Transit Design Guide: Standards & Best Practices

A Resource Manual for Transit System Design

Capital Metropolitan Transportation Authority | Austin, Texas

METRO

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STANDARDS & BEST PRACTICES

Purpose

This manual 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 stop design, station amenities, and safety and accessibility for all 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; fares and boarding techniques; and transit street design.

As a result of regional demographic trends and increased ridership demand, Capital Metro is undergoing 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 and the integration of multi-modal modes of transport. This guidance should not be viewed as an exhaustive list of techniques for improving transit service and operations.

The document is organized into ten main topics: Service & Operations, Transit-Supportive Roadway Design, Bus Stop Design, Transit Street Design, Transit Lane Configuration, Rail Station Design, Park & Ride Design, Security, Transit-Oriented Development, and Placemaking.

Current Conditions

Established in 1985, 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 biking community and the City of Austin to improve transit-related options for cyclists and first or last mile connections. This section discusses key regional trends, transportation growth 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 30 US Metro 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, 2014). Though 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 alleviate 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, 2014).

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 plans for addressing 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 growth" centers" (Austin, 2014). 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.

Austin Metropolitan Growth Impact on Travel - 1980-2010:

TTI Travel Data

283%
VMT (Vehicle Miles Traveled)

1,037%
Annual Hours of Delay

2,356%
Annual Cost of Congestion

Source: Austin Transportation Department

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 rides system-wide; launched a five-route frequent MetroBus network 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 MetroRapid corridors combined; and has experienced continued increases in MetroRail ridership to 65,600 average trips per month. MetroRail and MetroRapid ridership to special events, such as SXSW and ACL, has seen substantial growth from previous years.

Planning Initiatives

Capital Metro is involved in several initiatives to meet the greater demand on its system. The agency is in the process of developing an updated 10-year transit plan, Cap Remap, to guide the enhancement and expansion of its fixed-route bus system. The draft plan proposes nearly tripling existing frequent routes from 5 to 17, increasing frequency on many of its services to every 15 minutes or less, doubling the number of MetroRapid routes, and adding more east-west connections and on-demand circulator service. Capital Metro is improving the rail network by doubling the frequency and capacity of its MetroRail service through new train acquisition, infrastructure improvements, and the creation of a new downtown station.

Another agency initiative, Project Connect, aims to identify and evaluate potential high-capacity transit projects and funding strategies throughout the region that will enhance existing high-capacity transit service and connect people, places, and opportunities in an affordable, efficient, and sustainable way. Recognizing the importance of Transit-Oriented Development (TOD) in providing residents in Greater Austin with an array of housing choices and convenient access to the region's jobs, services, and amenities, Capital Metro is undertaking a system-wide initiative to encourage TOD along its high-capacity MetroRapid and MetroRail corridors by examining ways to establish a closer relationship between land use decisions, transit system efficiencies, and ridership.

Service & Operations

Capital Metro's bus network includes 2,700 bus stops, 60 Metro routes, two MetroRapid routes, seven Express routes, and 12 UT shuttle routes. Passenger rail service is provided between the city of Leander and downtown Austin, with nine MetroRail stations located along a 32-mile line. Seven MetroBike shelters are located at MetroRail stations and two major transit facilities; bicycle racks are installed on all local buses and trains, and at MetroRapid and P&R stations. This section provides more specific information concerning Capital Metro's operational characteristics, including fleet and vehicle technology.

Service Classification

Capital Metro provides several core and special services throughout the region, which have fundamentally different designs, purposes, and operating characteristics. The table below shows the services offered by Capital Metro and their function.

Core Services	Route #'s	
Radial	1-99	Local stop service on primary corridors connecting to downtown Austin
Frequent	7, 300, 325, 331	High-frequency, high-ridership Radial or Crosstown routes
Limited/Flyer	101-199	Limited stop service on primary corridors
Feeder	200-299	Local stop service from low-density areas to connecting services
Crosstown	300-399	Local stop service on primary corridors that bypass downtown Austin
MetroRail	500-599	Limited stop commuter rail service
MetroRapid	800-899	High-frequency, limited stop service on primary corridors
Express	900-999	Long-distance limited stop commuter service
Special Services	**Route #'s**	
MetroAirport	100	Limited stop service from downtown to Austin-Bergstrom International Airport
Ebus	410-419	Late-night/early morning safe ride service from entertainment district
Rail Connector	460-469	Service between rail stations and areas of employment or activity
Night Owl	480-489	Late night/early morning service on primary corridors
Senior	490-499	Midday service between senior housing and shopping and medical
UT Shuttle	600-699	Local and limited stop services between and within areas with dense UT population and the University of Texas campus

Source: Capital Metro, Service Guidelines

Services not covered in this document include the following:

- Rideshare: Carpool and vanpool service for registered customers
- Guaranteed Ride Home: Emergency taxi service for registered customers
- MetroAccess: Demand-responsive paratransit service complementary to fixed-route service provided in accordance with the Americans with Disabilities Act (ADA)

Vehicle Technology & Facilities

The agency has a fleet of 416 (revenue-generating) vehicles, including MetroBus, MetroExpress, MetroRapid, and MetroRail. MetroBus and MetroExpress balance flexibility and capacity and can operate on most streets. The articulated MetroRapid buses have extended coaches which pivot around a center bridgeplate and offer higher capacity than MetroBus or MetroExpress. MetroRapid buses are a Bus Rapid Transit (BRT) technology and offer increased amenities for bicycle integration, including on-board bicycle racks and additional space for wheelchair tie-ins. The MetroRail diesel electric vehicles operate on fixed track that is shared with regional freight.

Capital Metro's traditional bus shelters are 10'x10' and 7'x14'. Typically, bus stops are 25' wide (to catch the front and back door of the bus) by a minimum of 96'. In accordance with best practices, Capital Metro uses the Department of Transportation's ADA Standards for bus boarding and alighting areas to guide the field design of new bus stops: "Bus boarding and alighting areas shall provide a clear length of 96 inches (2440 mm), measured perpendicular to the curb or vehicle roadway edge, and a clear width of 60 inches (1525 mm), measured parallel to the vehicle roadway" (DOT, 2006). The agency has detailed station design and vehicle branding standards.

Vehicle Classification


MetroBus (35-ft)


MetroExpress (45-ft)


MetroBus (40-ft)

MetroRapid (40-ft)


MetroExpress (40-ft)

MetroRapid (60-ft)


MetroRail (134-ft)

Capital Metro's Fleet Characteristics (source: Capital Metro)

Vehicle Inventory:

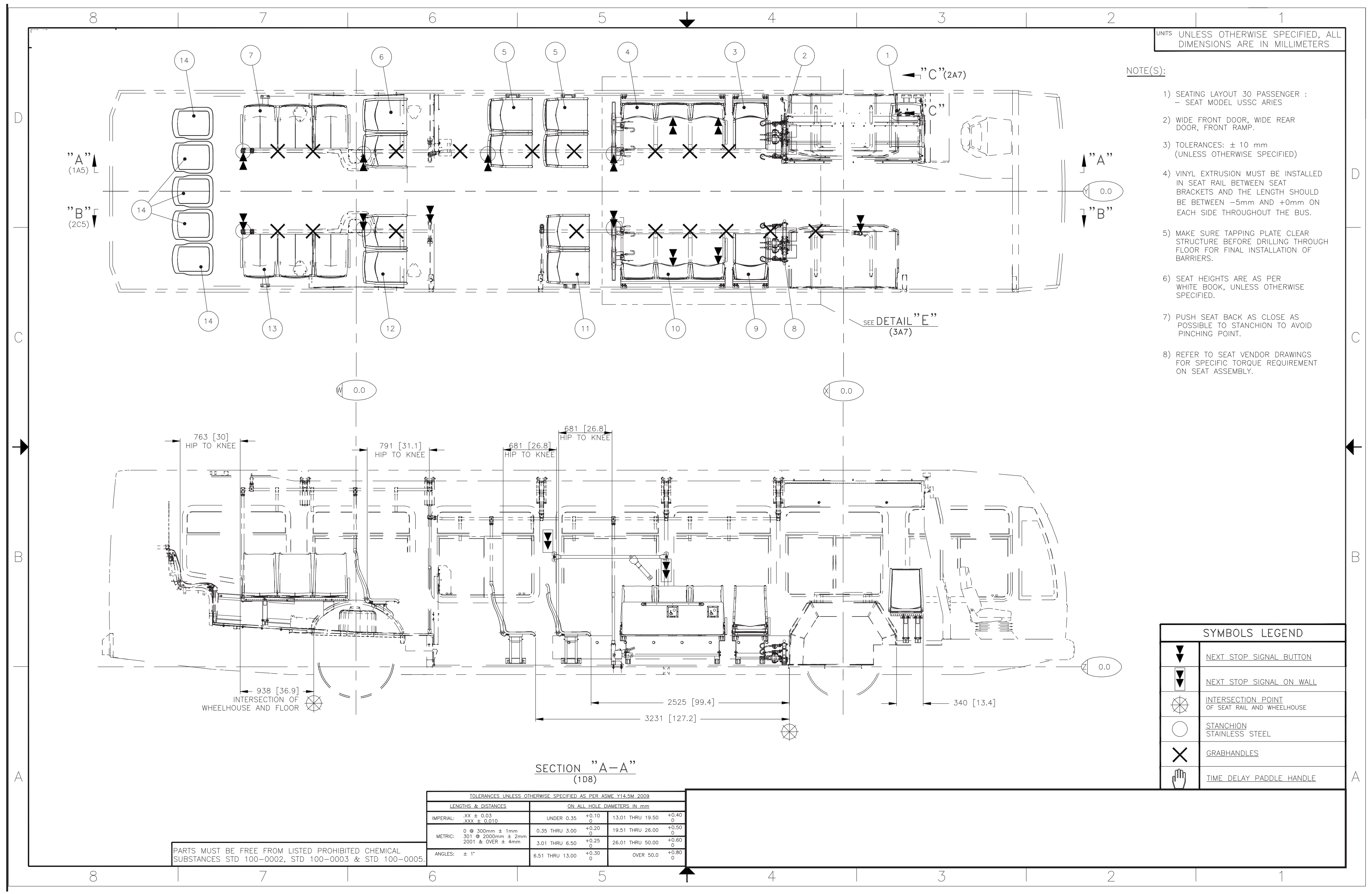
	MetroBus (35-ft)	MetroBus (40-ft)	MetroExpress (40-ft)	MetroExpress (45-ft)	MetroRapid (40-ft)	MetroRapid (60-ft)	MetroRail (134-ft)
Number of Vehicles	118	198	29	16	18	22	10
Seating Capacity	29	36	39	57	30	46	212
Fuel Type	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel Electric
Age	1-18 years	1-18 years	15-16 years	10-13 years	1-2 years	1-3 years	1 year; 9 years

Source: Capital Metro, 2015

Transit Vehicle Design (select representations)

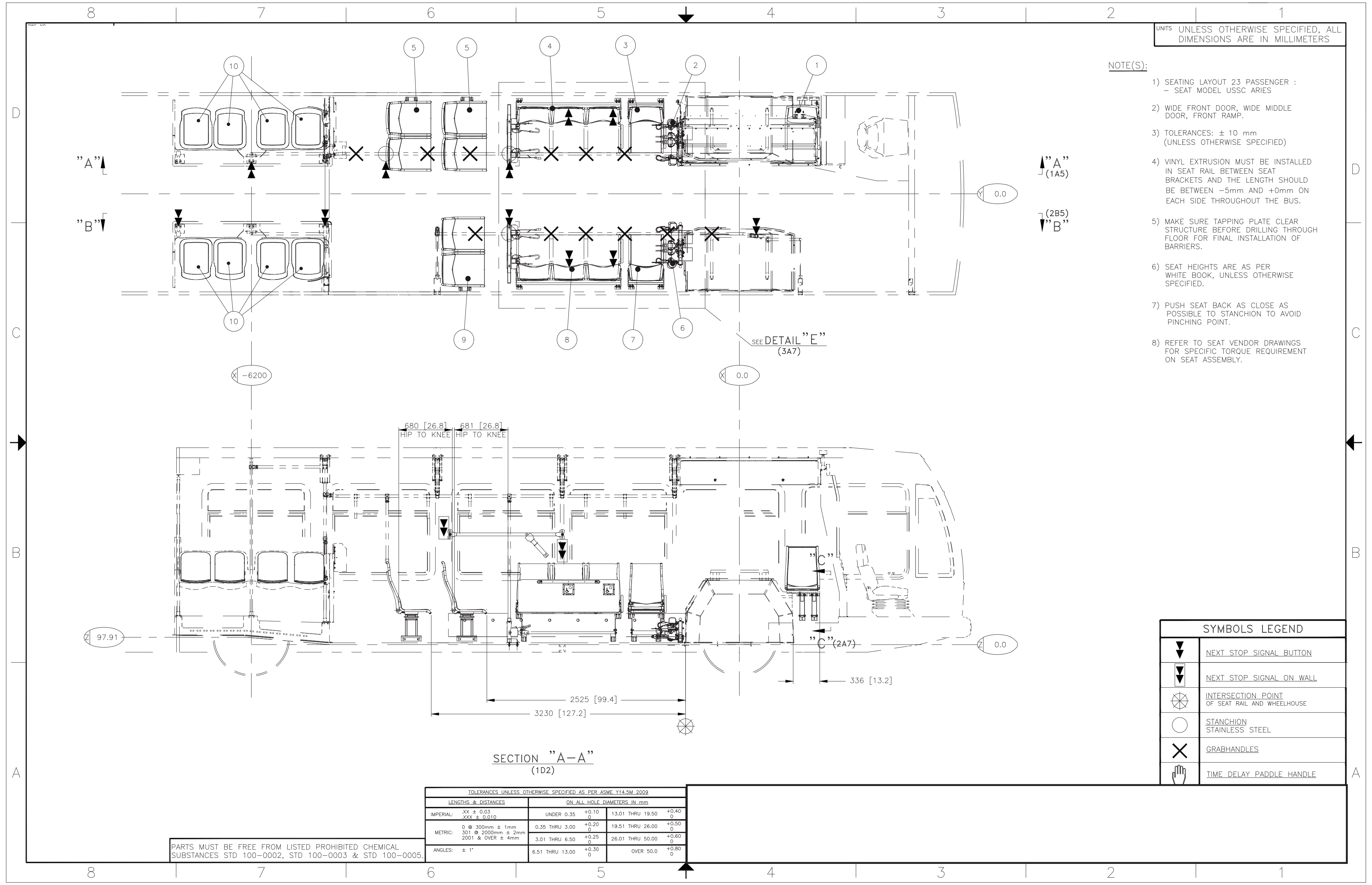
Examples of Vehicle Design (source: Capital Metro)

MetroRapid (NovaBus, 40-ft)



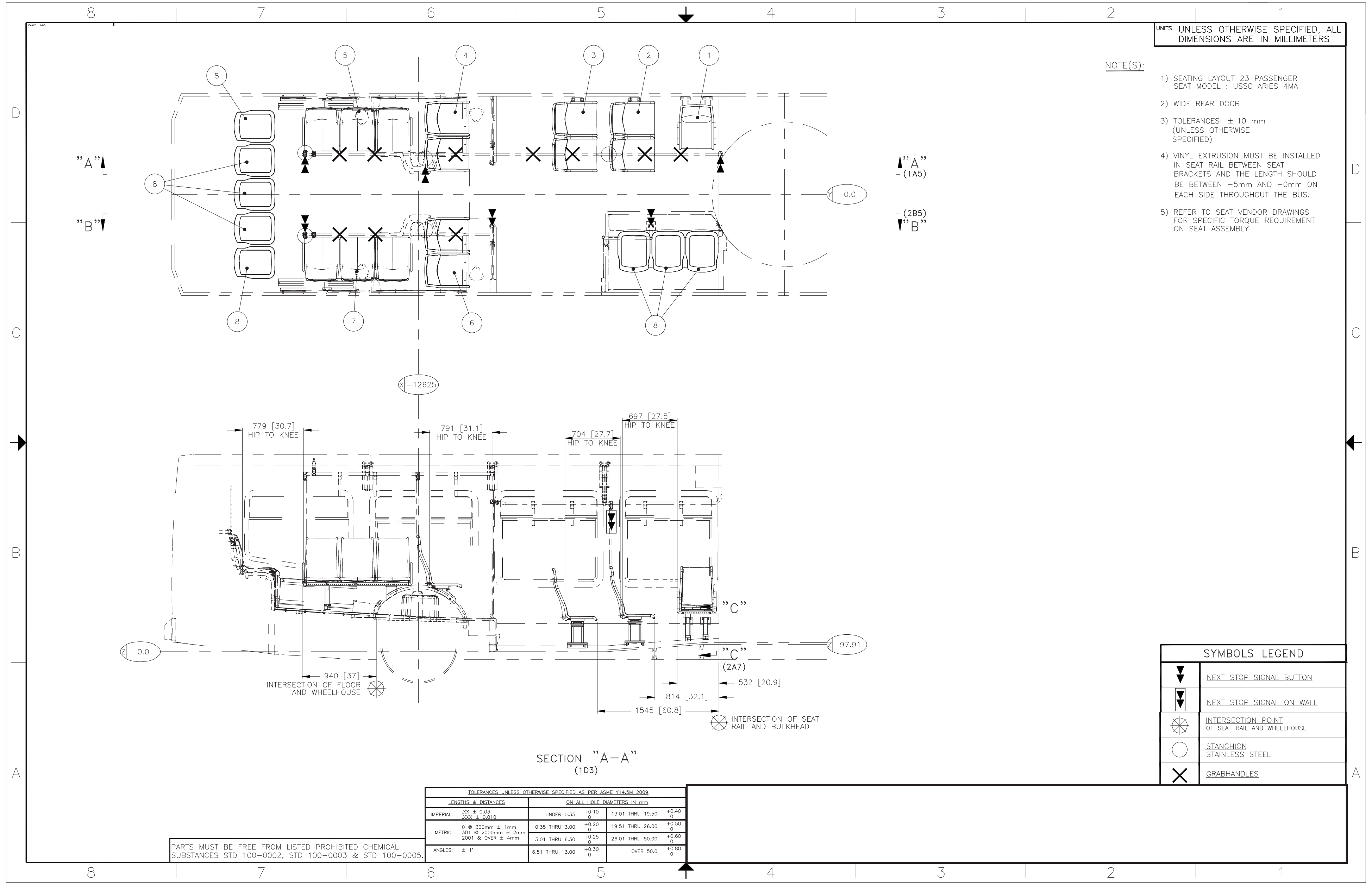
Source: NovaBus (reproduced)

MetroRapid (NovaBus, 60-ft): Side 1



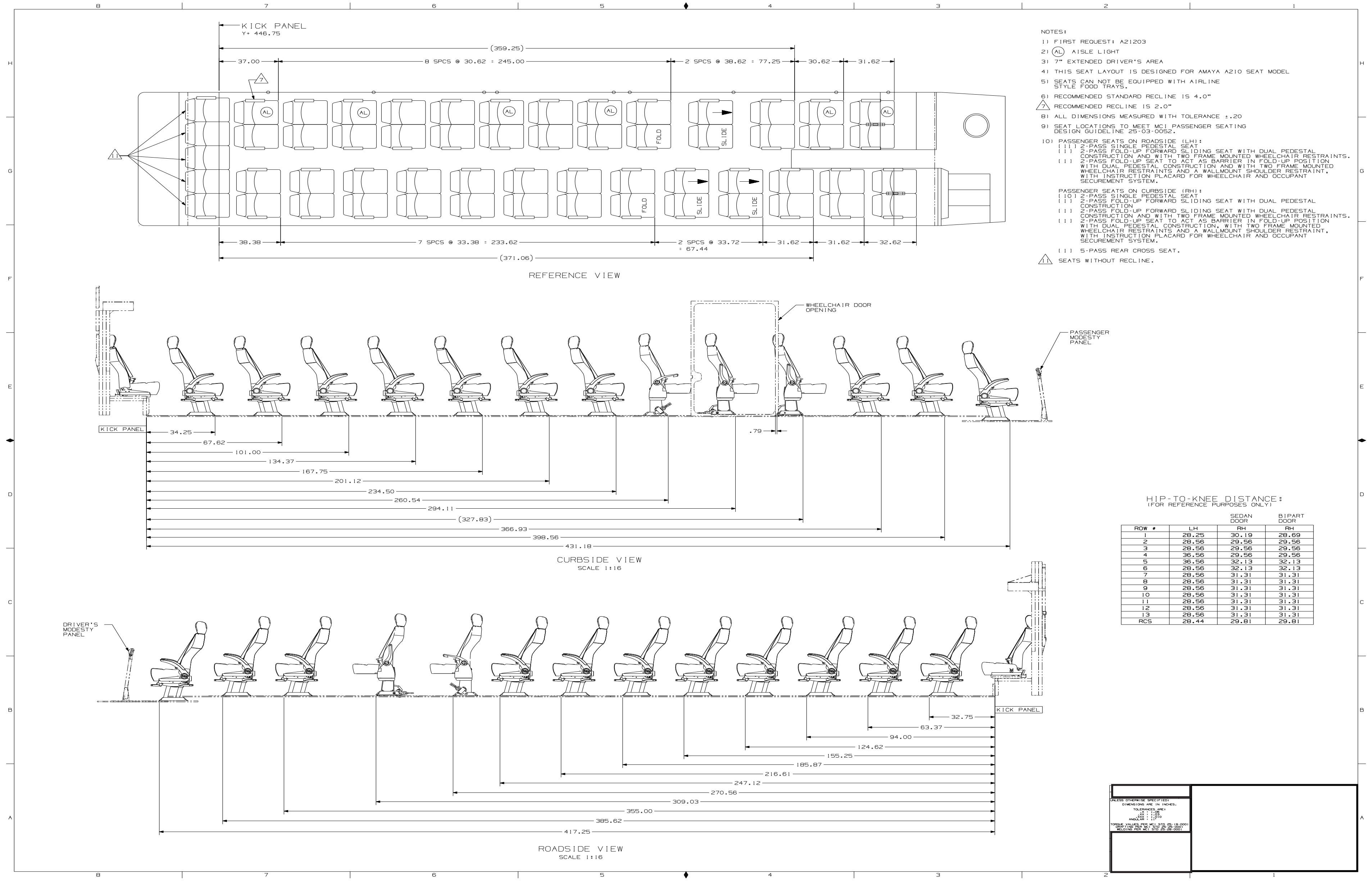
Source: NovaBus (reproduced)

MetroRapid (NovaBus, 60-ft): Side 2



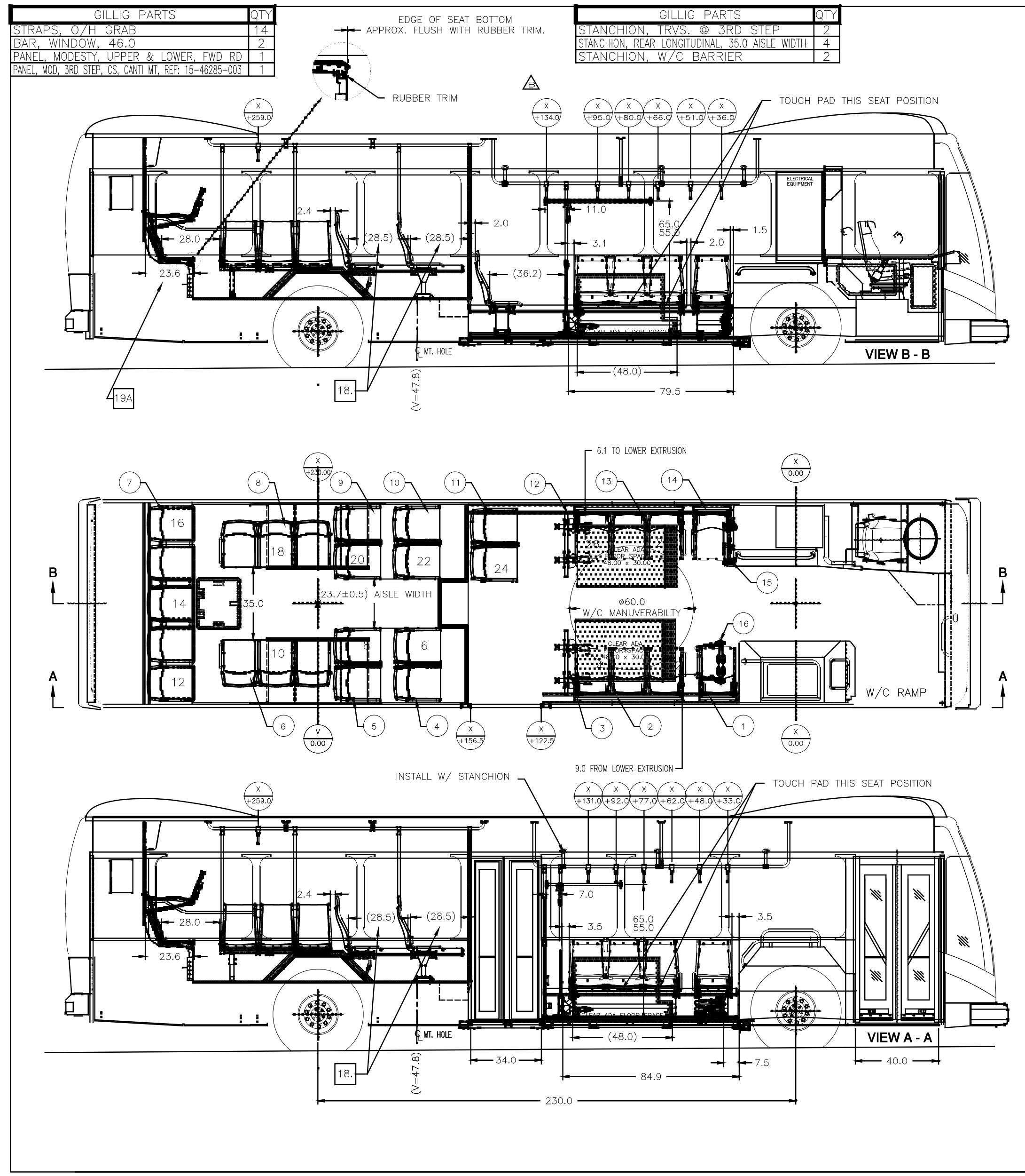
Source: NovaBus (reproduced)

MetroExpress (MCI, 45-ft)



Source: MCI (reproduced)

MetroBus (Gillig, 35-ft)



NOTES:

1. *TO MAXIMIZE OCCUPANT CRASH PROTECTION AND REDUCE THE POTENTIAL FOR SIGNIFICANT INJURY TO PASSENGERS SEATED IN THE FIRST FORWARD FACING SEATS IMMEDIATELY REARWARD OF THE ADA AREA, GILLIG REQUIRES EITHER: 1.1 THE PLACEMENT OF A BARRIER FORWARD OF THESE SEATS. 1.2 USE OF A GRAB/STANCHION POLE FOR THE AISLE SEAT AND WALL MOUNTED GRAB HANDLE FOR THE OUTBOARD SEAT OR 1.3 SEAT BELTS ON BOTH THESE SEATS.*
2. ALL DIMENSIONS ARE IN INCHES.
3. FLOORING LAYOUT: FL-67569R011.
4. THIS DRAWING IS TO BE USED FOR SEAT INSTALLATION. ALL OTHER GRAPHICS ARE SHOWN FOR REFERENCE ONLY AND THE FINAL DESIGN MAY VARY.

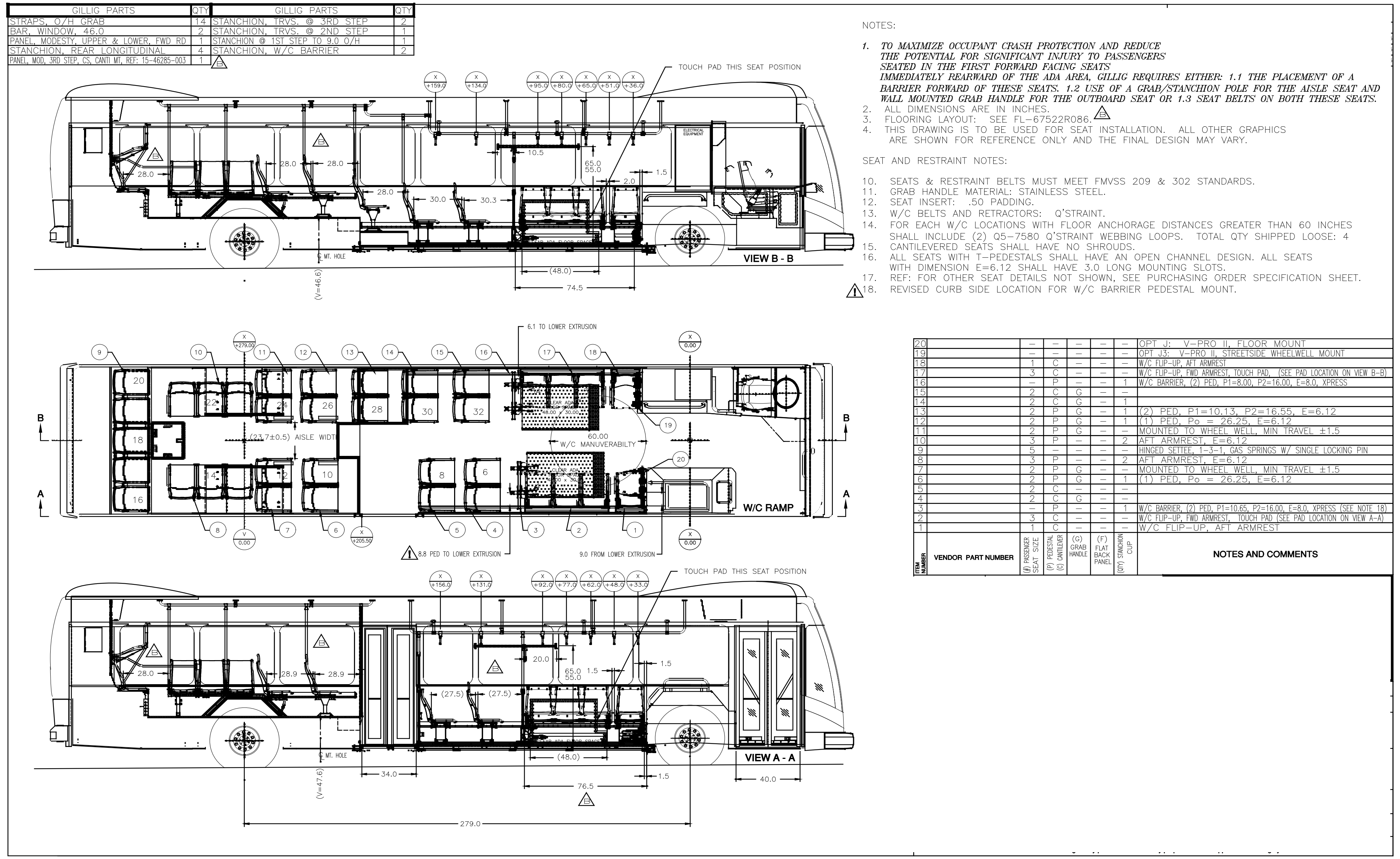
SEAT AND RESTRAINT NOTES:

10. SEATS & RESTRAINT BELTS MUST MEET FMVSS 209 & 302 STANDARDS.
11. GRAB HANDLE MATERIAL: STAINLESS STEEL.
12. SEAT INSERT: .50 PADDING.
13. W/C BELTS AND RETRACTORS: Q'STRAINT.
14. FOR EACH W/C LOCATIONS WITH FLOOR ANCHORAGE DISTANCES GREATER THAN 60 INCHES SHALL INCLUDE (2) Q5-7580 Q'STRAINT WEBBING LOOPS. TOTAL QTY SHIPPED LOOSE: 4
15. CANTILEVERED SEATS SHALL HAVE NO SHROUDS.
16. ALL SEATS WITH T-PEDESTALS SHALL HAVE AN OPEN CHANNEL DESIGN. ALL SEATS WITH DIMENSION E=6.12 SHALL HAVE 3.0 LONG MOUNTING SLOTS.
17. REF: FOR OTHER SEAT DETAILS NOT SHOWN, SEE PURCHASING ORDER SPECIFICATION SHEET.
18. HIP TO KNEE DIMENSIONS SHOWN ARE NOMINAL. SEAT WILL BE EQUALLY SPACED.
19. REAR SETTEE SEATS:
    A. SEAT VENDOR TO MODIFY SETTEE SEATS TO THE OVERALL DIMENSION SHOWN.
    B. SPRING CLIPS INSTEAD OF A BOLT ON SYSTEM SHALL BE USED UNDER THE HINGED SEATS. SPRING CLIPS CAN BE FASTENSED ON TO TOP OF THE SETTEE IF NEEDED.
    C. THERE SHALL BE NO PINCH POINT BETWEEN THE HINGED CENTER SEATS AND THE FIXED SEATS BY THE SIDE WALL.

