



APTA STANDARDS DEVELOPMENT PROGRAM  
**RECOMMENDED PRACTICE**

American Public Transportation Association  
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APTA Bus Rapid Transit Working  
Group

## Bus Rapid Transit Service Design

**Abstract:** This *Recommended Practice* provides guidance for the planning and design of the BRT service, including routing, service hours and frequencies and service issues related to scheduling and operations. Included are general service design principles and practices and specific service design issues related to various types of BRT facilities and approaches.

**Keywords:** bus rapid transit (BRT), design, headway, planning, routing, scheduling, service frequency, service hours

**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 **Bus Rapid Transit Working Group**, which provided the primary effort in the drafting of this *Recommended Practice*.

**Dave Roberts**

City of Brampton

**Pat Scrimgeour**

City of Ottawa (OC Transpo)

**Dan Freeman**

Greater Vancouver Transportation Authority (TransLink)

**Bryan Jungwirth**

Valley Metro (Phoenix)

**Christopher Norris**

Canadian Urban Transit Association

**Sean Rathwell**

McCormick Rankin Corporation

**Dave Reage**

Regional Municipality of Halifax (Metro Transit)

**Rick Takagi**

York Region Transit

**David Wohlwill**

Port Authority of Allegheny County

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## 1. Overall position of BRT within the transit system

### 1.1 The need for high standards

BRT should be viewed as a premium investment designed to maximize transit use in high travel demand corridors. As such, it should exhibit characteristics that differentiate it from traditional fixed route bus services, such as the following:

- faster travel times than traditional fixed-route bus service
- short wait times at stations
- limited stops or stations, generally located at major street intersections or activity centers
- unique branding to differentiate BRT from other transit services and identify it as a higher-order rapid transit service

Service standards for BRT should be similar to standards for rail rapid transit modes, especially where BRT and other rapid transit modes connect. Similar service frequencies, fare structures and hours of service will help to provide a seamless travel experience for riders. The operational attributes of BRT should define the service as distinct from other conventional bus services. These attributes, along with a high degree of connectivity with other transit modes, will enhance the overall efficiency of all transit services by providing the end user with a high degree of flexibility in making a trip.

While seen as a premium service, BRT should not be implemented at the expense of existing fixed-route service, but rather in a way that complements and enhances other transit services. Enhancing connectivity between BRT and fixed-route bus can improve the travel experience by reducing travel times and increasing overall accessibility to travel destinations.

Access must be a key consideration, especially if BRT is being considered as a substitute for some aspects of existing fixed-route service. The wider station spacing of BRT could adversely impact existing transit-dependent riders (particularly riders with physical disabilities) if some level of service is not maintained at existing conventional transit stop locations. A mix of BRT and local bus service might be considered to address this access concern.

### 1.2 Role within the family/suite of services

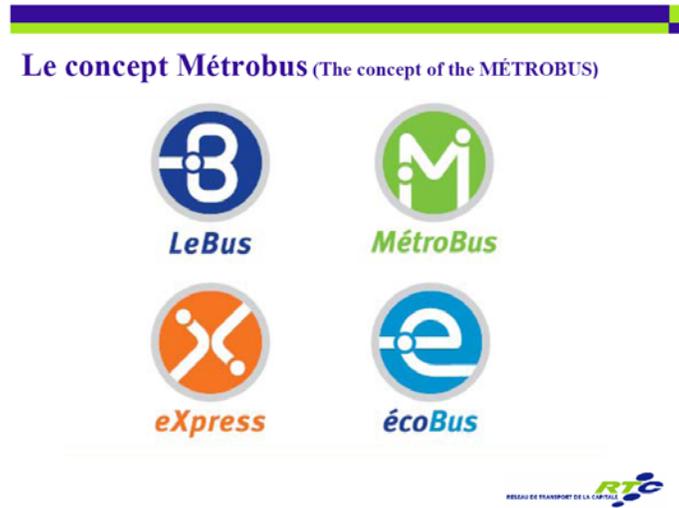
The role that bus rapid transit plays in a transit system may vary widely between cities. In some cities, there will already be a well-established rail rapid transit system, and BRT may be an application of rapid transit on a new corridor. Or BRT might be planned as the spine of the transit network in a city where no rapid transit already exists. In some cities that are not at the core of a metropolitan area, the BRT service may be the primary transit service of the municipality but may serve as a feeder to a rail rapid transit system in the central municipality.

In each case, the transit agency should establish the role that BRT will play within its family of transit services and, if applicable, within the family of transit services in the metropolitan area. Defining this vision for the BRT service will help to guide strategic decisions about the appropriate levels of capital investment, service design principles, branding and other matters.

