



APTA STANDARDS DEVELOPMENT PROGRAM
RECOMMENDED PRACTICE

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APTA Bus Rapid Transit Working
Group

Designing Bus Rapid Transit Running Ways

Abstract: This *Recommended Practice* provides guidance on the design of running ways for bus rapid transit services. Included is a review of different types of running ways and design guidelines related to busways on separate rights-of-way, separate busways or HOV lanes within freeways, or exclusive bus lanes or transitways on arterial streets. Also included is guidance on BRT facility geometry, cross-section dimensions, drainage and other engineering considerations, and pavement design.

Keywords: bus rapid transit (BRT), busway, geometry, queue bypass lane, queue jump, running way, shyway

Summary: BRT is a suite of elements that create a high-quality rapid transit experience using rubber-tired vehicles. This experience often includes a high degree of performance (especially speed and reliability), ease of use, careful attention to aesthetics and comprehensive planning that includes associated land uses. BRT seeks to meet or exceed these characteristics through the careful application of selected elements.

Scope and purpose: The purpose of this document is to provide guidance to planners, transit agencies, local governments, developers and others interested in developing new BRT systems or enhancing existing BRT systems. This *Recommended Practice* is part of a series of APTA documents covering the key elements that may comprise a BRT system. Because BRT elements perform best when working together as a system, each *Recommended Practice* may refer to other documents in the series. Agencies are advised to review all relevant guidance documents for their selected elements.

This Recommended Practice represents a common viewpoint of those parties concerned with its provisions, namely, transit operating/planning agencies, manufacturers, consultants, engineers and general interest groups. The application of any standards, practices or guidelines contained herein is voluntary. In some cases, federal and/or state regulations govern portions of a rail transit system's operations. In those cases, the government regulations take precedence over this standard. APTA recognizes that for certain applications, the standards or practices, as implemented by individual rail transit agencies, may be either more or less restrictive than those given in this document.



Participants

The American Public Transportation Association greatly appreciates the contributions of the following, who provided the primary effort in the drafting of this *Recommended Practice*.

Joseph Barr
New York City Department of Transportation

Jordan Beveridge
Transport Canada

Carl Clayton
Stantec Consulting Ltd.

Alan Danaher
Parsons Brinkerhoff

Jack Gonsalves
PB Americas, Inc.

Bob Koziol
MMM Group Limited

Sean Rathwell
McCormick Rankin Corporation

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1. Types of running ways

Running way types vary in the degree of grade separation and lateral segregation from general-purpose traffic. Running ways can be classified into three types:

1. separate (or segregated)
2. freeway
3. urban street

Within each of these types are a number of forms, which are described below.

1.1 Separate (or segregated)

A separate running way is the most developed form of a busway and consists of a road or guideway dedicated to buses built on its own alignment. It can include both at-grade and grade separated intersections with cross-streets and free-flow ramps to and from other types of BRT running ways. **Figure 1** illustrates a separate busway facility.

A separate running way developed with a guided track using curbing or another low barrier on the outside of the track to help steer vehicles is referred to as a guideway. **Figure 2** illustrates a guideway.

FIGURE 1
BRT Busway



Source: McCormick Rankin Corporation

South East Busway (Brisbane, Australia)

FIGURE 2
BRT Guideway



Source: Adelaide O-Bahn Web site

Adelaide O-Bahn Guided Busway

1.2 Freeway

A freeway running way is built within the limits of the cross-section of a freeway, either as part of new construction or by retrofitting an existing facility. The running way's geometry is controlled by the geometry of the freeway's general traffic lanes. The running way can have one of three forms:

- **Median busway:** A dedicated bus facility in the median area, usually separated physically from other forms of traffic and with free-flow ramps to and from other types of BRT running ways.
- **HOV lanes:** A running way shared with high-occupancy vehicles on either the median side or the outer lanes of the freeway and not necessarily separated physically from the general traffic lanes.

- **Shoulder:** Permitted use of the outside shoulder of the general traffic lanes by BRT vehicles. Sometimes limited to peak hour periods or congested conditions and usually with various operating constraints, such as maximum operating speed.

Figure 3 illustrates these three forms of freeway BRT running way.

FIGURE 3
Freeway Running Ways



Source: Texas Transportation Institute

Freeway median busway (Interstate 45, Houston)



Source: TRB

Freeway HOV lane (Highway 403, Mississauga, ON)



Source: McCormick Rankin Corporation

Bus on freeway shoulder (Ottawa, ON)

1.3 Urban street

An urban street BRT running way is developed within the limits of the roadway cross-section, either as part of new construction or by retrofitting an existing facility. The running way geometry is controlled by the geometry of the roadway. The running way can have one of three forms:

- **Median busway:** A dedicated bus facility in the median area sometimes shared with other high occupancy vehicles and sometimes physically separated from other forms of traffic with some form of transit priority at locations where it intersects with other traffic.

- **Bus lanes:** Similar to a median busway, but typically located on the outside of the arterial roadway and sometimes shared with other high-occupancy vehicles. Typically, the bus lane is not physically separated from the general traffic lanes. Variations of this form include shared use of the lane for business access and right turns; it is commonly known as a business access and transit (BAT) lane.
- **Mixed-use lane:** Mixed use of a lane by both transit and general traffic. Intersection treatments such as roadway widening and added auxiliary lanes at intersections provide buses with the ability to “jump the queue” at such locations and provide some level of improved service times and reliability.

Illustrations of these arterial BRT running way treatments are shown in **Figure 4**.

FIGURE 4
Urban BRT Running Ways



Source: McCormick Rankin Corporation

Former No. 3 Road Median Busway (Richmond, British Columbia)



Source: TCRP Report 118 – BRT Practitioner's Guide

On-street bus lane (Silver Line, Boston)



Source: TCRP Report 118 – BRT Practitioner's Guide

On-street bus priority corridor (London)



Source: Kittelson & Associates, Inc.

Queue jump lane (Portland)

In many instances, site constraints within established urban roadway sections, such as building faces, parks, curbs, rights-of-way, frontage business improvements, etc., may not allow any or only a few feet of expansion of the street section. This typically happens in the “last mile” when the BRT corridor in question terminates

into a central business district (CBD) in order to tie into an existing transit or transfer facility. In these cases, travel speeds are relatively slow (less than 30 mph) and the BRT in mixed traffic congestion may or may not meet the travel speed goals of the system.

In these cases, several strategies may be considered. These concepts are not ideal and should be used only when other strategies are financially or politically prohibitive:

- bidirectional lane
- reversible lane
- peak hour only exclusive lanes

1.3.1 Bidirectional lane

A bidirectional BRT lane is an exclusive single lane that allows the BRT vehicle to pass in one direction through a constrained section while a BRT vehicle waits or dwells at a station or bypass area until it can be given the green signal to pass through the section in the other direction. This strategy is used when there is enough room to install only a single lane (a 12-foot-wide lane being desirable) and the headways are restricted in length as a practical matter to traverse through no more than three signalized intersections. The signal system needs to have safeguards that “block out” the section so that only one BRT vehicle can be in the section at a time. It is worth noting that when comparing the operations of a bidirectional lane with the BRT traversing the section in question in mixed-use lanes, the bidirectional lane exclusivity can provide some level of reliability over a congested mixed-traffic scenario.

Figure 5 presents an example of a bidirectional BRT lane.

FIGURE 5
Bidirectional BRT Lane



Franklin Corridor BRT (Eugene, Ore.)

1.3.2 Reversible lane

A reversible BRT lane has the same physical characteristics as a bidirectional lane, in that it is a single, exclusive lane within the section. However, operationally it functions differently. The BRT vehicle uses the reversible lane in one direction during the morning peak period and the other direction in the afternoon peak

period. This allows BRT vehicles to bypass the most congested traffic in the peak direction during the peak traffic period. In the off-peak direction during a particular peak period, the BRT vehicle must use a mixed-traffic lane, as the volumes would likely be low enough that transit schedule and speed would not be critically affected.

This concept can be best used when there is a distinct and significant split of volumes between the morning and afternoon peak periods — on the order of 30 to 70 percent. When forecasted volumes are balanced between afternoon and morning, this concept is not as viable.

1.3.3 Peak-hour-only exclusive lanes

This concept is one of managed lanes where the curbside general purpose lanes or the parking lane areas are restricted for only BRT vehicle use during a set span of time. This is typically during the one- to two-hour morning and afternoon traffic peak periods. This concept can provide opportunities for travel time savings. However, aggressive enforcement of the lane(s) during the restriction may be needed.

1.4 Selecting the appropriate BRT running way

Running ways, along with stations and vehicles, are essential parts of any BRT system. Their performance has a significant impact on potential operating speed, reliability, identity and passenger attraction. Alternatives that have a high degree of right-of-way segregation cost more than alternatives where BRT operates in mixed traffic or in reserved bus lanes. However, the former provides the fastest and most reliable BRT service, offers a high degree of system performance, and due to the permanence of dedicated bus right of way, may stimulate adjacent land development.

The choice of running way type for any given corridor will depend on market potential and specific route opportunities and constraints. Running way types and forms can be varied along a corridor to address physical and funding constraints/opportunities. Key questions to be asked in defining the most appropriate elements include the following:

- What are the markets to be served, what level of demand is projected, and how well are these markets served by proposed alignments?
- Are the proposed improvements intended to be permanent, or are they part of a staged implementation plan?
- Will there be a sufficient “presence” of buses in any corridor to make running way improvements worthwhile — particularly for busways and bus lanes?
- Will the proposed BRT system replace or augment the existing fixed route service in the corridor?
- Are suitable rights-of-way obtainable for busway development, and can these rights-of-way effectively connect with the city center and other major activity nodes?
- Are arterial streets and roadways wide enough or potentially easy to widen to provide exclusive median BRT running ways?
- What budget and funding constraints exist?
- Is there community and overall political support for the proposal and elements being considered?
- Are there significant environmental impacts, and will the possible need for environmental permits and approvals impact the project and timing of its development?