ITEM NUMBER	VENDOR PART NUMBER	(#) PASSENGER SEAT SIZE	(P) PEDESTAL (C) CANTILEVER	(G) GRAB HANDLE	(F) FLAT BACK PANEL	(QTY) STANCHION CUP	NOTES AND COMMENTS
16		–	–	–	–	–	OPTION J: V-PRO 2, FLOOR MOUNT
15		–	–	–	–	–	OPTION J3: V-PRO 2, STREETSIDE WHEEL WELL MOUNT
14		1	C	–	–	–	W/C FLIP-UP, AFT ARMREST
13		3	C	–	–	–	W/C FLIP-UP, FWD ARMREST, 2X TOUCH PAD, (SEE PAD LOCATIONS ON VIEW B-B)
12		–	P	–	–	1	W/C BARRIER, (2) PED, P1=8.00, P2=16.00, E=8.0, XPRESS
11		2	C	G	–	–	
10		2	P	G	–	1	(1) PED, Po = 26.25, E=6.12
9		2	P	G	–	–	MOUNTED TO WHEEL WELL, MIN TRAVEL ±1.5
8		3	P	–	–	2	AFT ARMREST, E=6.12
7		5	–	–	–	–	HINGED SETTEE, 1-3-1, GAS SPRINGS W/ SINGLE LOCKING PIN (SEE NOTE 19)
6		3	P	–	–	2	AFT ARMREST, E=6.12
5		2	P	G	–	–	MOUNTED TO WHEEL WELL, MIN TRAVEL ±1.5
4		2	P	G	–	1	(1) PED, Po = 26.25, E=6.12
3		–	P	–	–	1	W/C BARRIER, (2) PED, P1=8.00, P2=16.00, E=8.0, XPRESS
2		3	C	–	–	–	W/C FLIP-UP, FWD ARMREST, 2X TOUCH PAD (SEE PAD LOCATIONS ON VIEW A-A)
1		1	C	–	–	–	W/C FLIP-UP, AFT ARMREST

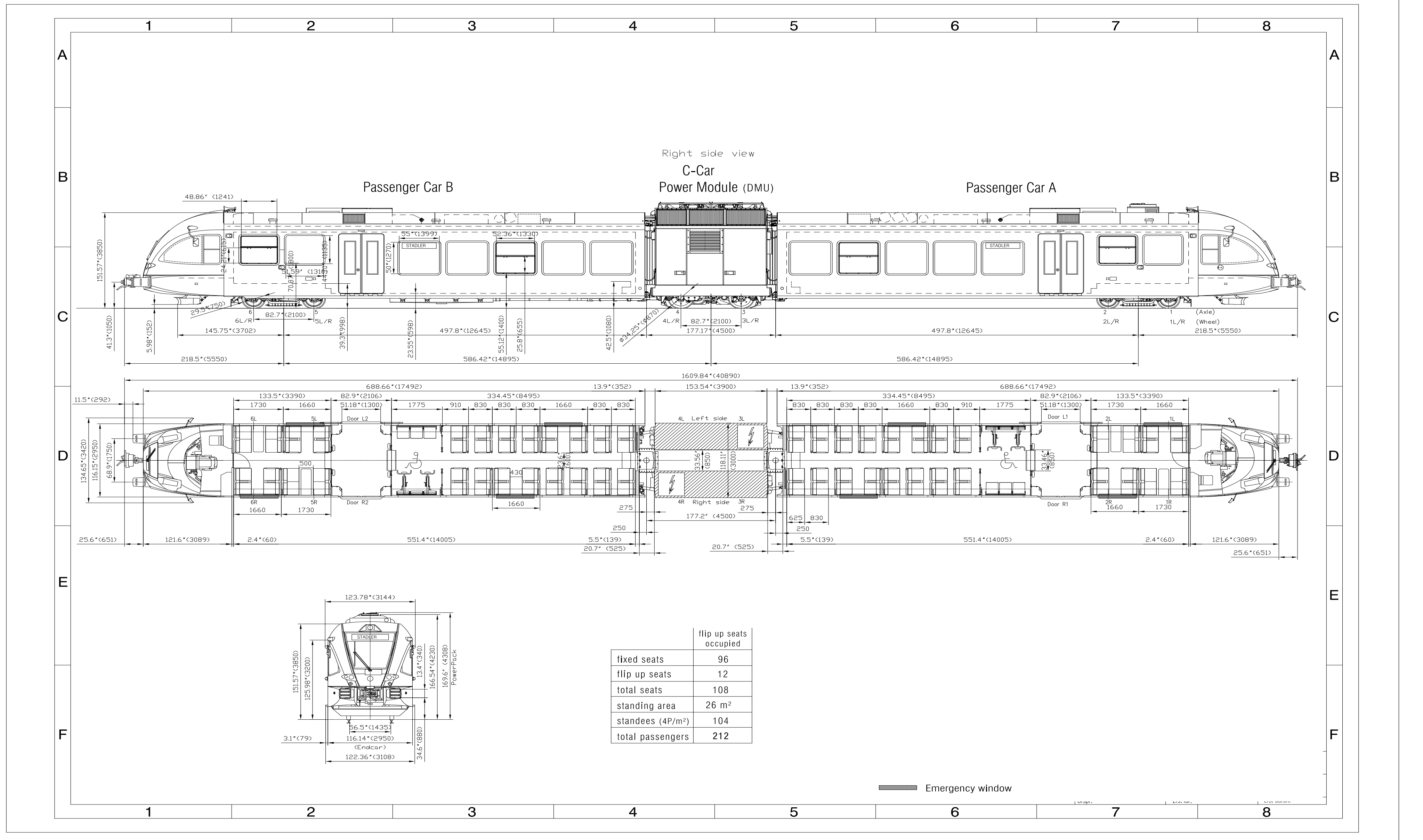
Source: Gillig (reproduced)

MetroBus (Gillig, 40-ft)



Source: Gillig (reproduced)

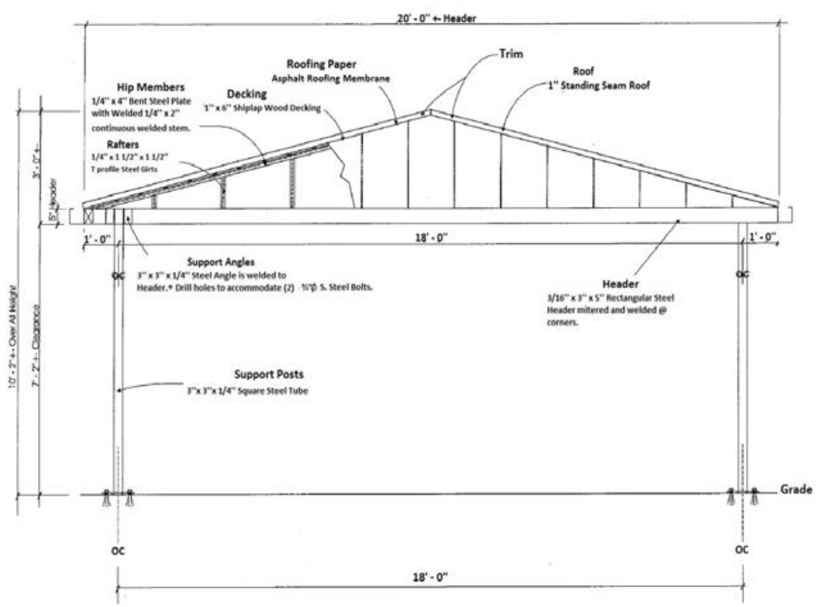
MetroRail (Stadler, 134-ft)

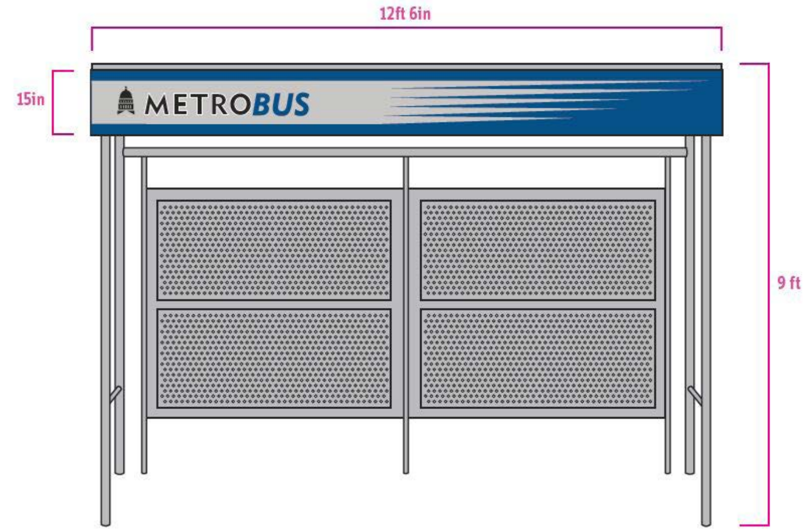


	flip up seats occupied
fixed seats	96
flip up seats	12
total seats	108
standing area	26 m²
standees (4P/m²)	104
total passengers	212

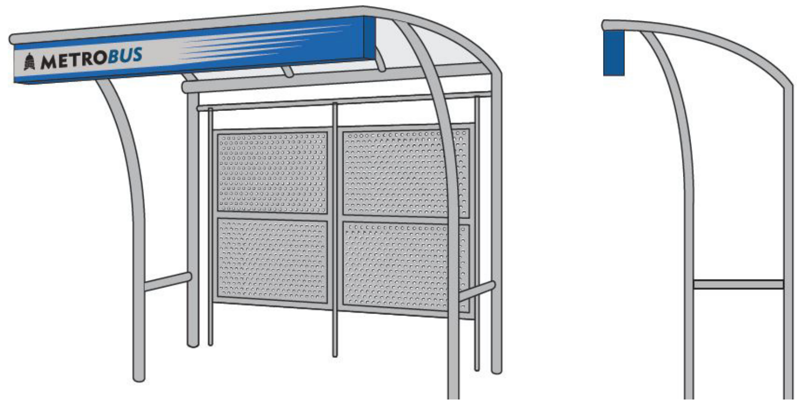
Source: Stadler (reproduced)

Bus Stop Design (select representations)





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



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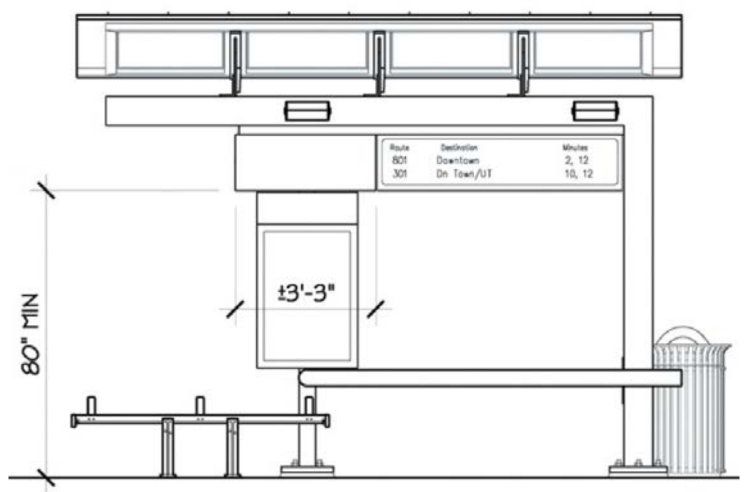
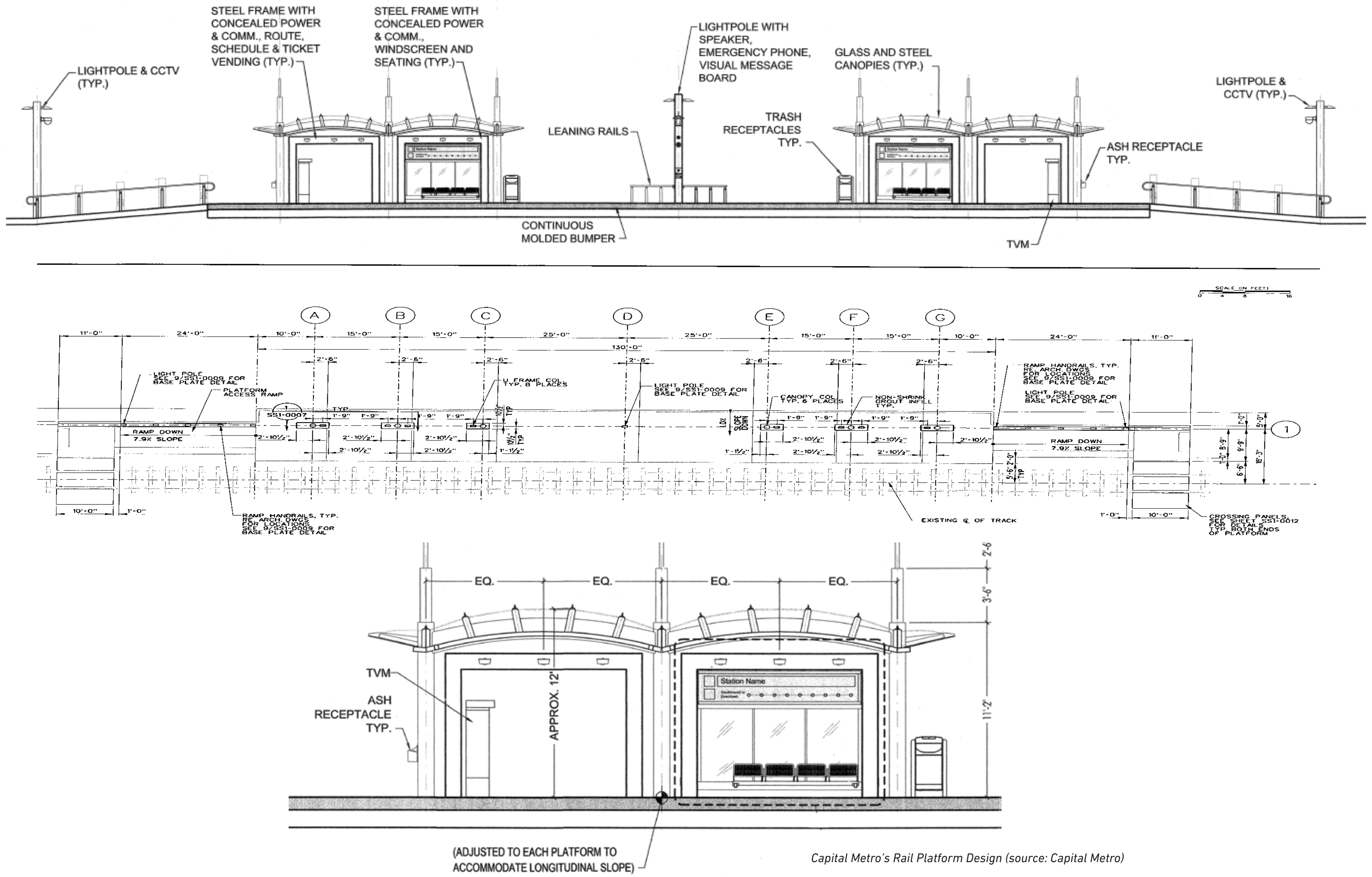
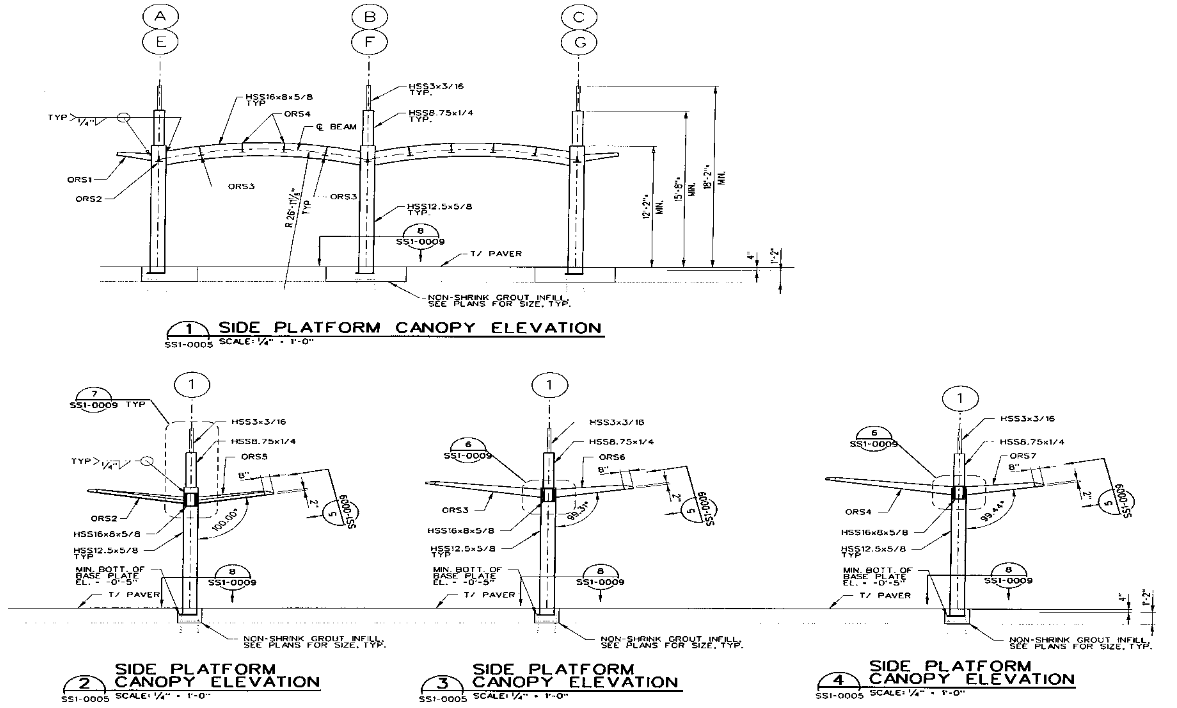


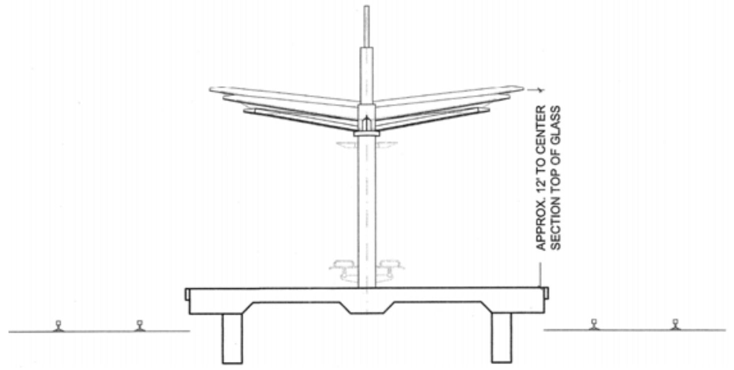
Capital Metro's Local Bus Stop Design (source: Capital Metro)

Rail Platform Design (select representations)



Capital Metro's Rail Platform Design (source: Capital Metro)

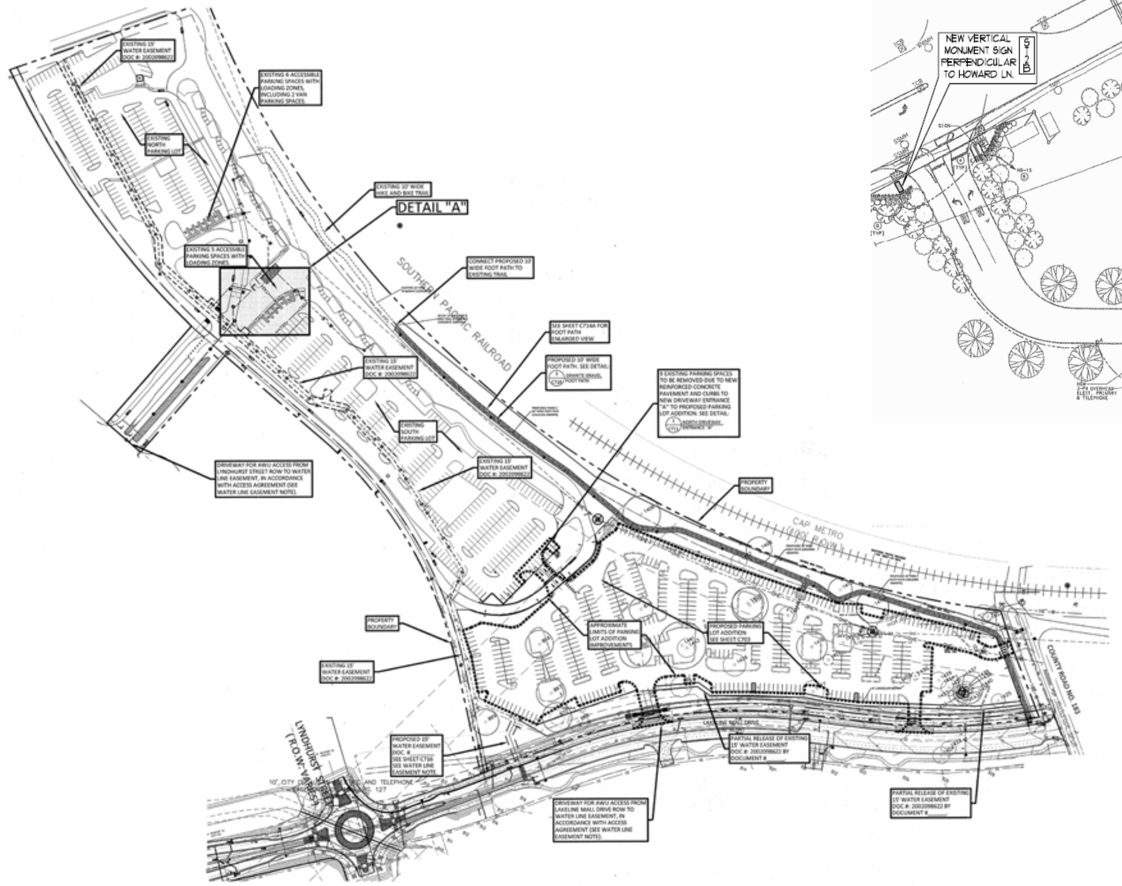




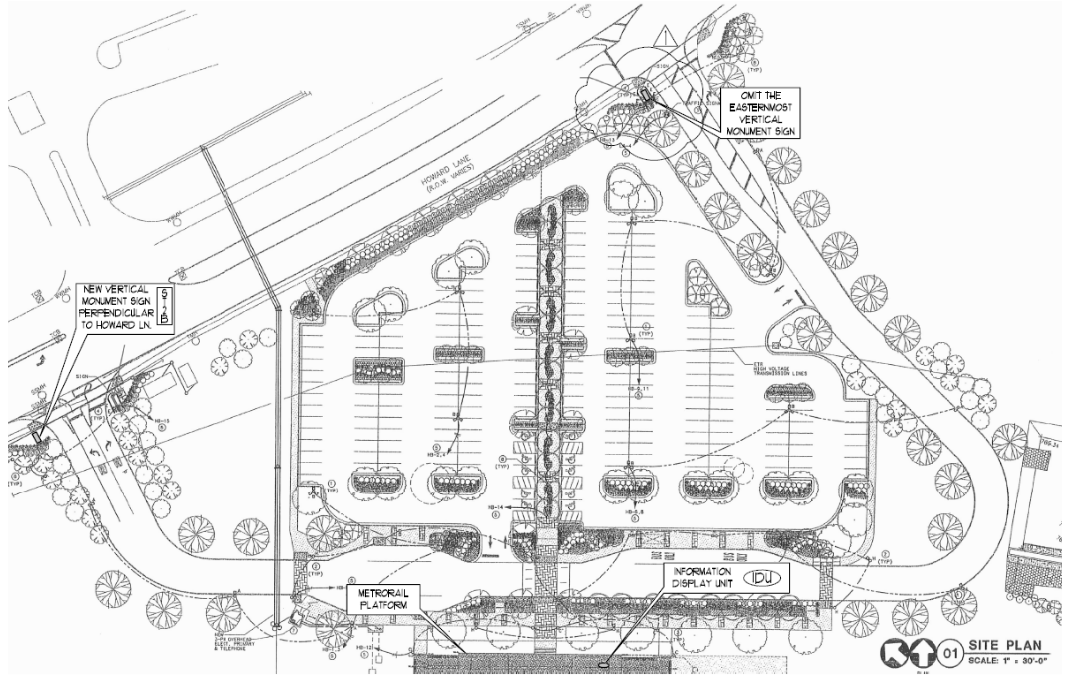
Capital Metro's Rail Platform Design (source: Capital Metro)

Capital Metro's Rail Platform Design (source: Capital Metro)

Park & Ride Design (select representations)



Lakeline Station Park & Ride Design (source: Capital Metro)



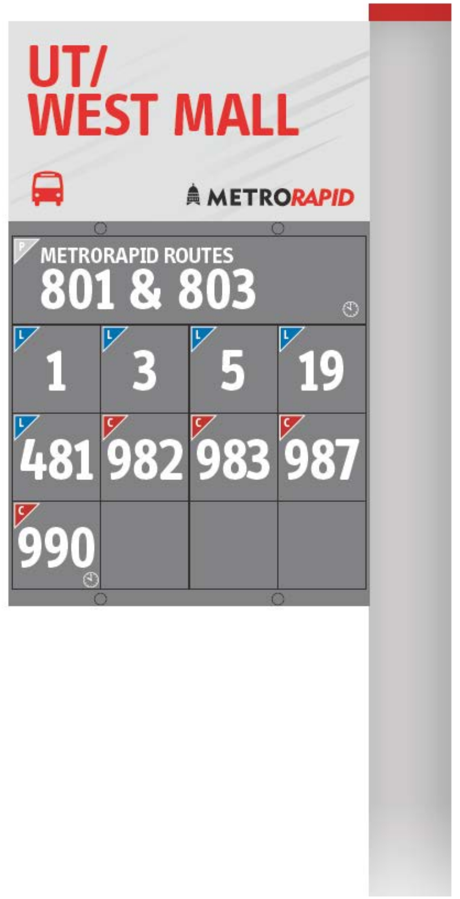
Howard Station Park & Ride Design (source: Capital Metro)

Howard Station Park & Ride Design (source: Capital Metro)

Signage (select representations)

Local Urban Pole Sign

MetroRapid Urban Pole Sign

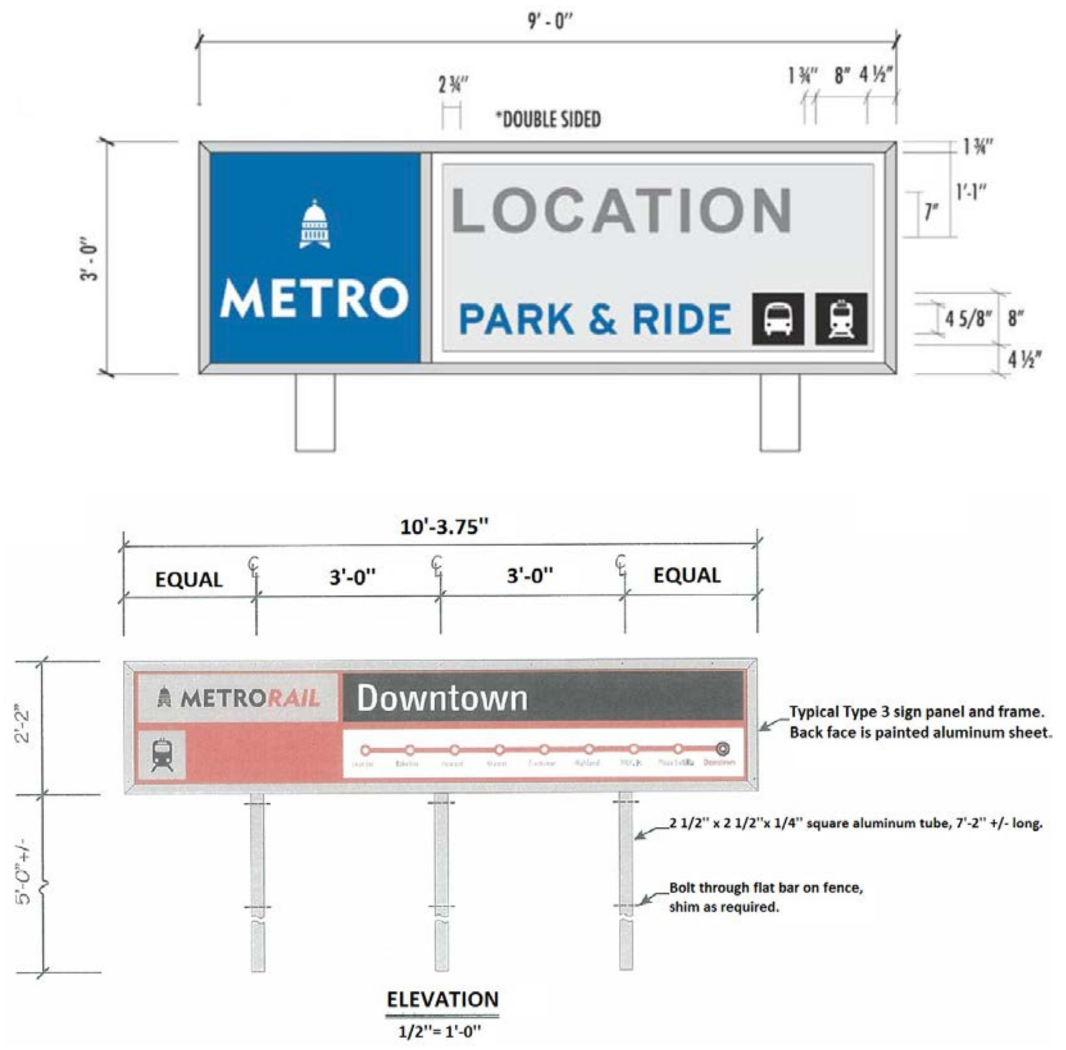


Local and MetroRapid Pole Signs (source: Capital Metro)

L **Local Routes:**
Routes 1–99, 200–499 & 600–699

P **Premium Routes:**
Routes 100–199 & 800–899

C **Commuter Routes:**
Routes 500–599 & 900–999



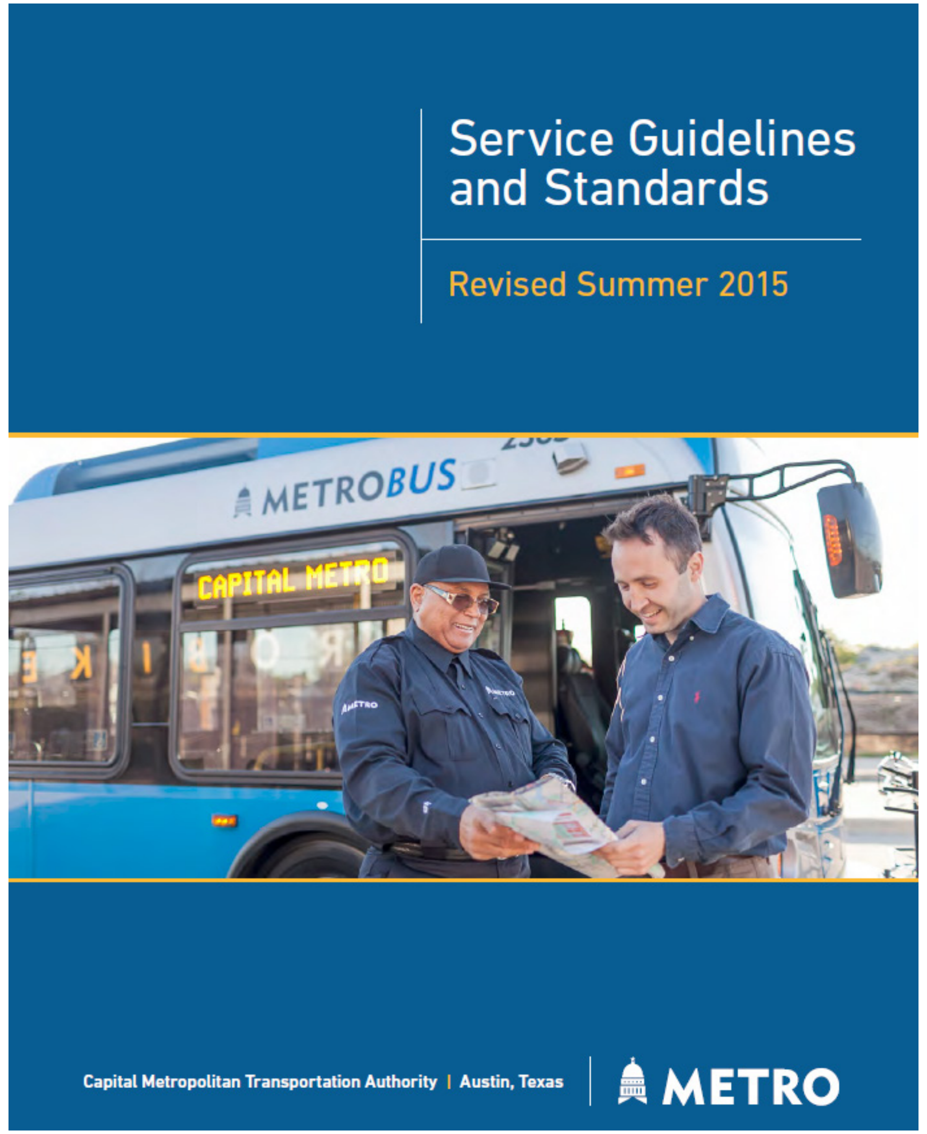
Strip, P&R, and Rail Station Signs (source: Capital Metro)

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*).