Two examples of BRT services and the roles they play in their respective systems are shown as follows:

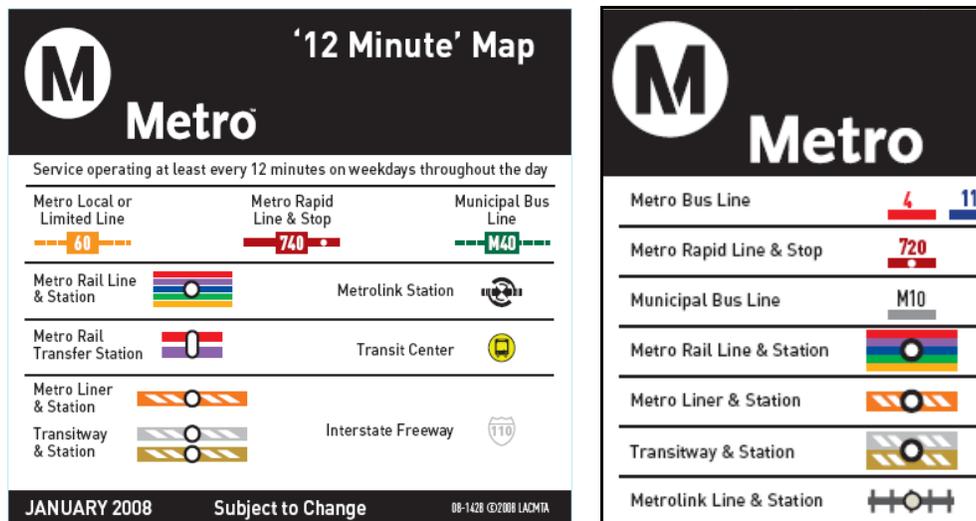
- **RTC (Quebec City):** Métrobus BRT is Quebec City's highest-order transit service. It uses a combination of exclusive lanes and mixed traffic with transit priority measures and is supported by a network of local, express and circulator shuttle services. See [Figure 1](#).

**FIGURE 1**  
RTC (Quebec City)



- LACMTA (Los Angeles):** As a much larger system, LACMTA operates three distinct BRT services that serve different roles in the regional transit network. The Metroliner (Orange Line) is a BRT line on an exclusive right-of-way and is considered to be a rapid transit line of equal status to the Metro Rail subway and light rail lines. Metro Rapid is a network of limited-stop, low-cost BRT services on major arterial corridors, primarily in mixed traffic with priority measures. The Transitways are reserved lanes for buses on limited-access highways, which are used by suburban express routes to downtown. These are all supplemented by local, limited stop and express Metro Bus routes, as well as Metrolink commuter rail. See **Figure 2**.

**FIGURE 2**  
LACMTA (Los Angeles)



### 1.3 Supporting or leading development patterns

Depending on the level of capital investment, BRT can serve to support existing development patterns or help establish new development patterns, especially transit-oriented development (TOD) or other higher-density developments. Typically, a greater level of investment in BRT infrastructure (grade separation, upgraded stations, dynamic message signs, dedicated fleet, etc.) leads to a greater eventual level of development along the corridor and especially at stations, since the public investment signals a long-term commitment to rapid transit within the corridor, similar to a rail investment. Additionally, high service levels and increased ridership will also drive development along the BRT corridor.

Services that feature a minimum level of capital investment, service levels and ridership are unlikely to influence development patterns unless they are viewed as a stepping stone to future higher-capacity transit investment (e.g., LRT) should passenger demand and land uses change to support such an upgrade.

### 1.4 BRT service design principles and standards

Agencies considering the implementation of a BRT system should know their purpose in designing a service that meets their needs and the needs of the customer. This can be done through an initial BRT planning study to define the principles, policies and standards of the system. Such a study or analysis should highlight the operational differences between BRT, Express Bus and local fixed-route bus services and define the travel markets that each service type would be tailored to address. Implementation of BRT should be justified based upon passenger demand (current and future), corridor land use plans, the operating funds available and the ability to attract and retain new and existing riders from other forms of transportation.

Policies that affect service design and ultimate quality of service may include the following:

- service levels (frequencies, span of service)
- stop/station spacing
- exclusivity of running way or lack thereof, including degrees of grade separation
- intersection and signalization improvements
- station platform designs, including precision docking
- vehicle type
- fare collection (on or off board)
- intelligent transportation systems (ITS)
- branding

Operational similarities to light rail transit should also be emphasized to further distinguish BRT from regular fixed-route bus service. Utilizing similar service frequencies, all-door boarding, and stations that borrow visual cues from LRT stations in the same market can reinforce BRT as a “rail-like” transit service. This can be especially useful where LRT and BRT lines intersect, providing a more seamless transfer experience for riders and de-emphasizing the differences between the modes.

Service standards for BRT should be adapted from the transit agency’s existing standards. This will ensure that the new service complements rather than duplicates existing service. It will also ensure that the service is tailored to existing local conditions and needs. The service design should address the span of service (hours of the day, days of the week), service frequencies, degree of reliability (on-time performance), and ridership goals. Service design likely will vary from system to system, depending upon individual system goals (e.g., capacity enhancement, ridership increases, community and economic development, mobility or extension to LRT).