2. Separate busway design guidelines

Separate busways represent the highest order of running way for a BRT system. Dedicated lanes allow buses to travel freely and without obstruction (save for other buses), which provides a clear time advantage relative to mixed-flow running ways. Separate busways also represent a significant advantage for use by emergency

vehicle traffic to and from travel areas that might otherwise be congested or difficult to access during peak travel times.

Where possible, the best balance of the most direct route and the smallest number of grade-separated crossings and other costly project elements should be chosen. While this may seem obvious from the outset, cost considerations tend to take precedence over rider convenience/attraction, which more often than not tends to be the amount of travel time. Striking the right balance between overall cost and rider convenience is one of the most challenging yet most important aspect of the planning process for a separate busway facility. Because bus services are flexible and may be modified over time to reflect changing passenger and development growth patterns, where possible, connections between a dedicated bus roadway and the street system should be designed from the outset to accommodate turns in all directions.

2.1 Geometry

The geometry of a separate busway facility can be considered for two types of corridors: “greenfield busways,” which are busways constructed in areas that offer few limitations in terms of space, direct routes to the desired destinations, and require few if any expropriations, as they are on mostly undeveloped lands. The second type of corridor, a “constrained corridor,” uses routes that are limited in width, located along routes that are not entirely direct and/or are constructed adjacent to or within developed areas. These factors will have a significant influence on the construction cost, convenience and travel time associated with the busway(s).

Assuming that sufficient land space has been acquired, separate busways should be constructed with passenger comfort in mind. Similar to any other busway lane(s), geometry will influence the comfort and ultimately the attraction of transit users, particularly patrons who are standing. Therefore, abrupt changes in horizontal alignment should be avoided as much as possible.

The design speed of the busway should be selected with the notion that as a restricted access road with few obstructions, design speeds should match those of major comparable thoroughfares, while recognizing that constraints or local policy may limit the maximum design speed to some degree or in some areas. In general, the geometry of the busway should meet current AASHTO or TAC geometric design guidelines for the desired design speed.

Table 1 presents a summary of basic geometric design criteria and recommended values for separate busway facilities. Exceptions can be warranted on a case-by-case basis.

TABLE 1
Typical Busway Geometric Criteria and Recommended Desirable Values

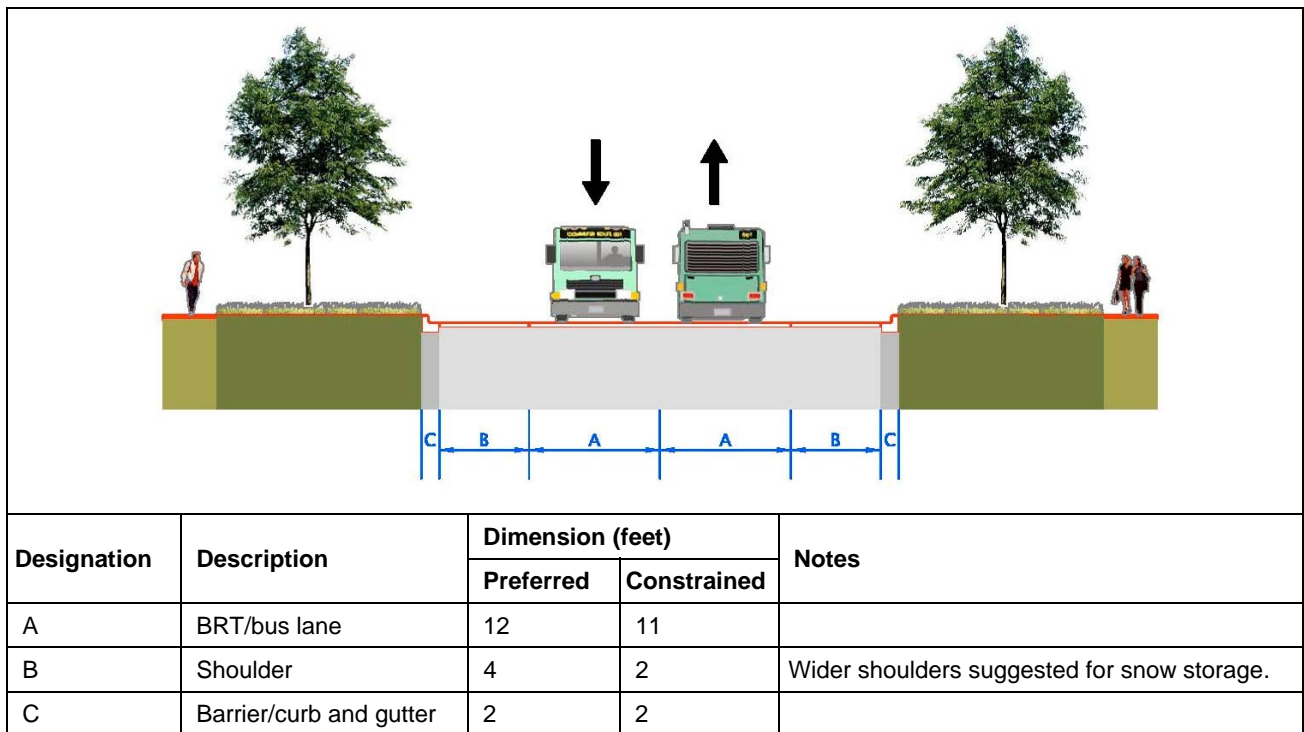
Criteria	Recommended value
Minimum design speed, mainline	40 mph (70 km/h)
Minimum design speed, station and CBD areas	35 mph (60 km/h)
Minimum design speed, arterial ramps and access roads	25 mph (40 km/h)
Minimum stopping sight distance	AASHTO/TAC standards
Minimum stopping sight distance at station areas (passenger comfort)	275 ft (85 m)
Minimum passing sight distance (station areas only)	AASHTO/TAC standards
Minimum horizontal sight distance	AASHTO/TAC standards
Maximum superelevation, separate busway	3%
Maximum superelevation, arterial/expressway facility	6%
Maximum superelevation at stations	2% (fall toward platform)
Maximum superelevation runout, main busway	1:400
Maximum superelevation runout, stations	1:200
Minimum horizontal curve radius, mainline	Based on minimum design speed
Minimum horizontal curve radius, stations and CBD areas	400 ft (120 m)
Minimum horizontal curve radius, absolute minimum	265 ft (80 m)
Minimum horizontal curve radius, ramps and access	150 ft (45 m)
Spirals, all curves less than 2850 ft (870 m) radius (when potential convertibility to LRT)	AASHTO/TAC standards
Minimum tangent at station ends (platform)	65 ft (20 m) (field or simulation modeling test if lower value desired)
Maximum intersection skew angle	20°
Minimum turning radius at intersections	Dependent on vehicle type, typically 40 ft (12 m) absolute minimum
Minimum grade, rural section	0%
Minimum grade, urban section	0.3%
Maximum grade, mainline	5%, up to 8% for short runs – 400-500 ft (120-150 m)
Grade range, stations	0.5% to 2.0%
Maximum grade, access roads and ramps	6%
Minimum crest and sag curves	AASHTO/TAC standards
Minimum crest and sag curves at stations (passenger comfort)	K = 17

2.2 Cross-section

Desirable cross-sections are based on those for public roadways with the same design speed. Minimum cross-section widths are constrained by the physical width of the bus. Typically, the bus width constraint occurs at the mirror level, where bus mirror to mirror widths can be on the order of 11 feet (3.35 meters).

The variability of separate busway cross-section elements and dimensions under both ideal and constrained conditions is illustrated in **Figure 6**, for a completely separated busway facility and where the busway is developed alongside one side of a roadway corridor.

FIGURE 6
Separate Busway Typical Section



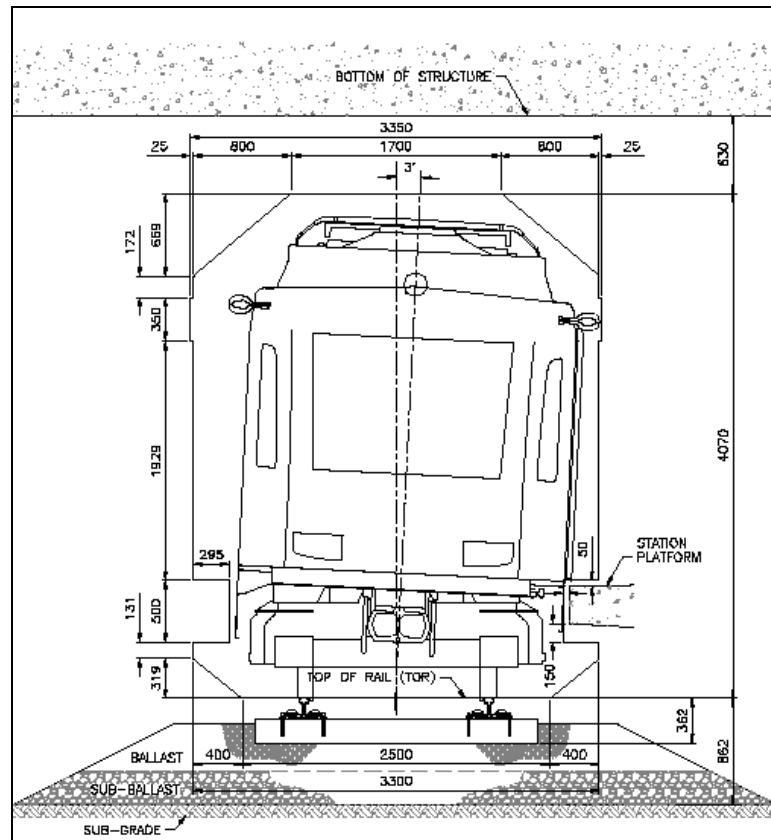
Ideally, lane widths should be 12 feet (3.65 meters), with shoulder widths outside station areas of a minimum of 4 feet (1.2 meters). Minimum recommended lane widths are 11 feet (3.35 meters) with a minimum shoulder width outside station areas of 2 feet (0.6 meters). Cross-section widths should be maintained across structures, although for long structures (more than 200 feet [60 meters] in length), cost constraints may warrant some reduction in the shoulder width.