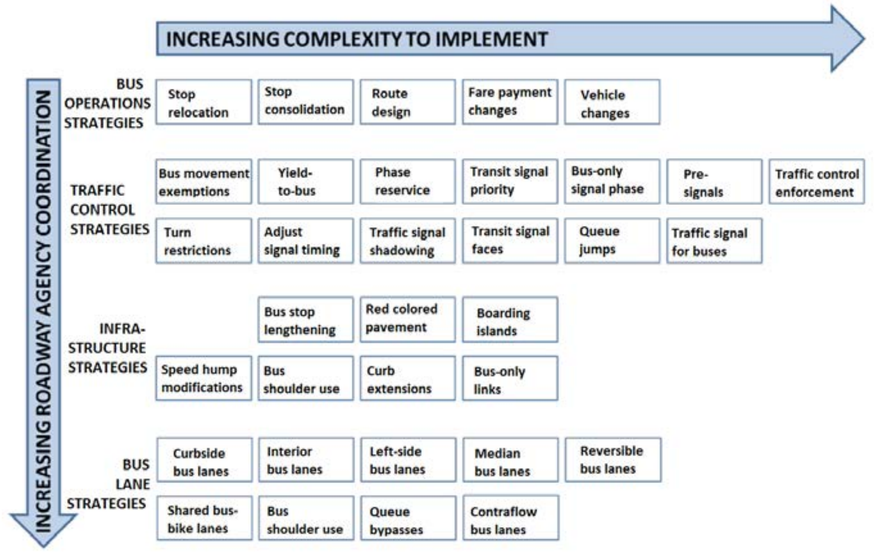
Capital Metro Service Guidelines (source: Capital Metro)

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. Transit-supportive roadway strategies may be used to improve transit speed and reliability on urban and suburban streets, helping buses move more quickly and with more consistent travel times. *TRB, 2015* defines four main categories of strategies, which are summarized in the diagram below:

- **Bus operations strategies:** Changes made by the transit agency in the way it provides service, such as relocating bus stops, consolidating bus stops, and changing the way fares are paid.
- **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 changes to 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.

Though 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 of these 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 a bus travel time benefit on their own, but help another strategy achieve its maximum effectiveness" (*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.



Transit-supportive Roadway Strategies (source: TRB, 2015)

Bus Stop Design

Bus stop design affects many aspects of the transit system and the built environment, such as ridership, public health, wait experience, multi-modal connectivity, and safety. Because riders expend a great deal of the 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). The following sections will examine several important elements and goals of bus stop design, including spacing, placement, and amenities.

Design Elements

Stations and stops play a key role in defining the transit system and the system's performance. As stated in *APTA, 2010*, good station or stop design can do the following:

- Attract new riders
- Promote visibility and facilitate 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 berthing 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, seating 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 negotiate 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 (*NACTO, 2016*).

Sunshine Station, Austin (source: Capital Metro)

BRIO BRT Bus Shelter, El Paso (source: Sun Metro)

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.

BRIO BRT Bus Shelter, El Paso (source: Sun Metro)

Safety
CPTED measures and accessible design reduce the risk for crime and accidents. Natural surveillance through design is preferred.

Thermal Comfort
Thermal condition is the most important factor determining comfort. Passive and active controls can be used to maintain a desired temperature range.

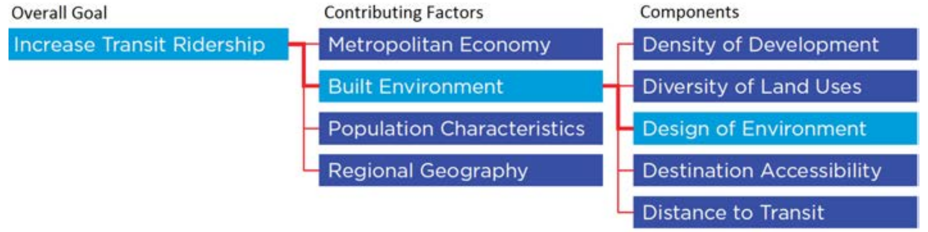
Acoustic Comfort
Traffic noise negatively affects both riders and adjacent residents. Elements should be arranged to best shield or absorb noise.

Wind Protection
Wind can have both mechanical and thermal impacts on the bus rider. Wind should be carefully mitigated as its cooling effects may be desired.

Visual Comfort
Sufficient lighting should be provided for safety and to conduct productive activities at a bus stop. Excessive light such as glare should be minimized.

Accessibility
The bus stop should be easily accessible by all segments of the population, of all physical abilities, and through all travel modes.

Integration
Being nodes within neighbourhoods, bus stops should cater to the needs of their surroundings and reflect the identity of the community.



Bus Stop Urban Design Goals (source: Zhang, 2012)

Lighting
Even, white light with minimal shadows provides the best environment for activities and enhances safety. Pedestrian scale lighting adds to the character of the location.

Seating and Surfaces
Adequate seating with a variety of microclimatic conditions is important for comfort and allows riders to adapt to their preferences. Special paving can denote pedestrian priority.

Cover
Cover provides primary weather protection from precipitation and excessive solar exposure. Where possible, cover may be achieved by adjacent awnings or vegetation.

Amenities
Amenities such as public art, drinking fountains, and waste bins not only improve the experience of the bus user, but they also benefit the immediate neighbourhood.

Information
Transit information provided at a stop can greatly reduce rider anxiety in waiting. Extra space may be dedicated to displaying community information if the stop is in a high traffic area.

Vegetation
Vegetation can manage the microclimate of a stop by providing shade, cover, and wind blocks. It can also be used to enhance the aesthetics of the location.

Traffic Management
Traffic management techniques focus on reducing vehicular speeds around bus stops and making biking and walking in the area safer and more pleasant.

Pedestrian Infrastructure
The pedestrian network around a stop is an extension of the transit line. Therefore, it is important to have high quality walking environments to attract new riders.

Bicycle Infrastructure
Many residents would bike to bus stops if it were more convenient. To encourage such behaviour, adequate bike paths and bike parking must be provided.

Bus Stop Urban Design Techniques (source: Zhang, 2012)

Techniques

There are several factors that influence transit user preferences and ridership. Walkability is one factor and walkable environments are often identified as areas that have more pedestrian traffic, environmental and social safety, pleasing aesthetics, natural features, pedestrian amenities, and land use diversity (*Brown, Werner, Amburgey, & Szalay, 2007*). A survey of transit user preferences in Los Angeles (Taylor et al., 2007) found that commuters required the stations to be, in order of importance:

- Easy to get around
- Feel safe during day
- Easy to find
- Well-lit at night
- Clean
- Sheltered
- Have places to sit
- Have food and washrooms nearby

Another survey of transit riders in Ottawa (*Taylor & Fink, 2011*) found that factors that influence ridership are, in order of importance:

- Bus information
- On-street service
- Station safety
- Customer service
- Safety en-route
- Reduced fare
- Cleanliness
- General attitudes towards transit

In identifying which amenities to focus on first, studies have shown that paving, lighting, and vegetation have the most pedestrian-perceived benefit per dollar over their life spans (*Fukahori & Kubota, 2003*). 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.

Spacing

The greatest predictor of transit use is proximity (*Cervero, 2002; Gutiérrez & García-Palomares, 2008*). The closer one lives to a transit stop, the more likely one will take transit (*Hoehner, Brennan Ramirez, Elliott, Handy, & Brownson, 2005*). The typical catchment for a bus stop is contained within a 400 meter (approximately 1,300 feet) radius around the stop and can be larger for faster forms of transit (*Gutiérrez, Cardozo, & García-Palomares, 2011*).

Stop spacing is determined by on several factors including customer convenience, ridership demand, and service type. Customer convenience involves a trade-off between proximity to stops and travel time. Closely spaced stops reduce customer walking distance but result in slower transit speeds, reducing operating efficiency and cost effectiveness. Though few stops spaced 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 350 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 suburban and other low-density areas, stops may be spaced over 1,200 feet apart.

Sufficient ridership demand is necessary to support the investment of stops. Specific service types such as limited stop, rapid, and express require increased stop spacing to maintain higher speeds, while radial and crosstown services have frequent stops to maximize ridership potential and convenient access to local activity centers and/or residences. *TRB, 2015* guidance states that, in general:

When existing stop spacing is every block or two, block lengths are reasonably short (e.g., 250 feet or less), 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.

Recommended minimum distance between bus stops:

Area Type:	Ideal Stop Spacing Range (Min-Max)
Regular local stops in downtown or arterial streets	800-1,600 feet
Suburban and other low-density areas	1,200-2,500 feet

Source: Capital Metro, 2015

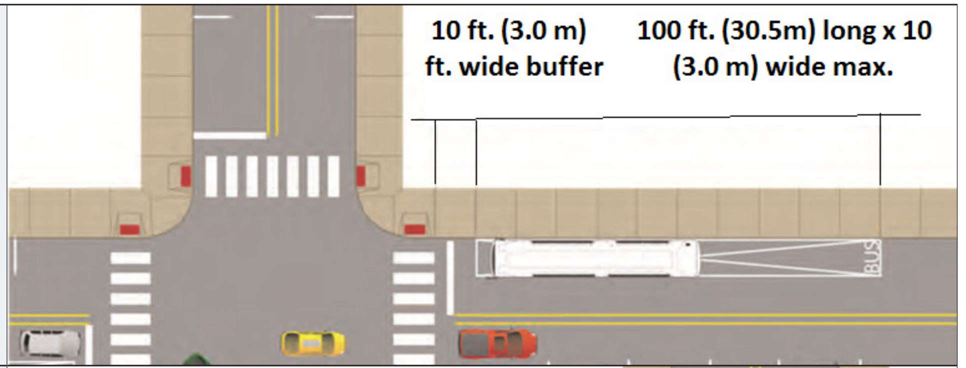
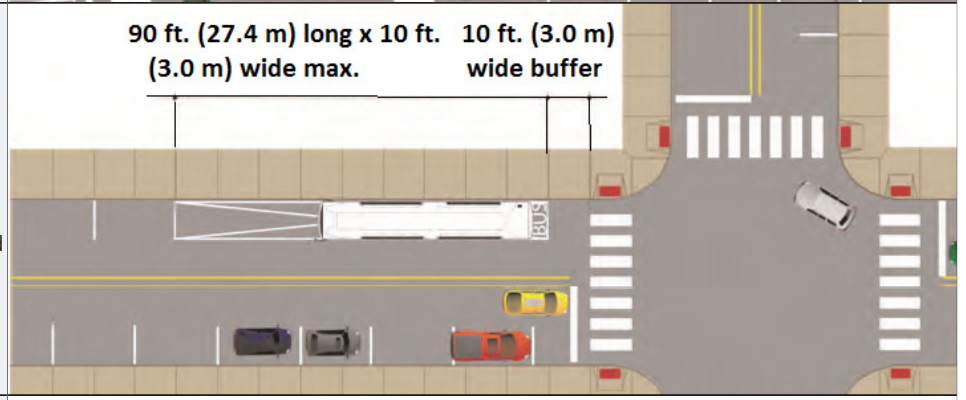
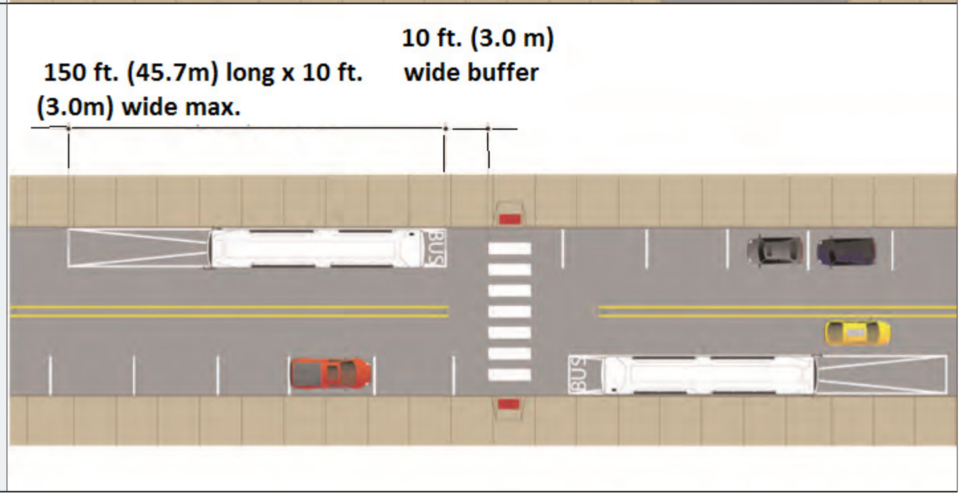
Stop Placement & Configuration

Determining where to locate stops and stations is one of the chief operating 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 (*SEPTA, 2012*). TCRP Report 19 (*TRB, 1996*) and the Platform Length section of *NACTO, 2016* 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 pathway. 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 ridership generators may determine the placement of a bus stop. This section provides general design guidelines for common stop configurations. See *SEPTA, 2012; NACTO, 2016; and TRB, 2015* for more detailed guidance on stop placement, relocation, and additional stop configurations.

Common Bus Stop Configurations

<table>
<tr><td>Near-side Stop</td><td>Near-side 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 also eliminate the potential of alighting passengers waiting through a red light.</td><td>
</td></tr>
<tr><td>Far-side Stop</td><td>Far-side 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.</td><td>
</td></tr>
<tr><td>Mid-block Stop</td><td>Mid-block stops occur when the bus stops in between intersections, usually in a well-defined area. They should be considered when pedestrian crosswalks are present. If pedestrian crossings are not present, Capital Metro will work with appropriate entities to address the potential of installing treatments like flashing pedestrian beacons to accommodate this issue. Mid-block stops may be the only option at major intersections with dedicated turn lanes.</td><td>
</td></tr>
</table>

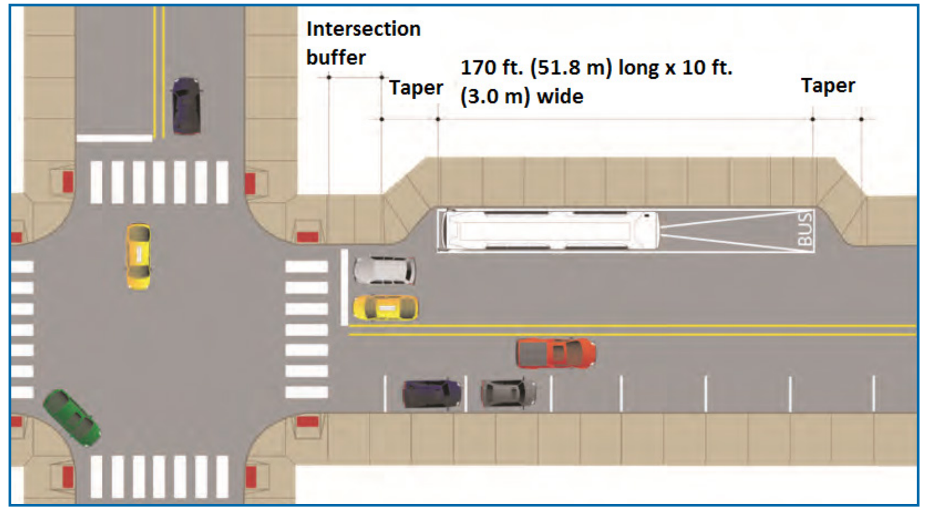
Source: SEPTA, 2012

Sidewalk Stop: Turnout

The bus bay or turnout is a location off-line with respect to the travel lanes, with a special 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 apartment complex. Typical dimensions are 170 feet (51.8m) long by 10 feet (3.0m) wide (*SEPTA, 2012*).

Far-side Bus turnout on City Avenue (source: SEPTA, 2012)

Bus turnouts are not generally desirable from an operations standpoint, as they can result in bus delays waiting for a gap in traffic when leaving the turnout, however they have several advantages. They are particularly useful where in-lane stops are not geometrically feasible, or where an intersection presents a particular hazard or conflict with transit operations. Bus turnouts are most effectively used on higher-speed roadways where traffic speeds are more than 35 mph- when long dwell times are common- or as a system layover stop (*SEPTA, 2012*). Bus turnouts are sometimes needed due to traffic operations considerations, such as "the number of vehicles that might be delayed, the length of time they might be delayed, and inability of vehicles to pass a stopped bus" (*AASHTO, 2014*).



Near-side Bus Bay Example (source: DVRPC, 2012)

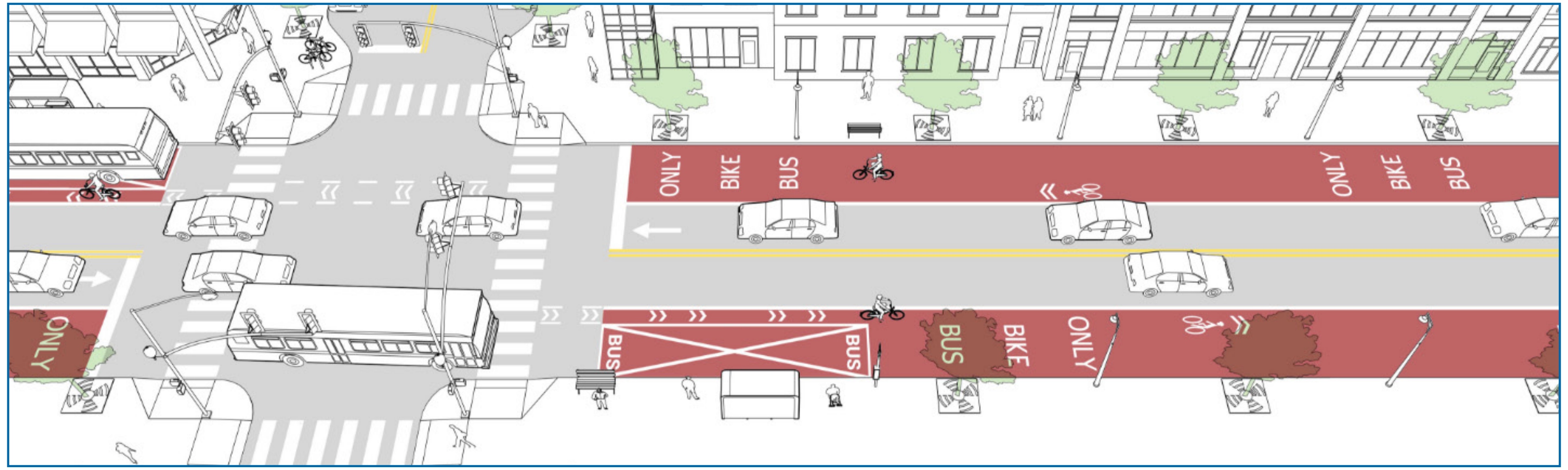
The "lay-by" configuration should only be applied where sidewalk width is sufficient for the shelter and a pedestrian clear zone is behind it (*NACTO, 2016*). A variation of the bus bay is the open bus bay, which provides additional maneuverability toward the upstream side of traffic flow. *SEPTA, 2012* provides further information on the open bus bay.

TRB, 2015 provides guidance on integration of bus turnouts and bicycle lanes:

If a pullout is required, it should allow a bus to stop without blocking the adjacent bicycle lane or shoulder bicycle way (if present). If a bicycle lane exists, the lane lines would be dotted in the vicinity of the bus stop to indicate buses can pass through the lane while entering and exiting the stop. When sufficient right-of-way (ROW) exists to install a pullout, there may be benefit to routing a bicycle facility (if present) around the stop, to avoid bicycle–bus conflicts when buses are entering and exiting the stop.

Sidewalk Stop: Curbside

In-lane curbside stops often occur along curbside running ways in either dedicated transit lanes, or in mixed-traffic streets with low to moderate transit frequency and speeds of 30 mph or lower. Curbside stops allow passengers to board and alight directly from the sidewalk and are typically the lowest-cost treatment, requiring only signage and an ADA boarding area to receive transit passengers on the existing curb. Buses save time and reduce wear, while improving pedestrian space, where pull-out bus bays (or lay-bys") can be filled in to create in-lane curbside stops (*NACTO, 2016*).



Far-side In-lane Stop with Shared Bus-Bicycle Lane (NACTO, 2016)

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 a "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*

A key constraint is the potentially large number of competing users that also have a stake in how the curb space is used, including: bus stops, right-turning traffic, deliveries, passenger pick-up and drop-off, parking, deliveries, taxi stands, bicycles, service and maintenance vehicles, and usage as a temporary sidewalk when an adjacent building is under construction (*AASHTO, 2014*). Though some of these competing users may be accommodated in other locations, such as on the opposite side of the street, on side streets, or off the street, enforcement is an important consideration due to unauthorized use of the space by competing users, particularly when the lanes convert to parking during off-peak hours (*TRB, 2015*).

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 seam of the concrete 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 *(NACTO, 2016)*.

Curb Extension

A curb extension (or "bus bulb") is a modification of the curb and sidewalk to extend the bus loading/waiting area out to the edge of the parking lane, creating an in-lane stop. Bus bulbs can be as short as 15 feet (4.6m), conserving curbside space for parking relative to a curbside stop with a bus zone and also allow buses to make in-lane stops, thereby reducing dwell time and transit delay waiting for a gap in traffic (re-entry delay) when leaving the stop. Bus bulbs increase bus speed and reliability, decreasing the amount of time lost when merging in and out of traffic, and also reduce pedestrian crossing distance, exposure to traffic conflicts, and time required to service pedestrian movements at signalized intersections (TRB, 2015). These stops can provide a larger 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 (SEPTA, 2012). They are best suited for areas with high-density development and where transit passenger volumes require a larger dedicated waiting area than is available on the sidewalk. On-street parking is a prerequisite, as curb extensions are constructed within the area used by the parking lane (TRB, 2015; NACTO, 2016). Boarding bulb stops are applicable in both dedicated and mixed-traffic conditions, particularly where merging into traffic from pull-out stops creates operational delays, and can be installed at near-side, far-side, and mid-block stops, at both signalized and unsignalized locations (NACTO, 2016).

Further conditions supportive of installing curb extensions include (Danaher 2010, Fitzpatrick et al. 2001):

- Low to moderate traffic volumes (<400-500 vehicles per hour per lane in the same directions).
- 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 using the stop (e.g., is sidewalk flow or access to adjacent businesses impacted by passengers waiting on the sidewalk?).
- Relatively low right-turning volumes, particularly larger vehicles such as trucks and buses.

Boarding Bulb (source: NACTO, 2016)

1. At stops adjacent to crosswalks, provide at least 10 feet of clear sidewalk space, ahead of transit vehicle at near-side stops and behind the transit vehicle at far-side stops.
2. If shelters are placed on boarding bulbs, they must be placed clear of front-and back-door boarding areas.
3. At Include green features like bioswales or planters to improve streetscape and stormwater recapture (optional)

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, 2015 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. 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 modified for Capital Metro's fleet, as appropriate.

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 each accessible door must be five by eight feet, along with four-foot clear paths to reach each accessible door (ADA Std. 403.5.1) (see page 67).
- Boarding area amenities may include shelters, seating, trash bins, plantings, utility boxes, wayfinding and route information, which must be placed clear of accessible paths.
- Cross-slopes no greater than two percent should be provided along the accessible paths and landing area.
- Coordinate to ensure placement of accessible boarding areas is compatible across all vehicles in the transit fleet serving the stop. Boarding area should be at least long enough to serve all doors of at least one design vehicle.
- At bus stops, extend the bulb to within two feet of the edge of the travel lane; bulbs typically extend six–eight feet from the existing curbline, and require minimal lateral movement for bus access.
- Extend the boarding bulb at far-side stops to provide room for cars to queue behind a dwelling bus. Signs and markings should communicate to drivers not to "block the box."

Source: *NACTO, 2016*

In-Street Boarding Island

Located on a raised concrete island between center-running transit lanes and general traffic lanes to the right, the in-street boarding island provides streetcars and buses priority within the street while allocating space for through-moving vehicles. In-street boarding island stops enable the use of center-running transit on relatively small streets where full-scale stations are not feasible or necessary, reduce transit vehicle dwell times, and provide dedicated space for transit passengers and amenities while maintaining a clear pedestrian path on the sidewalk. These stops also allow for bus stops to remain at intersections, where desired, and are appropriate for a wide variety of 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*).

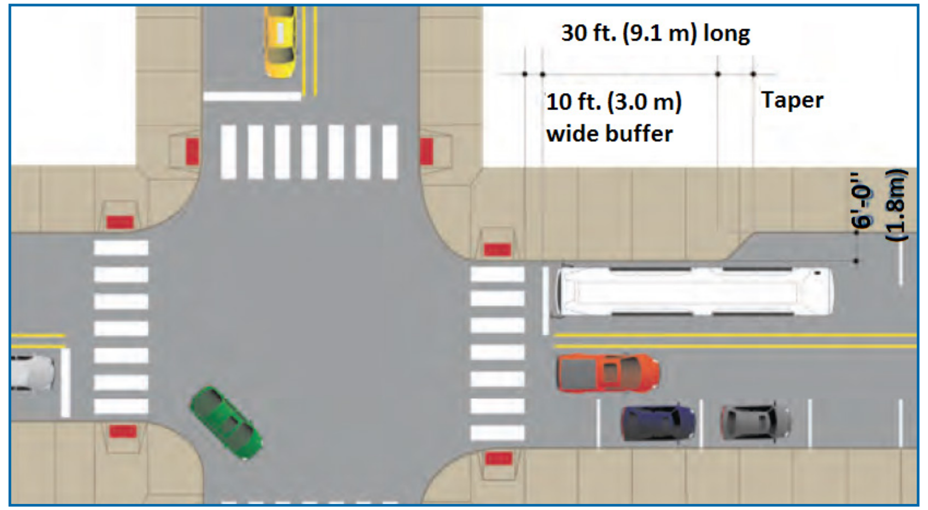
Curb Extension Dimensions for Various Vehicle/Door Configurations

Vehicle	Vehicle length	Doors served	Bulb length (feet)*	Bulb Length (meters)*	On-street parking displaced**
All vehicle types: front doors only (min. length)	varies	1	15	4.6	1 space
Standard bus/trackless	41.5 ft.	2	30	9.1	2 spaces
Articulated bus/trackless	60.75 ft.	2-3	50	15.3	3 spaces
Kawasaki LRV Series 100, Single-end	50 ft.	2	32	9.7	2 spaces
Kawasaki LRV Series 100, Double-end	53 ft.	2	50	15.3	3 spaces
Conceptual LRV (5 door)	105 ft.	Front 2 only	45	13.7	3 spaces

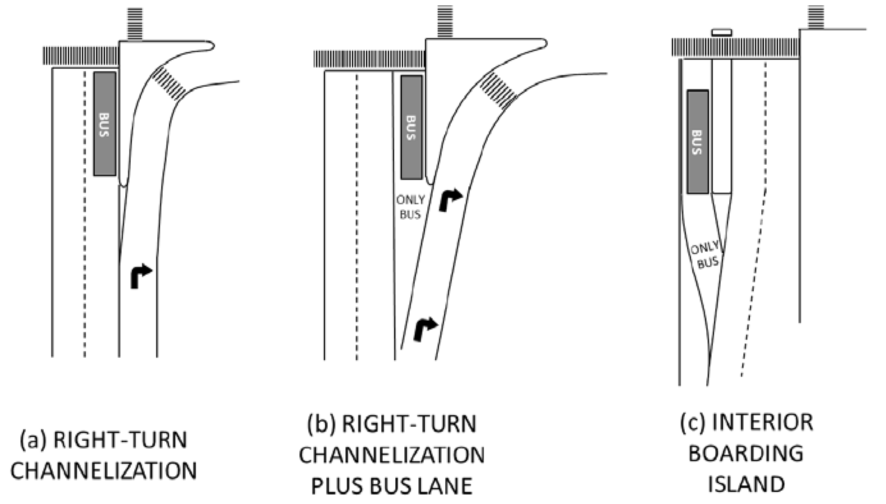
*Plus 10-foot safety buffer from the crosswalk

**Assuming 20 feet length per parking stall, rounded up to the next stall

Source: DVRPC, 2012



Near-side Curb Extension Example (Source: DVRPC, 2012)



Illustrative Boarding Island Configurations (source: TRB, 2015)

Boarding islands support bus-only signal phase, queue jumps, and most forms of bus lanes (TRB, 2015). It is important to provide a safe and accessible route connecting to a pedestrian crosswalk leading away from the island, in the form of controlled intersections (with stop signs or signals), sufficient crossing width to and from the island and short pedestrian wait times, accounting for potentially high pedestrian volumes. Strategies for accommodating bicycle traffic when designing boarding islands are discussed in TRB, 2015 and NACTO, 2012. Turn management strategies should be considered for near-side stops, particularly at intersections without the conflicts presented by left-turn movements. The following diagrams illustrate three potential applications for boarding islands located at intersections.