Performance targets should relate to the transit agency’s existing performance measures and targets. They should reflect the unique characteristics of BRT and may include variables, as an example, for a higher

customer propensity to drive to the transit service than would be experienced by traditional fixed-route service.

Performance targets that distinguish between new and reallocated boardings can help determine whether a new BRT service is increasing overall system ridership or just reallocating existing riders. A primary focus in the performance of a BRT system is to attract new or “choice” riders and retain existing riders through an improved customer experience and riders making BRT their mode of choice. This also should be the focus of associated marketing efforts.

## 2. Routing

### 2.1 Route selection

When considering BRT during a transportation master planning or transit system development process, communities typically consider all their major travel demand generators and decide how best to connect them. Typical travel demand generators that can be effectively connected by rapid transit services include the following:

- central business district (downtown)
- colleges and universities
- regional shopping centers
- hospitals and other major medical facilities
- entertainment and sports complexes
- intercity transportation facilities (airports, rail stations, bus terminals)
- concentrations of high-density residential or commercial development

If the location of a BRT corridor has been selected in a master planning process, it remains for the transit agency to decide the details of the way that transit service will be provided on the corridor. These considerations are outlined in the sections that follow.

In some cases, the designation of a BRT service will arise from ongoing route planning and service management work and will not have been defined in a master planning process. The identification of a service as BRT can be a way to draw attention to the importance of a route in the transit network, either for customers as they navigate their way on the network or for decision-makers as they allocate capital and operating resources. A transit agency may decide to allocate funds to bus routes in an important corridor to provide, for instance, new vehicles, transit priority measures, improved customer amenities at stops or increased service levels.

### 2.2 Basic BRT design types

There are two types of BRT that are generally implemented in urban centers around the world:

- **BRT service:** This type of BRT consists of a single route serving stations along a defined corridor. The route might operate in mixed traffic with some use of bus lanes and transit signal priority (e.g., Boston’s Silver Line and York Region’s Viva system) or on a separate facility in a roadway median or unique corridor (e.g., Los Angeles Orange Line).
- **BRT facility:** This form of BRT consists of purpose-built infrastructure intended to be used by multiple routes. The infrastructure is usually a separate busway and can be fully grade separated (e.g., Pittsburgh and Ottawa) or can accommodate at-grade intersections (e.g., South Miami-Dade Busway).

Making a determination to either introduce a single BRT route or to construct a BRT facility that can accommodate several different transit services is a key early decision that needs to be made to provide the foundation for further routing and service design decisions.

## 2.3 Service structure and route types

The following sections describe the variety of service alternatives that can be found in operation on a BRT service or facility.

### 2.3.1 All-stops or mainline BRT service

This type of routing operates like a typical rail transit service, running over the full length of a busway or BRT corridor and stopping at each station to serve passengers. It can also include short-turns (selected trips terminating at a midpoint where demand drops off significantly) or branches, either within or beyond a BRT corridor.

All-stops routes are the type usually chosen when a single BRT service is operated in a corridor. The Eugene EmX service and Los Angeles MetroRapid routes are examples of all-stops routes operating as single BRT services. They are also found on BRT facilities that serve multiple route types (e.g., Ottawa's Route 95).

The all-stops route service frequency will usually be high during most time periods (e.g., every five to 10 minutes or better during peak periods and 10 to 15 minutes during the midday). The type of route often requires even higher-frequency service along busier sections close to major travel demand generators and may require the use of high-capacity vehicles such as articulated buses.

### 2.3.2 Express or limited-stop service

A BRT service can also include an overlaid express or semi-express operation as a supplement to an all-stops service. This can provide a quicker service for longer-distance trips but is usually justified only when the passenger demand is high enough to support both types of service operating at rapid transit frequencies. Typically this is done only during peak hours and can apply to either a BRT facility (busway) or other BRT service (e.g., arterial). This type of approach can apply to either a busway facility or a BRT service corridor (e.g., an arterial), but in both cases, the BRT right-of-way would need to be designed to allow express vehicles to pass vehicles making all stops when the latter is stopped at a station not served by the express service.

### 2.3.3 Routes using a BRT facility as part of their route

A key feature of exclusive BRT busways is their ability to offer a high-frequency, no-transfer service to a higher proportion of trips than is usually the case for rapid transit in suburban areas. This is achieved through the operation of a network of one-way, high-frequency express/limited stop services. In the morning peak period, for example, buses pick up passengers in residential areas away from the busway, travel on the local street system to the busway, and then operate on the busway in an express or limited-stop mode, depending upon the demand levels and trip patterns. The intermediate busway stations allow customers to directly access developments next to the stations and to transfer to the all-stops and counter-peak direction services for travel to other locations in the corridor. In the afternoon peak period, the one-way service is provided in reverse.

Express or limited-stop services combined with feeder/line haul services provide a high degree of flexibility, which gives this type of BRT the ability to offer a high-frequency, no-transfer service to a higher proportion of trips than is usually the case for rapid transit in suburban areas. For example, in the Ottawa system, 70 percent of the passengers use this type of service. On Pittsburgh's East Busway, about half the riders board at points outside the corridor, and on the Adelaide guided busway, 64 percent of passengers access their bus

before it reaches the busway. In addition, other routes can also use the BRT facility for short distances to use the travel time advantages that the facility can offer.

