

When designing a P&R, surface and/or structure facilities should be located as close as possible to major streets and freeways serving a site. In addition, Sound Transit, 2007 states that:

- Where possible, the maximum distance between the farthest stall of the P&R and the board area should be 1/2 mile. The design should provide underserved populations between all areas of the P&R and the boarding areas wherever possible.
- Connections between the P&R area and boarding area should be as direct as possible and include walking paths connecting in the boarding area. To assist the wayfinding experience of customers, these paths should be as direct as possible and include walking paths connecting in the boarding area.
- In the P&R area, pathways between all areas of the P&R lot and board areas should be as direct as possible and include walking paths connecting in the boarding area.
- Where possible, the maximum distance between the farthest stall of the P&R and the board area should be 1/2 mile. The design should provide underserved populations between all areas of the P&R and the boarding areas wherever possible.
- Connections between the P&R area and boarding area should be as direct as possible and include walking paths connecting in the boarding area.

The siting process is based on a long-term strategic plan, existing and project transportation, land use and economic conditions, including, but not limited to, the following items:

- Existence of informal P&R activity
- Signage by transit
- Site visibility and accessibility
- Proximity to other major corridors or critical junctions
- Intensity, concentration, and location of employment centers
- Density and location of residential areas
- Distance between major residential areas and employment or activity centers
- Current and future levels of service on sub-area and corridor level roadways
- Existing and future transportation-related improvement plans and programs
- Anticipated future development activity at both the trip origin and destination


Size

As stated in FDOT, 2012, “scale, complexity, and project cost should govern the type of approach used for estimating size needs for P&R facilities. In most cases, site planning techniques based on local travel and socio-economic data are preferred over sophisticated and data-intensive modeling techniques.” Determining the size needed for a P&R facility consists of eight steps:

1. Calculate the number of motorists that will use the facility
2. Convert the number of motorists to the number of parked vehicles
3. Adjust the number of parked vehicles to account for
   - Stalls for the maximum accumulation of shared-ride vehicles
4. Calculate the maximum accumulation of shared-ride vehicles
5. Calculate the number of accessible spaces required
6. Convert the total estimated number of spaces to an area measure
7. Calculate additional space needs for bus facilities, turn ratios, and other design criteria
8. Develop space needs for additional landscaping, sidewalk, drainage, and other design criteria


Additional space may be included to accommodate areas for community art, security, vendors, waiting areas, and passenger drop off and pick up areas.
PARK & RIDE DESIGN

Multi-Modal Access

As pedestrian movements within P&R areas normally occur within the parking areas, such lots should be designed to pedestrian needs and safety, as well as lot capacity. Pedestrian walkways may also be required to minimize vehicular interference, to reduce the number of points where pedestrians cross aisles, and to shorten irregular routes through successive aisles. Where practical, speed bumps may be considered to reduce vehicle speeds for pedestrian safety (Sound Transit, 2007). P&R facilities should accommodate first and last mile transit/bicycle connections from adjacent roadways. In addition, P&R should provide long-term bicycle storage.

Leaves access points to P&R facilities should consider adjacent land uses and avoid large unplanted or paved areas that are south of those uses. Vehicular access form local residential streets should be avoided and access directly from highly congested corridors into a P&R facility should be minimized due to relatively high speeds and traffic volumes. Access locations should minimize potential vehicle, pedestrian, and bicycle conflicts and site layout and facility design features should allow for potential management of access. Curb cuts should also be minimized and "access roadways to P&R facilities should be maintained as straight as practical to meet highest travel needs."

The following design considerations should also be followed to ensure a multi-modal access to P&R lots:

- Vehicular access to and from the lots should minimize interference with street traffic.
- To reduce impacts on local streets or highway access to P&R lots should be from major streets (although avoiding high-speed arterials if possible). Secondary access points may be from minor streets.
- Wayfinding signage to and within the lot or parking garage should be provided.
- Vehicle entrances and exits should occur away from street corners. Parking lots should be configured to provide access for emergency vehicles, including fire equipment and ambulances in the event of an emergency.
- Fire lanes should be clearly marked on the pavement.


Parking

Surface parking/structured garages will be provided at selected transit facilities as determined by Metro. Parking facility design should consider pedestrian potential spaces that may occur and identifying locations for a temporary P&R lot while expansion takes place. It is recommended that parking facilities with over 500 stalls should be in a structure, including when expansion of existing P&R facilities result in a net total of more than 500 stalls (Sound Transit, 2007). Sound Transit, 2007 provides detailed guidance on parking design, including information on dimensions of parking stalls and garages. Some design considerations for parking at P&R locations include:

- Where board width and given site constraints, construction work should be kept within Sound Transit’s rights-of-way.
- Curbs should be provided at all parking lot edges constructed on fit into higher and high, while guard rails should be considered at higher than 10 feet. Borders adjacent to curbs or guard rails should be provided to minimize pedestrian conflicts and site layout and facility design features should allow for potential management of access. Curb cuts should also be minimized and "access roadways to P&R facilities should be maintained as straight as practical to meet highest travel needs."