Design considerations for in-street boarding islands include:

- Stops for rail vehicles may require a nine-foot moving lane next to the island, or other track or lane realignment to bring vehicles close to the platform.
- 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. 810.2.2) (see page 67), generally requiring islands to be at minimum eight feet wide. Islands with railings along the rear side will require an extra foot of space, making the total width nine feet.
- Center island platforms must be either level or near-level boarding and provide the minimum required ADA clear area for each bus loading area.
- 24-inch wide detectable warning strips should be placed along the entire boarding edge of the platform to indicate vehicle position. Detectable warning strips must be placed on both sides of every flush pedestrian crossing.
- Consider potential sight distance issues created by a bus shelter or stopped buses when placing stops on right-turn channelization islands.

Source: *NACTO, 2016; TRB, 2015*

In-Street Boarding Island (source: NACTO, 2016)

1 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. 405.2, 810.2.2).

2 Reflective signage or other visible raised element on the leading corner (back left corner) of the island. KEEP LEFT or KEEP RIGHT (MUTCD R4-8) or object marker (OM-3) signs may be used.

3 At intersections, install refuge island tips at least six feet wide to provide pedestrians protection in the crosswalk.

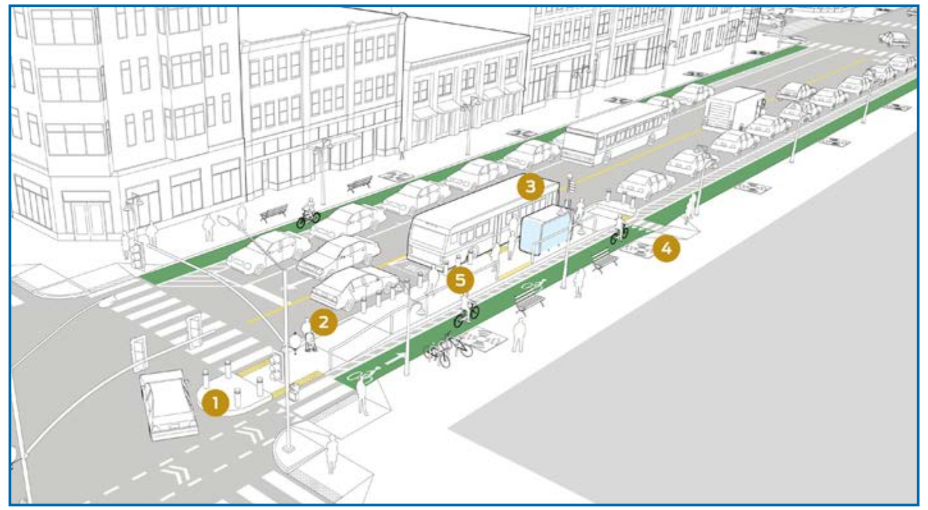
4 Boarding island extensions can be used for green infrastructure, including rain gardens and other stormwater retention facilities.

Side Boarding Island

Side boarding islands are dedicated boarding areas that are separated from the sidewalk by a bicycle channel, mitigating conflicts between transit vehicles and bicycles at stops. Similar to bus bulbs, side boarding islands streamline transit service, improve accessibility by enabling in-lane stops with near or level boarding, and reduce transit vehicle dwell times, particularly on busy streets, where in-lane stops may reduce stop delay between five and 20 seconds per location. Boarding islands eliminate bus-bicycle "leapfrogging" conflict at stops, as both buses and bicycles can move straight at the stop, in their own dedicated space. These stops provide more space for transit passengers and amenities and operators are able to deploy ramps or bridge plates, as needed, onto the island without disrupting pedestrian flow (*NACTO, 2016*).

The most applicable locations for side boarding islands are streets "with moderate to high transit frequency, transit ridership, pedestrian or bicycling volume, which can use boarding islands to maintain in-lane stops and provide more separation for users" (*NACTO, 2016*). Design considerations for side boarding islands include:

- 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.* 810.2.2) (see page 67). For low-floor vehicles using bridge plates, near-level boarding can usually be achieved with a 9.5- to 12-inch platform. Higher (14-inch) platforms typically require that all doors be configured for level boarding, and may be incompatible with some buses.
- Where the bicycle lane or cycle track 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 thorough phase.
- Platform may require nine-foot moving lane or other track or lane realignment in cases with right-lane mixed-traffic operations.
- 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.* 405.2).



Side-boarding Island (source: NACTO, 2016)

1 Use reflective signage or other visible raised element on the leading (back left) corner of the island. KEEP LEFT or KEEP RIGHT (MUTCD R4-8) or object marker (OM-3) signs may be used.

2 An accessible ramp should be placed at the intersection end of the island entering the crosswalk. If there is no crosswalk at the intersection, install one, with a refuge island tip to protect pedestrians (at least six feet wide).

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

4 Shelters should be located at least 10 feet from crosswalks over the bicycle lane to allow visibility between people on bicycles and people exiting the island. Leaning rails may be located along this gap.

5 Install leaning rails along the edge of the island along the bicycle channel on portions of the island without a shelter or accessible boarding area. If leaning rails or fence are installed along the accessible boarding area, the total island width usually must be increased to nine feet. Boarding islands can be extended to include bicycle parking, additional seating, parklets, or other community facilities.

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 transit 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 stop 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 Mode (source: Capital Metro)

Level of Service Rating	# of Parking Stalls	Modes	Customer Shelter Type	Type of Landscaping	Extensive Lighting	Enclosed climate-controlled facility	Security Personnel or Facility Attendants	Water Fountains	Vending Equipment	Information kiosks	Single use restroom for attendant and operators	Additional Seating areas with shelters/canopies	On-call security officer	Emergency call box	System and Route Information	Newspaper racks and other publications racks
LOS A	400 +	Bus, Light rail, commuter rail, etc.	May include an enclosed climate-controlled facility. Enhanced shelter with lighting, heating/ventilation and windscreen protections, and integrated seating for 12 or more customers	Enhanced landscaping and site amenities	Present throughout facility	X	X	X	X	X	X	X	X	X	X	X
LOS B	200-400	Bus (varying route types)	Enhanced shelter with lighting, heating/ventilation and windscreen protections, and integrated seating for 12 or more customers	Limited landscaping and site enhancements	Present in parking and bus loading areas				X				X	X	X	X
LOS C	< 200	Bus (typically express only)	1-2 canopies with integrated benches	Minimal landscaping and site enhancements	Not present										X	X

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
- Improving organizational identity
- Deterring vandalism
- Increasing safety and security

MLK, Jr. Station Shelter Public Art (source: Capital Metro)

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, texting functions, or the online trip planner.

As a high-traffic area, Guadalupe and Lavaca Streets downtown have lollipop signs with a unique alphabet in a red circle atop the bus stop sign for wayfinding purposes. They also include Corridor Map and Next Bus panels. Temporary wayfinding signs point new riders and tourists to Capital Metro services and popular Austin landmarks during events and festivals. See Wayfinding section of this document for more information on wayfinding. Capital Metro has detailed branding and signage design standards (Capital Metro Brand Standards, 2017).

All basic information contained on the sign is designed to be ADA compliant and most stops have Braille and raised lettering corresponding to the bus stop ID# and the routes that serve the stop. The preferred sign location is set back from the curb edge two feet (0.6m) and with two feet (0.6m) clearance from the bus pad (SEPTA, 2012).

Lighting

The bus stop area should contain lighting that enhances safety by improving driver and passenger visibility, in addition to providing a sense of security and defining the waiting area. Areas around stops should be kept adequately lit at night and during certain times of the day. Pedestrian scale lighting, typically includes lamps less than 25 feet high, is important for creating a safe and comfortable environment for the commuter and is more likely to integrate into the surroundings than standard street lights. Pedestrian scale lighting is characterized by lights that are:

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) intervals for maximum pedestrian benefit to cost ratio and may be integrated with the bus shelter, with other pieces of furniture at the stop, or be stand-alone. Choosing lighting styles that complement the architectural style of adjacent developments can enhance the visual coherence and attractiveness of the setting (Zhang, 2012).

As defined by SEPTA, "lighting may take several forms in any combination to provide an average level of 1.3 to 2.6 f.c. (horizontal foot candles) or 13 to 26 lux, which is roughly the typical light level around a building entrance...Wherever possible, energy saving devices, such as efficient lamps, solar power, and daylight sensing equipment, should be used." (*SEPTA, 2012*). Bus stop signage should be illuminated and bus stop fixtures or nearby street lights can provide additional lighting.

Bus Stop Signage: Lollipop Sign, Corridor Map, Next Bus Panel (source: Capital Metro)

Street Furniture

Street furniture enhance 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. Being able to sit while waiting for the bus significantly reduces commuter stress and disutility of waiting at a stop, leading to an increased catchment area and ridership (*Zhang, 2012*).

Transit Shelters

Shelters protect passengers from weather conditions while waiting and should be constructed of durable, architecturally sound materials to withstand heavy use and continual exposure to the elements. They should be oriented to protect against exposure and modular to adapt to a variety of location and site conditions (*SEPTA, 2012*). 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, or locate shelters in a well-lit area. Ensure the shelter can be seen from outside by using glass or open design for the back wall. Capital Metro's branding standards should be followed where possible for shelter design, though flexible and context-sensitive design may be allowed in certain circumstances (ex. Mi Jardin Plaza and 38th St/Medical Station).

Seating

Stops 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). If viable, seating should "be seamlessly integrated with the surrounding urban landscape; serve non-commuters during non-rush hours; and be sufficiently shielded from vehicular traffic (*Zhang, 2012*).

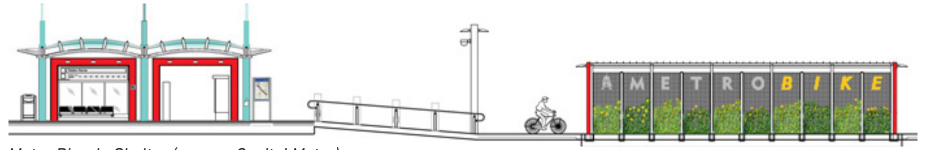
Guidance from SEPTA states that benches should be constructed of durable material, resistant to vandalism and wear from exposure to weather, and ADA-compliant in dimension. The recommended minimum length for a Bench is 6.5 ft. (2.0m), or the equivalent of three seats, whereas leaning rails should be 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 seniors and the disabled, and antisleeping bars should be considered to prevent unintended use (*SEPTA, 2012*).

Bicycle Racks & Parking Shelters

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 securely. 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.

VIA Bus Shelter, San Antonio, TX (source: Glasstire.com)

Seating Incorporated into Landscape, Yards Park, DC (source: Landscape Forms)



Metro Bicycle Shelter (source: Capital Metro)

Capital Metro and City of Austin have received a grade of Gold from the League of American Bicyclists, indicating a high level of cyclist accommodation in the area. Capital Metro's system has over 6,000 bicycle spaces, including bicycle racks that are placed at all permanent MetroRapid stations, rail stations, and P&R facilities. The presence of bicycle parking at transit stops enhances multi-modal connectivity and ridership catchment, with bicyclists often willing to travel further than pedestrians to transit (1-5 miles vs. ¼ - ½ mile). Capital Metro has partnered with Austin B-Cycle, a bicycle sharing service in Austin, to place on-demand bicycle stations throughout downtown in close proximity to key transit hubs in the urban core.

Wayfinding

Wayfinding is the science of navigation in public spaces. Transit stops serve as a gateway to the neighborhood and should be recognizable landmarks that enhance rider experience, which includes decision-making and transit access. Easy-to-follow wayfinding signage makes it easier to locate bus stops and connecting routes, particularly where stops for opposing travel directions are not located immediately nearby one another (*NACTO, 2016*). Maps, schedule and route details, real time arrival information, directional signage to key destinations, and relevant station names are all components of high-quality station facilities that enhance wayfinding and increase ridership. The Metropolitan Transportation Commission (MTC) has developed comprehensive wayfinding guidelines and standards, which illustrate wayfinding best practices (*MTC, 2012*).

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

- Locate wayfinding in predictable locations, such as overhead or eye-level, place at regular intervals, and disclose necessary information at decision points.
- Include relevant transportation connections and services, such as regional routes and bike share stations, to expand rider options.
- To direct riders to and from stations to destinations in the station area, indicate travel direction and times in easily understood units, such as walking time.
- Provide area maps at all stations.
- Wayfinding should include clear, simple guidance to nearest street intersections, landmarks, and points of interest.

Wayfinding signage can also be provided to direct vehicles to permitted turns or recommended diversion paths and should be "consistent with regional or agency brand; using consistent logos, colors, and fonts to reinforce visibility. For stops in less densely population areas, wayfinding signs directing the commuter towards the stop should be labeled and include the remaining distance to the stop, as this is helpful to seniors who "may plan their stop choice based on the walking time required (*Hess, 2012*).

The Regional Transportation District (RTD) specifies several wayfinding standards in application to Denver's Civic Center Station (*RTD, 2016*):

- Directional signage; common-sense mapping; welcomes visitors in a comprehensive system; and integration of wayfinding with consistent urban design themes in kiosks, landmarks, and public art in a way that universally orients users and provides good user movement to, from, and through the area.
- Destination branding elements: Enhance people's 'Experience' of the transit station through the elements of 'Identity'- iconic images, color palette- and its integrated application to signs, crosswalks, and art create beacons of wayfinding.
- Integrate station with activity nodes, which should inform wayfinding. Wayfinding signs should use color to identify and define geography; and have strong forms with small footprints which create activation zones but do not impede pedestrian flow on sidewalks. Signs should be highly visible "beacons" and create a "wayfinding trail."

Conceptual "Artist Canvas" Signs

RTD Wayfinding Signage & Public Art (source: RTD)

Unified wayfinding standards and guidance should be developed to address a transit agency's facilities, operations, remote signage to direct transit users to the facilities, and the needs and sizes of the various modes the agency has or would like to have. Transit operations should collaborate with Business Improvement Districts (BIDs), civic groups, and local stakeholders to align wayfinding and branding. In addition to following Capital Metro's brand standards, the agency's wayfinding system should compliment wayfinding plans and policies of service area communities, such as the Downtown Austin Wayfinding Project, which integrates signage, brochures, kiosks, and smart-phone applications for navigating the downtown area. Capital Metro has developed wayfinding maps for 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.

Primary Directory: Elevations & Plan Views *Secondary Directory: Elevations & Plan Views*

RTD Public Realm Plan (source: RTD)

MetroRapid Wayfinding Map, Austin History Center Station (source: Capital Metro)

Information Technology

Information plays an important role in the performance of a bus stop and schedule information will ideally be presented both in real time and in static form (Wardman et al., 2001). 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 (*Zhang, 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 (*Ercoskun & Karaaslan, 2011*).

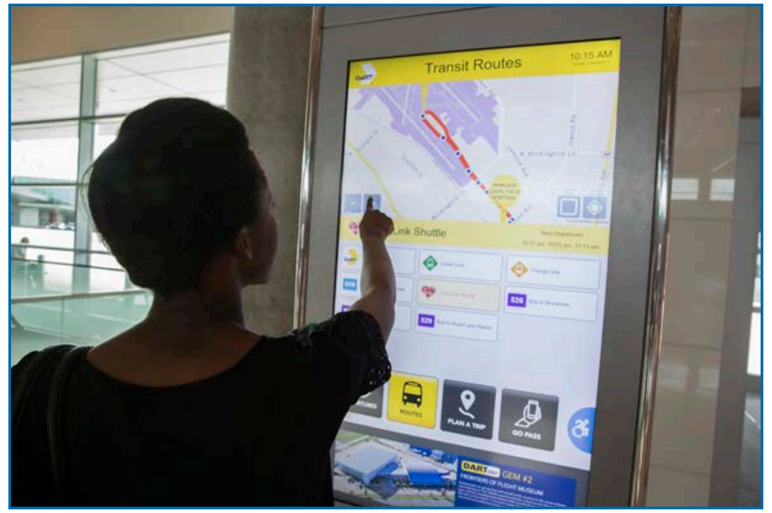
As updating static information like flags, system maps, and placards require enormous time and financial resources for a transit agency, digital information technology allows for wayfinding information to be presented to transit users in a quick, up-to-date, and easy to understand format that is also 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 understand manner. As stated by DART,

These kiosks integrate with tracking and location systems, scheduling systems, and other DART information systems to provide comprehensive information to customers. Touchscreen technology allows for intuitive 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 local mapping for each stop. Trip-planning tools include detailed travel 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 smart phones at the decision-making point (i.e. the stop).

Mobile apps can also be useful for providing accurate, timely service information. Capital Metro was among the first agencies in the country to launch a mobile app that not only provides maps and timetables, but also gives departure information in real-time and allows users to purchase a digital ticket or plan their transit trip. The app allows users to select favorite destinations, designate specific routes and trips for frequent use, and customize a trip by mode (i.e. MetroRail, MetroRapid, Local, etc).

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. **projectaction.org** provides more detailed information on these and other disability-specific wayfinding strategies.



ConnectPoint® Interactive Kiosk, Dallas Love Field Airport (source: DART)

Wayfinding Map and Digital Travel Time Display, Republic Square Station (source: Capital Metro)

Wayfinding Elements (source: Metrolinx)

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 run-time (*NACTO, 2016*). Same-level bus boarding plus pre-boarding fare payment results in reduced dwell time at a stop. Common fare payment methods including cash payment, ticket vending, Radio Frequency ID (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 per-passenger dwell time. Total dwell time may be 20-25 percent of vehicle revenue time" (*NACTO, 2016*).

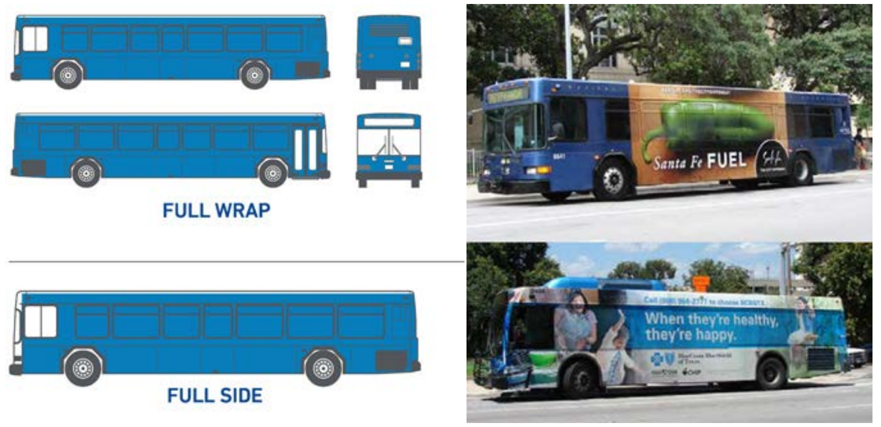
Advertising

Capital Metro Transit Advertising, 2018 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.
- Constant Exposure: Ads will be seen 12+ hours a day and allow an agency to reach 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.

METROBUS ADVERTISING TYPES

PACKAGE	SHOWING	BUS SIZE	AD SIZE	UNITS	STANDARD RATE	PEAK RATE (SXSW, ACL FEST, F1)	INSTALLATION FEE
FULL WRAP	—	40'	Sides: 490"x100" Front/Rear: 100"x85"	1	$3,850	$4,812	$2,100
	—	35'	Sides: 444"x100" Front/Rear: 100"x85"	1	$3,630	$4,535	$2,100
FULL SIDE	—	40'	490"x100"	1	$2,200	$2,750	$690
	—	35'	444"x100"	1	$2,090	$2,612	$690



Capital Metro Advertising, MetroBus Example (source: Capital Metro)

Ticket vending machines may be on/off-board, acting as a proof-of-payment (and frequently as a transfer ticket). Providing off-board ticketing machines may be expensive and should be used on high-frequency or high-volume corridors where reduced dwell time is priority. Off-board fare collection can "significantly reduce passenger boarding times, with dwell per passenger falling from about four seconds to two-2.5 seconds" (*NACTO, 2016*). Vending machines must not block accessible path and boarding areas, or bus door zones.

Another option available in some cities, fares may also be paid using cashless RFID cards, which must be tapped at a reader to be validated. RFID readers are placed either on-board the transit vehicle- at multiple doors, or at the front door- or off-board at the stop, which speeds boarding times. Mobile technology for fare and pass purchases can significantly reduce the need for on-board fare payment or ticket vending, as electronic tickets can be purchased via smart phone and presented to the driver or fare control officers upon request. Smart payment systems can be integrated across transit types and agencies, or with bicycle share. Integrated fare payment "simplifies fare payment between transit systems, especially for passengers who must frequently transfer between systems" (*NACTO, 2016*). Further streamlining strategies for bus boarding and fares can be found in *NACTO, 2017*.

Passenger Queue Management

Managed boarding procedures can make the boarding process more efficient, reducing the major delay on high-volume transit routes that occurs where large numbers of passengers board and alight in a constrained space, especially curbside bus and BRT stops. Queue management may be applicable for multi-door boarding platforms serving large transit vehicles, or where transit passengers are observed blocking the sidewalk, especially at high-volume stops (≥100 boardings per hour at peak). Well-marked queuing space "organizes waiting passengers at busy transit stops and preserves a pedestrian through-zone, evenly distributing waiting passengers along the entire platform and speeding the boarding process"(*NACTO, 2016*).

Some considerations for passenger queue management include the following:

- Ensure markings and signs communicate the requirement for alighting passengers to be able to exit before boarding passengers enter.
- Stops serving multiple routes must provide a separate boarding and queuing area for each route.
- Mark queue lines for each door of the transit vehicle, with pathways directed clear of the pedestrian through-zone.
- Use wayfinding principles of progressive information; alert passengers of the route number and which door to board through markings and signs.

Source: *NACTO, 2016*

Mobile Ticket Scanner (source: Capital Metro)

Turnstiles, Montréal (source: Société de transport de Montréal)

BRIO Ticket Vending Machine, El Paso (source: Sun Metro)

Transit Street Design

Roadways that are transit-supportive are designed for multiple modes of transportation, such as transit, cycling, walking, and driving. Good street design for transit requires transit agencies and their partners to strike a balance between serving higher intensity, mixed-use places where walking is practical and pleasant with providing service that offers reasonable transit travel time and reliable operations (NACTO, 2016). The following sections will examine several important elements and goals of transit street design, including types of transit streets, elements, flexible design, and platform design criteria.

Design Elements

Streets that are well-integrated with transit are active streets, providing safe, low-stress, and complete pedestrian and bicycling infrastructure, including comfortable sidewalks and bicycleways, and orderly motor vehicle traffic moving at safe speeds. They are living streets, bringing more people to a street in less space than other modes of transportation, creating nodes of activity around stations and along routes. These "transit streets" are designed to prioritize transit at every scale and support future growth, directly improving transit travel time, reliability and capacity, in addition to generating higher ridership, better service, local economic growth, and more compact, sustainable development (*NACTO, 2015*).

Transit streets that are designed as linear public spaces with bicycle and pedestrian facilities, mixed land uses, and transit stop amenities can enhance ridership, in additional to its ability to support healthy urbanism. In TRB, 2015, ridership was found to be most strongly correlated with transit level of service, frequency, alternatives, and route density. Increasing ridership and active use of the street also means providing intuitive travel paths with frequent crossings and shifting vehicular priority from cars to transit, which can also unlock space for parklets, plazas, sidewalk cafes, and bicycle lanes (*NACTO, 2016*).

Further strategies for designing high-quality transit streets include providing dedicated lanes and all-door boarding to increase transit speeds and total person capacity of the street; adding fine-grained improvements like bus bulbs and signal timing; re-purposing street space for transit; and designing efficient and comfortable stops, dedicated space, and coordinated signals. Investments in transit-supportive infrastructure attract new riders, reveal latent demand for better transit service, and demonstrate the value of dedicating space to transit through near-term projects to support long-term plans. Research from around the world shows that rededicating lanes for transit use has a strong safety impact, reducing crashes by 12-15 percent for exclusive transit lanes and more than 60 percent for other transit priority designs (*WRI Ross Center, 2015*).

Design Flexibility

It is important for the designer to be flexible in selecting design criteria for transit streets that are based on a context-sensitive understanding of the needs of the local community and desired function of the roadway. Flexible design allows for the consideration of multiple types of users and their unique mobility concerns, improving first-last mile connectivity to transit stops and stations and reducing conflicts between different transportation modes. This section discusses strategies for improving multi-modal access to transit facilities and mitigating potential conflicts between different users. Further information may be found in *FHWA, 2016*.

Elements of Successful Transit Streets (source: NACTO, 2016)

Multi-modal Access to Transit Facilities

Connected and consistent pedestrians and bicycle networks can reduce conflicts among modes, enable a comfortable trip from beginning to end to maximize use, and encourage higher levels of walking and bicycling for users of all ages and abilities. Disconnected street networks, highway or railroad barriers, high-crash or uncomfortable intersections, and difficult mid-block crossings must be addressed to allow pedestrians and bicyclists to access transit stations and stops, mixed-use developments, commercial districts, residential areas, employment centers, and other destinations, particularly those located in close proximity that make short trips likely (*FHWA, 2016*).

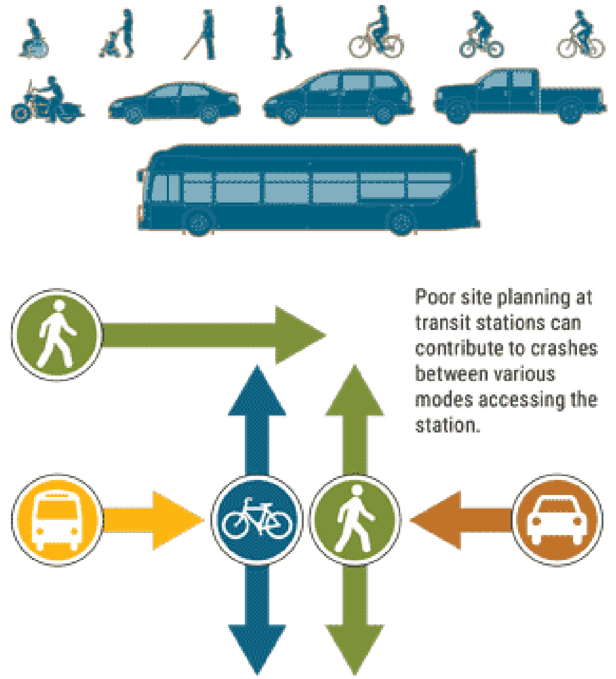
To reduce conflicts, pedestrian and bicycle network facilities should be safe, accommodating, comfortable, coherent, predictable, context sensitive, and allow for innovation. Pedestrian and bicycle facilities should be appropriate to the surrounding environment; allow travel on predictable, defined facilities that are delineated and continuous throughout the user's trip; and allow for innovative solutions to create connected networks, particularly at crossing locations where conflicts are more likely and on higher-speed streets (*FHWA, 2016*).

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/bicycle 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" (*FHWA, 2016*). To address potential conflict areas through station design retrofits, bicycle and pedestrian trip generators and catchment zones in the station's service area should be identified. Desire lines and travel routes from 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 principles should be applied: "pedestrians and bicyclists seek the most direct route possible; bicycle parking options should be secure and convenient; and infrastructure improvements should address on-site, off-site, and approaching roadways through agency and inter-jurisdictional coordination. Conflicts between vulnerable road users, private vehicles, and transit buses should be reduced through the separation of modes at and around transit station." (*FHWA, 2016*). Access to and from the transit station should be provided along a clear path of travel for each mode, serve all users, and provide a sense of comfort. The station and its surroundings should support community health, economic, and livability goals (*FHWA, 2016*). As bicycling serves as an important first- and last-mile connection to transit stations, stations should provide sufficient parking to accommodate both short- and long-term needs by:

- Providing a variety of parking options, such as high-quality access-controlled parking areas, on-demand lockers, and enclosed bicycle racks.
- Locating bicycle parking along or easily visible from the bicycle access routes leading to the station entrance.
- Distributing bicycle parking equipment on the station site to conveniently serve all bicycle access routes.
- Locating rack parking as close as possible to the station entrance, without creating conflicts with pedestrians in heavy pedestrian flow areas.
- Lockers and high-quality access-controlled bicycle parking may be located further from the entrance, but should be adjacent to primary bicyclist access routes.

Source: *FHWA, 2016*



Transit Station Access Conflicts (source: FHWA, 2016)

Well-designed retrofits that prioritize direct and convenient pedestrian and bicycle circulation through avoidance of barriers and circuitous routes to the station entrance can often address conflicts at and around transit stations. Separating transportation modes as they approach the station 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). Station design should comply with Federal accessibility standards as adopted by U.S. DOJ and U.S. DOT to support users of all abilities.

Design strategies to improve access to transit stations include:

- Provide street crossing improvements on all legs of intersections near the station.
- Provide context-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-street and not within the station site itself.
- Reduce pedestrian crossing distances by installing pedestrian crossing islands or curb extensions.
- Tighten curb radii to reduce vehicle turning speeds or provide slip lanes and crossing islands to accommodate bus turning movements.
- Provide bicycle and pedestrian accommodations and wayfinding across station surface parking lots. Ensure walkways from accessible parking and loading to accessible station entrances are as direct as possible.
- Provide designated crossings at bus loading, pick-up and drop-off areas, and motor vehicle access roads.
- 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 other measures that will slow vehicle speeds.
- Install new sidewalks along well-worn tracks on grass (goat paths) that enter or cross portions of the station site.
- Provide direct bicycle connections to the station via separated bicycle lanes or shared use paths along desire lines that are not served 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 stairs on which bicycles can be rolled-on stairways to minimize conflicts with users of pedestrian ramps. Handrail designs must meet current accessibility standards.
- Separate bicyclists from bus-only access roads and driveways on the station site, where possible, by providing adjacent parallel bicycle routes.
- Minimize dismount zones-locations where bicycle riding is prohibited or discouraged. Their use should be limited to station lobbies, concourses, and areas with consistently high pedestrian volumes

Source: *FHWA, 2016*

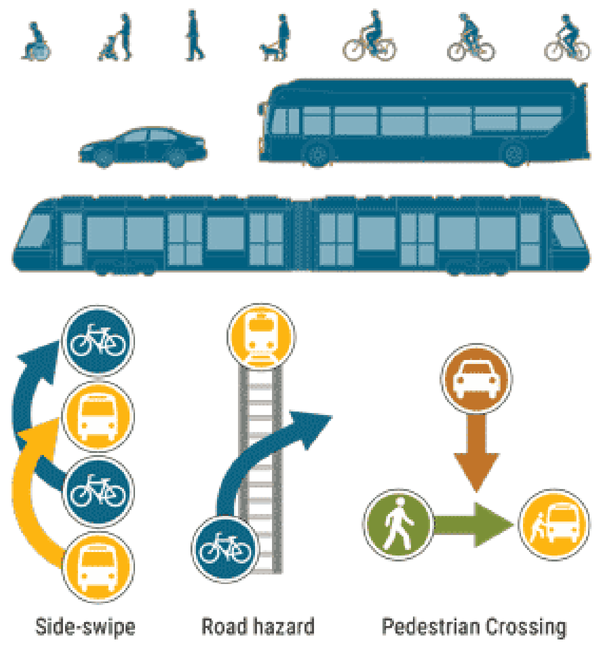
Transit Conflicts

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 rail tracks, or a pedestrian or bicyclists 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 that clearly delineates the travel path for each mode, maximizes predictability between users, and provides connected and convenience access to and from transit facilities can help mitigate transit conflicts.

Conflicts between buses and bicyclists (i.e. bus-bicycle 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 operations of the floating bus stop for pedestrians and bicyclists.
- Provide adequate tapers for bicyclists to transition from bicycle lane to behind the bus stop.
- Provide bus 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 continuous separated bicycle facility behind the boarding area.
- Provide clearly marked crosswalks from the island to the adjacent sidewalk.
- Consider a raised crosswalk across the bicycle facility.
- Consider yield or stop lines and YIELD [or STOP] HERE FOR PEDESTRIANS (R1-5) signs to alert bicyclists of the passenger crosswalks (MUTCD 2009, Sec. 2B.11).