In the operating plan, it will be important to design the express/limited stop routes so that they each have a large enough catchment area and serve a sufficient number of destinations and intermediate stations to justify a service frequency of at least a bus every 10 minutes. It is usually preferable to achieve this by adding destinations rather than by increasing the size of the residential pickup loop, since this usually minimizes the running time per passenger served.

When implementing routes that overlap the main trunk route, especially for routes with lower frequencies, efforts should be made to integrate the schedules of both routes where possible to create an evenly spaced headway and increase the overall corridor service frequency. This can usually be done quite easily for routes with identical service frequencies but may be more challenging when dealing with routes with different service frequencies.

One important caveat is that the use of no-transfer express or limited-stop services that route off a BRT facility, as described above, does not lend itself to a pre-paid off-board fare payment system, since it would be difficult to justify purchasing and installing ticketing machines or other fare equipment at stops along local routes outside the BRT facility (see Section 6.2.2, “On-board vs. off-board fare collection”). In an off-board pre-payment system, the BRT vehicles would typically stay on the corridor and the feeder services would be separate independent routes with transfer connections at the BRT stations. Similar restrictions would also apply to technologies such as precision docking and automated guidance systems.

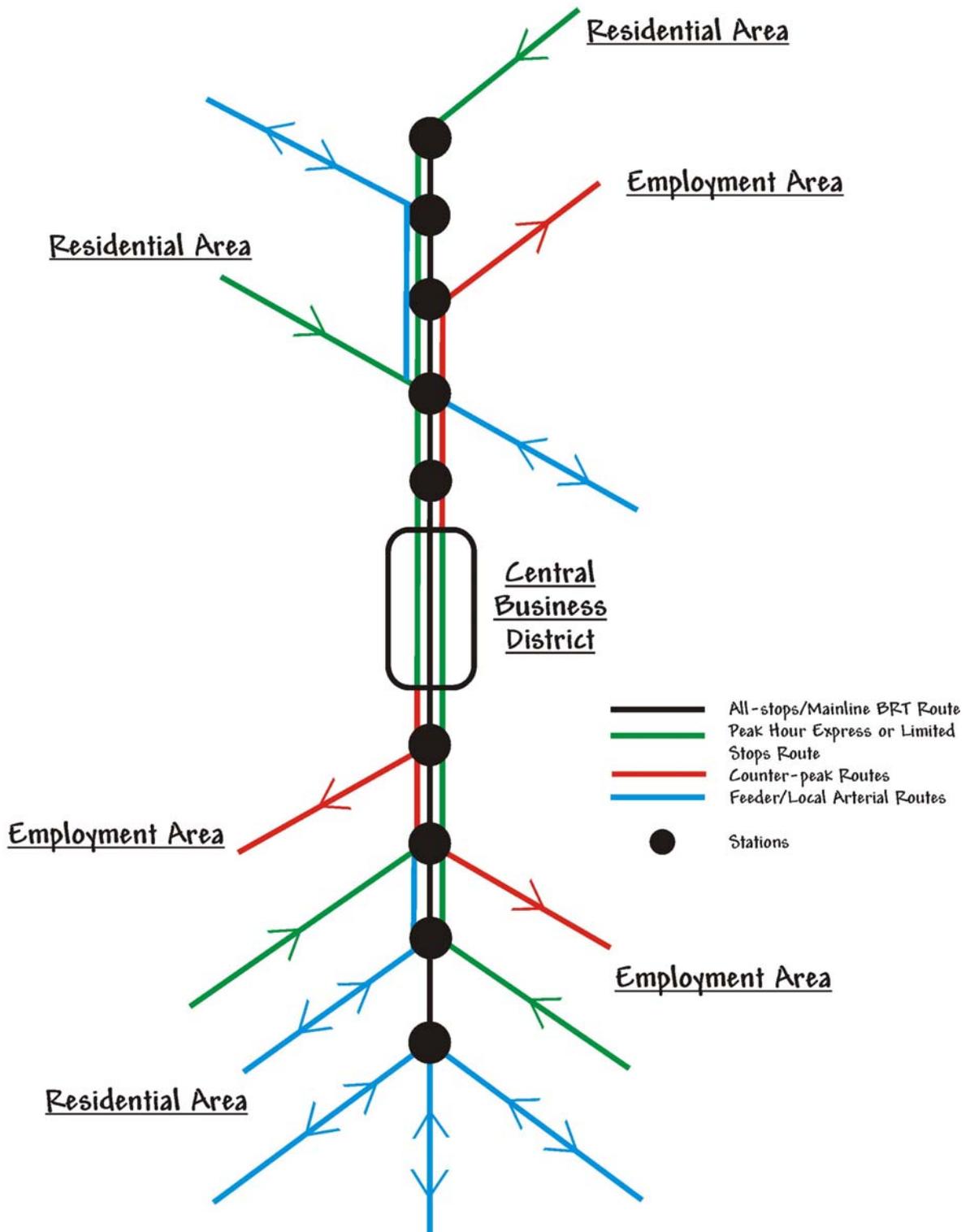
### 2.3.4 Counter-peak direction routes

Additionally, to reduce the need to transfer to major destinations away from a busway, counter-peak direction express or limited stop routes can be operated. These routes operate during the peak period, typically starting at a busway station close to the city center in the morning, travel along the busway, then operate on the local street system in order to access a commercial area, business park, hospital, education center, or a series of facilities located near one another. Because these routes operate in the counter-peak direction, they can be provided at a low marginal cost by using bus trips that would otherwise be the out-of-service links for the one-way peak direction express services.

### 2.3.5 Overall route hierarchy

**Figure 3** illustrates the hierarchy of routes and positioning of BRT, as described in this section.

**FIGURE 3**  
Typical BRT Service Hierarchy (Morning Peak Period)



## 2.4 Relationship with parallel conventional services

Many BRT lines are implemented in corridors with established, well-utilized conventional service. When a new BRT service is implemented, transit agencies must decide on the respective roles of BRT and local service and how to modify parallel conventional services, if at all. The usual options include the following:

- removal of the parallel service
- reduction in the parallel service
- no changes to parallel service

In deciding on these options, there are several factors to be considered:

- ridership and potential for new ridership in the corridor
- station/stop spacing
- physical attributes of the route
- transfer convenience/demand
- congestion on parallel streets and highways
- transit system operating budget
- public and community support for the BRT project

If all parallel service is to be removed, then service levels on the new BRT system must be able to handle the passenger volumes currently carried by the conventional service, as well as any increases in ridership expected as a result of the new, more attractive BRT service. In this case, stations would normally be spaced closely enough so that passengers located between stations, who likely had a conventional transit stop nearby, can easily walk to a nearby BRT station. If station spacing results in unacceptable walking distances, it may be desirable to retain at least some parallel conventional service, especially if the BRT is on an established transit corridor.