At stations, the width of a bus bay or parking area at a station platform may be reduced to 10 feet (3.0 meters), assuming a separate bus passing lane is provided. Added width should be provided where needed to allow parking for maintenance vehicles or storing disabled buses.

In the case of a guided busway, the width of each bus lane can be reduced to as narrow as 8 feet, 10 inches (2.8 meters), with curbing provided on one or both sides of the busway. Curbing can also be provided on the outside of the busway cross-section outside station areas where there is limited lateral clearance, assuming bus operating speed is reduced.

The unobstructed vertical clearance over the busway should desirably be a minimum of 16.5 feet (5.0 meters). The minimum recommended clearance is 15.5 feet (4.7 meters). This will allow other vehicles, such as maintenance and emergency vehicles, to utilize the busway as well as allow possible future conversion to light rail transit. **Figure 7** shows the clearance box for a typical light rail vehicle.

FIGURE 7
Typical Light Rail Vehicle Clearance Box (Metric)



2.2.1 Access

There may be some situations where it is desirable to link the busway with a crossing or adjacent high-standard roadway or controlled access highway. Conventional one-way or two-way ramps are used.

Single-lane ramps should have a minimum width of 14 feet (4.2 meters) with 4-foot (1.2 m) shoulders to allow for passing of disabled buses or maintenance vehicles. For radii of 500 feet (120 meters) or less, off-tracking of a bus becomes significant and should be determined to verify the minimum width needed for passing. Multiple lane ramps should have lane widths consistent with the adjacent sections of the busway. In the case of an urban section ramp, the width of the curb and gutter is in addition to the width of the ramp lanes.

2.3 Other design considerations

2.3.1 Pavement structure

Guidelines for the design of busway pavements stem from direct experience with the design of flexible and rigid roadway pavement systems. These guidelines are proposed for use in the planning stage only and do not preclude the need for detailed pavement structure design.

Subsequent detailed investigation, necessary before final design, will almost certainly indicate the need for modifications to the typical pavement thickness given in this document. Factors such as design traffic, subgrade conditions, environmental effects, availability of acceptable construction materials, construction traffic, performance of similarly loaded pavements in the area and economics all need to be considered in order as part of detailed design to arrive at an optimum pavement structure.

Table 2 identifies some typical bus and gross vehicle weights for different potential BRT vehicle types.

TABLE 2
Typical Bus Weights and Gross Vehicle Weights

Bus type	Bus weight		Gross vehicle weight	
	lbs	kg	lbs	kg
40 ft (12 m)				
Diesel	27,500	12,500	39,600	18,000
CNG	29,000	13,100	39,600	18,000
Diesel-electric	30,800	14,000	39,600	18,000
60 ft (18 m)				
Diesel	41,500	18,800	63,900	29,000
Double-decker				
Diesel	32,100	14,600	51,100	23,200

Pavement design is directly influenced by the expected number of heavy axle loadings, as opposed to the gross vehicle weight, as multiple axles help spread the load on the pavement and reduce the impact. However, loading is not even across axles, and typically the rear axle on a two-axle vehicle will carry 70 to 75 percent of the gross vehicle weight. Note that even small increases in weight on an axle can cause disproportionately large amounts of damage to the pavement structure.

For the purposes of design, the traffic volume is represented by the number of equivalent standard axles (ESAs) typically using a design period of 20 years for flexible pavements and 40 years for concrete pavements. When comparing different pavement structures, a whole-life analysis of the alternatives is required to produce an equitable comparison.

Typical pavement section depths for a rigid pavement are in the range of 8 to 12 inches (175 to 250 millimeters) of portland cement concrete on a 6-inch (150 millimeter) deep crushed granular base course. For a flexible pavement, the typical depths are 7 to 8 inches (125 to 175 millimeters) of asphaltic concrete pavement over 12 to 18 inches (300 to 375 millimeters) of crushed granular base course. The life cycle of asphalt would include an overlay of 2 inches at approximately 12 to 15 years.

Additional consideration should be given to pavement design in BRT systems with lane guidance systems, as these systems tend to maintain a single wheel line loading that may promote faster rutting.

Experience has shown that rigid pavements perform better at bus stops and intersections, and their use is recommended in these cases.

2.3.2 Restriction of non-bus traffic

Pedestrian restrictions

Separate busways, while posing advantages due to restricted access and ability to travel at higher speeds, have the added responsibility of limiting access to pedestrians as well as vehicular traffic.

Where the busway is located in its own right-of-way, a fence or other barrier should be provided throughout the length of the busway for safety, for pedestrian control and to prevent trash dumping. Engineering judgment may dictate exceptions in areas of precipitous slopes or other natural barriers to access or in park-like areas. “No Trespassing” signs should be mounted on the fence or barrier at appropriate intervals.

Where retaining walls, abutments, buildings, etc. form a portion of the right-of-way to be protected, and are suitable for top-mounted fencing, the height of the wall may be considered as part of the fence height.

Where pedestrian crossings are required, it is recommended that they be at signalized crossing locations to avoid conflicts with buses. These could be equipped with transit signal priority

Vehicular traffic restrictions

Provision should be made in the design of all busway entry and exit points for the future installation, if necessary, of boom gates or other positive traffic control devices to permit the closure of the busway during off hours to prevent its unauthorized use.

Provision should be made for emergency vehicle access to busway right of way (e.g., through special access points). In the case of unguided busways, where the access point is gated, the gate should be a “crash gate” capable of entry by a fire truck. Where required for operations and maintenance purposes, access may be provided, with gates with suitable locking devices, to prevent unauthorized use. For ease of use, locking devices should be standard throughout the busway.

2.3.3 Drainage

Provision of adequate drainage is important in providing a safe driving surface during storm events and preserving the pavement structure. New or upgraded drainage systems, especially in urban areas, can have a significant cost depending on the storm frequency design event (1 in 5 year, 1 in 10 year, etc.) to be accommodated. Careful consideration to the cost and operational impacts is recommended. Placement of catch basins at station areas should be located upstream of the platform to intercept as much as stormwater as practical to avoid splashing patrons waiting to board.

Accommodation of further snow storage requirements where conditions warrant.

2.3.4 Landscaping

Landscaping requirements will vary depending on available right-of-way, agency policy, community desires and funding constraints.

2.3.5 Lighting

Street lighting is generally not warranted along separate busways. At stations, appropriate lighting levels are recommended for passenger comfort, safety and security.

2.3.6 Communication ducts

Consideration should be given to communication ducting requirements or opportunities associated with crossing or adjacent road or rail corridors. Where the busway is to be covered by closed-circuit television (CCTV) cameras, the duct location should reflect the likelihood that such cameras will be placed to minimize interference by bright sunlight. However, in general, communication ducts should be placed adjacent to an urban cross-section busway, in all structures, and under all platforms and paved surfaces to avoid future disruptions.

2.3.7 Signage, pavement markings and traffic control

Busway signage and traffic control should comply with Manual of Uniform Traffic Control Devices (MUTCD) guidelines and local practices:

At busway entry points and at stations, special busway signage should be installed to indicate the following:

For busway users / operators:

- maximum operating speeds
- cautionary operating speeds
- upcoming intersections
- changes in roadway geometry
- upcoming merges
- stop and yield conditions

For passengers and other users:

- pedestrian prohibitions and at-grade crossings
- busway entry prohibitions
- bicycle and private vehicle prohibitions

At all busway ramps and entry points, signage should indicate that entry onto the busway is restricted to authorized vehicles only. At the same location advisory signage should show busway operating speeds and the general prohibition on passing except where the busway is specifically widened for this purpose. In locations, where hazards may delay BRT vehicles, signs should be placed upstream of the potential hazard at locations that permit BRT vehicles to detour onto the local street system and avoid the hazard.

Signalized traffic control should be used at all intersections with other streets and where necessary at intersections with restricted sight distance (i.e., where walled). Otherwise, traffic signals should be used only to alert busway vehicle drivers in sections of the busway that are determined to require signals for safety considerations. Examples would include tunnels, bridges and contraflow lane sections.

All traffic control signals at BRT intersections (including on-street operation) should have in-pavement detector loops or other bus detection devices installed on board the BRT vehicles tied to the priority treatment at the traffic signal controller. Signal timing and phasing should be designed to minimize any disruption to the smooth flow of buses in the BRT corridor.

Provision should also be made for automated advisory signage visible to the public (triggered by approaching buses), including accommodation for people with vision impairment, at any at-grade crossings of the busway.

Busway pavement markings should consist of a single, solid, yellow line on the centerline throughout and solid, white edge pavement lines at stations and channelization.

Based on local station features, suitable directional and information trail-blazer signage should be considered to direct potential busway patrons from controlled-access highways, arterial roads and suburban streets to busway parking areas and drop-off zones.

2.3.8 Rail corridor interface

Where a separate busway alignment is adjacent to active railway tracks, the busway should be designed to meet the specific railway design criteria and standards, in particular addressing the following design elements:

- design speed
- maximum horizontal and vertical geometry
- horizontal and vertical clearances
- superelevation criteria
- storm frequency for drainage design/minimum pipe size and pipe material
- minimum depth for ballast and sub-ballast
- live/impact loads for structural design
- minimum widths of bridges

While rail authority criteria will govern, the following criteria are provided as generally applicable guidelines:

- Minimum offset from the centerline of the railway tracks to the edge of the busway right-of-way should be 18 feet (5.5 meters).
- A concrete barrier or a crash wall, if required, should separate the two facilities if the distance between the center line of the railway tracks and the edge of pavement of the busway is less than 20 feet (6.1 meters) on tangent or 21 feet (6.4 meters) on curve.
- For over-rail bridges, the minimum horizontal clearance measured from the center line of track to the near face of the obstruction is 20 feet (6.1 meters) for tangent track and 21 feet (6.4 meters) for curves. The minimum vertical clearance is 22 feet (6.7 meters).

3. Freeway design guidelines

3.1 Median busway

Within freeways and expressways, there are often opportunities to construct busways between the median barrier and the general-purpose traffic lanes.