Landscape

Landscape design should enhance pedestrian safety and security and provide attractive approaches to stations and enhance pedestrian safety and security and provide clear sight lines for both vehicles and pedestrians between parking areas and station platforms (Sound Transit, 2007). Landscape design should follow relevant ODOT guidelines identified in Chapter 11. Additional design considerations for landscaping are most likely:

- Provide planting islands and/or rain gardens in parking lots to create visual relief and shade in large paved areas. The ratio of planting islands to paving may be up to 10 percent.
- Establish visual screening of parking areas from adjacent properties while allowing for surveillance of public areas and open operation of the facility.
- Integrate design elements with adjacent areas.
- Design planting to reinforce vehicular and pedestrian movement paths.
- Consider local jurisdictional codes for landscaping in parking areas.

A suburban parabola is located more than 5 miles from downtown. The parabola will be pointed in the direction of the downtown area. The parabola will be 1 mile in the opposite direction of their commute to reach a P&R.

Evaluation Criteria
New P&R lot capacity improvements will be prioritized at locations where HDV direct access and regional bus service improves demand and where the capacity currently exists. Criteria used to guide P&R lot investments include: HDV direct access, forecasted demand on local and regional services, and achieving standards for current and future facility needs. Criteria used to guide P&R lot investments include: HOV direct access, forecasted demand on local and regional services, and achieving standards for current and future facility needs.

Security
Passenger security is an important component of transit facility design. The physical security of passengers is vital to the success of any transit system. The cost of fear and insecurity discourages existing riders but also to encourage new riders. This is true both while passengers are on board a transit vehicle as well as when they are accessing the system (FHWA, 2008). There are multiple strategies for improving passenger safety on and off the transit vehicle, some of which have been discussed previously (Camera surveillance, security telephones, lighting, fencing, and landscaping). These and other best practices are presented in more detail in APTA, 2010 (which focuses on a multi-dimensional approach to addressing safety at transit facilities known as Crime Prevention through Environmental Design (CPTED). CPTED is “the application of designing safety and security into the natural environment of a specific area. Specifically, CPTED concepts and strategies use the three interrelated principles of natural surveillance, natural access and territoriality, plus activity support and maintenance. By using the behavior of people, a knowledge of crime generators, the physical environment, and the space of people on and off the system, CPTED provides benefits for safety and security if applied in the conceptual design and planning stages of a project” (APTA, 2013).

Agency Policy
As stated in Capital Metro's service guidelines, Capital Metro conducts vehicle count surveys during specific time periods, excluding non-holiday months, winter weather months, and summer vacation months. The vehicle count surveys at its park-and-ride facilities to determine occupancy levels, identify trends, and assess future needs. The seasonal surveys typically take place during one week in the fall (September — November) and one week in the spring (March — April). The time of year is chosen based on transit industry standards to target “normal” travel periods, excluding non-holiday months, winter weather months, and summer vacation months. The survey methodology typically involves two or more days of vehicle counts during the period chosen to conduct the surveys. During these days, a sample day is selected to ensure the seasonal averages are produced each year to track identity trends. One facility reaches the industry standard average occupancy range (75-95 percent), plans for expansion are developed in accordance with following policies.

Future Facility Policies
4. Capital Metro will conduct bi-annual (fall and spring) seasonal surveys for each park-and-ride facility in order to track overall utilization.
2. Capital Metro will investigate potential solutions to improve utilization for any park-and-ride facility that has less than 60 percent occupancy for three consecutive seasonal surveys.
4. Capital Metro will evaluate the utilization of existing park-and-ride facilities every five years during its Service Plan update process.

Future Facility Policies
1. Capital Metro will consider potential future park-and-ride facilities every five years during its Service Plan update process.
2. Capital Metro will evaluate the cost and benefits of future park-and-ride facilities, including user benefits and ridership impacts, proposed along a high-capacity transit corridor during the corridor-level study, environmental review process or through an independent planning process.
3. Capital Metro will coordinate with affected jurisdictions on proposed park-and-ride facilities during the corridor-level study, environmental review process or independent planning process.
4. Capital Metro will coordinate with other regional transportation providers for input on purpose and need, goals and objectives, and financial resources necessary to construct and service future park-and-ride facilities. These providers may include City of Austin, Capital Area Metropolitan Planning Organization (CAMPO), Central Texas Regional Mobility Authority (CTRMA), Texas Department of Transportation (TxDOT), and Capital Area Rural Transportation System (CARTS).
Remote surveillance can also be provided at the station and are particularly useful in areas with sparse reporting options. Design and planning of all remote surveillance systems should be coordinated with local and Capital Metro police and the noting of notices indicating the presence of remote surveillance is recommended as a criminal deterrent. Closed circuit television (CCTV) cameras may be installed as a deterrent and should be placed in areas with maximum visual coverage and exposure.