Source: *FHWA, 2016*



Transit Conflicts (source: FHWA, 2016)

Floating Bus Stop, UT West Mall Station (source: Capital Metro)

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 tires. Tracks 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 between 60 and 90 degrees to reduce the risk of getting bicycle tires caught in the tracks.
- Consider a median to force deflection of bicyclist to cross the tracks at the appropriate angle and prevent illegal parking by motorists.
- Provide advance track warning signs to alert bicyclists of the tracks ahead.

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 complement the sidewalk and bicycle facilities to connect passengers with the surrounding pedestrian and bicycle networks. At intersections, bus stops can be provided on the near- or far-side of the intersection. Far-side bus stops are preferred when feasible as near-side bus stops can block visibility between turning vehicles and pedestrians. At mid-block bus stops locations, depending on the proximity of other crosswalks, a mid-block crossing may be necessary and may require enhanced crossing treatments" (*FHWA, 2016*).

Education of transit vehicle drivers and bicyclists is an integral part of reducing conflicts. Transit vehicle drivers should be aware and cautious around vulnerable users and be alert that the exiting passengers may cross in front of the bus. Drivers should receive training, ideally through driving simulators, on how to operate when bicyclists and pedestrians are present. In addition, "educating bicyclists to be cautious and courteous at transit stops can help reduce conflicts. Consider installing educational signs at strategic locations such as on buses and shelters" (*FHWA, 2016*).

Transit Street Types

Three basic transit street configurations, each with their own distinct design needs, are discussed below: Neighborhood Main Streets, Corridor Streets, and Destination Streets.

Neighborhood Transit Streets

Neighborhood transit streets are important multi-modal 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 (≤25mph). Successful neighborhood transit streets are lively, serving as the nexus of neighborhood life, and provide all-week demand and moderate ridership/bicycle traffic. They are characterized by a human-scale built environment, comfortable sidewalks, and reliable transit service providing moderately frequent 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 caused by bus and automotive vehicles waiting to turn, particularly at small intersections; potential conflicts between buses and bicycles at pull-out stops; and difficulties encountered by transit vehicles attempting to make lateral shifts at stops, where pulling back into traffic requires waiting for signal change and where stops are frequently blocked (*NACTO, 2016*).

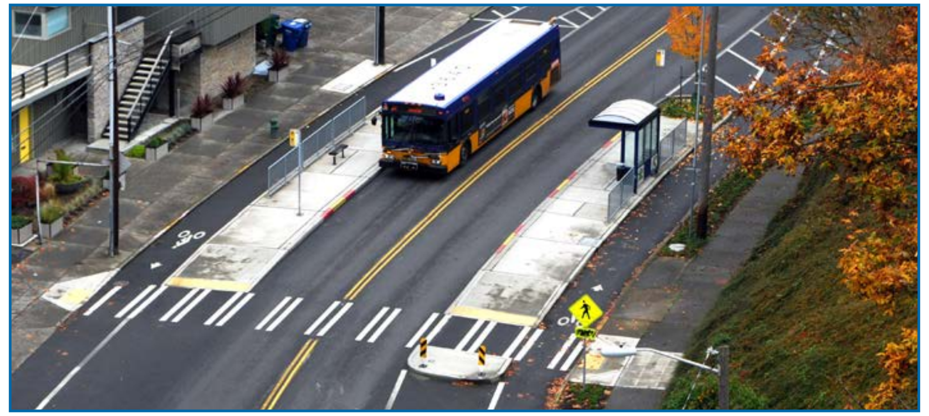
As neighborhood transit streets are desirable bicycle routes and have moderate or high amounts of walking and congregating on sidewalks and in public spaces, quality pedestrian and bicycle infrastructure and clustered local destinations enhances access and capacity for multi-modal users along the corridor. 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 delay.
- Upgrading bicycle facilities can draw more spending, while cutting vehicle parking needs.
- Neighborhood streets can benefit from increased street legibility by better organizing traffic flows, such as using with left turn lanes where space permits.
- Sidewalks should be widened where pedestrian volumes or density of destination merits.

Source: *NACTO, 2016*

Neighborhood Main Street (source: NACTO, 2016)



Dexter Avenue, Seattle (source: Oran Viriyincy)

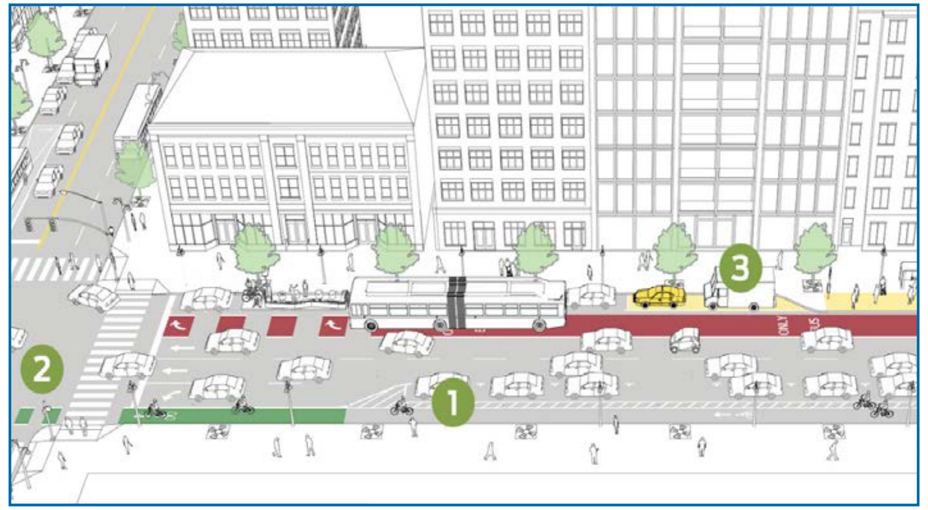
Corridor Streets

Transit corridor streets serve as the spine of a city's mobility network, providing major connections between neighborhoods, downtowns, emerging urban centers, and major destination and employment clusters. They have high frequency and existing or potential ridership, offering multiple transit service types, with limited, local, and express service often sharing the corridor. Transit corridor streets accommodate long trips by transit, cars, and bicycles, often in wider rights-of-way with faster travel speeds. Streets for these corridors are generally wide and relatively straight, providing potentially excellent routes for high-frequency transit service. Street width varies from 40-75 feet curb-to-curb and may be one-or two-way, with high traffic volumes of all modes (*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 bicycle facilities and dangerously high motor vehicle speeds. Buildings along corridors have been designed to face away from the street or with large setbacks and parking lots, though density in the transit-shed may be high (*NACTO, 2016*). Further 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 a hostile pedestrian environment. Wide 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 progression.
- On-street parking is often a low priority, though driveways may be frequent depending on land use context.

Source: *NACTO, 2016*



One-Way Transit Corridor Street (source: NACTO, 2016)

❶ To upgrade the street's role within the transit and bicycle networks, transit and bicycle lanes can be placed on opposite sides of the street, reducing bicyclist stress and bicycle-bus conflicts.

❷ Consider turning restrictions to mitigate conflicts by cars traversing transit lanes.

❸ Freight and taxi/livery vehicle standing may intrude on transit or bicycle lanes. Designate curbside loading zones, potentially with additional width or on the opposite side of the street, to accommodate frequent curbside activities without impacting transit operation.

As one-way corridor streets often have multiple travel lanes with significant daily throughput, connecting multiple urban or activity centers, these streets may be prime corridors to implement dedicated transit lanes that may serve as trunk line transit routes where multiple bus lines converge and connect. Enforcement of transit lanes can only be done at select times, using methods such as dynamic signs to inform road users of lane restrictions, and allowing private vehicles to enter transit lanes must be done strategically to minimize degradation of transit service. Transit service reliability and comfort can be enhanced through operational improvements, such as transit-friendly signal progressions, active TSP, all-door boarding, and extended or tiered stops. Skip-stop placement should be evaluated where multiple routes operate along the same corridor, particularly with heavy passenger loads, and stops should be co-located to reduce pedestrian walking distance to make transfers. Lastly, an easy-to-follow wayfinding system should be created to direct passengers to the location of stops in both directions along a route (*NACTO, 2016*).

Destination Streets

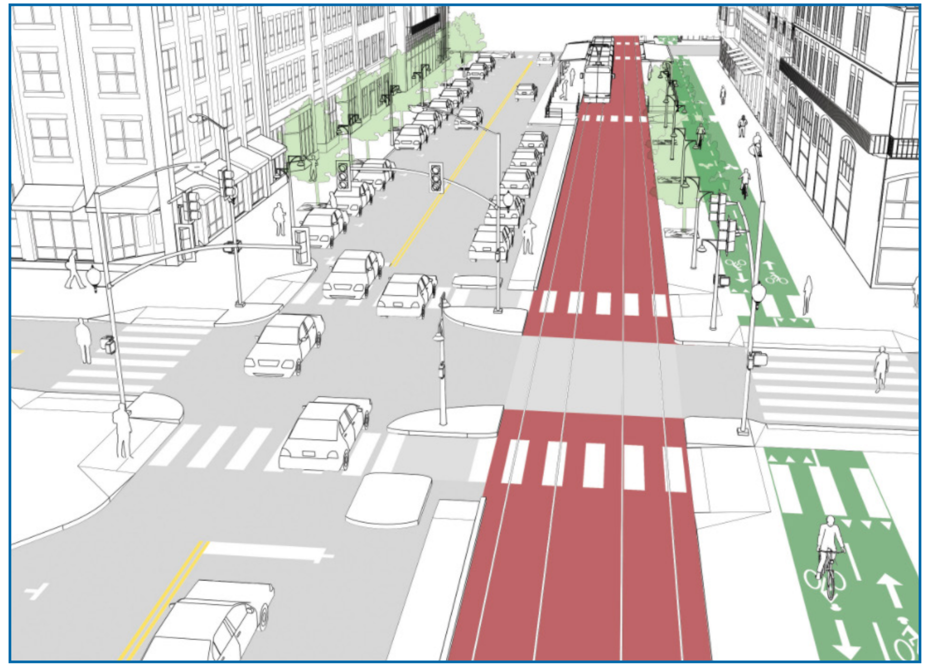
Destination streets are typical of downtowns, multi-modal station areas, or other urban activity centers, and are where the highest ridership routes come together with the core of the city. These streets act as terminals or major points of interest for transit, having high frequencies and pedestrian/transit volumes, as a result of the high density of nearby destinations. Stops occur frequently on Destination Streets and shorter stop spacing distances spread out waiting passengers along routes and decrease sidewalk congestion. Streets vary in width from 50-75 feet curb-to-curb and accommodate the full range of transit modes, vehicles and service types, and can be one-or-two-way. Destination streets often have low or moderate vehicle volumes apart from buses and other transit and may have vehicle parking on one or both sides, though some have none *(NACTO, 2016).*

It is often necessary to separate transit from general traffic to achieve safe and efficient transit performance, while supporting pedestrian activity on these vibrant streets. Geometric constraints and traffic volumes along these streets can present challenges for providing predictable on-time service for transit vehicles. Streets built to accommodate maximum peak demand and prioritize capacity for private autos without adequately considering transit often induce congestion and slow transit operations and travel speeds during peak periods, particularly for mixed traffic lanes with high-frequency transit and mixed-traffic volumes.

Design considerations for destination streets include the following:

- Observe sources of transit delay, and count vehicle, pedestrian and bicyclists volumes throughout the day to determine how the street cross-section can be most efficiently allocated.
- Evaluate the network around the destination street to determine transit priority routes, and integrate transit network planning into broad complete streets projects.
- For on existing multi-lane streets, consider four-to-three lane conversions, which can organize traffic flow and unlock space for multi-modal improvements.
- Observe loading and parking behaviors-if needed, creating dedicated space for deliveries and managing delivery times may ease congestion during the busiest hours.
- Consider transit signal progressions, stations with near-level platforms, longer spacing of stops, and all-door boarding to speed up the boarding process.

Source: *NACTO, 2016*



Transitway (source: NACTO, 2016)

Transit Lane Configuration

The following sections discuss key elements of transit lane design, including transit priority lanes, lane width, turn radii, markings and signage. See cited guidance for further details.

Transit Priority Lanes/HOV Lanes

Transit Priority Lanes (HOV Lanes) are a section of the street designated by signs and markings for the preferential or exclusive use of transit vehicles, sometimes permitting limited use by other vehicles. These dedicated lanes are not physically separated from other traffic and are implemented by re-purposing general traffic lanes or parking lanes on streets that generally accommodate private motor vehicles in at least one direction *(NACTO, 2016).*

Transit Priority Lanes can provide reliable and efficient transit service, reducing the delay that occurs when buses must share a lane with other traffic and "allow buses to avoid traffic delays waiting for a gap when exiting bus stops, to bypass queues of through vehicles stopped at a traffic signal and, with some types of lanes, to avoid the delay caused by turning vehicles" (TRB, 2015). In addition, providing dedicated lanes or a transitway along a central median provides a high-capacity, high-quality transit facility, increasing total street capacity transit speeds, while limiting conflicts with mixed traffic, bicyclists, and pedestrians.

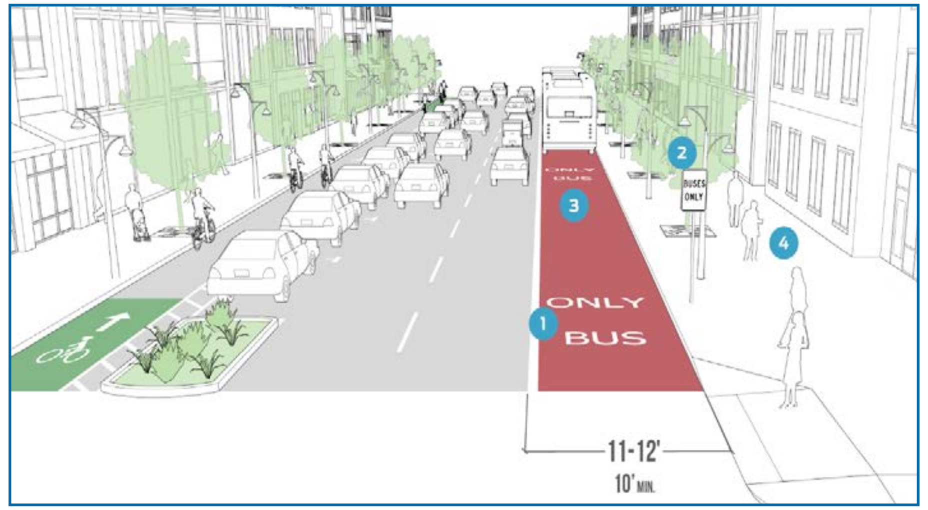
Transit Priority Lanes are flexible, operating either full time or only during peak times or daylight hours and may be dedicated to bus use only, allow designated vehicles (e.g., taxis, bicycles) to share the lane, or allow other vehicles to enter the lane to make right turns or to pick up and drop off passengers. Full-time lanes better serve transit 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 delay; in corridors with BRT or other premium 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 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 (see TRB, 2015 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 some 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 lanes 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 it a greater appearance of being used to build support for the bus lanes with other stakeholder groups that would benefit.
- Measures that increase the visibility of a bus lane, such as overhead signage and red colored pavement, can reduce the number of inadvertent bus lane violations and make the lane easier to enforce, maximizing the lane's travel time and reliability.

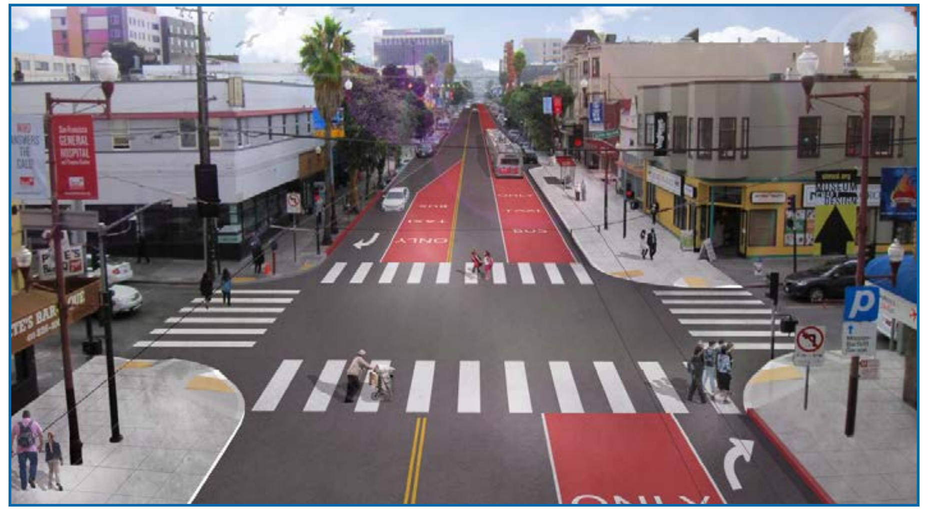
Source: *NACTO, 2016; TRB, 2015*

Multi-modal Complete Street, NYC (source: Street Design, 2013)



Curbside Transit Lane (source: NACTO, 2016)

1. Designate lanes using a single or double solid white line, as well as a stenciled "BUS ONLY" marking (refer to MUTCD 3D.01). In some jurisdictions, markings may be required for each permitted user (e.g. "TAXI, LRT, BUS ONLY").
2. Signage must designate the transit lane as restricted. Place signs either on the curbside or overhead (MUTCD 2B.20).
3. Mark the transit lane with red color. Red color treatments are effective in reinforcing lane designation.
4. Wider sidewalks, especially those buffered with plantings or furnishings, increase pedestrian safety and comfort adjacent to curbside transit lanes.



Rendering of Mission Street Redesign (source: SFMTA)

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 transit vehicles, provision of adequate buffer space to ensure the safety of vulnerable users during bus operations, design speed, turning radii, and limiting obstructions. "Transit design controls, like all street design controls, should always be driven by the targeted outcome and the unique issues and opportunities to increase the character and efficiency of the street" (*NACTO, 2016*).

Lane Width & Buffers

The width of vehicle lanes affect 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 number and severity of total crashes involving transit vehicles. Providing safe pedestrian linkages across travel 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 occasionally accommodate intrusion into adjacent lanes, which may occur where buses operate in a narrow mixed-traffic lane or when two buses pass each other (*NACTO, 2016*). As stated by NACTO,

Encouraging safe transit movement while accommodating efficient operations requires a predictable, even, and low-speed environment. Narrower transit lanes that are co-implemented with signal and intersection treatments, in-lane stops, appropriate stop spacing, and adjacent buffer zones, allow transit to progress comfortably at consistent speeds.

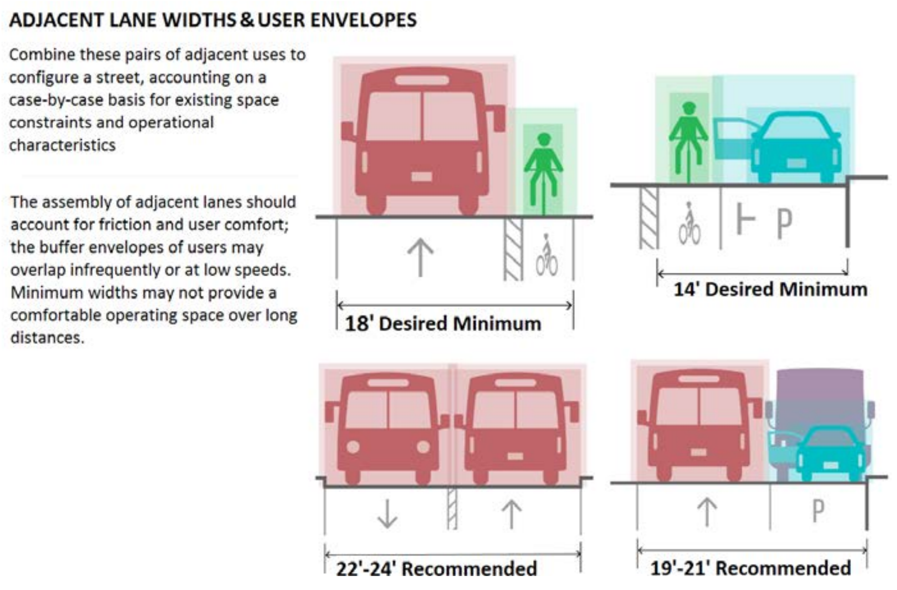
Vehicles have both clearly defined vehicle spaces (the size of the vehicle itself) as well as a buffer space (or operating space) which defines the space needed to operate comfortably at a moderate speed. Where space is available, buffers should be used rather than widening lanes to reduce side-swipe risks to bicyclists, motorists, and pedestrians, without increasing design speed. Overlapping buffer zones can be safely accommodated at slower speeds and added width may be assigned to buffer zones in mixed-traffic lanes to visually narrow them. Parking buffers or wider curbside lanes can provide additional maneuvering space and variance for buses to avoid wide trucks parking or loading in a parallel parking lane (*NACTO, 2016*).

Lane width considerations for specific facilities, such as contraflow lanes and offset transit lanes are discussed in more detail in NACTO, 2016. The following table provides recommended guidelines for general lane configurations:

Recommended Lane Width Design Standards

Lane Type	Design Standard
Bus Lane	Bus lanes may be 11 feet wide when offset, and 11 feet when configured curbside or in transitway adjacent to an opposing lane of bus traffic.
Bus-Bicycle Lane	Shared bus-bicycle lanes may be 11 feet wide along segments where neither is expected to overtake the other, such as where bus volumes are moderate or where bus speeds are low. Passing at stops may be accommodated with a 13-foot shared lane.
In-street Rail Vehicle	In-street rail vehicles, including streetcar/tram/trolley and multi-unit LRVs, can operate in travel lanes 10–11 feet wide, depending on vehicle model. Mirror clearance may be a more significant factor for streetcars than for buses. Guideway and vehicle operating space must remain clear of obstacles, such as wide vehicles parked in an adjacent lane.

Source: NACTO, 2016)



Source: NACTO, 2016)

Obstructions & Driveway Placement

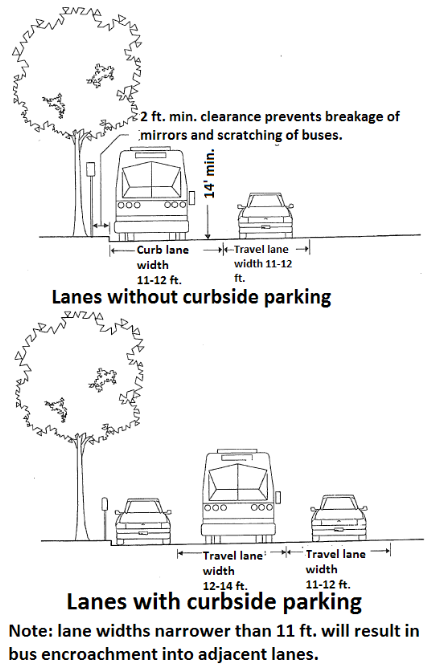
When designing transit-supportive roadways, it is important to ensure that obstructions to transit vehicles are mitigated. As buses often travel in the curbside traffic lane and make frequent stops to drop off and pick up passengers, utility poles, signs, and other physical obstructions must be set back far enough from the curb to allow space for bus "tilt" from crowned roadway sections and provide mirror clearance (TriMet). In-street stop design requires consideration of horizontal and vertical clearances for both passengers and vehicles. *SEPTA, 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 curbside stop area 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 (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.

**Capital Metro prefers 11 ft travel lanes*

Aside from recommended clearances, strategies for reducing the occurrence of obstructions include dedicated transit lanes and pavement coloring. Dedicated transit lanes can reduce double parking and other obstructions. *TRB, 2015* cites a recent study that found "red colored pavement significantly reduced the occurrence of obstructions (other roadway users legally or illegally entering the lane) for interior bus lanes". In addition, the same study found 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 unobstructed (*Safran et al. 2014*).

Red transit lanes enhance motorist and pedestrian awareness of curbside transit lanes and transit vehicles (*NACTO, 2016*). NACTO provides detailed clearance recommendations for specific stop typologies and configurations, including far-side stops, median stops, and boarding bulbs and islands.

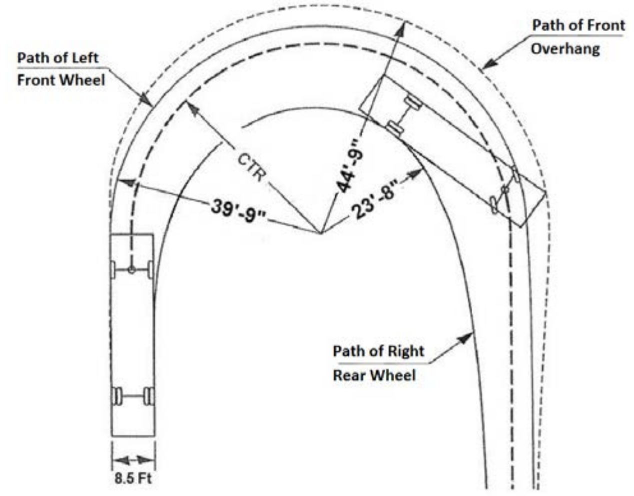


Roadway Clearances for Buses (source: Tri-Met)

Driveway placement and design should consider the effect of the bus stop on sight lines for cars entering and leaving the ROW. *TriMet* 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 in driveways except where this would block a property's only access point or severely restrict sight distances."

Turn Radii

Designing turn geometry 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 varying turn 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 modes of transportation. Properly designed corner curb 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.

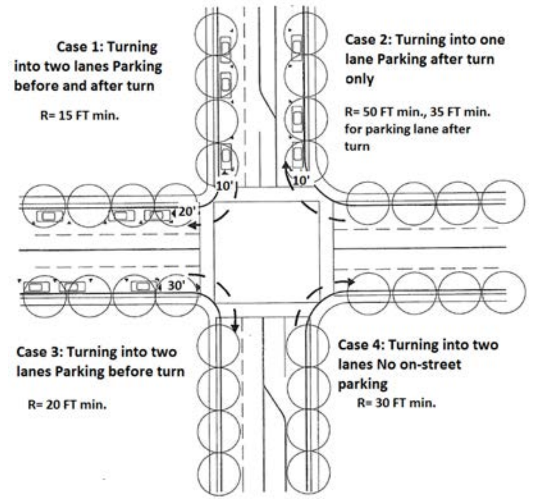


Minimum Turning Path for 40 ft Bus (source: Capital Metro)

Intersection curb radii vary from 15 to 50 feet, depending on site constraints, on-street parking locations, 12-foot travel lanes, desirable operations, and assuming no encroachment on adjacent lanes (*TriMet*). Encroachment on adjacent lanes may be allowed on certain low-volume streets or where ROW is limited. Standard 40' buses have a minimum 43' turning radius at intersections; articulated buses have a 40' minimum radius, though 45-50 feet may be preferred (*NACTO, 2016*). As a general rule to permit comfortable bus movements, corners should be designed for 50 feet outside and 30 feet inside turning radii (*SEPTA, 2012*). As Capital Metro's 45' buses require a larger turning radius than the 60' articulated, a 50' turning radius is recommended to accommodate all of the buses in the fleet. Capital Metro's bus turning path, lane width, and clearance requirements differ depending on bus length.

The pedestrian crossing distance will increase as the intersection radius increases. Where larger radii are developed, longer walking time at signalized intersections must be accommodated. In addition, guidance from TriMet specifies that turn radii allowances should be made under special circumstances, such as the following:

- Bus speeds greater than 10 mph
- Reverse turns
- Sight distance limitations
- Changes in pavement grade
- Restrictions to bus overhang
- Width of roadway



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

Curb extensions, recessed stop bars, and mountable curbs can be used to help provide flexible pedestrian space that can accommodate bus turns on infrequent routes or in cases of challenging turn geometries through small intersections. As stated by NACTO, stop bars should be recessed "on the receiving street and pair with a sign reading "Stop Here on Red" to allow the turning bus to use the full width of the receiving street;" and "mountable curbs must be delineated with color or paving treatments that both prohibit cars from entering and alert pedestrians to look for buses" (*NACTO, 2016*).

Design Speed

Human context and proactive street design are the primary determinants of safe vehicle speeds on the street. Streets should be designed to accommodate prevailing transit speeds, create a safe operating environment for transit, and provide a safe, comfortable street for people walking and bicycling to transit. This can be accomplished by choosing a small corner radius, keeping to a minimum the total number of general through-traffic lanes, traffic calming, providing a full urban streetscape (e.g. trees and street furnishings), and other traffic management techniques. As speed limits are not the primary factor in urban travel time, particularly in mixed traffic environments, streets should be designed using target speed, a safe speed at which drivers should drive, rather than reducing the speed limit or using existing operating speed or statutory limit (*NACTO, 2016*).

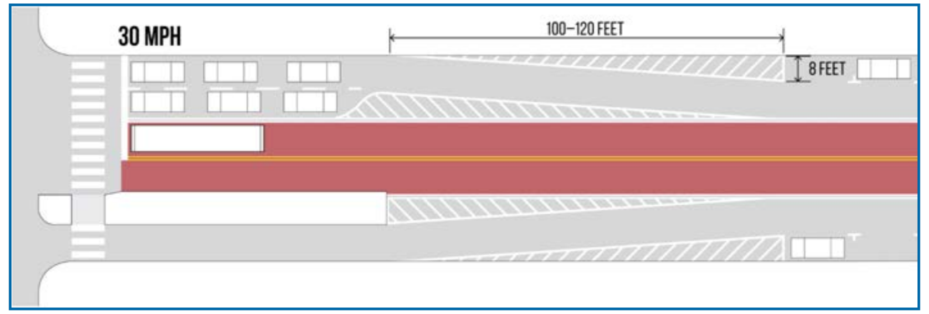
There are several methods transit agencies can assess speed and reliability for transit and other vehicles. Automatic vehicle location (AVL) and automatic passenger counter (APC) equipment can be installed on buses to identify where and when speed and reliability problems occur, quantify the magnitude of the problem, and quantify how many passengers are affected by the problem. Bluetooth readers, global positioning system (GPS) data, or traditional speed tests can be used to compare typical speeds and travel delay in the project area for transit and automobiles before and after transit enhancement projects (*TRB, 2015*). Additional techniques to improve design speed include:

- Align the design speed with target speed by implementing traffic calming measures, including narrower lane widths, roadside landscaping, speed cushions, and curb extensions.
- In selecting the design speed basis for such values as signal progression speed, lane width, and transition taper length, it may be appropriate to 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 accidents. Speeds as low as 5-10mph may be appropriate for shared transit streets, so that transit can operate safely in a traveled way shared by people walking.
- Speed enforcement cameras have proven highly effective at reducing speeds and improving speed limit compliance by private motor vehicle drivers (*IIHS, 2015*).

Source: NACTO, 2016

Stopping distance is substantially longer for rail vehicles than buses. While most urban conditions require frequent stopping and low speeds for on-street routes, transitways may have higher speeds and may require longer stopping sight distance (*NACTO, 2016*). For buses, shorter transition distances are acceptable immediately before a stop since deceleration for transit vehicles has already begun. As stated in *TRB, 2015*,

Because of their slower acceleration, longer buses are better suited from a speed perspective for routes where buses do not have to stop as often (e.g, limited-stop or BRT routes). Implementing strategies that help reduce the number of times a bus must stop due to traffic congestion or traffic control can help offset the impact of slower acceleration on bus speeds. When larger buses are used to serve the same number of passengers using fewer buses, dwell times will increase unless other strategies (e.g., all-door boarding or other fare-payment changes) are used to offset the increased passenger boarding and alighting volumes per bus (Hemily and King, 2008).



Lane Shift Transition Distance at 30mph (source: NACTO, 2016)

Markings & Signage

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

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. Colored pavement can be considered anywhere a roadway lane is reserved exclusively or primarily for buses and "can be applied solely at the start of a lane (e.g., to guide turning vehicles away from the bus lane), only in the sections where only buses are permitted (e.g., to indicate where vehicles may enter the lane to make right turns), 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 *(NACTO, 2016)*.