3.1.1 Geometry

The design speed of the median busway should match the design speed of the adjacent freeway to avoid differences in alignment geometry between the busway and the freeway. As a result, the geometry of the busway should meet current AASHTO or TAC geometric design guidelines.

3.1.2 Cross-section

The median busway should be designed with at least a 2-foot (0.6 meter) paved shy distance between the edge of the median barrier and the edge of the bus lane. The bus lane should be at least 10.5 feet (3.2 meters) wide, with a preferred width of 12 feet (3.6 meters). The median busway does not require a horizontal separation between the bus lane and the adjacent general-purpose traffic lane, although 2 feet of painted marking separation is considered desirable unless speed differential regulation applies in which case greater separation may be required.

The unobstructed vertical clearance over the busway should desirably be a minimum of 16.5 feet (5.0 meters). The minimum recommended clearance is 15.5 feet (4.7 meters). This will allow other vehicles, such as

maintenance and emergency vehicles, to utilize the busway, as well as allow for possible future conversion to light-rail transit.

3.1.3 Signage, pavement markings and traffic control

Lane designation signs should be installed at the start and end of the median busway. Overhead signs designating the busway should also be installed at intervals of about 15 seconds based on traveling at the posted speed. The maximum spacing of the signs should not exceed 30 seconds.

Pavement markings should be in accordance with the guidance of the MUTCD. Typically, these would consist of a solid white pavement marking between the bus lane and the general-purpose traffic lane and the words “Bus Only” painted in the busway cross-section, similar to HOV standard markings.

3.2 Bus use of shoulders

A possible configuration for longer-distance BRT routes is to use the existing shoulders on expressways or freeways. This configuration is often referred to as a reserved bus lane (RBL) or bus on shoulders (BOS). BOS typically uses the right-hand shoulder, though left-hand shoulders can also be used for BOS if it is an express-type service. There are a number of advantages to placing the BRT running way on the shoulders, including the following:

- Transit vehicles have the ability to enter and exit the shoulder whenever necessary to leave or enter the general-purpose outer traffic lane to maintain operating speed.
- The investment costs to convert a conventional shoulder to a BRT guideway are relatively low, typically limited to upgrading the pavement structure on the shoulder to accommodate the heavier and more constant use by BRT vehicles and the adjustment of stormwater inlets for ride quality.
- Transit vehicles have the ability to exit the freeway without weaving if they are making connections at interchanges.
- Freeway design standards usually permit high BRT vehicle operating speeds.

The disadvantages of having the BRT running way on a freeway shoulder include the following:

- Disabled vehicles on the shoulder require that all transit vehicles re-enter the adjacent general-purpose traffic lane to pass the disabled vehicle.
- Upgrading of the shoulder pavement structure to accommodate the loadings from BRT vehicles may create delays to freeway traffic during construction work, unless there is sufficient room in the median to permit the lanes to be shifted during construction.
- Extra signage and motorist information is required to explain the use of the shoulders by buses.
- Transit vehicles may have to merge into the general-purpose lanes in advance of interchange exits if the bus does not exit at that location.
- Consideration needs to be given in operating policies to possible major speed differentials between buses and other traffic on the adjacent congested general-travel lanes.

It is desired that an RBL have an 11-foot (3.35 meter) wide travel lane with an additional 2-foot (0.6 meter) wide paved shy distance between the edge of the running way and any obstructions, piers, sign supports, walls, ditch edges or guiderails, as well as a 2-foot (0.6 meter) buffer between the RBL and the adjacent general-purpose lanes. However, in retrofit situations, the dimensions are typically limited by existing adjacent obstructions. Widening of the existing shoulder width to the desired 15-foot (4.5 meter) section is not always attainable.

3.3 HOV lanes

High-occupancy vehicle (HOV) lanes can be used for BRT and other transit vehicles on freeways and expressways. The HOV lane can be located on either the median side or the outer side of the general-purpose traffic lanes. The operational challenge with use of a median HOV lane is getting buses out of the lane and across the general-purpose traffic lanes in order to exit.

3.4 Pavement structure

The pavement structure of the existing median or shoulder should be reviewed carefully to ensure that it can accommodate the additional loads from the BRT vehicles. Typical bus weights and axle loadings for potential BRT vehicle types are addressed in Section 2, “Separate busway design guidelines.”

3.5 Drainage

Often, the existing drainage system will be adequate to accommodate increased run-off from any pavement widening required. In this case, drainage work will likely be limited to relocating of catch basins or culvert extensions. Where an assessment suggests that the additional pavement area will result in the original storm frequency design event (1 in 5 year, 1 in 10 year, etc.) not being accommodated, careful consideration to the cost and operational impacts is recommended.

4. Arterial design guidelines

In many locations, BRT will operate on an arterial street, which implies a much greater degree of interaction both with other elements of the transportation system (i.e., intersections, traffic signals, parking) and with other users of the transportation system (i.e., private vehicles, pedestrians, cyclists).

The context for an arterial running way can vary from an urban arterial in a dense, built-up area all the way to a suburban or even semi-rural arterial with shoulders. Given this diversity of potential locations and surrounding contexts, each BRT running way on an arterial must be carefully designed to match the specific needs of that location. This section attempts to lay out the major types of arterial running ways and some of the most common design issues that must be addressed.

4.1 Median busway

A median busway is a reserved (exclusive) lane running down the center of a street, with stations located within or adjacent to the busway. This layout is similar to the operation of many LRT systems, particularly as they travel through areas where a separate right-of-way is not available. These are typically two-way facilities, although it is possible to have a one-way facility, either paired with another facility on a parallel street, or as a bidirectional lane or as a reversible facility (when there is strong peaking of demand). Another variation exists on a one-way street, where the “median” busway would actually be located adjacent to one curb, since the second direction of traffic that would normally be on the other side of the busway does not exist.

One major advantage of a median busway is that there is typically no demand for other vehicles to stop in the center of the street for purposes such as parking or as a breakdown lane. As a result, there is a lot less reason for vehicles to want to occupy the center of the road and less resistance to creating a physical barrier separation between the busway and the adjacent general-traffic lanes. This translates into fewer problems with enforcement and greater integrity of the bus lane.

4.1.1 Geometry

Between stations

Functionally, a median busway is a road-within-a-road, typically a two-lane road located within the right-of-way of a larger road. As such, the geometry of the busway will almost always follow the geometry of the existing road, unless there is some very specific need for a separate layout. One example of this, although not common, would be to have the busway cross a major intersection with a grade separation, while the rest of the roadway uses an at-grade intersection.

Station areas

The geometry of the busway and the surrounding roadway must be given careful consideration at and approaching stations. As discussed in greater detail in the APTA *Recommended Practice* “Bus Rapid Transit Stations and Stops,” there are two main types of BRT stations associated with a median busway: center platform and side platform.

- **Center platform:** The use of center platforms is most practical if the buses have doors on the left side, but it is also possible if the buses operate in a contraflow manner to traffic. Where utilized, both the busway and the surrounding roadway typically must be realigned to the outside to provide adequate space for the station. The design of the tapers for this transition must carefully take into account the design speed for both the roadway and the busway, and any unique handling characteristics of the buses being used.

Consideration should be given to providing an outside passing lane (located to the right of the stopping lane), to accommodate multiple services or to improve the overall level of service. This will increase the space required for the station, both laterally to accommodate the extra lane and longitudinally to accommodate the additional taper length for the main roadway.

- **Side platform:** In the case of a side platform station, the busway will typically continue straight, but the adjacent roadway will need to be realigned to the outside to accommodate the stations. Consideration should be given to how the platforms will be protected from general traffic, both in the taper area and where general traffic is adjacent to the platform. Consideration should also be given to increasing the length of the taper beyond the minimum length, to provide a smooth transition for general traffic and to minimize the chances of an errant vehicle crashing into the platform area.

If the busway itself includes a center passing area, then this will require the design of an entry taper for buses that are moving into the stopping lane. However, this taper can take into account that these buses will be slowing as they enter the station, potentially reducing the design speed. Conversely, to avoid system performance issues, the exit taper will also need to take into account the acceleration profile of the buses, to provide for a smooth merge back into the main flow of the busway.

4.1.2 Cross-section

The recommended cross-section of a median busway is similar to a two-lane road, with a 12-foot (3.65 meter) wide lane in each direction divided by a pavement marking. If space allows, the width of the bus travel lanes could be expanded to 13 to 15 feet (3.9 to 4.5 meters), to provide greater lateral separation, particularly through curves and to improve safety. In constrained urban areas, the recommended minimum width of the travel lanes is 11 feet (3.35 meters).

One of the major advantages of a median busway is that there is typically no legitimate reason why other vehicles would want to access the facility, as compared to curb lanes, where there may be a demand for access to the curb for short-term loading and parking, even when a bus lane is present.

It is therefore possible to design a greater level of physical separation to self-enforce the facility. Treatments can range widely, including options such as median barriers, low curbs, landscaping, vertical delineators, rumble strips and painted markings. Although the introduction of a physical separation such as a concrete barrier adds additional protection, it also adds additional width to the section, as shy distance on either side of the barrier needs to be added in addition to the barrier width. The choice of separation between the busway and the general-purpose lanes of the main roadway should take into account the operational impacts on buses using the busway, the length of the blocks, the adjacent land uses and the character of the street. The levels of traffic on the surrounding street also need to be considered, as high levels of congestion could lead some drivers to attempt to use the busway as a bypass lane, if it is not properly protected.

In the area of the stations, the cross-section of a median busway will widen significantly, if space is provided for both stopping lanes and passing lanes. This widening may require acquiring additional right-of-way. If it is impractical to acquire additional right-of-way, then the extra space required for the station can sometimes come from restricting on-street parking in the area adjacent to the station, or by reducing the number of general purpose traffic lanes. As discussed in Section 4.1.3, “Signage, pavement markings and traffic control,” this roadway widening can also be used to create protected left-turn bays.

Existing or proposed roadway cross-fall needs to be considered. If excessive, it may not allow the use of the wheelchair ramp provided in many modern buses.