Surveillance is an important security procedure for ensuring passenger security and property, crucial components of station design. The visibility of paths and entryways should be maximized.

Five strategies are involved in CPTED: Natural Surveillance, Natural Access Control, Activity Support, Territoriality, and Maintenance.

Natural Surveillance

- Surveillance involves reducing crime by decreasing target opportunities in a space area by placing physical features, activities and people to maximize visibility.
- Natural access control: Channeling people into, alongside or out of spaces/areas and determining entry/excursion along the boundary are the concepts of this principle (through the judicial placement of barriers, e.g. fencing, landscaping and lighting). This concept allows one to control target crimes and results in a perception of risk for would-be offenders.
- Territoriality: Territory notifies users and non-users of the boundaries of a space/area or facility. It creates a psychological deterrent to crime by notifying users of the space/area or facility that they are being watched and that the community is the space/area or facility. It creates a psychological deterrent to crime by notifying users of the presence of users and non-users of the boundaries of a space/area or facility. It creates a psychological deterrent to crime by notifying users of the presence of property and space/area or facility. It creates a psychological deterrent to crime by notifying users of the presence of restrictions on space/area or facility. It creates a psychological deterrent to crime by notifying users of the presence of property and space/area or facility. It creates a psychological deterrent to crime by notifying users of the presence of property and space/area or facility. 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These findings show an overabundance of parking at TODs and the limitations of current engineering standards to accommodate this type of development. Six roles for better aligning industry standards with current parking needs include:

- Incorporate shared parking, unbundled residential parking, and paid commercial parking into development.
- Ensure proper connectivity of P&R with TOD development.
- Revise zoning code to allocate reduced parking for mixed-use developments by-right, including unbundled parking and shared parking.
- Ensure proper connectivity of P&R with TOD development.
- Educate developers, financiers, and stakeholders that TODs do not require as much parking as standard development.
- Establish a well-defined vision of transit's capability to energize an area.

There are several strategies for estimating TOD parking demand. If a TOD already exists and is being expanded, or if new developments are going to near existing TODs, counties and intercept surveys similar to those conducted in NITC, 2017 should be initiated to estimate the performance characteristics of the expanded TOD or new development. For planned TODs, the statistics applied in NITC, 2017 may be used in conjunction with regional travel model forecasts for a particular TOD or its respectiveEfficiency zones. Also, one could estimate minimum and maximum parking ranges by finding the best match to a particular TOD being proposed from among the sample TODs studied in NITC, 2017.
Placemaking

Placemaking is an important element of well-designed transit facilities. Founded on principles advanced by revolutionary figures in urban planning, such as Jane Jacobs and William H. Whyte, it centers on the premise that cities should be designed for people and not just cars or shopping centers and should create inviting public spaces.

As defined by Project for Public Spaces, “Placemaking refers to a collaborative process by which we can shape our public realm in order to maximize shared value. More than just promoting better urban design, an effective Placemaking process capitalizes on a local community’s assets, inspiration, and potential, and it results in the creation of quality public spaces that contribute to people’s health, happiness, and well-being.”

The principles of Placemaking should be incorporated in designing a transit facility and integrating the stop/station area with the surrounding community. For more information on Placemaking, see: pps.org/reference/what_is_placemaking.

Placemaking is:

- Transformative
- Flexible
- Collaborative
- Scaled
- Dynamic
- Trans-disciplinary
- Community-driven
- Visionary
- Function before form
- Inclusive
- Creative Destinations
- Context-specific

Resources for Further Reading

APTA: apta.com/resources/standards/Pages/default.aspx


Transit-Oriented Development: capmetro.org/tod


Metro: metronet.com/engineering/design-guidelines/

NACTO: nacto.org


TRB: trb.org/Main/Blurbs/173932.aspx


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Appendix: Errata Sheet

(This section will contain a list of future revisions made to the document)
Estação Xaxim, Curitiba (source: BostonBrt)

Casa Voyageurs Station, Casablanca (source: Andy Nash)

Pampulha, Belo Horizonte (source: BostonBrt)
Avenida Jiménez Station, Bogotá (Karl Fjellstrom)

BRT Transit Center: Concept (source: BostonBrt)
Enclosed BRT Station: Concept (source: BostonBrt)
Dedicated BRT Lane: Concept (source: BostonBrt)
Complete Streets Separation Elements: Concept (BostonBrt)
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