If the BRT is operating on a running way that does not allow space for passing of other vehicles, then the parallel conventional service would need to operate on another running way, typically in general traffic lanes on the corridor or paralleling the corridor, depending on the nature of the BRT running way.

The following sections contain examples of the approaches that can be taken.

### 2.4.1 Removal of parallel service

In Eugene, Oregon, the EmX BRT service replaced a portion of conventional Route 11, which was truncated and continues to operate from the Springfield EmX terminus. The introduction of EmX provided increased service levels and reduced trip times over the previous conventional service in the corridor. Station spacing on EmX varies from a quarter-mile (0.4 km) to one mile (1.6 km).

In Pittsburgh, some service that previously operated on highways and arterials was shifted to the BRT service in order to realize operating cost savings and travel time benefits from not being stuck on congested road facilities.

### 2.4.2 Reduction of parallel service

In York Region, Ontario, the introduction of the Viva BRT service resulted in a reduction in service frequencies for conventional transit in some of the Viva corridors, especially Route 99 on the busiest corridor (Yonge), as demand shifted to the new BRT service. Parallel limited-stop services operated by GO Transit in the corridor were also significantly reduced. Station spacing on the Viva system varies from 0.3 km (less than a quarter-mile) to almost 5 km (3.1 miles), although some of the longer station spacing is through undeveloped areas or along an express portion to transfer stations in Toronto.

### 2.4.3 No changes to parallel service

In Halifax, Nova Scotia, a decision was made to make no changes to parallel conventional service upon implementation of the MetroLink BRT service. This was initially done as a test, to monitor ridership levels on conventional routes to more accurately determine which services were no longer warranted, if any. The result was that there was enough new ridership (both MetroLink and conventional) to allow for the retention of parallel conventional services. An additional consideration in Halifax was station spacing, which ranges from 0.75 km (0.5 miles) to 3 km (1.9 miles) within urban developed areas and as high as 12 km (7.5 miles) along a sparsely developed highway corridor.

## 2.5 Connections with local routes and other services

Local arterial and feeder bus services operate in conjunction with BRT services to extend the benefits of BRT and to integrate BRT into the overall transit network. To take maximum advantage of BRT, these routes may need to be modified to reflect the presence of BRT. These modifications could include the following:

- Route diversions to ensure that each route intersects the BRT in at least one location where passengers can transfer conveniently at a station.
- Route diversions where the arterial route may actually use a section of busway or BRT corridor for a portion of its route.
- Route extensions along a busway section or BRT corridor to take advantage of the faster operating speed and to connect passengers on feeder and arterial routes to more transfer opportunities.
- The elimination of route sections where bus service can be replaced by walk-in access to a BRT station.
- Timing changes to provide a timed transfer or pulse operation at major transfer locations (particularly late at night when service frequencies may be low).

How the BRT services and regular transit services connect will depend on the overall objectives and principles of the BRT system and the preferred service design structure. Such attributes as passenger demand and station location may also be influencing factors.