Figures 8-11 illustrate typical cross-sections for both two-lane/two-way and one-lane reversible median busway designs, given different surrounding roadway widths and station configurations. The cross-sections are presented for both midblock and intersection configurations. These are shown for both an ideal cross-section (where available right-of-way is not an issue) and a constrained cross-section (where the available right-of-way is limited). Although each median busway will need to be carefully designed to the specific context where it is being installed, these typical cross-sections provide a good starting point for detailed design, as well as a good visual tool for explaining this configuration to decision makers, community residents and other stakeholders.

FIGURE 8
Two-Way Median Busway, Typical Cross-Section

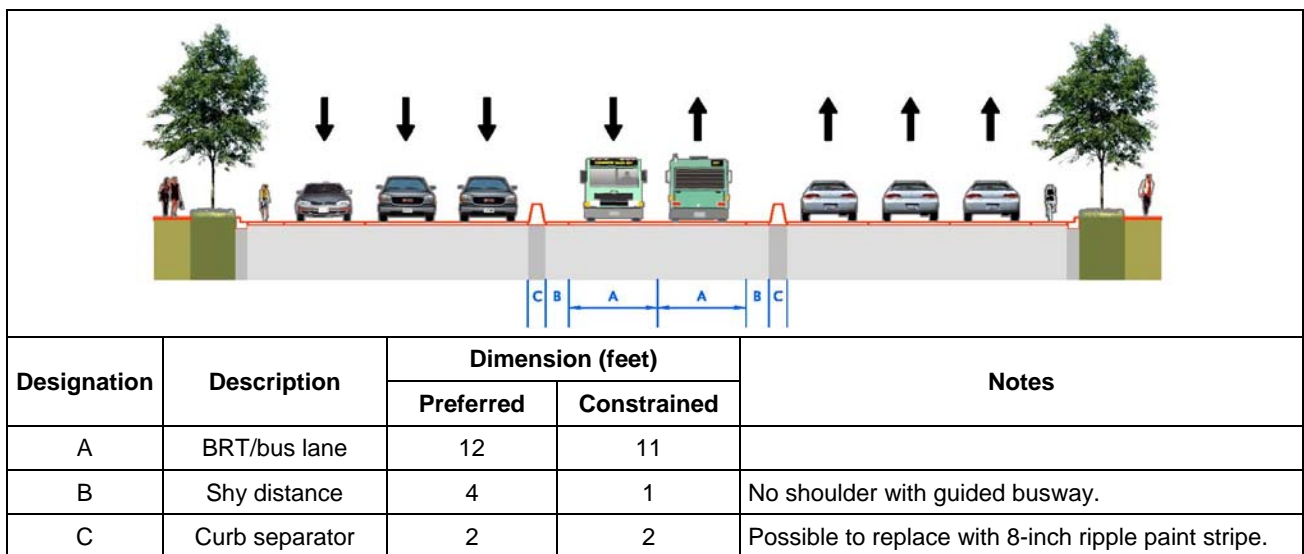


FIGURE 9
Two-Way Median Busway, Typical Cross-Section

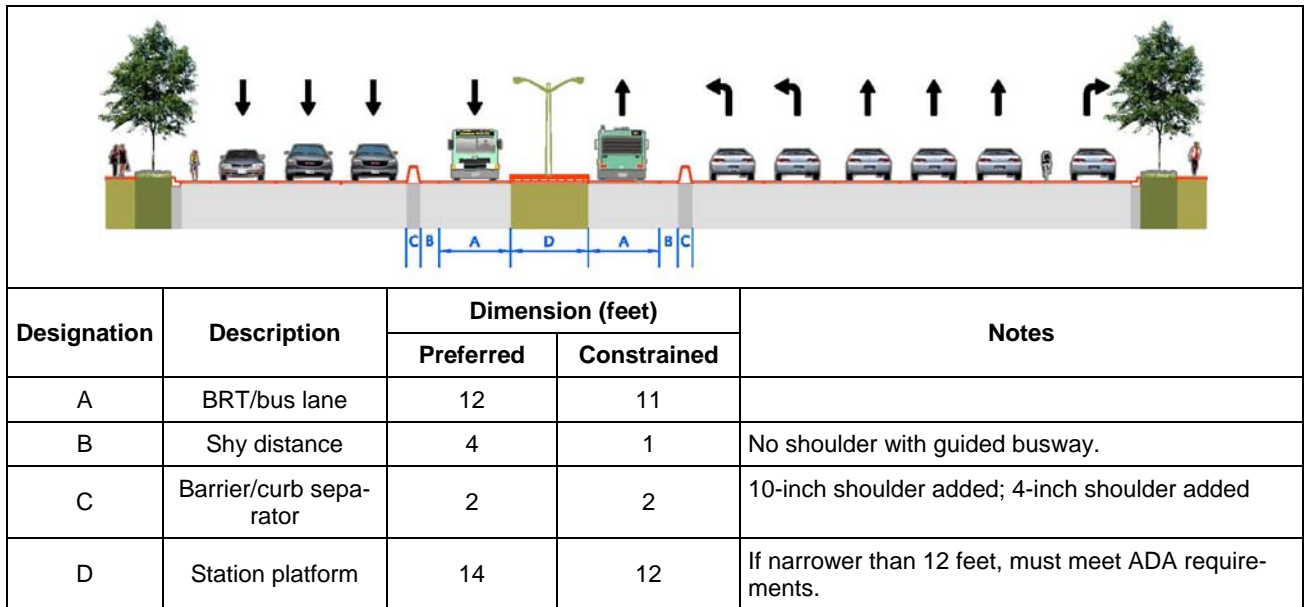


FIGURE 10
Two-Way Median Busway, Typical At-Station Section

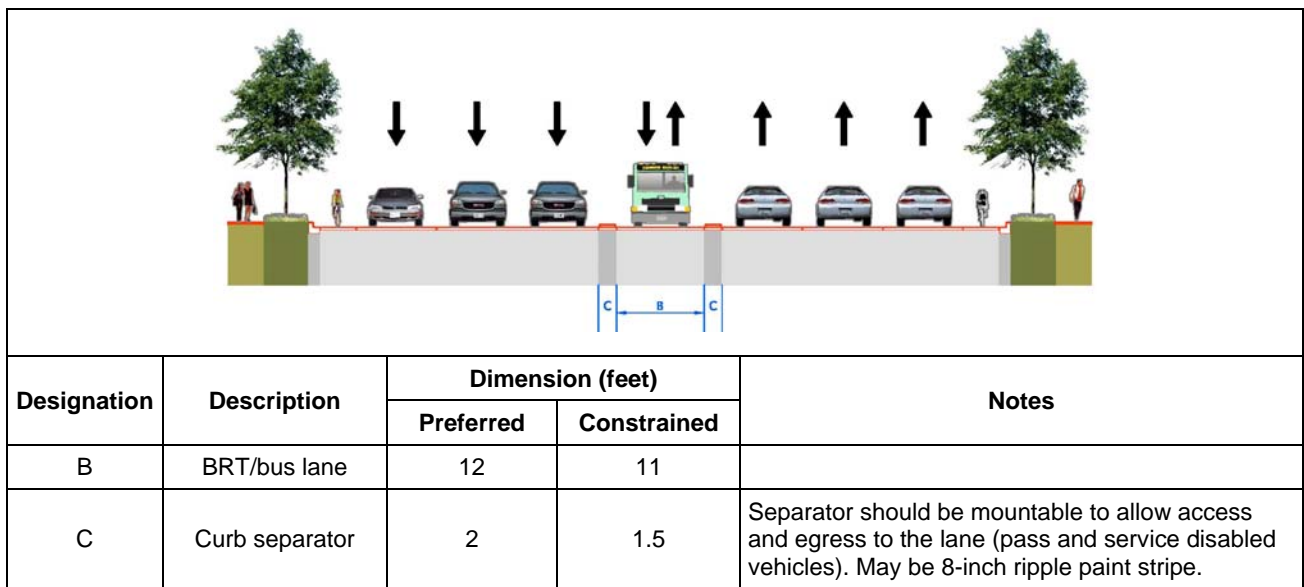
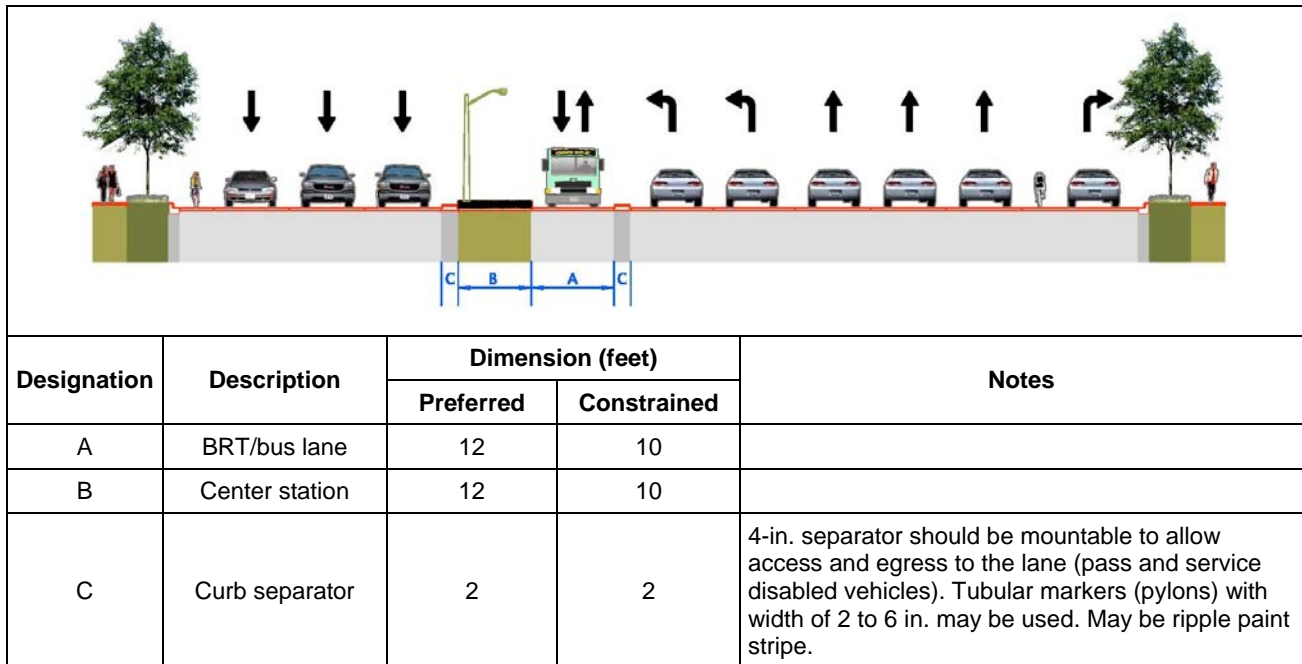