Red Epoxy-based Transit Lane (source: NYC DOT)

Coloring application requires roadway agencies to submit an experimentation request to the Federal Highway Administration (FHWA) for approval (*MUTCD, 2009*) and depends upon factors such as climate, use and stress, and age and condition of pavement. Different materials may be used for marking material, including red paint, red thermoplastic, and methyl methacrylate (MMA). See *NACTO, 2016* for more information on the use of these materials and comparison of their benefits. Alternatives to applying red color to entire road segments include providing a solid red stripe to highlight stops or sections of a transit lane with turn prohibitions, which helps self-enforce lane restrictions, or applying red thermoplastic or painted backing around the "BUS ONLY" lane markings to increase the visibility of the restriction (*NACTO, 2016*).

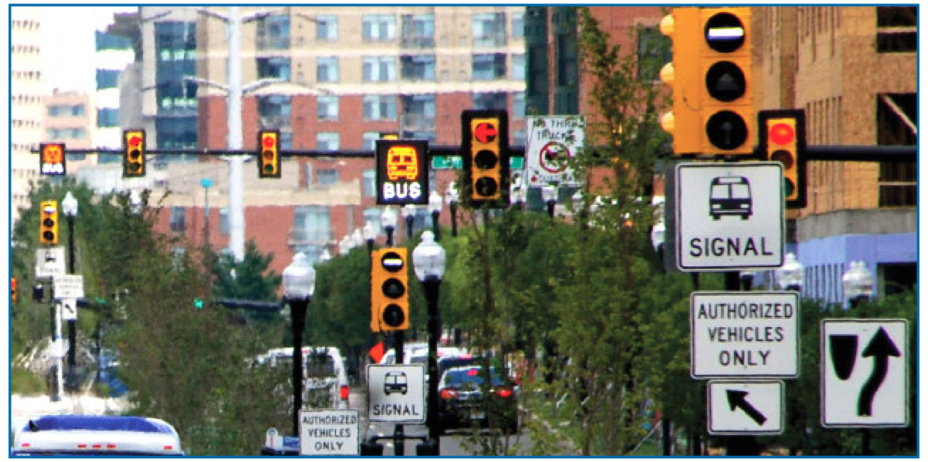
Color and size variations of pavers and concrete can subtly suggest street space and modal zones while increasing the use of space by people on foot in shared environments; can help maintain a cooler, more comfortable street environment due to the higher albedo of lighter colored pavers and concrete; and can be used in on-street railbeds to designate the streetcar path and discourage other vehicles from entering or blocking the travel path (*US EPA, 2015*). Pavers must be laid over a 12" concrete base. Large paving blocks can be used on non-fixed path routes, as smaller pavers may shift under the weight of a bus. Concrete or large pavers can be used for fixed path routes for the path of the bus wheels, with smaller paving blocks adjacent to the running way and between the two running courses, forming a visual guideway (*NACTO, 2016*).

Contrasting Pavement (source: Seattle Bicycle Blog)

Signs & Signals

Multiple sign and signal options are used in the United States to communicate required or prohibited movements, enhance overhead and other regulatory signage, and alert other street users of approaching transit vehicles. These include regulatory signs, flashing beacons, overhead signs, transit signal heads, and dynamic signs. *MUTCD, 2009* provides guidance on specific configurations and uses for sign, signals and markings standards, which vary by state.

Regulatory signs provide information on required or prohibited movements and should include turn restrictions on overhead signs or signal mast arms, particularly for movements that are not adjacent to the curb or a median on which a sign can be placed; flashing indications on signs are used to alert street users during times of day when part-time transit lanes are in effect (*NACTO, 2016*). Overhead signs above transit lanes and transitways should include information about permitted vehicles, time-of-day restrictions, and permitted turns and can include dynamic elements to indicate approaching transit vehicles and regulate turns and other movements that are prohibited when transit vehicles are approaching. Transit signal heads clarify that a movement or phases is exclusive to transit and may be used on rail lines or with buses when transit lanes or transit vehicles in mixed-traffic lanes have an exclusive phase or for queue jumps (*NACTO, 2016*).



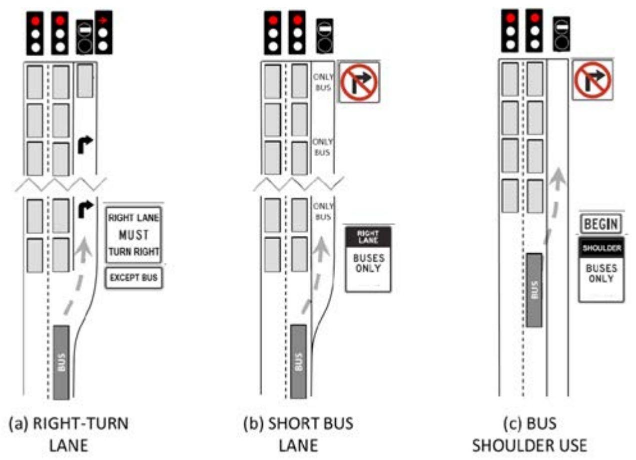
Signage (source: NACTO, 2016)

Queue jumps may be used for shared right-turn, short bus, and shoulder bus lanes to allow buses to bypass any queue 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 lack of 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 to the lane. AASHTO, 2011 recommends that "1.5 to two 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, 2015*).

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 strategies depends on speed, loading, and parking activities, as well as available width, traffic conditions, and local laws or traffic conventions. Separation elements include hard curbs, rumble strips, low vertical elements, bollards, planting strips, and mountable curbs.

The placement and height of vertical separation elements should maintain the integrity of dedicated transit space, but should not obstruct travel paths or sight lines. Hard curbs are generally four-six inches in height, should include curb ramps at crossings and reflective elements to improve visibility of the curb, and can be installed for limited



Various Signs and Signals (source: NACTO, 2016)

or block-length sections to physically prevent intrusion into the transitway. Mountable curbs "can be used on corners or roundabouts where a small curb radius is desired for design vehicles, while allowing larger control vehicles like buses to mount the curb, creating a larger effective curb radius" and should include a curb slope of no more than 2:3 (less than 1:4 to be mountable by bicycles); a non-mountable beveled curb with a 1:1 slope is conducive to bicycle-friendly but not mountable separation (*NACTO, 2016*). Curbs that are less than six inches tall can be rounded or sloped to alert other users of dedicated transit space and provide flexible entry for limited occasions.

Rumble strips are a low-cost treatment to reduce vehicle incursions, providing drivers with a tactile cue when they encroach upon a transit lane, and are typically reserved for high-speed streets removed from pedestrian areas like crosswalks, where transitways 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 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 style. As stated by NACTO, "bollards must be readily visible and include either retro-reflective surface or 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."

Round Traffic Buttons & Bollards (source: Flickr user Roy Luck)

Planting strips can be used to compliment the streetscape 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. Xeriscaping may be used as a low-maintenance alternative to planting strips and bioswales and connected planters assist with stormwater management (*NACTO, 2016*).

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 sustainable principles that are applicable to transit system design.

Integrating green infrastructure into 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 canopies 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 canopy, and xeriscaping.

Armadillos (source: Cyclehoop)

Ideal side slopes for bioswales are 4:1, with a maximum slope of 3:1. A maximum two percent gentle side slope should be used to direct water flow into the facility. Appropriate media composition for soil construction should be used (*NACTO, 2016*).

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 (xeriscaping) reduces water and maintenance requirements. The planter should drain within 24 hours, especially near transit stops, where pooling can degrade transit access.
- Choose green infrastructure based on pedestrian volume and the intensity of use on a sidewalk.
- As required, install a perforated pipe at the base of the facility to collect the treated runoff.
- Ensure that infiltration rates meet their minimum and maximum criteria. The engineered soil mixture should be designed to pass five–10 inches of rain water per hour.

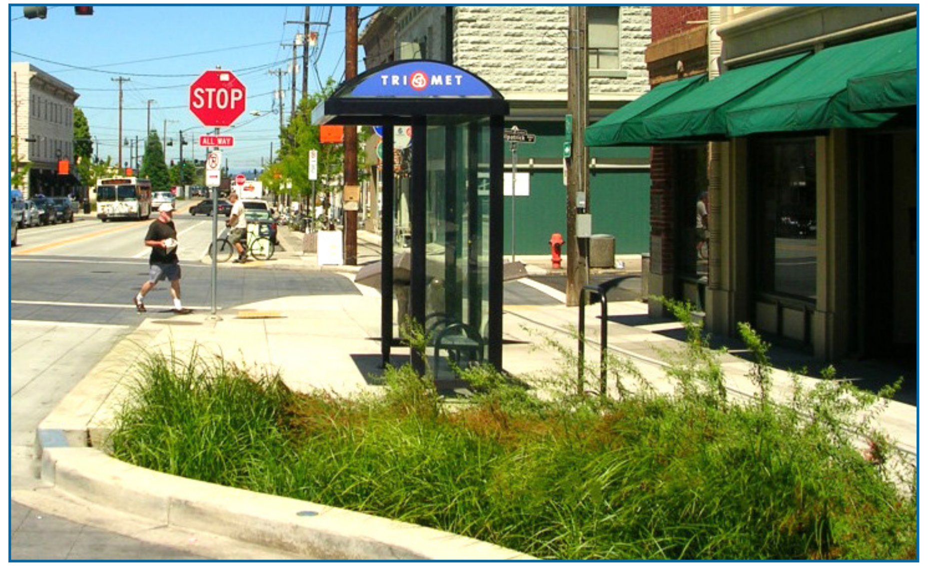
Source: *NACTO, 2016*

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 tracks or bus 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 space along the street provided by large areas of green space (NACTO, 2016). These 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 enclosed in a noise absorber, filled with a porous base layer, covered with an anti-root membrane, and covered with a porous paving grid 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, with the swale surface at a lower grade than the adjacent roadway. In this case, deeper water penetration should be permitted through. In most climates, rails must be elevated to avoid flooding.

Source: *NACTO, 2016*

Capital Metro recognizes sustainable infrastructure rating systems, such as ENVISION (ISI) and INVEST (FHWA) as industry best practices. ENVISION allows sustainable infrastructure to be evaluated through a transparent system of metrics, providing a "holistic framework for evaluating and rating the community, environmental, and economic benefits of all types and sizes of infrastructure projects. This resource consists of a broad range of criteria that help individuals make better decisions at each step of the project. These criteria address a project's impact on the surrounding community and environment, technical considerations regarding materials and processes, and other critical choices spanning the project's life-cycle" (ISI). Similarly, INVEST (Infrastructure Voluntary Evaluation Sustainability Tool) is a "web-based self-evaluation tool comprised of voluntary sustainability best practices, called criteria, which cover the full life-cycle of transportation services, including system planning, project planning, design, and construction, and continuing through operations and maintenance" (FHWA).



Bioswale near TriMet Station (source: NACTO, 2016)

Lincoln St/SW 3rd Ave Station, Portland (source: Flickr, Landscape Forms)

BRT Implementation

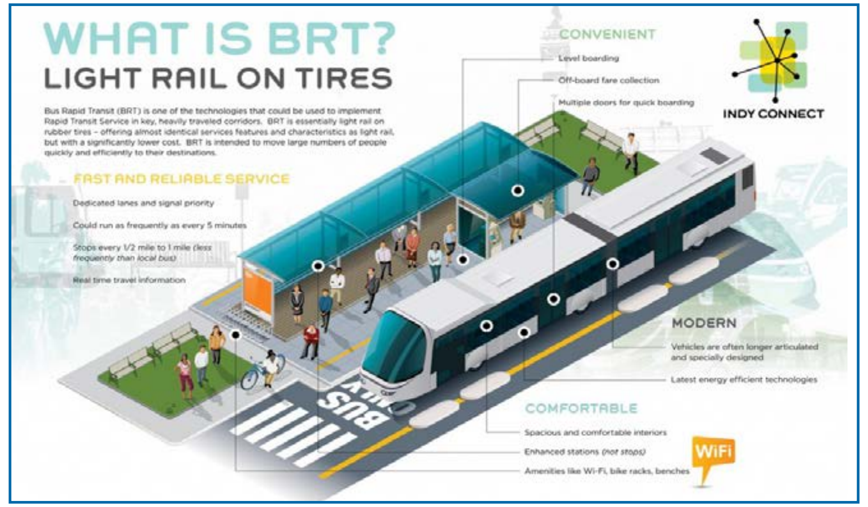
The integration of quality BRT corridors is an essential component of a quality transit system. As stated by the Institute for Transportation & Development Policy (ITDP):

BRT is a high-quality bus-based transit system that delivers fast, comfortable, and cost-effective services at metro-level capacities. It does this through the provision of dedicated lanes (minimum length of 1.9 miles), with busways and iconic stations typically aligned to the center of the road, off-board fare collection and fast and frequent operations.

The BRT Gold Standard, a set of scored criteria to rate BRT corridors, was developed by an international committee of experts as an evaluation tool for world-class BRT. According to the Gold Standard, there are five essential elements of BRT:

- Dedicated Right-of-Way: Lanes off-limits to other traffic, allowing for unimpeded travel.
- Busway Alignment: Center of roadway or bus-only corridors keep buses from traffic and curb activity, minimizing delays.
- Off-board Fare Collection: Paying fares in advance (i.e. using turnstiles) reduces passenger boarding delay.
- Intersection Treatments: Prohibiting turns for traffic across the bus lane reduces delays caused to buses by turning traffic.
- Platform-level Boarding: Stations should be at level with the bus for quick and easy boarding, including for passengers with disabilities, strollers, and carts.

Source: ITDP; Better Rapid Transit for Greater Boston (Boston BRT, 2015)



Elements of BRT(source: Smart Transit Future)


Lincoln St/SW 3rd Ave Station, Portland (source: Flickr, Landscape Forms)

Platform Design

Transit platforms may have multiple uses, serving the needs of transit service while functioning as a walking zone for pedestrians, a resting place for users, or channelizing traffic modes. It is important to correctly size and configure the height, length, and width of a platform in order to balance efficient transit operation, pedestrian and street user safety and comfort, and vehicle design. Platform size, configuration, and frequency should be designed to "enable efficient operations and comfortable ridership, accommodate accessible boardings, and provide capacity for boarding, alighting, and waiting transit passengers without unnecessarily interrupting the flow of pedestrian traffic" (*NACTO, 2016*).

Platform Height

Platform height affects ease of boarding and route efficiency, as raised platforms enable easier and more accessible passenger boarding and alighting by decreasing step-down distance and gap between vehicle floor and platform. Level and near-level platform stops allow vehicles to enter and exit stops more quickly, increasing route efficiency (*NACTO, 2016*). Different platform configurations have different platform heights and include sidewalk/curb level, near-level, and level boarding stops. Platform height and design considerations for these platform types are discussed briefly in the following table. Further information and additional configurations can be found in *NACTO, 2016*.

Platform Configurations

Sidewalk/Curb Level	Sidewalk/curb level platforms allow passengers to board from the sidewalk or curb level, often at a curb height of four-six inches	May be preferred where there is inadequate space to provide accessible slopes and ramps onto a higher platform	• Markings or detectable warning strips can be used for platform edge or boarding positions and "curb level boarding may be applied with boarding bulbs and, conditionally with side boarding islands
Near-Level Boarding	Near-level platforms allow an operator to either kneel the bus or deploy a short bridge plate or ramp and place the curb height at eight-11 inches	Allow faster boarding and are compatible with most existing transit fleets, side and center boarding islands, boarding bulbs, and sidewalk stops with sufficient width to provide a raised area	• ADA-compliant ramps should be provided to achieve desired height leading to the boarding pad • Ramps should not impede pedestrian paths or crossings • Install detectable warning strips along the edge of the boarding platform, except when part of an existing sidewalk • Refer to "Part 38-Accessibility Specifications for Transportation Vehicles" in FTA, 2007 for slope requirements for bridge plates
Level Boarding	Level Boarding platforms have a platform height that matches the floor height of transit vehicles (typically 12-14 inches for on-street low-floor vehicles	Ramps do not have to be deployed and vehicles do not kneel, reducing delay and adding convenience. Can apply to light rail, streetcar, or retrofitted low-floor buses	• Transit vehicles must be able to pull in close to curbs to eliminate the gap • Install detectable warning strips or another detectable surface along the edge of the boarding platform

Source: NACTO, 2016)

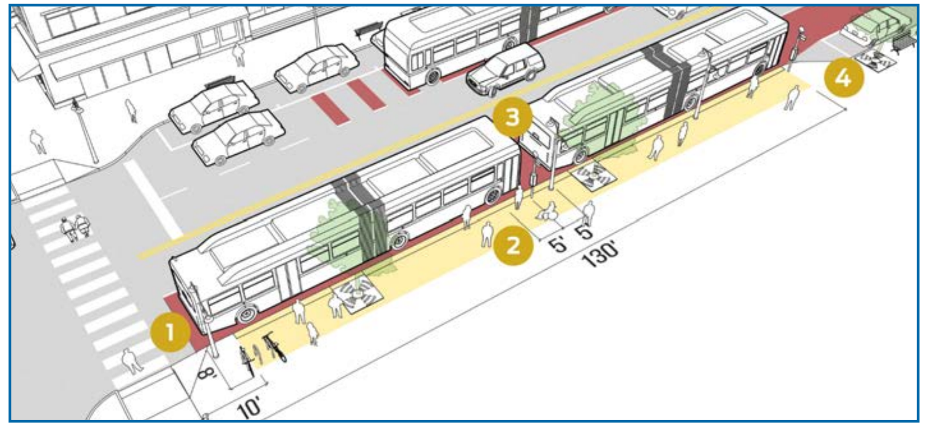
Platform Length

The length of the stop platform is dependent on factors such as vehicle length, stop configuration, available ROW, and target speed. The following tables illustrate minimum platform length for in-lane and pull-out stops according to vehicle type. Pull-out stops require longer clear curb zones than with in-lane stops, as bus zone lengths for these stops include transition or taper space in addition to platform length *(NACTO, 2016).*

In-Lane Stops: Desired Minimum Platform Length by Vehicle Type (feet)

Stop Position	40' Bus	60' Bus	2 x 40' Bus	2 x 60' Bus
Near-Side	35	55	80	115
Far-Side	45	65	90	130
Mid-Block	35	55	80	115

Source: NACTO, 2016)



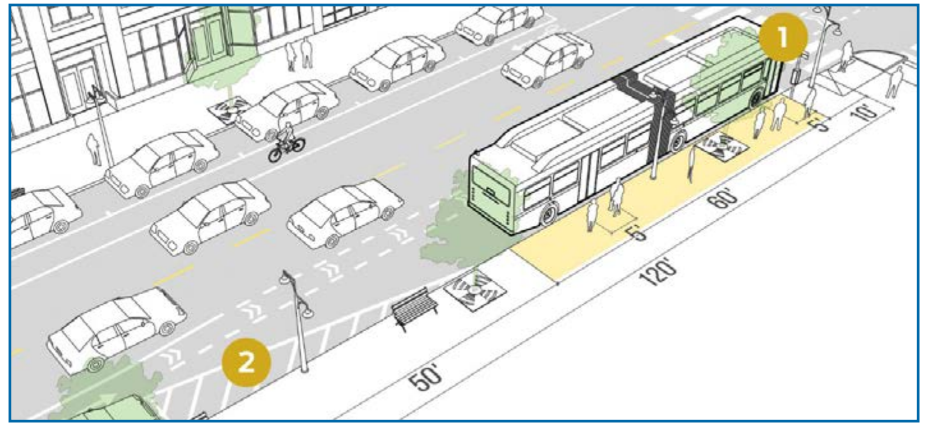
In-Lane Stop (source: NACTO, 2016)

1. Locate platform with at least 10 feet of clear distance from crosswalk or curb return. Measure to transit stop pole at near-side, or rear of transit vehicle at far-side.
2. While 5 feet is the minimum curb length for a receiving facility at each boarding door (ADA Std. §810.2.2), design platforms to be continuous through all doors, and consider additional elements to improve passenger comfort (see Station & Stop Elements).
3. Provide five–10 feet of distance between each additional transit vehicle expected to be dwelling at the platform consistently throughout the day.
4. Design boarding bulbs and islands to accommodate proper drainage and sweeping; tight radii may require maintenance agreements to ensure bulbs are properly cleaned and maintained.

Pull-Out Stops: Desired Minimum Platform Length by Vehicle Type (feet)

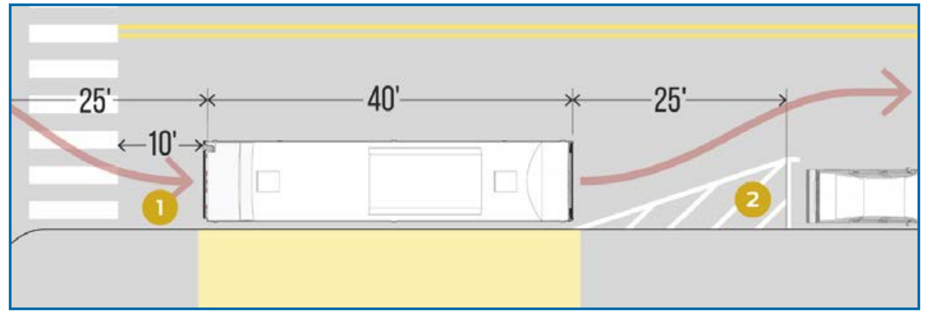
Stop Position	40' Bus	60' Bus	2 x 40' Bus	2 x 60' Bus
Near-Side	100	120	145	185
Far-Side	90	100	125	165
Far-Side (Right Turn)	140	160	140	230
Mid-Block	120	145	185	210

Source: NACTO, 2016)



Pull-Out Stop (source: NACTO, 2016)

1. Locate stop zone with at least 10 feet of clear distance from crosswalk or curb return. Measure to transit stop pole at near-side, or rear of transit vehicle at far-side.
2. White diagonal hatch line markings may be striped to delineate the entry and exit tapers and discourage blocking.



Pull-Out Stop Transition Space (source: NACTO, 2016)

Platform Width

From the curb's edge, the width of the boarding platform runs perpendicular to length and accommodates ADA-required boarding space for ramps and bridgeplates; shelters and amenities; and clearance zones for pedestrians to traverse safely. Comprising the interface for boarding and alighting, width must be adequate to house 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 mobility. When separating the boarding platform from the pedestrian through-zone, boarding platforms, bulbs, 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 volume.
- Install 1' wide detectable warning strip along front of boarding pads.
- At least three feet width should be completely clear along the platform edge between landing areas to accommodate all users. Shelters, trash receptacles, newspaper boxes, and seating must be located behind this line. If rails are installed, an additional foot is needed to accommodate six inch recess from curb and railing width.
- On boarding islands and median platforms, ramps should be at minimum four feet wide to enable turning movements in wheelchairs.

Source: *NACTO, 2016*

Universal Design & Accessibility

Universal street design is critical to the design of transportation facilities, facilitating transit access, system equity, reduced operational costs, and making it possible for any street user to comfortably and conveniently reach every transit stop, such as the elderly, someone temporarily encumbered by groceries or packages, a parent with a stroller, and those with disabilities or mobility impairments. All new or newly renovated facilities must be designed and upgraded to meet current ADA accessibility standards and special attention should be placed on the pedestrian travel path to the transit stop, loading area clearances, and any furnishings that may be part of the stop (*SEPTA, 2012*).

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:

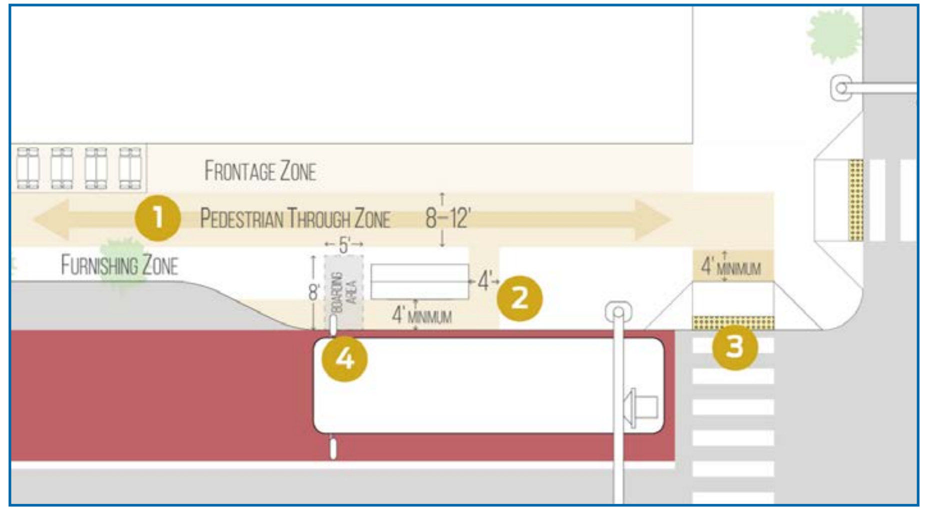
- Detectable warning strips may be used to indicate door locations at sidewalk-level stops and must be at least 24 inches wide, and should be applied at all curb ramps for their entire width, or at any location where pedestrians cross into another modal zone (i.e. bicycle lanes or vehicle lanes) along a flush transition (DOT 504 §406.8). Detectable warning strips should visually contrast with adjacent surfaces to alert pedestrians that they are crossing into a new modal zone (such as a transitway, bicycleway, or vehicle traveled way).
- 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 bicycle zones or crossings may be green (terra cotta for bicycle lanes also is an option). Color repetition reinforces legibility, and should be employed at conflict zones, flush crossings, or likely sites for encroachment.
- Higher illumination lighting around transit stops should be gradual rather than sudden to avoid creation of virtual shadows as driver and bicyclist eyes adjust.
- Stops and stations with real time arrival information should include audible announcement capabilities. If audible cues for signalized crossings rely upon push-button activation, the button should be located near the curb ramp for each crossing direction, and far enough apart to distinguish from other ramps.

Source: *NACTO, 2016*

Curbside passenger facilities consist of three primary elements: a loading area that provides sufficient space for loading and unloading passengers, an adjacent waiting area, and an accessible pedestrian path to access the stop. Factors such as passenger volume, nearby trip generation, and local needs determine sufficient stop dimensions and amenities, however the following are some general considerations for appropriate design of passenger facilities. See NACTO, 2016 for further design guidance on accessible paths and passenger facilities.

Crosswalk/Bike Lane Delineation in Victoria, BC (source: Shayne Calhoun)

Example of Color Delineation (source: Teresa Boyle)



Accessible Design: General Principles (source: NACTO, 2016)

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 development or neighborhoods, though eight-12 feet is preferred where transit is present; the pedestrian travel path may be wider based on pedestrian and transit rider capacity (*NACTO, 2016*). The travel path should have a non-slip surface to meet ADA accessibility requirements.

Transit Platforms

Transit platforms should, at a minimum, provide a clear and level loading area where the front doors open to receive and discharge passengers, allowing for easy deployment of the front door ramp or the kneeling feature of the vehicle for disabled persons. A second loading platform should be installed, when space permits, to allow passengers to alight from the rear doors of the bus. Loading pads should be comprised of a firm, slip resistant surface suitable for use in all weather conditions and can include a detectable edge at the curbline of contrasting color and appropriate material to help drivers and passengers clearly identify the bus stop (*SEPTA, 2012*).

Bus stop dimensions and specifications can be tailored to meet a community-specific need, however, the minimum loading pad should be maintained. "Each stop type includes the basic building block of a five foot (1.5m) long parallel to the curb by eight foot (2.4m) deep bus pad connected to a pedestrian path that is four feet (1.2m) wide or wider, which is the ADA standard" (*SEPTA, 2012*). The width includes five feet for a wheelchair waiting area, plus additional width to deploy a wheelchair ramp to serve the waiting area (generally three feet), though longer ramps may require additional length (see *ADAAG §810.2.2*) (*NACTO, 2016*).

Waiting Area

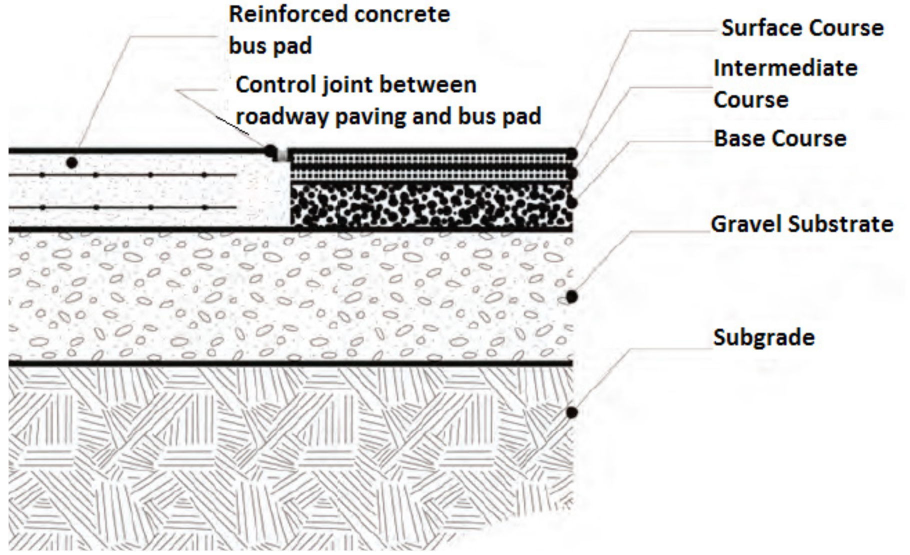
A well-defined waiting area should be sized to reflect expected passenger volumes and, at a minimum, should be wide enough at the curbline to provide a safe place for passengers to wait outside the loading area. In addition, the surface must be durable, slip resistant, and free of horizontal or vertical obstructions or tripping hazards (*SEPTA, 2012*). The Transit Capacity and Quality of Service Manual (*TCQSM*) and *TCRP Report 100* provide guidance on space allocation for detailed waiting area calculations:

A standing waiting area should consist of seven square feet (0.65 m^2) per person net area to achieve a level of service between C and D. The net area is defined as the area remaining after subtracting the areas reserved for pedestrian pathways and the bus loading pad from the total area. Excluding the ADA-specified clearances for the loading pad and other street furnishings, additional clearance space for obstructions by local barriers, such as poles or hydrants, should be evaluated.

Bus Pads

Roadways should be designed to accommodate the wear and tear of constant vehicular traffic and passenger unloading, which can disrupt traffic flow and affect customer convenience and safety. It is important that "a transit stop's road surface be durable enough to withstand heavier loads than average daily traffic under normal conditions" (*SEPTA, 2012*). Roadway pavement design must be assessed using the American Association of State Highway and Transportation Officials' (*AASHTO*) Guide for the Design of Pavement Structures and the local version of this standard should be used to determine appropriate design for a particular site. Roadway design must also conform to both Texas Department of Transportation (*TXDOT*) and local jurisdictional pavement standards, in addition to particular soil and climate conditions. SEPTA discusses the basic steps for evaluating paving surface requirements for bus stop location *(SEPTA, 2012)*.


Concrete Bus Pad at Capitol Station (source: Capital Metro)



Concrete Bus Pad Design (source: DVRPC, 2012)

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 pose a hazard to bicycle wheels, and stop amenities should not block boarding pads or walking path (*NACTO, 2016*). At a minimum:

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

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, where 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*).

Pavement Materials

The use of appropriate pavement materials is important for minimizing roadway damage caused by transit vehicles. Asphalt is the most common street material and the least expensive to implement, however "asphalt street surfaces are prone to deforming under the weight of a bus, especially during acceleration and braking" (*NACTO, 2016*). Though concrete street surfaces are more expensive than asphalt, these surfaces are stronger, last longer, generally shift less under the weight of heavy buses, and can have a lower life cycle cost than asphalt, particularly in warm weather locals.