Where the route structure places a high reliance on transfers, travel from low-frequency services to high-frequency services will be more convenient than travel from high-frequency services to low-frequency services. This is most evident when the service frequencies of the BRT trunk routes are much greater than those of the local connecting services.

In cases where frequencies of both the BRT trunk routes and local connecting services are more closely matched, there may be a case for timed transfers. Generally, lower frequencies require that connections be timed to minimize passenger transfer waiting times. In cases where both the BRT trunk routes and local connecting routes have good frequencies (typically 10 minutes or better), timed transfers are usually not required.

The local services connecting with the BRT systems may require time allowances for connections. This may be required to ensure that connecting passengers have sufficient time to transfer from one service to another and is generally used when service frequencies are moderate to low. Decisions regarding timing at stations or major transit transfer points can also be affected by other factors, such as local weather conditions.

BRT systems also provide opportunities to interface with other transit services, such as other types of rapid transit, regional commuter operations and inter-city motorcoach services. The latter two may also run along the BRT corridor, linking their respective origins with destinations along the corridor. In Pittsburgh, seven regional transit operators meet at the East Busway Penn Station, with transfer privileges provided as well as

access to the Amtrak and Greyhound stations. Transit systems may also choose to partner with the other transit services by offering joint ticketing or transfer privileges between services.

## 2.6 Routing implications on service reliability

As a “premium” service, it is especially important that BRT service be reliable and that the system meet its schedule as often as possible. The service standard for schedule adherence is often higher for BRT than for conventional service. There are several factors to consider that can affect the reliability of the service:

- the proportion of the route that is in mixed traffic, especially congested streets in the central business district and other high-activity centers.
- the effectiveness of transit priority measures (TPMs);
- route length
- the number and spacing of stations

The proportion of a route that operates in mixed traffic has the largest single impact on route reliability. The impacts of traffic congestion can be mitigated substantially with TPMs, such as signal priority and exclusive intersection “queue jump” lanes at major intersections and congestion points. It is important that TPMs be considered early in the planning process, as some require substantial infrastructure changes and considerable time to design and implement. BRT planners should also coordinate with local public works departments and state departments/provincial ministries of transportation.

A case that requires special attention is the service through the downtown core, where there is usually significant traffic congestion and fewer opportunities for dedicated BRT facilities. Aggressive implementation of transit priority measures may be needed in such cases. Another option may be to terminate the BRT service near major trip generators in downtown rather than running all the way through downtown, if this reduces the amount of time BRT vehicles spend navigating congested streets.

When planning route length, a longer route may provide a more seamless journey for the passenger, but it can also be more difficult to manage in terms of reliability, since there is more opportunity for the vehicle to fall behind schedule on any given trip. A shorter route will have more opportunity for layovers to recover lost time. An alternative is to introduce layover time at time points along the route, although this will increase overall travel time and is not likely to be popular among long-distance passengers. Also, there may be problems with buses sitting in traffic lanes or in trying to secure suitable layover space.

The number of stations along a route can also affect the reliability of service. Dwell time at stations is one of the most significant variables in the reliability of service, especially in a limited-stop service such as BRT. While fairly regular ridership patterns can emerge at stops along a route, it is still hard to predict how many people will get on or off a bus at any given stop on any given run. On a route with a high number of stops, such variations can add up quickly and result in vehicles struggling to stay on schedule.

For any of these scenarios, intelligent transportation system (ITS) technology offers excellent opportunities to maximize service reliability, especially the use of automatic vehicle location (AVL) and computer assisted dispatch (CAD) systems. These can track the location of vehicles and give dispatchers or controllers the information they need to take corrective measures. These also can facilitate headway-based scheduling (described in the APTA *Recommended Practice* “Operating a Bus Rapid Transit System”) and can provide real-time information to improve the service convenience to passengers.

### 3. Station location

#### 3.1 Station spacing

In many cases, the stop spacing and locations are established during the facility planning process, based on existing and anticipated land uses and location of intersecting transit lines, although service planning input should also be incorporated into the design.

In determining stop or station spacing, the criteria for spacing and location should be established and documented. Major factors to consider:

- maximum acceptable and desirable walking distances
- whether or not a parallel local service is available
- speed and service objectives for the BRT service

Walking distances between stations will vary based on local public expectations and transit agency service standards. The distance people are willing to walk to transit varies but is typically in the order of 0.25 to 0.33 miles (0.4 to 0.5 km), typically a five- to 10-minute walk. In higher-density or high-activity areas, expectations are usually for shorter walks. Many people are willing to walk farther to access a higher-order service such as BRT compared to conventional transit, although there is still a limit on how far people will walk before the trip is no longer attractive. Customers also prefer not to walk too far in the opposite direction of their desired path of travel to access public transit facilities.