FIGURE 11
 Bidirectional, One-Lane Median Busway, Typical Midblock Cross-Section



4.1.3 Signage, pavement markings and traffic control

In general, a median busway is readily apparent to other users, so there should be limited need to mark the lanes in an aggressive manner, particularly if there is some type of physical separation. One location where close attention should be paid to signs and markings is at intersections, to make sure that other vehicles do not mistakenly enter the busway. In particular, cars turning left from a side street may find it somewhat difficult to distinguish the busway from the general traffic lanes, and an appropriate package of signs and markings should be deployed. This could include “RIGHT LANE BUSES ONLY” signs (MUTCD R3-11b), “Keep Right of the Median” signs (MUTCD R4-7), and “peg-a-track” or guideline markings to direct vehicles to the outside of the busway.

Sight-line constraints for left-turning traffic may be created by a median busway. This must be avoided by allowing left turns only at traffic signalized intersections and through use of a fully protected left-turn phase. This protected left-turn operation typically requires a dedicated left-turn lane, unless the turning volumes are very low, in which case it might be more desirable to prohibit the left-turn movement altogether. While this left-turn phase requires stopping the oncoming traffic *and* all traffic in the busway, application of transit signal priority technology can help to minimize delays for buses by ensuring that the left-turn phase is not activated when a bus is approaching the intersection. It is also common to pair a left-turn lane leading up to an intersection with a far-side BRT station, such that the station platform is located “in the shadow” of the left-turn lane, taking advantage of the extra width required for the station to also accommodate a dedicated left-turn lane.

4.1.4 Drainage

Often, the existing drainage system will be adequate to accommodate increased run-off from any pavement widening required. In this case, drainage work will likely be limited to relocating of catch basins or culvert extensions. Where an assessment suggests that the additional pavement area will result in the original storm frequency design event (1 in 5 year, 1 in 10 year, etc.) not being accommodated, careful consideration to the

cost and operational impacts is recommended. When considering physical separation such as with median barriers or curbs, it is also critical to look at the cross-flow drainage impacts and any costs that might be associated with required utility relocations.

4.2 Curb bus lanes

The most common form of an arterial bus lane is one located at the right side of the street, adjacent to the curb or the shoulder. While this layout is common in locations throughout North America, simply installing a curb bus lane does not imply the creation of a BRT running way, as curb bus lanes are subject to a variety of interference and conflicts, including right-turning vehicles, vehicles seeking to park or load at the curb, and vehicles entering or exiting at curb cuts. In this context, maintaining the integrity of the bus lane through signs, markings, education and ongoing enforcement is critical to ensuring the speed and reliability of bus service in these lanes.

A variation of the curb bus lane that addresses some of these conflicts is an interior or “offset” bus lane, which operates in the lane adjacent to the curb lane. This configuration leaves the curb lane available for other uses, including direct curb access for loading and parking and right-turn lanes. The negative aspect of an interior or “offset” bus lane is that it has a significant impact on the travel capacity of the street, whereas the installation of a curb bus lane on a street with on-street parking will not change capacity. However, in some locations there may be less concern about eliminating roadway capacity, particularly if there are good alternative routes, as compared to eliminating parking or loading that may have a greater impact on viability of local businesses.

4.2.1 Geometry

Both a curb bus lane and an interior bus lane will necessarily follow the geometry of the roadway along which it is located. As a result, very little consideration needs to be given to the geometry of the road, as this is typically a fixed input. In the case where a bus lane is being installed as part of a new street, consideration should be given to the presence of a bus lane in laying out the street geometry, but this is unlikely to be a significant factor, since arterial streets by their nature are typically designed to handle buses as a baseline condition.

Where space is available and there is likely to be a need for buses to pass each other (for example, if there are multiple tiers of service operating in the same bus lane), it is sometimes desirable to install bus pull-outs, which allow buses to pull to the right and leave the bus lane clear, similar to the passing area at a station. The design of these types of pull-outs should take into account issues such as deceleration distance, the distance necessary for a bus to transition into the pull-out and maintaining proper drainage.

In the case of an interior bus lane, it is common to use curb extension bus stops, or “bus bulbs,” where the sidewalk is extended out into the curb lane to meet the interior bus lane. This avoids the need for buses to pull to the curb to stop, speeding bus operations and potentially reducing the length of the bus stop. This design also increases the space available for station amenities and can allow for a raised curb height that provides level boarding with a low-floor bus. The design of a bus bulb should follow local geometric guidelines for items such as curb return radii, drainage and sidewalk materials. It is also important to consider the need to modify and/or relocate any utilities that are within the footprint of the bus bulb.

4.2.2 Cross-section

The cross-section of a curb bus lane is typically only a redesignation of the curb or an interior lane as a bus lane. The recommended minimum width for a bus lane is 12 feet (3.65 meters) to allow for unimpeded bus operations, although a reduction to 10 to 10.5 feet (3 meters) may be necessary in particularly constrained locations. If additional width is available to provide a 13- to 15-foot (3.9 to 4.5 meter) curb lane, this is

desirable. This is because it is often difficult or uncomfortable for bus drivers to travel directly adjacent to the curb due to the presence of catch basins, uneven pavement and adjacent mounted signs.

If a curb bus lane is replacing on-street parking or loading, then the bus lane will typically require greater width than the parking lane it is replacing, which may require adjusting the lane widths of the adjacent lanes to provide sufficient width for the bus lane. In contrast, an interior bus lane is usually installed in place of an existing travel lane, which will typically be of the appropriate width.

Existing roadway cross-fall needs to be considered. If excessive, it may not allow the use of the wheelchair ramp provided in many modern buses.

Given the other uses of curb space, it is generally not possible to totally physically separate a curb or interior bus lane, unless these other uses are relocated to the outside of the physically separated area. However, some options do exist for providing a “soft” separation between the bus lane and general traffic. These include a continuous rumble strip, similar to what is commonly used along the edge of highways, raised pavement markings (usually only used in areas where snow plowing is uncommon) or widely spaced vertical delineators. Because there is not a great deal of experience with these types of treatments, these should be carefully considered and analyzed in any given location or context to ensure their safety and appropriateness.

Figures 12-15 illustrate several typical cross-sections for both concurrent and contraflow curb bus lanes in midblock areas and at intersections, given different surrounding roadway widths. These are shown for both an ideal cross-section, where available right-of-way is not an issue, and a constrained cross-section, where the available right-of-way is limited. Although every bus lane will need to be carefully designed to the specific context where it is being installed, these typical cross-sections provide a good starting point for that detailed design, as well as a good visual tool for explaining this configuration to decision makers, community residents, and other stakeholders.

FIGURE 12

Concurrent Flow Curbside Bus Lanes on a Two-Way Street, Typical Intersection Section

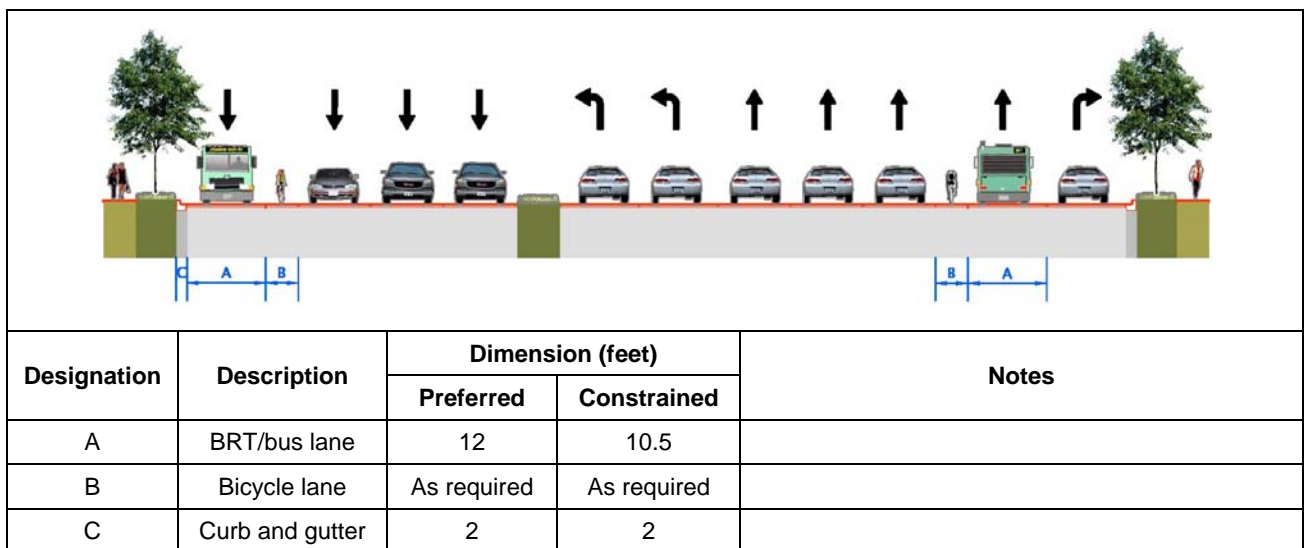
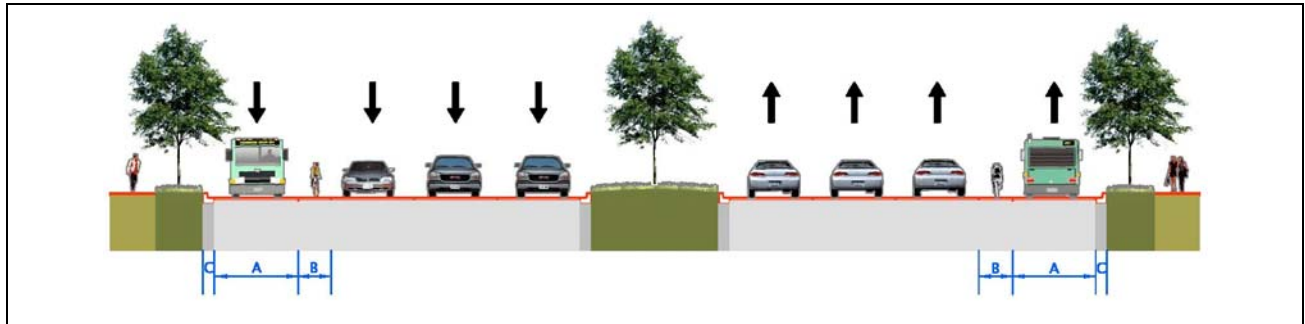