All pavements that pedestrians access should be firm, stable, and slip resistant regardless of material selection (*US Access Board, Department of Education*, 2011). Installing a concrete bus pad at bus stops can minimize pavement deformation, which negatively affects bicyclists and drivers, though thick courses of asphalt may also be considered. 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.

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 pedestrians to no longer feel the need to hide at the margins of the street (Gallimore et al., 2011; Rosén & Sander, 2009). Traffic calming elements such as chokers, raised crosswalks, and bicycle bypasses are already popular in many major European cities (Ewing, 2008). 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., 2007). Trees and shrubs lower than 6 meters (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 thermal comfort of the setting (Fukahori & Kubota, 2003). See **ite.org** and **trafficcalming.org** for further information on 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 in a region 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 zones and heightened driver awareness (*Zhang, 2012*).


Shared Space Design in Naarden, Netherlands (source: Dick van Veen)


Time Square Redesign (source: Auckland Council)

Traffic Calming Measures

Technique	Description	Applications
Speed Hump		
	Rounded raised areas of pavement typically 12 to 14 feet in length. Often placed in a series (typically spaced 300 to 600 feet apart).	• Residential streets • Not typically used on major roads, bus routes, or primary emergency response routes • Mid-block placement, not at an intersection • Not on grades greater than eight percent • Work well with curb extensions
Speed Table		
	Long raised speed humps with a flat section in the middle and ramps on the ends; sometimes constructed with brick or other textured materials on the flat section. Height= three-3.5 inches; Length= 22 feet.	• Local and collector streets • Main roads through small communities • Typically long enough for the entire wheelbase of a passenger car to rest on top • Work well in combination with textured crosswalks, curb extensions, and curb radius reductions • Can include a crosswalk
Raised Intersection		
	Flat raised areas covering entire intersections, with ramps on all approaches and often with brick or other textured materials on the flat section and ramps.	• Work well with curb extensions and textured crosswalks • Often part of an area wide traffic calming scheme involving both intersecting streets • In densely developed urban areas where loss of parking would be unacceptable
Neighborhood Traffic Circle		
	Raised islands, placed in intersections, around which traffic circulates. Motorists yield to motorists already in the intersection. Different than roundabouts, traffic circles require drivers to slow to a speed that allows them to comfortably maneuver around them.	• Intersections of local or collector streets • One lane each direction entering intersection • Not typically used at intersections with high volume of large trucks and buses turning left

Source: Institute of Transportation Engineers; Traffic Calming.org

Traffic Calming Measures

Technique	Description	Applications
Chicane		
	A series of narrowings or curb extensions that alternate from one side of the street to the other forming S-shaped curves.	• Appropriate for mid-block locations only • Most effective with equivalent volumes on both approaches • Typically, is a series of at least three curb extensions • Can use on-street parking to create chicane
Choker		
	Curb extensions at mid-block or intersection corners that narrow a street by extending the sidewalk or widening the planting strip.	• Local and collector streets • Pedestrian crossings • Main roads through small communities • Work well with speed humps, speed tables, raised intersections, textured crosswalks, curb radius reductions, and raised median islands
Center Island Narrowing		
	Raised islands located along the centerline of a street that narrow the travel lanes at that location.	• Are often nicely landscaped to provide visual amenity and neighborhood identity • Can help pedestrianize streets by providing a mid-point refuge for pedestrians crossings • Sometimes used on wide streets to narrow travel lanes • Work well when combined with crosswalks

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 among various modes of transport (*TRB, 2015*). The interactions between transit and other forms of transport should avoid conflict and ensure that bicyclists, pedestrians, and transit riders can move safely, freely, and comfortably.

Safe and legible through paths for pedestrians and bicyclists with open sightlines and lighting should be provided on transit streets, allowing for the most direct access to destinations and the public realm. Vulnerable users like bicyclists should always be given sufficient space to operate safely at a comfortable distance from fast-moving traffic or from larger vehicles like buses and trucks, outside of the door zone (*NACTO, 2016*). Where buses use a travel lane adjacent to a bicycle lane, both bus and bicycle operational comfort are enhanced by providing a buffer space between them where width is available. The following table illustrates a number of design configurations for managing on-street bus and bicycle interactions.

Special consideration should be given at transit stops to manage bicycle and pedestrian interactions. Design strategies include raising the cycle track to sidewalk level and wrapping it behind the transit stop zone at mid-block or signal protected intersections to reduce conflicts with transit vehicles and passengers (as shown above for diverted bicycle lanes); providing an extended mixing zone with signage at intersection bus stops to direct bicyclists to yield to buses and loading passengers; or incorporating a raised median, bus bulb, or curb extension in the cycle track buffer area to accommodate transit stops (*NACTO, 2012*). Bike boxes, designated areas at the head of a traffic lane at signalized intersections, provide bicyclists with a safe and visible way to clear an intersection quickly during the red signal phase and minimize conflict with transit or other traffic.

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 zone vehicle length (*SEPTA, 2012*). Where bicycles are allowed on transit vehicles, level-boarding platforms should be provided, along with signage and markings to direct bicycles 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. There should be 5' wide access paths around bicycle parking to avoid impeding traffic; including near transit vehicle doors, on adjacent sidewalks and through long-term storage facilities (*NACTO, 2016*). See *NACTO, 2012* and *NACTO, 2016* for further information on bicycle facility design and coordination with transit.

Bike Lane, Victoria, BC (source: Shayne Calhoun)

Bike Box, Capital Station-SB (source: Capital Metro)

Bus and Bicycle Facility Design

Technique	Description	Effectiveness
Shared Bus & Bicycle Lane		
	Used where it is desired to benefit both bus and bicycle traffic, but ROW constraints prevent developing separate bus and bicycle facilities. This is not the preferred option when others are available due to potential bus and bicycle conflicts.	Buses travel more quickly than in a mixed-traffic environment; bicyclists are provided with some separation from general traffic. Allowing bicyclists to use the bus lane may generate broader support for developing a bus lane by increasing number of users that benefit.
Separate Bus & Bicycle Lane		
	Where ROW permits, it may be possible to provide separate bus and bicycle lanes. Except when bus volumes are high enough that bicyclists are frequently passed by buses, the bus lane serves as a buffer between bicyclists and motor vehicles.	Although buses need to pull into the bicycle lane at bus stops, sufficient space is provided with the construction of floating bus stops to allow bicycles to go around buses without having to merge into the general traffic lane, reducing conflicts where no bus lane is provided, but still forcing bicyclists out of desired travel path.
Left-Side Bicycle Lane		
	On one-way streets, an additional option for providing separate bus and bicycle lanes is to locate the bus lane on the right side of the street and the bicycle lane on the left side of the street.	Bicycle-bus conflicts are eliminated at bus stops and can also reduce the "dooring" risk for bicyclists, as passenger-side car doors are opened less frequently. Additional signs and pavement markings may be required to highlight to motorists bicyclist locations.
Diverted Bicycle Lane at Bus Stops		
	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. Requires an ADA-compliant pedestrian access route connecting stop to sidewalk.	This treatment can be an effective way to minimize conflicts and delays for both buses and bicyclists. Potential bicycle-pedestrian conflicts (e.g. conflicts arising from pedestrians crossing the bicycle lane or queuing in the bicycle lane while waiting for the bus) need to be addressed.

Source: TRB, 2015

Rail Station Design

As commuter rail differs from local and rapid bus service in terms of vehicle technology and supporting infrastructure, rail stations should be designed to offer safe, attractive, functional, and well maintained facilities that meet the needs of this service. Many of the guidelines and standards discussed in this document are relevant to rail stations and should be incorporated, if applicable. This section summarizes some general guidance obtained from other U.S. transit agencies, including information on platform design, station design, and security. Capital Metro has prepared guidelines for rail facility design and operations, including *Capital Metro, 2007; CMTY, 2014; and CMTY, 2015. See Metra, 2007; Sound Transit, 2007; Caltrain, 2011; and FWTA, 2014* for more information on rail facility design.

Platforms

Station platform design must address four key issues: location, dimensions, access, and amenities. The location addresses the relationship of the platform to the station buildings and the preference to avoid locating platforms on curves; the width and length of the platform is dictated by the operational needs of Capital Metro and includes issues concerning the platform height and materials; platform access is affected by the location of the station buildings, the type and size of the platform, the location of the parking lots, and may also be governed by various local codes, state codes, and federal regulations; and the platform amenities include the fixtures, furnishings, and equipment which provide convenience to riders (*Metra, 2007*).

Location

The platform design process should consider the location of depots, shelters, points of public access, and parking areas. The platforms should be located to avoid interrupting the road traffic at nearby existing at-grade crossings and the end of the platform should be at least 100 feet from an at-grade crossing. The distribution of passengers among the rail cars should be considered where there are multiple access points to a platform (*Metra, 2007*).

For single line tracks, one platform should be provided on the same side of the track as the station building, or near public access and parking where no station building exists. The preferred location of the platform and parking lot for a new station is on the inbound side of the track, as this allows space for a second track at the station in the future. For multiple line tracks, a platform should be provided on the outside of each track and island platforms should be used at stations with three or more tracks or where site conditions and/or station configuration make outside platforms difficult to build on double track lines (*Metra, 2007*).

Curved platforms 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.

Dimensions

Dimension criteria for rail platforms vary according to a transit agency's operational needs, vehicle technology, and platform configuration. The following tables provide dimensional criteria obtained from Metra guidance and should be examined and adjusted to match Capital Metro's needs. The platform length of 135 feet is based on a car length of 135 feet. Actual platform length may vary due to site constraints and may be based upon projected peak ridership and train operational requirements (*Metra, 2007*).

The length of the platform should be the greater length of either the inbound or the outbound platforms. The platform should be lengthened where platform lengths are shorter than required, if possible, and specific line operations and individual site conditions such as controlled crossings, station buildings, or stairways will determine the new length of the platform. If conditions require shortening a platform length, the excess platform should be removed rather than abandoned (*Metra, 2007*). See the Platform Design section for further information on platform dimensions, as applicable.

Minimum Standard Platform Dimensions

Standard	Specification
Floor Height:	23"-23.5"
Min. Distance (tangent):	5'-6" from centerline of adjacent track to edge of platform.
Center Platform Width: Side Platform Width:	22' 11'
Material/Support: Slope:	Reinforced concrete 1 percent*
Tactile warning:	2' wide precast along trackside edge.

Source: Capital Metro; Metra, 2007

* For side platforms, the slope should be down away from track, for center platforms there should be a crown along the center of the platform and the slopes should be down to platform edge.

Minimum Inbound Platform Length

Projected Peak Train Boarding or Alighting	Diesel Lines	Electric Lines
1 to 175	380 Lin. Ft.	465 Lin. Ft.
176 to 210	465 Lin. Ft.	550 Lin. Ft.
211 to 245	550 Lin. Ft.	635 Lin. Ft.
246 to 280	635 Lin. Ft.	635 Lin. Ft.
281 to 315	720 Lin. Ft.	635 Lin. Ft.
316 to 350	805 Lin. Ft.	635 Lin. Ft.
351 to 385	890 Lin. Ft.	635 Lin. Ft.

Source: Metra, 2007

Minimum Outbound Platform Length

Projected Peak Train Boarding or Alighting	Diesel Lines	Electric Lines
1 to 105	380 Lin. Ft.	380 Lin. Ft.
106 to 140	465 Lin. Ft.	465 Lin. Ft.
141 to 175	550 Lin. Ft.	550 Lin. Ft.
176 to 210	635 Lin. Ft.	635 Lin. Ft.
211 to 245	720 Lin. Ft.	635 Lin. Ft.
246 to 280	805 Lin. Ft.	635 Lin. Ft.
281+	890 Lin. Ft.	635 Lin. Ft.

Source: Metra, 2007

Access

Platforms should provide a clear path to direct commuters to and from the platform and should be designed to provide handicap access into train cars. Train cars generally have a flip plate to bridge between the platform and the car. Where public access and platforms are at different elevations, ramps or stairs, or a combination of both, should be provided. "Platform edges bordering a drop-off and not protected by platform screens or guardrails shall have a detectable warning strip that shall be 24 inches wide running the full length of the platform edge drop-off" (*Metra, 2007*).

Ramps provide safety and ease of access for the elderly and individuals with disabilities and are required where there is a grade difference along the accessible route and the slope between those grades exceeds 1:20 (five percent). Ramps should conform to the ADA guidelines and should be located to minimize the distance between the platform and the access point. Signage to identify the accessible entrance and route will be provided where the circulation path differs from that of the general public. Stairs made of concrete or concrete and steel construction may be provided in addition to ramps and should conform to all applicable accessibility requirements (*Metra, 2007*). See *Metra, 2007* for detailed 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, accommodating all ages and abilities. Pedestrian crossings should include infrastructure that meets safe crossing standards in a way that can be replicated throughout the service area. Caution is needed when requiring infrastructure that, 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/texturing. 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*).

Railroad Crossing with a Variety of Passive Devices (source: Flickr user Donald Lee Pardue)

At-grade street and highway crossings should conform to *The Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD) standards and are subject to the required US DOT approval process. Slopes to at-grade crossings should comply with grades to curb ramps and crossings should be 12 or 16 feet wide depending on ridership and constructed of precast concrete panels. "The crossing shall extend from the face of one platform to the face of the opposite platform at the same elevation as the top of rail. The platform shall be depressed to the crossing at a rate that does not exceed 8" rise for 16' of run" (*Metra, 2007*).

Signalized crossings should be provided at locations where two or more tracks are crossed; gates at crosswalks should not be allowed at these locations. Cross track boarding is to be avoided and warning signals should be provided at all existing at-grade crossings. The number of at-grade crossings is based on the platform length and the maximum distance between grade crossings is 405 feet (*Metra, 2007*). See the Universal Design & Accessibility section and *Metra, 2007* for further guidance on station accessibility.

Recognizing that there are specific situations that sometimes require elevated safety measures, when these arise it should be documented as to why additional infrastructure is necessary, so application of these measures can be anticipated and the estimated costs/timeline of installing them known and shared with the project management. It is recommended that crossings being considered for safety improvements "be reviewed by a diagnostic team and undergo an engineering study to select the appropriate warning devices for each crossing. All pedestrian railroad crossings should be designed to minimize the time required for pedestrians to cross, with emphasis on avoiding entrapment of pedestrians on or between sets of tracks" (*FHWA, PEDSAFE*).

See the following resources for further guidance on improving pedestrian safety at crossings: Railroad-Highway Grade Crossing Handbook (*FHWA, 2007*); Compilation of Pedestrian Safety Devices in use at Grade Crossings (*FRA, 2008*); Guidance on Pedestrian Crossing Safety at or Near Passenger Stations (*FRA, 2012*).

Amenities

As stated in the Amenities section, passenger amenities, such as benches, trash receptacles, advertising displays, and telephones provide added convenience and comfort to the trip and passenger experience. Specific types and quantities of amenities will vary from station to station and are discussed in Capital Metro's service guidelines. See the Amenities section and *Metra, 2007* for additional guidance on station amenities, including salt box locations, fencing and guardrails, intertrack fencing, and advertising displays.

Stations

New and existing stations must comply with ADA, accessibility, and agency standards. Station design may vary by station depending upon factors, such as passenger volume, unusual site conditions, or community involvement, though such deviations from planning guidelines should be discussed with Capital Metro prior to design and implementation. *Metra, 2007* provides detailed guidance on station area design, including waiting areas, depots, restrooms, accessibility of station buildings, auxiliary spaces, shelters, and security considerations. Highlights of this guidance are briefly summarized below. Station facilities should be permanent, safe, durable, easily and economically maintained, and energy efficient (*Metra, 2007*).

Spacing

Rail station placement should follow the guidance established by SEPTA, including where employment densities are greater than population densities, in which case station locations will be governed based on a number of factors such as location, municipal zoning and related comprehensive plans, surrounding land uses, highway and pedestrian access, P&R and transfer opportunities with other Capital Metro services (*SEPTA, 2014*).

Recommended minimum distance between rail stations:

Area Type:	Ideal Stop Spacing Range (min):
Urbanized Areas (first generation suburbs with population densities between 1,000 and 10,000 per square mile)	1,320 feet
Suburban and other low-density areas beyond first generation suburbs (population densities less than 1,000 per square mile)	2,640 feet

Source: SEPTA, 2012

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*).

Rail Platform Shelter, Lakeline Station (source: Capital Metro)

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

Criteria:	Dimensions:
Clear Width	36" Minimum
Turning Widths	36" for 900 turn with no additional turn for 48"
Passing Spaces	Required at 200' intervals if route is less than 60" wide 60" x 60" floor space
Headroom Clearance	80" minimum
Running Slope	1:20 (5 percent) Maximum
Cross Slope	1:50 (2 percent) Maximum
Level Changes	Up to 1/4" - no edge treatment required 1/4" to 1/2" - beveled edge with slope no greater than 1:2 Greater than 1/2" - requires ramp, elevator, or lift
Floor Surfaces	Firm, stable, slip-resistant
Protruding Objects	Objects projecting below 27" above finished floor may protrude any amount Object with leading edges between 27" and 80" above finished floor should protrude no more than 4" into walls or corridors Free Standing objects on posts may overhang 12" maximum from 27" to 80" above floor
Clear Floor Space	Single wheelchair - 30" x 48"
Alcove Clearances	36" minimum width for forward approach to alcove deeper than 24" 60" minimum width for parallel approach
Reach Ranges	15" Minimum height forward approach 48" Maximum height forward approach 9" Minimum side reach parallel approach 54" Maximum side reach parallel approach
Egress	Same number of exits as for life safety regulations

Source: Metra, 2007

Bus Passenger Shelter, Midtown, Charlotte, NC (source: Landscape Forms)

Landscaping

Well-planned and properly maintained landscaping, whether functional or decorative, creates an attractive atmosphere for passengers and the community. Landscaping is important for both bus and train stations and serves a variety of purposes, as planting and landscape materials "can also be used to provide screening from adjacent residential properties, shape and define large parking areas, stabilize slopes and embankments, keep unpaved horizontal surfaces in good condition, and provide weather protection" (*Metra, 2007*). Landscaping should follow Capital Metro and local standards. *SCRRA, 2010* contains further guidance on landscaping design.

Station parking areas should be screened from adjacent residential and civic areas using plants designed for height and density to block views and protect the privacy of neighboring parcels. Decorative screening material and fencing may be used where appropriate to supplement planting and screening and buffer zones should comply with applicable municipal code or requirements whenever possible. Landscaping in 10-foot wide buffer zones is recommended (*Metra, 2007*).

Materials for Slope Stabilization & Erosion Control

Criteria:	Dimensions:
Turf, mowed	1 to 3
Grass	1 to 2
Myrtle, pachysandra, etc.	1 to 2
Stone, rip-rap	1 to 1.5
Cut Stone	1 to 1
Brick Paving	1 to 1
Concrete block paving	1 to 1

Source: Sound Transit, 2007

Rendering of Landscaping at Bus Station (source: Newlands & Co.)

Trees used for landscaping should have a minimum planting distance of 30 feet between trees and away from structures and should be adequately sized for strength, appearance, and durability. There should be a 500' clear line of site at crossings, whenever possible, and trees planted behind platforms should be located so that they do not block the view of the platform at maturity.

Bushes should be placed so that they do not create blind areas for safety reasons and embankments should be stabilized with low maintenance material that will prevent erosion and the growth of weeds and underbrush (*Metra, 2007*). Landscaping should follow relevant CPTED guidelines identified in *APTA, 2010*.

Park & Ride Design

Park & Rides (P&R) are specialized parking lots generally located on the suburban fringe of urbanized areas outside of the "ring 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 (rail, bus, van- and car-pools) (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 Amenities 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 lot and the boarding area should be ¼ mile. The design should provide unobstructed sight lines between all areas of the P&R lot and the boarding areas wherever possible. Connections between the P&R area and station boarding areas should be as direct as possible and include walking paths connecting to the boarding areas. To assist the wayfinding experience of customers, these paths should generally be lit at a higher foot-candle level than surrounding parking area.

The site selection 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
- Served 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

Source: *FDOT, 2012*

Leander Station P&R (source: Capital Metro)

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, sketch planning techniques based on local travel and socio-economic data are preferred over sophisticated and data intensive modeling techniques." Determining the lot size needed for a P&R facility consists of eight steps:

1. Compute 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 fluctuations in demand created by seasonal factors
4. Compute the maximum accumulation of shared-ride vehicles
5. Compute 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 radii, and other design criteria
8. Develop space allowances for landscaping, setbacks, drainage, and other design criteria

Source: *FDOT, 2012*

Additional space may be needed to include areas for community art, security, vendors, waiting areas, and passenger drop off and pick up areas.

Park & Ride Facilities

Lot Type	Description	Standards	Considerations
Remote or Rural Facilities	Remote lots are located in areas with low population growth and are not expected to grow excessively. Lots are generally located outside the urban area in a rural or small town setting. Trip lengths for home-to-lot and lot-to-work tend to be longer than for other lot types.	• Between 20-60 miles from employment centers • More than 20,000 employees at trip end • Centrally located • Publicly-owned Right-of-Way (ROW) available • Less than 1 mile from commute route	The success of a remote lot is dictated by the level of employment located at the destination end and the distance traveled. Lots should be centrally located to the service area population. Usage will be greater if located near a major commute route.
Urban Fringe Facilities	Urban fringe lots are located at the edge of urban development. These lots can be, but are not generally served by transit. Trips tend to originate outside or at the outer limits of the urban area while the destinations may be concentrated or dispersed within the urban area.	• Trip destination patterns may be concentrated or dispersed within the urban area • Located along arterial roadways with 4 lanes or more • Minimum of 10,000 employees per square mile to support the formation of car pools Located in the vicinity of an urban area boundary • More than 3/4 mile from commute route	Service area demand and concentration of employment are factors that determine the usage of an urban fringe lot. 35,000 Average Daily Traffic (ADT) is suggested as a working traffic minimum.
Peripheral Facilities	Peripheral lots are typically located at periphery or on the edge of an intensely developed, highly congested or access-restrained activity center. These lots are designed to supplement parking deficiencies and include facilities that service activity centers with limited parking and/or auto access such as auto-free zones, colleges, and universities.	• Congested or restricted access • On a major access route • Insufficient parking facilities in the area • Distances from residential areas generally longer than other P&R facilities, while distances to the activity center are usually shorter	• Parking demand/supply • Activity center circulation • Activity center access routes • Existing parking facilities
Urban Corridor Facilities	Urban corridor lots are located along a major commute route within an urban area, typically served by express bus, urban rail, or commuter rail services. Trip origins tend to be disbursed along the corridor; destinations are usually concentrated in a Central Business District (CBD) or employment center.	• Level-of-Service E or worse • 50,000 ADT • Traffic based on support of one 100-space lot operating at 75 percent capacity • More than 2,000 dwellling units within 2 miles of lot • More than 10 miles from employment center	Identify areas in highly congested corridors. Prime corridors are operating at Level-of-Service (LOS) E or worse. It is better to locate a lot closer to trip origins and further from trip destinations.
High Occupancy Vehicle (HOV) Corridor Facilities	HOV corridor lots are a subset of the urban corridor, located adjacent to a major commuter highway constructed with HOV lanes. They support carpool formation and access to express buses using the HOV lanes.	• High volumes more than 35,000 ADT • Confluence of feeder roads near facility • 5-10 miles minimum spacing between lots	Take lot spacing and its effect on the utilization of individual lots into account to maximize usage. Parkers tend to use the first lot encountered. Lots too closely spaced together may become underutilized.

Source: FDOT, 2012

Multi-Modal Access

As pedestrian movements within P&R areas normally occur within the parking aisles, such aisles should be designed to consider 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/or 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&Rs should provide long-term bicycle storage.

Vehicular access points at P&R facilities should consider adjacent land uses and avoid large unplanted or paved areas that are out of scale with those uses. Vehicular access form local residential streets should be avoided and access directly from major highways/arterials into a P&R facility should be minimized due to relatively high speeds and traffic volumes. Access locations should minimize potential vehicle, pedestrian, and bicyclist 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 transit facility sites should be designed to contain sufficient traffic storage capacity to meet expected transit patronage at peak times and to prevent traffic backing up onto public streets" (*Sound Transit, 2007*).

The following design considerations should also be followed to ensure 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, primary access to P&R lots should be from major streets (although avoiding high-speed arterials if possible). Secondary access points may be from major or 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.

Source: *Sound Transit, 2007*

Parking

Surface parking or structured garages will be provided at select transit facilities as determined by Capital Metro. Parking facility design should consider potential expansion 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 feasible and given site constraints, parking lots should be designed so as to avoid the use of earth-retaining structures.
- Where feasible 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 fills more than five feet high, while guard rails should be considered on fills higher than 10 feet. Borders adjacent to curbs or guard rails should be wide enough for landscaping and planting, subject to local jurisdiction requirements for storm water management and critical areas.
- Parking lots and garages should be appropriately illuminated.

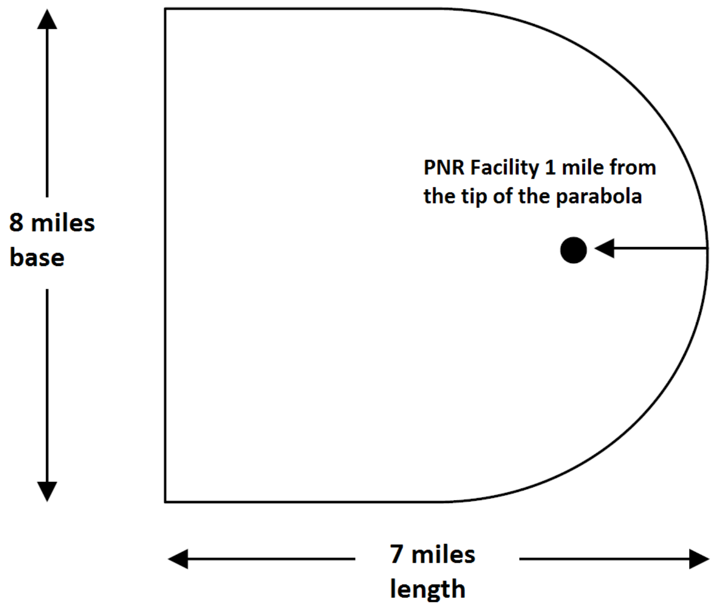
Source: *Sound Transit, 2007*

Landscaping

Landscaping should enhance pedestrian safety and security by providing attractive approaches to stations and enhance pedestrian safety and security by providing clear sight lines for both vehicles and pedestrians between parking areas and station platforms (Sound Transit, 2007). Landscaping should follow relevant CPTED guidelines identified in *APTA, 2010*. Additional design considerations for landscaping at P&R locations include:

- 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 30 percent.
- Establish visual screening of parking areas from adjacent properties while allowing for surveillance of public areas and secure operation of the facility.
- Integrate design elements with adjacent areas.
- Design plantings to reinforce vehicular and pedestrian movement paths.
- Consider local jurisdictional codes for landscaping in parking areas.

Source: *Sound Transit, 2007*



Example of a suburban parabola (source: Capital Metro)

Evaluation Criteria

New P&R lot capacity improvements will be prioritized at locations where HOV direct access and regional bus service increases demand and where no surplus capacity exists. 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 projected use (*Sound Transit, 2007*). The Texas Transportation Institute (TTI) developed the following criteria to assess demand for new P&R facilities in suburban and urban locations, according to parabolic catchment area for the P&R:

- Suburban Parabolas
  - » TTI methodology states that a parabola that is 7 miles long and 8 miles wide is an effective size for capturing suburban P&R demand.
  - » The parabola comes to a point 1 mile in front of the P&R. Riders will travel up to a mile in the opposite direction of their commute to reach a P&R.
  - » The parabola will be pointed in the direction of the downtown area.
  - » A suburban parabola is located more than 5 miles from downtown.
- Urban Parabolas
  - » An urban parabola follows the same methodology as a suburban except that it is between 3 to 5 miles from downtown.
  - » An urban parabola is approximately half the size of a suburban parabola at 4 miles long and 4.5 miles wide.

Methodology for Calculating Ridership Demand

	Data	Source
Market Area Population	Working population	2013 Census Journey to Work (for total commuters)
	Transit mode share	2013 Census Journey to Work by mode (percent that use transit)
	Average number of riders per vehicle	City of Austin Transportation Department (average passengers in a car, 1.1 for Austin)
Modal Split	Eligible population	2010 Census Tract Flows (from catchment area to activity center of CBD, Capital Complex and UT)
	Depart for work in service period	National Report on Commuting Patterns and Trends
	Mode share	2010 Census Tract Flows (percent of population living in catchment area and working in activity center)
	Average number of riders per vehicle	City of Austin Transportation Department (average passengers in a car, 1.1 for Austin)
Regression	Population	2013 Census Journey to Work (for total commuters)
	Maximum Delay Time	Google Maps (travel time from catchment area to activity center at different times of day)
	Maximum Average Annual Daily	TxDOT statewide planning map
	Vehicle Capacity and Frequency	Capital Metro
	Average number of riders per vehicle	City of Austin Transportation Department (average passengers in a car, 1.1 for Austin)

Source: TTI

Agency Policy

As stated in Capital Metro's service guidelines, Capital Metro conducts 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 chosen week to produce an average occupancy. As a result, the two seasonal averages are produced each year to help identify trends. Once a facility reaches the industry standard average occupancy range (70-85 percent), plans for expansion are developed in accordance with the following policies.

Park & Ride Planning Policies:

Existing Facility Policies

1. Capital Metro will conduct bi-annual (fall and spring) seasonal surveys for each park-and-ride facility's occupancy in order to track overall utilization.
2. Capital metro will investigate future expansion options for any park-and-ride facility has achieved 80 percent occupancy for three consecutive seasonal surveys.
3. Capital Metro will investigate potential solutions to improve utilization for any park-and-ride facility that has less than 40 percent occupancy for five years in a row.
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).

Security

Passenger security is an important component of transit facility design. "The physical safety of passengers is vital to the success of any transit system-not only to retain 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 *FHWA, 2008*. This section 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 an area, CPTED can provide benefits of safety and security if applied in the conceptual design and planning stages of a project" (*APTA, 2010*).

CPTED places emphasis on the utilization of structures, lighting, spaces, and people around an area to prevent crime and increase loss prevention. Whether the principles are applied separately or are combined with other practices, CPTED provides the following benefits:

- Creates a welcoming environment.
- Fosters a sense of physical and social community order.
- Creates a sense of ownership by transit users and employees.
- Maximizes the presence of transit staff and law enforcement figures.
- Minimizes opportunities for out-of-sight activity.
- Manages access to authorized areas and controls access to non-public areas.