Consideration can also be given to varying the spacing of stations to allow for more frequent stops, or more stations in higher-density portions of the route, while allowing for greater spacing between the stations in less dense portions of the route. In a typical grid system, locating stations at intersect points with local bus routes should result in spacing consistent with acceptable walking distances, assuming similar standards have been used to determine the spacing of the crossing bus routes.

Long station spacing (significantly beyond desirable walking distances) may require the retention of parallel conventional services. If there is an initial decision to retain parallel conventional services, then spacing BRT stations beyond normal walking distances will speed up the service and may be the most efficient way to operate the system. Longer station spacing may also be appropriate if the main objective of the BRT service is simply to connect major activity centers (e.g., transit hubs or park-and-ride facilities) or if the alignment does not follow a typical arterial-type transit corridor.

**Table 1** provides a summary of the typical distances between stations for several BRT systems (note that some of the longest distances represent express portions of a route rather than the more typical rapid transit designs).

**TABLE 1**  
Distances Between BRT Stations

BRT System	Shortest	Longest	Average
HealthLine (Cleveland)	0.13 mi (0.20 km)	0.50 mi (0.81 km)	0.20 mi (0.32 km)
Silver Line (Boston)	0.10 mi (0.16 km)	1.90 mi (3.06 km)	0.32 mi (0.52 km)
EmX (Eugene, Ore.)	0.24 mi (0.38 km)	0.98 mi (1.58 km)	0.42 mi (0.68 km)
MAX (Las Vegas)	0.25 mi (0.40 km)	1.00 mi (1.61 km)	0.50 mi (0.81 km)
Metro Rapid (Los Angeles)	0.25 mi (0.40 km)	1.00 mi (1.61 km)	0.70 mi (1.13 km)
Viva (York Region)	0.16 mi (0.26 km)	3.07 mi (4.94 km)	0.93 mi (1.50 km)
Pittsburgh	0.51 mi (0.82 km)	1.70 mi (2.74 km)	0.97 mi (1.56 km)
Orange Line (Los Angeles)	0.54 mi (0.87 km)	2.20 mi (3.54 km)	1.10 mi (1.77 km)
MetroLink (Halifax)	0.45 mi (0.73 km)	7.70 mi (12.40 km)	3.28 mi (5.28 km)

### 3.2 Station location considerations

For stop or station locations, the following are the major factors to consider:

- location of major origins, destinations and activity nodes
- location of major cross streets and transfer points
- density and land-use patterns in the corridor

As much as possible, stations should be located at major origins and destinations as well as major transit transfer points. Often, these are the same location, such as a transfer terminal location at a retail development or a downtown transfer terminal. These locations should receive priority as BRT stations, since they will generate ridership from both walk-on and transfer passengers.

Other factors for both station spacing and location may include the following:

- availability of pedestrian infrastructure (e.g., sidewalks)
- quality of pedestrian environment (trees, block spacing, store fronts, street furniture)
- width of streets
- stops shared with or separate from conventional service
- near-side versus far-side stops
- topography
- weather
- customer demographics (e.g., seniors)
- typical spacing for non-BRT service (bus and rail) in the region
- local conditions and expectations

- urban design opportunities (see the APTA *Recommended Practice* “Sustainability and Urban Design Standards”)

When BRT and local services share a running way, BRT stops can either be co-located with local stops or separate from local stops. If the stop is sufficiently large so that the BRT vehicle can service the stop without interference from a conventional bus also using the stop, then this is the preferred practice since it will ease transfers between modes. However, if there is insufficient space to accommodate both, then stops should be separated. Also, from a service branding perspective, it may be desirable to separate the stops, especially if the BRT service is being marketed as a totally separate system from the conventional service.

If the decision is made to separate BRT and conventional stops, then consideration will need to be given to which stops will be placed in preferential locations. Since BRT is typically branded as a premium service, the BRT stop will receive the preferential treatment, especially if this could improve service reliability or brand image. However, if this approach has a significant negative effect on conventional passengers, such as moving their stop a considerable distance from a major trip generator, it would be prudent to explore alternative options.

For BRT operating within an arterial corridor with at-grade signalized intersections, stops or stations are generally preferred on the far side of the intersection, especially to maximize the effectiveness of transit signal priority. At a far-side stop, the bus can make its call for TSP on approach to the intersection, proceed through the intersection in a relatively predictable manner, and then make its stop after clearing the intersection. With a near-side stop, an approaching vehicle can make a request for TSP when approaching the intersection but the time required for boarding and alighting passengers is hard to predict, and the extended signal time may be lost if the actual dwell time varies.

## 4. Span of service

### 4.1 Principles

Span of service defines the extent of time over which service is provided. This includes both hours of service during the day and days of service over the week.

As with other aspects of service design (such as service frequency), the span of service offered should ideally replicate as much as possible true rapid transit, as for subway, light rail and other higher-order transit modes. The objective for doing so is to instill in the mind of the rider or potential rider a high level of confidence that the service will always be there when desired. This also implies that a rider, especially an occasional rider or one who wishes to travel outside of regular commute times, does not have to consult a timetable or other means of information to determine whether or not the service is available.