FIGURE 13

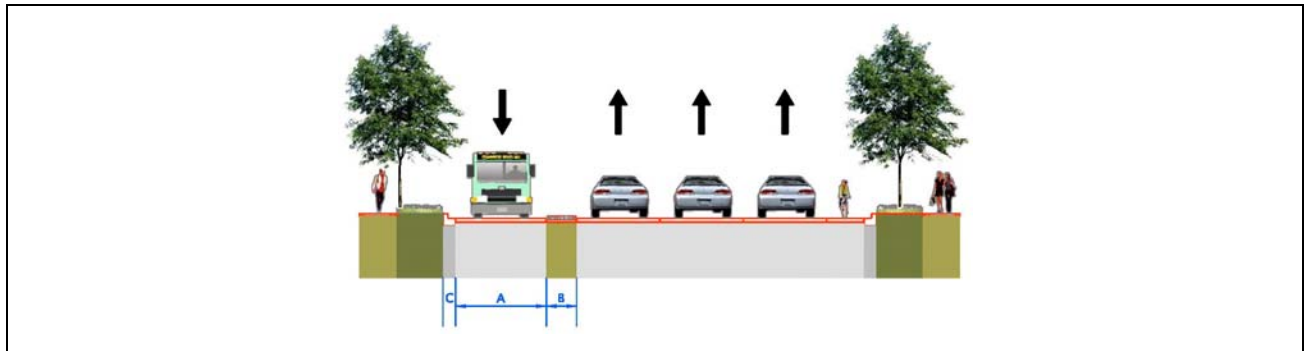
Concurrent Flow Curbside Bus Lanes on a Two-Way Street, Typical Midblock Section



Designation	Description	Dimension (feet)		Notes
		Preferred	Constrained	
A	BRT/bus lane	12	10.5	
B	Bicycle lane	As required	As required	
C	Curb and gutter	2	2	

FIGURE 14

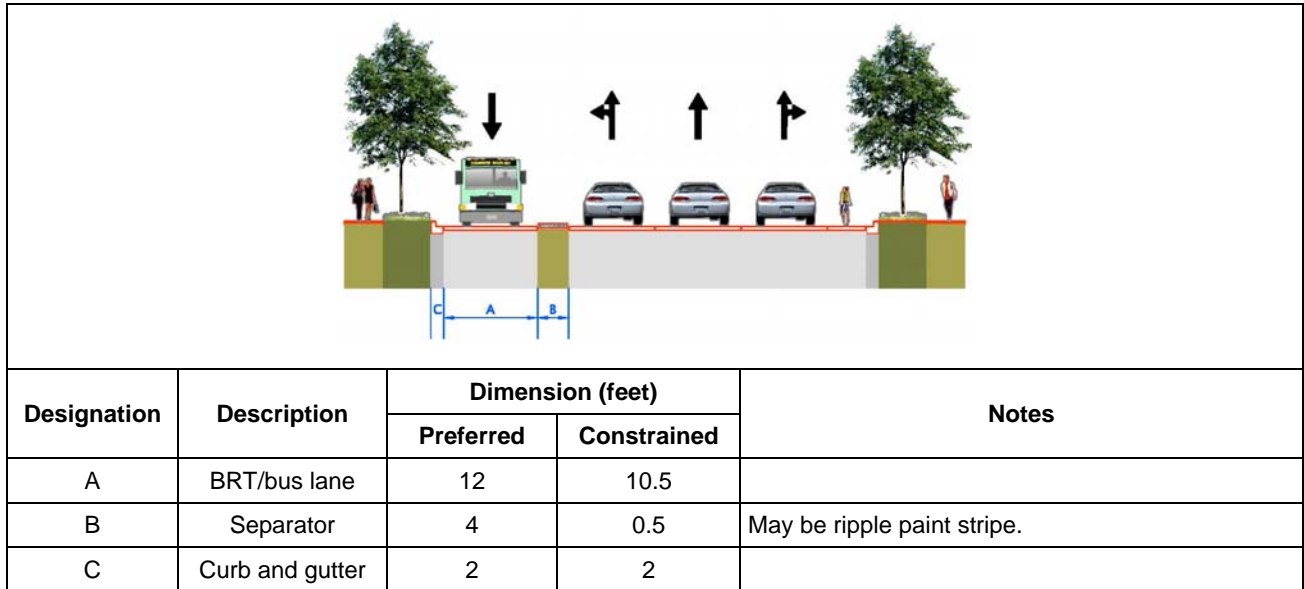
Contraflow Curbside Bus Lanes on a One-Way Street, Typical Section



Designation	Description	Dimension (feet)		Notes
		Preferred	Constrained	
A	BRT/bus lane	12	10.5	
B	Separator	4	0.5	May be ripple paint stripe.
C	Curb and gutter	2	2	

FIGURE 15

Contraflow Curbside Bus Lanes on a One-Way Street, Typical At-Station Section



4.2.3 Signage, pavement markings and traffic control

Signage and pavement markings are an important element of a curbside bus lane, given that it is often difficult to implement a physical separation and that the lane may not serve as a bus lane 24 hours a day or seven days a week. The decision as to how aggressively to mark and sign a bus lane should be based on the specific context and environment in which a bus lane is being installed. For example, a suburban location with longer blocks will likely require less intensive signing and marking than an urban location with frequent intersections and/or curb cuts and significant visual clutter.

In general, some type of sign should be located on each block, to ensure that all vehicles are directed out of the bus lane and to provide a basis for enforcement at any location along the bus lane. Signs mounted on overhead mast arms above the bus lane are more effective than signs mounted at the side of the road, because they are more visible and more directly indicate the location of the lane, particularly in the case of an interior lane. Preferential pavement markings should be in accordance with the MUTCD.

Using a portland cement concrete pavement rather than an asphaltic concrete pavement can assist in differentiating the bus lane from the general purpose traffic lanes. In some countries the use of colored pavement or painted bus lane is common, with colors such as red (the most common), green and blue in use. Although there have been experiments and short sections that have used color in North America, these experiences are relatively limited.

TAC Standards currently in development on this subject will recommend red coloring for bus lanes, with green reserved for bicycle lanes and blue for disabled parking facilities.

One of the greatest sources of conflicts with curbside bus lanes is other vehicles making right turns, since these vehicles are generally allowed to enter the bus lane to make a turn. Particularly in areas with higher pedestrian volumes where there may be conflicts that create delay for right-turning vehicles, these right turns can create significant delays for buses as they wait for vehicles to turn or maneuver around them. Careful consideration should therefore be given to the impact of right turns and pedestrian volumes on the overall integrity of the bus lane.

If right-turn conflicts create too much interference with the bus lane, then it may be necessary to consider banning right turns at certain locations, which can be difficult to enforce, or providing a separate turning phase for right turning vehicles. Installing an interior bus lane also provides a solution for right turns, as a right-turn only lane can be created in the curb lane, with buses circulating relatively unimpeded in the interior lane even if right-turning vehicles are queued.

4.2.4 Drainage

The edge of the roadway where a curb bus lane is located is also typically where catch basins and other drainage and utility features are located. This can create an uneven roadway surface, and over time, this surface may deteriorate more due to the regular passage of heavy buses. Although it is not possible to move many of these features out of the bus lane, it may be necessary to undertake some preventive maintenance in advance, for example to ensure that catch basin covers are set level into the pavement or that side inlet catch basins are utilized and that the surrounding pavement is in good condition. More frequent assessment of the running way in these areas is also recommended, to ensure that any problems are identified and addressed early, before they deteriorate into more serious problems. The gutter pan within the curb and gutter should be equal in depth to the adjacent pavement to fully support the BRT vehicle loading.

4.3 Intersection treatments

4.3.1 Bus bypass lanes and queue jumps

Where BRT vehicles operate in mixed traffic along an arterial street, intersection-specific running way improvements can still be developed through the development of bus bypass lanes. These typically involve the BRT vehicles using either an existing right-turn lane curbside to bypass the through traffic, or the development of a separate bypass lane between a right-turn lane and adjacent through lane. In either case, it is desirable to have the bus bypass lane be sufficiently long to allow buses to bypass the through-traffic queue. In the case of a separate bus bypass lane, it would have the same signing and pavement markings as an extended bus lane along the street.

The bus bypass lane at intersections can operate in one of two ways. The first option would be tied into a “queue jump” treatment, where buses would obtain a “green” advance signal to pull ahead of through traffic before the general signal phase. In this case, if there is a BRT stop at such an intersection, it would be located near-side, before the queue jump phase. The second option would have the bus continue through the intersection on the through signal phase into a far-side bus pullout. In this case, a separate signal phase is not provided.

The development of a bus bypass lane treatment will be dependent on intersection approach conditions. At a location with on-street parking, this can be done by clearing the curb parking in the area of the queue jump to create a dedicated approach lane. At locations without on-street parking, this creation of a dedicated approach lane can be done either by restricting a specific lane, typically the curb lane, for use only by buses, or by physically widening the roadway to provide an additional lane for buses in the area of the queue jump. In any of these cases, it may also be desirable to consider creation of a “receiving lane” on the opposite side of the queuing location, particularly if the queue jump is not accompanied by a separate signal phase.