Source: *APTA, 2010*

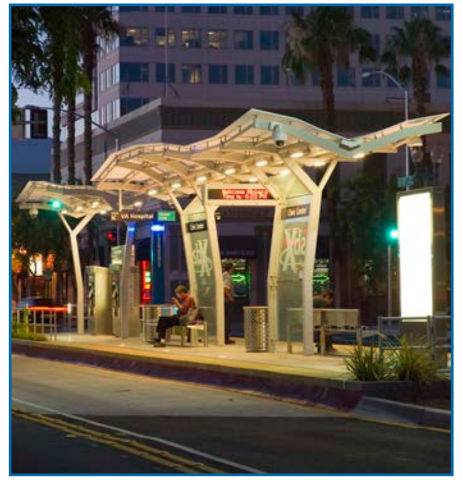
Five strategies are involved in CPTED: natural surveillance; natural access control; territorial reinforcement (using buildings, fences, pavement, signs and landscaping to express ownership); activity support (placing the right activity in the space); and maintenance (addressing the inspection, repair and general housekeeping of the space):

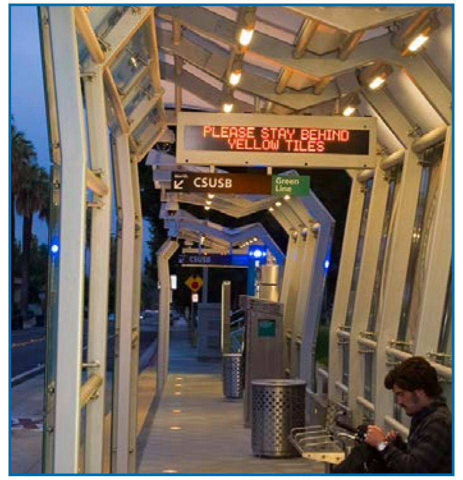
- **Natural surveillance**. This strategy involves reducing crime by decreasing target opportunities in a space/area by placing physical features, activities and people to maximize visibility.
- **Natural access control**. Channeling people into, alongside or out of spaces/areas and deterring entry elsewhere along the boundary are the concepts of this principle (through the judicial placement of entrances, exits, fencing, landscaping and lighting); This concept denies access to crime targets and creates a perception of risk for adversaries.
- **Territoriality**. Territoriality 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/facility that they are being watched and that the community is the space/area/facility for purposeful activities.
- **Activity support**. By encouraging authorized activities in public spaces, the community and transit system ridership understand its intended use. Criminal acts are discouraged, and an increase in safety and security of the transit system, its operations, facilities, ridership and people are realized.
- **Maintenance**. Care and upkeep demonstrates expression of ownership for the intended purpose of the area. A lack of care indicates loss of control of a space or area and can be a sign of tolerance for disorder. Establishing care and maintenance standards and continuing the service preserves the intended use of the space/area. CPTED maintenance and care standards also safeguard the best interests of the community and transit agency where they serve.

Surveillance is an important security procedure for ensuring passenger security and protection of property, crucial components of station design. The visibility of paths from access points to station buildings and platforms, as well as the potential for surveillance by local or Capital Metro security officers, should be considered in station design. Surplus station spaces that encourage evening occupancy should be repurposed and additional security and surveillance should be provided. Night security lighting controlled by time-clocks for minimum operating costs should be provided to improve surveillance of station buildings, platforms, and the overall site (*Metra, 2007*).

Remote surveillance can also be provided at the station and are particularly useful in locations without direct surveillance. Design and planning of all remote surveillance systems should be coordinated with local and Capital Metro police and the posting 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 located for maximum visual coverage and protection from vandalism. The effectiveness of any remote surveillance system is dependent upon a timely response to any observed incident (*Metra, 2007*).

Cal State Station San Bernadino (source: Omintrans)





Concepts: E. St. Station, San Bernadino (source: Gruen Associates)

CPTED Strategies and Application for Transit

Natural Surveillance	Territoriality
• Maximize visibility by designing doors and windows to look into public areas, such as parking lots, roadways or sidewalks. • Ensure adequate illumination of public areas. • It is directed at keeping intruders under observation. Organized surveillance strategies include use of police and guard patrols. Lighting and CCTV are mechanical strategies for surveillance, and natural strategies include widows, low landscaping and raised entrances.	• 2013 Census Journey to Work (for total commuters). • 2013 Census Journey to Work by mode (percent that use transit). • City of Austin Transportation Department (average passengers in a car, 1.1 for Austin).
Natural Access Control	**Activity Support**
• Clearly distinguish the difference between restricted and public areas. • Implement landscape plantings, pavement surface treatments, fences, T-walls, etc., to reinforce the territory of restricted or public areas. • Create physical designs that enhance or extend the sphere of influence so that users develop a sense of proprietorship. Organized territorial strategies typically include neighborhood crime watches, receptionists, and guard stations. Mechanical strategies can be perimeter sensing systems. Natural territorial strategies include fences, walls and landscaping.	• Identify activities that create community involvement in the public space. • Ensure that public space activities complement other activities in the same space. General Guidance • CPTED should be considered early in design and planning to optimize investment, safety, and security. • Transit agencies should conduct a system wide and asset-specific risk assessment to identify safety and security threats to their transit systems. The risk assessment will serve as a guide to determine appropriate application of CPTED practices. FTA provides information on threat and vulnerability assessments for CPTED applications, in addition to other useful security resources. • A CPTED survey is a component of the risk assessment process and focuses on identifying exposures within the transit system's built and natural environments and recommends enhancements that reduce risks to people, operations, and facilities. • CPTED strategies should be identified in consultation with security staff.
Maintenance	
• Maintain the cleanliness and functionality of revenue and nonrevenue areas and spaces. • nspect assets, equipment and facilities to ensure satisfactory operation. • Keep up with repairs; make necessary replacements; paint; trim landscaping; remove trash and debris; enforce a zero tolerance policy to graffiti and vandalism; and maintain aesthetic appearance of assets, equipment and facilities.	

Source: APTA, 2010

Transit-Oriented Development

Transit-oriented development (TOD) is a "type of community development that includes a mixture of housing, office, retail and/or other commercial development and amenities integrated into a walkable neighborhood and located within a half-mile of quality public transportation" (Reconnecting America). TOD features vibrant streetscapes, pedestrian-oriented built forms, and land use characteristics that make it convenient and safe to walk, cycle, and use public transit. TOD is not a building or a project: it's a pattern of development. The American Public Transportation Association (APTA) developed standards, guidelines, and best practices to articulate the value in the planning and design of transit facilities, and the streets and neighborhoods connected to those facilities, in order to create "transit-oriented" communities. These are places in which:

- Transit services contribute to making a "place," are attractive and functional, and serve as community destinations.
- Access to transit balances the needs of all modes and users to support and encourage pedestrian, bicycle, and transit trips.
- The neighborhoods around transit facilities support and encourage a vital mix of activities through existing and new development.
- Transit corridors take advantage of the variety of nearby neighborhoods and destinations to encourage a diversity of places and access modes.
- The transit network connects users to key regional destinations and supports the economic health of the region and its communities.

The planning and design of transit facilities and the streets and neighborhoods connected to those facilities should incorporate the principles of TOD in order to create "transit-oriented" communities that can maximize Capital Metro's system ridership and provide Central Texas residents in the Greater Austin area with an array of housing choices, and convenient access to the region's jobs, services, campuses, and amenities. Capital Metro's Transit-Oriented Development Policy and Joint Development Project Selection Guidelines (2013) outline agency regulations, goals, and strategies for pursuing TOD development around its stations, which include the following:

Goals

1. Increase transit ridership
2. Generate long-term revenue and optimize value of assets
3. Create and promote equitable mixed-use and mixed-income communities around transit
4. Respond to local community vision and values

Strategies for Capital Metro Property

1. Pursue creation of transit oriented developments on appropriate sites.
2. Build transit facilities to support transit-oriented development. Ensure safe multi-modal connectivity with pedestrian and bicycle infrastructure.
3. Ensure that transit-oriented development opportunities are appropriately considered in all acquisitions of new properties, location of new transit facilities, and design of all transit facilities.

Strategies for Transit Station/Stop Areas

1. Establish and maintain partnerships for the development and promotion of plans and policies that encourage appropriate development in transit-rich areas.
2. Encourage transit-supportive development around MetroRail and MetroRapid Stations, and other selected transit facilities.
3. Encourage the creation of safe direct pedestrian and bicycle connections to stations and stops from proximate development.

The biggest challenge in a development is to accurately determine how much parking is needed. Too much parking makes a development less pedestrian-friendly, wastes valuable real estate, and leads to higher exactions and development costs. To answer this question, many engineers and planners consult the Institute of Transportation Engineers' (ITE) Trip Generation and Parking Generation guides. Though these publications represent data collected from mostly isolated suburban land uses- not walkable urban places served by transit- few alternative guidelines for this type of development are available. Recent studies of TOD parking utilization reveal that well-designed TODs generate fewer vehicle trips than ITE publications estimate (often 50 percent or less) and use less parking than many regulations require for similar land uses (*NITC, 2017*).

These findings show an overabundance of parking at TODs and the limitations of current engineering standards to accommodate this type of development. Strategies for better aligning industry standards with current parking needs include:

- Incorporate shared parking, unbundled residential parking, and paid commercial parking into development.
- Consider joint development/public-private partnership, and mixed-income residential
- Revise zoning code to allow reduced parking ratios for mixed-use developments by-right, including unbundled parking, and shared parking.
- Ensure proper connectivity of P&R with TOD development.
- Educate developers, financers, 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 in near existing TODs, counts 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 respective traffic analysis zone. 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*.

Example of TOD, Portland (source: Valley Metro)

Capital Metro has developed a Transit-Oriented Development Guide, a collection of best practices for TOD development. The document provides further specifics on TOD planning principles, including design elements, implementation and financing strategies, a TOD checklist for new projects, and resources for further reading. The agency has also developed the TOD Priority Tool, which examines the potential for TOD development within a half-mile radius around high-capacity transit stations on the MetroRapid and MetroRail system. Through careful research and analysis of each station, the tool encourages a closer relationship between land use and transit and identifies on-the-ground, station-specific implementation action items to create attractive, walkable, and sustainable development around high-capacity transit.

Street Front Experience

Street fronts at and connecting people to transit stops/stations should be designed around the pedestrian. The areas between building fronts and streets should be the most dynamic of all collective spaces in the TOD. They should purposefully blur the line between public and private areas, encouraging shopping and eating to come outdoors and directly engaging people as they walk by. Creating a visually interesting, functional and comfortable street front offers a transit-supportive experience that includes many inter-related elements, including high quality pedestrian zones between the building front and street, pedestrian-oriented uses, and pedestrian-scaled architecture. Transit stops and stations are best located where there is activity and visual connectivity.

Example of a pedestrian-oriented street (source: ITDP)

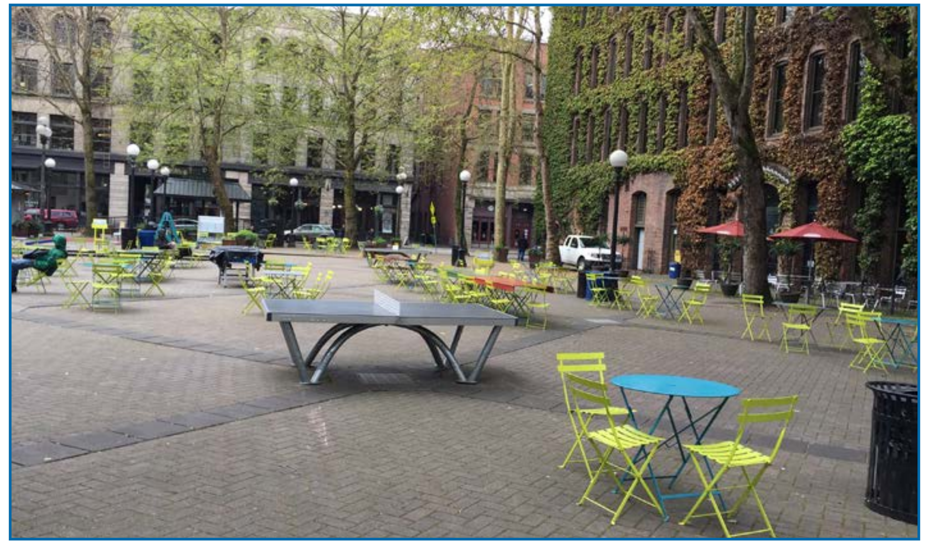
Placemaking

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
- Sociable
- Dynamic
- Trans-disciplinary
- Community-driven
- Visionary
- Function before form
- Adaptable
- Inclusive
- Creates Destinations
- Context-specific

UPS Waterfall Garden Park, Seattle (source: Shayne Calhoun)



Occidental Square, Seattle (source: Shayne Calhoun)

Resources for Further Reading

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

Capital Metro:

Service Guidelines and Standards: capmetro.org/servicechange.aspx?id=130

Transit-Oriented Development: capmetro.org/tod

FDOT: fdot.gov/transit/pages/finalparkandrideguide20120601.pdf

Metra: metrarr.com/engineering/design-guidelines/

NACTO: nacto.org

SEPTA:

Bus Stop Design Guidelines:
septa.org/strategic-plan/reports/SEPTA-Bus-Stop-Design-Guidelines-2012.pdf

Service Standards and Process:
septa.org/strategic-plan/reports/service-standards-2014.pdf

Sound Transit:
soundtransit.org/Projects-and-Plans/Developing-Regional-Transit/Design-standards-and-guidelines

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

TriMet: nacto.org/docs/usdg/bus_stop_guidelines_trimet.pdf

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Bus Stop, Downtown Seattle (source: Shayne Calhoun)

BRIO BRT, El Paso (source: Sun Metro)

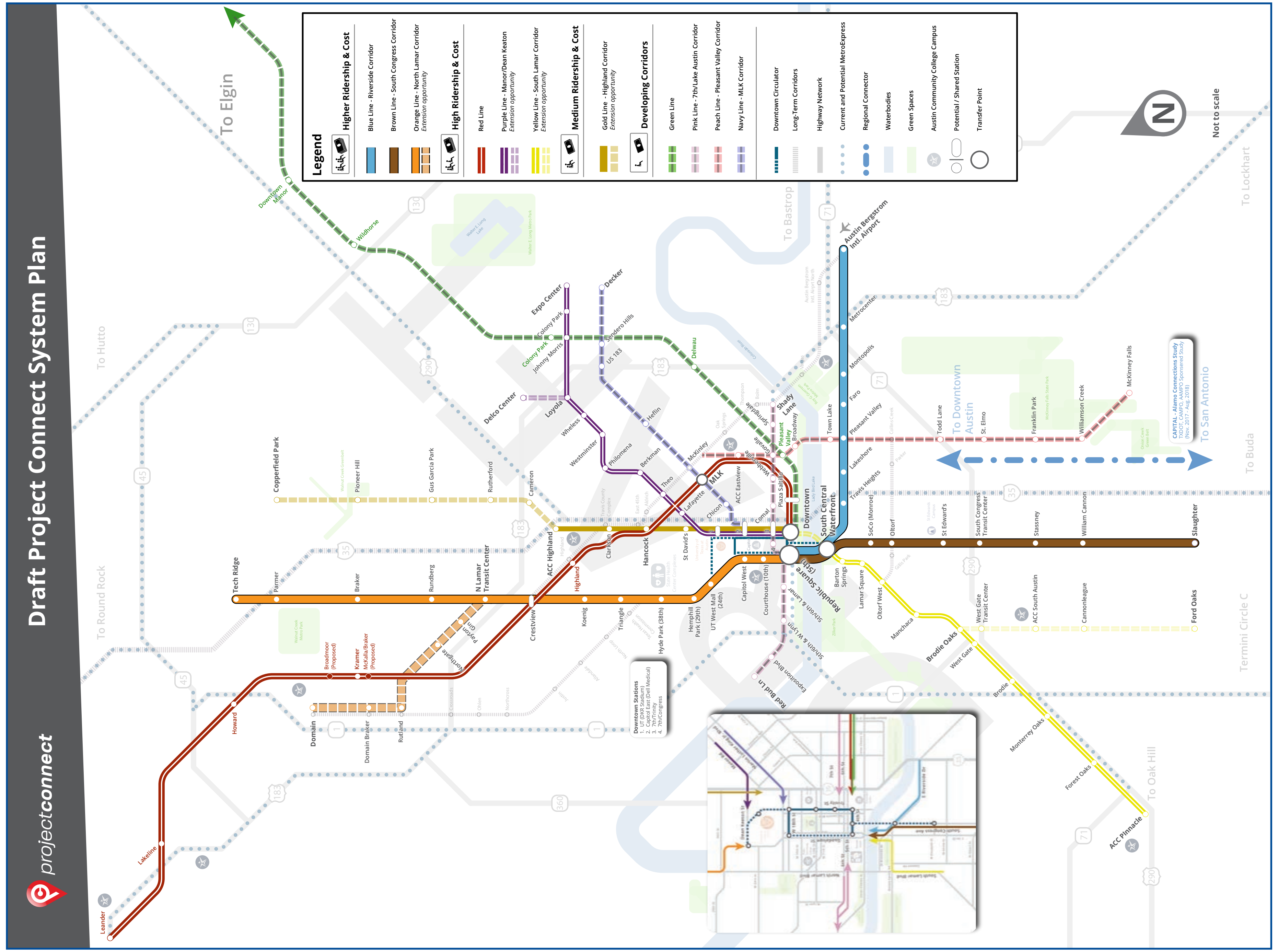
Context-sensitve Seating, Barclays Center, NY (source: Landscape Forms)

OMSI/SE Water MAX Station, Portland (source: Landscape Forms)

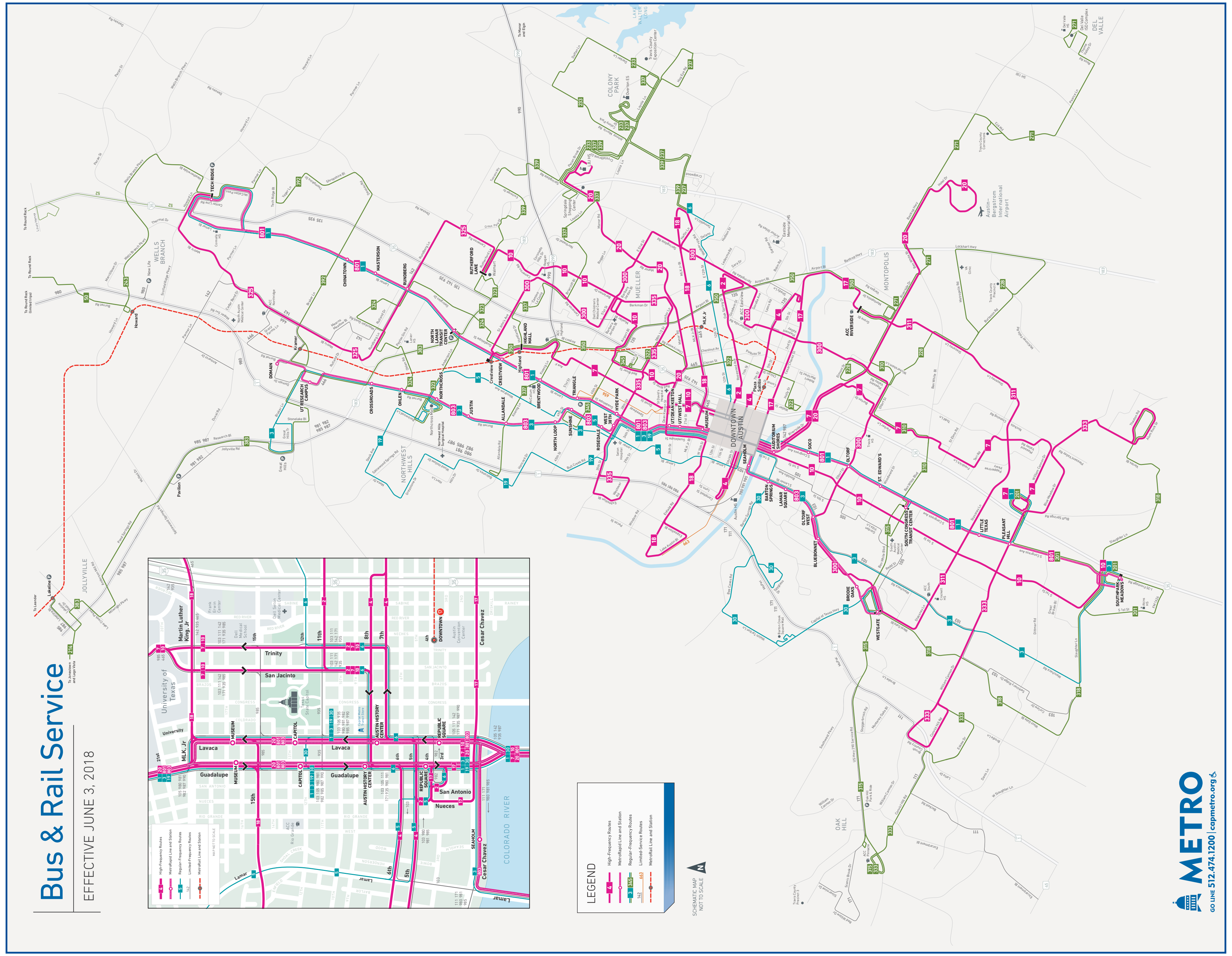
Appendix: Errata Sheet

[This section will contain a list of future revisions made to the document]

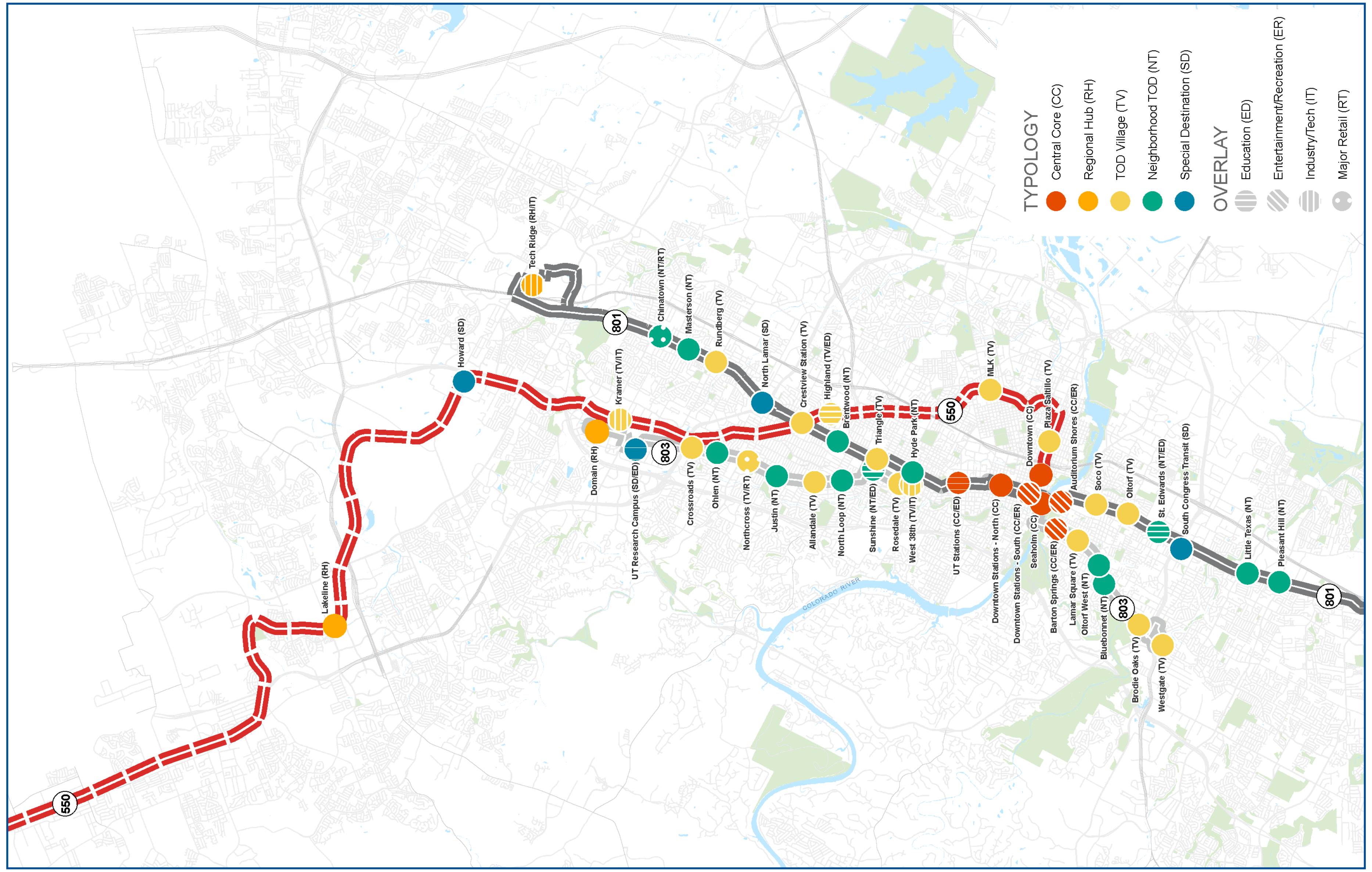
Preliminary Project Connect System Plan



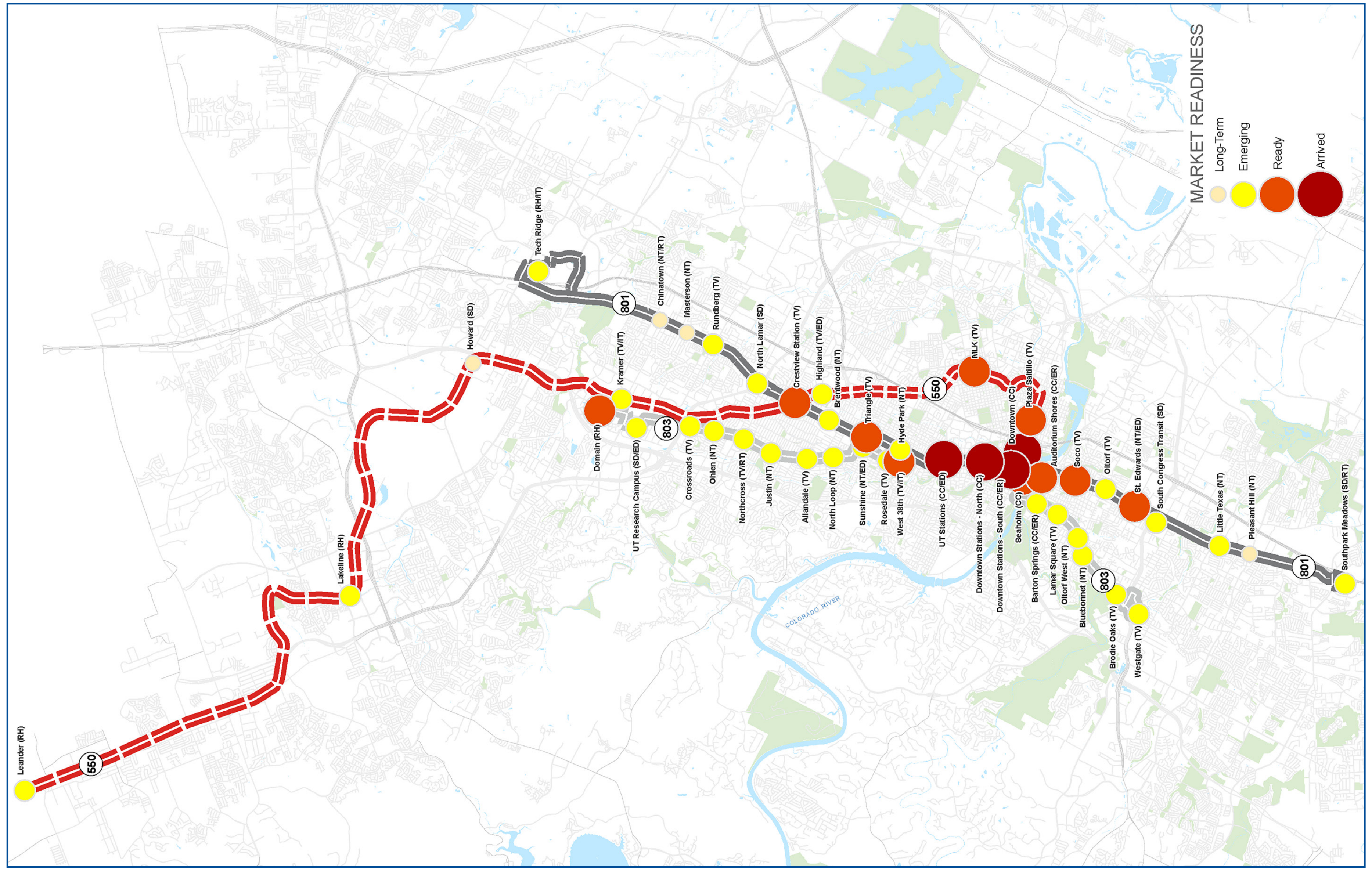
System Plan



TOD Typology Map



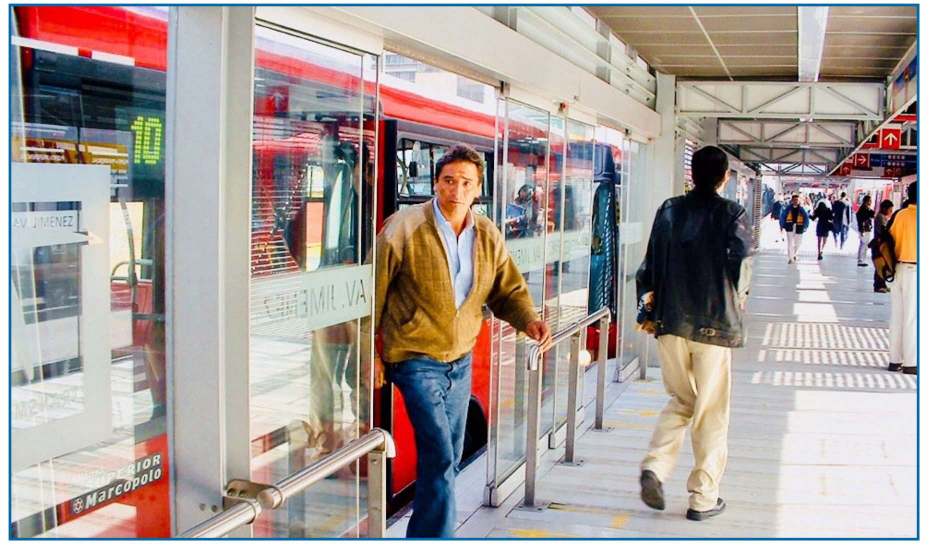
TOD Readiness Map



Casa Voyageurs Station, Casablanca (source: Andy Nash)


Estação Xaxim, Curitiba (source: BostonBrt)


Pampulha, Belo Horizonte (source: BostonBrt)

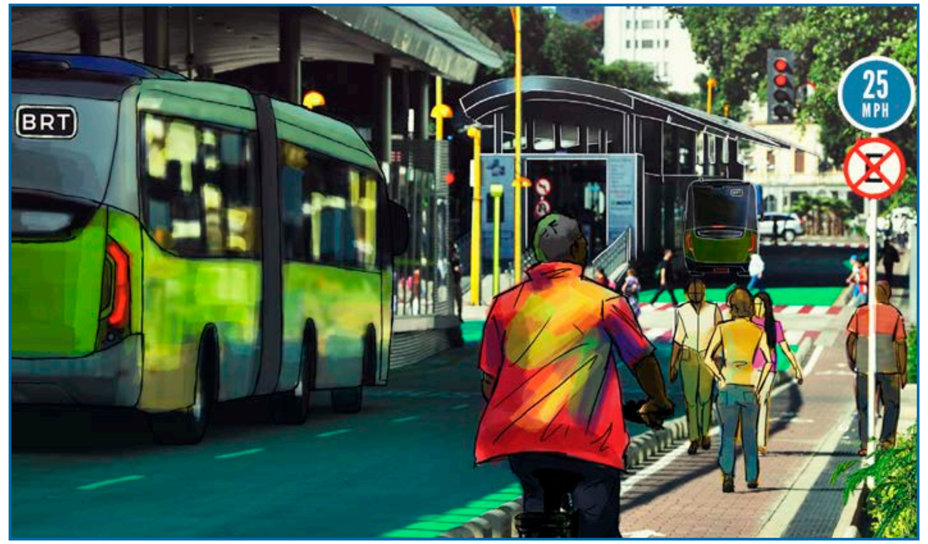

Avenida Jiménez Station, Bogotá (Karl Fjellstrom)

METRO | ILLUSTRATIONS


Enclosed BRT Station: Concept (source: BostonBRT)

BRT Transit Center: Concept (source: BostonBRT)

Dedicated BRT Lane: Concept (source: BostonBRT)



Complete Streets Separation Elements: Concept (BostonBRT)

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