In addition to physically creating a queue bypass, the dedicated space for buses can also be accompanied by a special signal phase that allows buses to move ahead prior to other stopped traffic. This phase would typically be activated for a short period (three to seven seconds), usually immediately prior to the normal green phase for traffic traveling in the same direction as the queue jumping bus and desirably based on an actuation from the bus. This allows buses to move forward and merge ahead of other traffic, which is particularly important for locations where there is no receiving lane. This type of signal treatment can also be used at the end point of a dedicated running way, to allow buses to exit the running way and transition into the normal flow of traffic.

There are a number of specific issues to consider in developing a bus bypass lane:

- **Length of lane:** The purpose of a bus bypass lane is to allow buses to move ahead of vehicles stopped at a queuing location. As a result, it is important that the bypass lane be long enough that buses can enter the lane without being blocked by that queue. Analysis of the expected queue length is therefore required so that the proper length of the bypass lane can be determined. Although it may not always be physically possible to implement a lane that is of the required length, this issue needs to be given careful consideration in order to determine how much benefit the bypass lane will generate and whether the treatment is worthwhile. This analysis can be done using a variety of tools, including highway capacity analysis software, micro-simulation and direct observation of existing conditions.
- **Signal aspect:** In cases where buses are provided with an advance signal for a queue-jump treatment, the signal aspect used to indicate this advance phase must be clear to bus operators, while not being obvious or confusing to other drivers. One fairly simple option is to use a standard green-amber-red signal with either the outline of a bus or the word “BUS” on the lens. Some locations have also adapted light-rail style lunar (white) signals for this use, indicating the queue jump with a vertical white bar that is illuminated only when the queue jump is activated. This second option has the advantage of being less immediately legible to general traffic, making it less likely that vehicles other than buses will try to move during the queue-jump phase.
- **Turning vehicles:** Bus bypass lanes can create conflicts between buses and right-turning vehicles. Consideration should therefore be given to ensuring that any queue of turning vehicles is cleared prior to the queue-jump phase being activated. This can generally be accomplished by ensuring that right turns on red can be made safely, but sometimes it may require a special right-turn phase or physical design elements to ensure that right turns can be made safely and easily without delaying bus traffic.

4.3.2 Transit signal priority

Transit signal priority (TSP) uses communication between the transit system and the signal system in order to dynamically adjust signal timing to prioritize the movement of buses. In contrast to pre-emption systems, which will quickly change to a specific signal phase to allow emergency vehicles or trains to move through an intersection or railroad grade crossing, signal priority systems make more minor adjustments to signal timings, by bringing up a green phase earlier than normal or extending a green phase longer than normal. More sophisticated systems allow for phase skipping, phase insertion and phase rotation, but continue to operate within the general parameters of the existing phasing, rather than completely pre-empting that phasing.

TSP can be an extremely important element of BRT, particularly in situations where buses are operating along arterials with frequent intersections and traffic signals. One critical issue to keep in mind with TSP is that it requires a strong and ongoing partnership between the transit agency and the transportation agency that operates the signals.

Transit signal priority is discussed in greater detail in the APTA *Recommended Practice* “Implementing BRT Intelligent Transportation Systems.”

References

- Transit Cooperative Research Program, “BRT Practitioner’s Guide,” TCRP Report 118, July 2007. http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_118.pdf
- Florida Department of Transportation District 4, “Bus Rapid Transit Functional Classification Study,” June 2003.
- Federal Transit Administration, “Characteristics of Bus Rapid Transit for Decision Making,” August 2004. <http://www.fta.dot.gov/documents/CBRT.pdf>
- Transportation Association of Canada, “TAC Geometric Design Guide for Canadian Roads,” 1999. <http://www.mrc.ca/pdf/p29.pdf>
- American Association of State Highway Transportation Officials, “AASHTO Policy on Geometric Design of Streets and Highways,” 2001. <http://t2.ce.ufl.edu/facers/2002/mills/mills.pdf>
- Transit Cooperative Research Program, “Bus Rapid Transit Volume 2: Implementation Guidelines,” TCRP Report 90, August 2003. http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_90v2.pdf
- City of Winnipeg Transit Department, “Busway Planning and Design Manual,” September 2004.
- TAC Transit Signal Display Guideline

Definitions

arterial: A moderate- or high-capacity roadway designed for the continuity of movement. Arterials are usually broken into categories by their throughput ability, with principal arterials being of higher capacity than minor arterials.

at-grade: Operation at the ground level facility that may require signals or other traffic controls at junctions with other facilities, depending on volumes of traffic, visibility and other factors such as speed that determine the extent of the probable conflict between the traffic flows.

bus rapid transit: Frequent, faster and higher-capacity bus service designed as an integrated system of service, facilities and strategies that distinguish it from regular bus service. The elements of bus rapid transit can vary depending on the operating environment and may include priority through separate right-of-way, preferential treatments at intersections, intelligent transportation systems, as well as other actions that improve bus speed and reliability, including limited stops, vehicle design and fare collection systems and high quality bus stations that allow for greater efficiency. Bus rapid transit is often branded to promote the service as unique from regular bus transit service.

bus lane: A traffic lane for dominant or exclusive use by buses, generally used to speed up public transport otherwise held up by traffic congestion.

center platform: A horizontal surface above the level of rails or roadways and positioned in the center to allow boarding and alighting of passengers. Center platforms make it difficult to separate passenger and vehicles flows and can require crossing vehicles to reach the platform to board and alight passengers if vehicles are not equipped with left-side doors.

dedicated lane: A lane set aside for a specific mode so that that mode can operate separately from all others.

expressway: A divided highway for through traffic with full or partial access control and including grade separations at all or most major intersections. (Source: Bureau of Transportation Statistics Dictionary)

freeway: A type of road designed for safer high-speed operation of motor vehicles through the elimination of at-grade intersections, usually with limited access points. This is accomplished by preventing access to and from adjacent properties and eliminating cross traffic through the use of grade separations and interchanges.

grade separation: The separation of two or more transport axes at different heights to eliminate conflicts between traffic flows when they cross one another.

greenfield: A piece of property that is undeveloped except for agricultural use, especially one considered as a site for expanding urban development.

guideway: A grooved or channeled pathway that controls the direction in which a moving object travels. For rubber-tired transit, an automated guideway is a fully automated, grade-separated system in which buses operate across these grooves and channels.

HOV lane: A traffic lane limited to carrying high-occupancy vehicles designated by a minimal vehicle occupancy requirement. This includes carpools, vanpools and buses.

lateral segregation: A physical barrier or guidance system operating throughout a running way or in specified sections, such as narrow right-of-way, tight curves or approaching and leaving stations, that provide lateral separation providing safe operation.

median busway: A middle section of a roadway reserved for buses only.

queue bypass lane: A short lane used by buses to bypass traffic queues at signalized intersections. The bypass is usually a right turn lane that allows through travel for buses only, but may include left turn for cars and through movement for transit in conjunction with a specific signal phase.

queue jump: Usually a form of transit signal priority, where there is a separate signal phase for transit vehicles so they can get ahead of other traffic. Queue jumps can be partnered with a queue bypass lane or may operate from a regular traffic lane.

ramp: An inclined roadway connecting roads of differing levels. (Source: BTS Dictionary)

reserved bus lane: A lane on an urban street or freeway for bus use only, separated from other lanes by pavement markings, signs or rubber cones, but not by fixed physical barriers. Also known as an exclusive lane.

right-of-way segregation: A fully controlled legally and physically separated strip of land for use by transit vehicles without grade crossings or any legal access by other vehicles or pedestrians.

running way: A path that provides exclusive lanes and roadways in which transit vehicles travel.

separate running way/busway: A roadway reserved for buses only. It may be grade-separated or a controlled-access roadway. (Source: BTS Dictionary)

mixed-use lane: A roadway lane designated for use by different types of vehicles and users. Shared use lanes may be limited to specific users and include business-access transit lanes, HOV lanes and lanes designated for both motorists and bicyclists.

bi-directional lane: A single, exclusive BRT-only lane.

contraflow lane: A lane that opposes general traffic.

reversible lane: A single, exclusive BRT-only lane that changes direction to each peak traffic direction.

shyway: The space left between the travel lane and a barrier, between vehicles or between vehicles and pedestrians as they pass each other. The amount of shy distance required for safety tends to increase with speed.

shoulder: An edge or border running on either side of a roadway, generally kept clear from traffic, that provides a place of refuge in emergencies.

side platform (lateral platform): A horizontal surface above the level of a rails or roadways, and positioned on each side of the roadway or rail tracks to allow boarding and alighting of passengers. Lateral platforms can easily separate the directional flows of passengers and minimize conflicts with vehicles without requiring vertical pedestrian movements.

signal aspect: A combination of colored lights displayed by a traffic signal, often collaborated with a signal indication (action required by the signal aspect: red means stop, yellow means caution, green means go).

transit signal priority: An operational strategy that facilitates the movement of transit vehicles, either buses or streetcars, through signal-controlled intersections. Signal priority modifies the normal signal operation to provide speed and reliability to transit vehicles. The priority offered to transit may vary from preemption to a request for priority that considers operating plans (priority for a particular segment or route) and schedule factors, such as minutes behind the published schedule, spacing between transit vehicles, etc.

Abbreviations and acronyms

AASHTO	American Association of State Highway and Transportation Officials
BAT	business access and transit (lane)
BOS	bus on shoulders
BRT	bus rapid transit
BTS	Bureau of Transportation Statistics
CBD	central business district
CCTV	closed-circuit television
CNG	compressed natural gas
ESA	equivalent standard axle
HOV	high-occupancy vehicles
LRT	light rail transit
MUTCD	Manual on Uniform Traffic Control Devices
RBL	reserved bus lane
TAC	Transportation Association of Canada
TSP	transit signal priority