When starting a new BRT service, even with a full span of service being the ultimate objective, a major consideration may be whether to offer the full service at the outset or to offer a limited service at first (e.g., weekdays only) and expand to a full service after ridership has grown, land use development has responded or additional funding has become available. A significant factor related to this type of choice might be the location of the BRT, in that a new service in an established, built-up area would more likely warrant full service, whereas an application in an outlying or newly developing area might suggest an incremental or phased strategy.

The most common approach has been to offer full service from the first day that the BRT service is introduced (again, replicating true rapid transit). A good ridership response has typically tended to support that approach, especially because of the high confidence factor described above, which helps to better justify the capital investment in the facility.

Even if a new BRT service cannot justify full service in the early stages, the goal should still be to work toward full service as soon as the agency has the justification or capability. Again, this will meet the principles described above and help get the maximum ridership benefit from the new facility.

## 4.2 Days of the week

In keeping with the above service design principles for BRT, the most common and preferred approach is to offer BRT service all seven days of the week, including holidays. Offering service only on weekdays, for example, might arguably create the impression that the service is more of a commuter-oriented service than true rapid transit. At the very least, if service is not provided on weekends or other lower-demand times, then there should be a substitute service available, such as a parallel local route.

The vast majority of BRT systems in the United States and Canada provide service seven days of the week.

## 4.3 Hours of the day

Again to meet the service design principles for BRT and to establish the impression that the service is true rapid transit, the most common and preferred approach for the span of service during the day is to offer BRT service approximately 18 to 20 hours per day. This helps to ensure that the span of service covers all or most times of potential service demand:

- start and finish times for shift workers (e.g., medical institutions, retail), especially those outside of traditional peak hours (the service will not capture the trip to work if the trip home is not covered)
- opening and closing times for malls and other major retail developments
- classes at colleges and universities
- opening and closing times for institutions and community facilities (museums, libraries, etc.)
- times for the more popular entertainment or leisure activities (sporting events, theatres, etc.)
- intercity transportation services (airport, rail, bus)

At a minimum, in order to qualify as a Small Start under FTA guidelines in the United States, a corridor-based bus project is required to offer the service at least 14 hours per day, but most U.S. systems offer more than that for the reasons noted above. **Table 2** summarizes the hours of the day by day of the week that BRT service is provided on many of the more established and well-known BRT systems in North America as of early 2008:

<b>FIGURE 1</b> Typical BRT Service Hours			
<b>BRT System</b>	<b>Weekdays</b>	<b>Saturday</b>	<b>Sunday</b>
South Busway (Miami)	24 hours	24 hours	24 hours
Transitway (Ottawa)	4 a.m. to 2 a.m.	5 a.m. to 2 a.m.	6 a.m. to 2 a.m.
Pittsburgh	5 a.m. to 1 a.m.	5 a.m. to 1 a.m.	5 a.m. to 1 a.m.
99-B Line (Vancouver)	5 a.m. to 1 a.m.	5 a.m. to 1 a.m.	5 a.m. to 1 a.m.
MAX (Kansas City)	5 a.m. to 1 a.m.	5 a.m. to 1 a.m.	5 a.m. to 1 a.m.
Orange Line (Los Angeles)	4 a.m. to 12 a.m.	4 a.m. to 12 a.m.	4 a.m. to 12 a.m.

San Pablo (Oakland)	5 a.m. to 12 a.m.	5 a.m. to 12 a.m.	5 a.m. to 12 a.m.
Silver Line (Boston)	5 a.m. to 12 a.m.	5 a.m. to 12 a.m.	6 a.m. to 12 a.m.
Viva (York Region)	6 a.m. to 12 a.m.	6 a.m. to 12 a.m.	6 a.m. to 12 a.m.
MAX (Las Vegas)	5 a.m. to 10 p.m.	5 a.m. to 10 p.m.	5 a.m. to 10 p.m.
Eugene	5 a.m. to 11 p.m.	7 a.m. to 11 p.m.	8 a.m. to 8 p.m.
Los Angeles	6 a.m. to 9 p.m.	6 a.m. to 8 p.m.	8 a.m. to 7 p.m.
Halifax	6 a.m. to 12 a.m.	—	—

As illustrated in the above table, there are several elements that should be considered when determining the hours of service during the day for BRT, as follows:

- Span of service is usually consistent, or close to consistent, for all days of the week (maximizes the level of public confidence).
- A slightly later start is sometimes done on Sundays and, in a few cases on Saturdays, but that is not always the case.
- Evening finish times tend to be the same for all days, due to the desire for consistency and factors such as shift times, although a few systems end service earlier on Sundays.
- Holiday service hours are usually the same as those for Sundays.
- Late-night and/or early morning service (e.g., on weekends) could be provided by another service, such as a parallel local route, especially if demand cannot justify the minimum desirable “rapid transit” frequency (e.g., 15 or 20 minutes).

## 5. Frequency of service

### 5.1 Policies to set service frequencies

As for other aspects of BRT, policies and standards need to be in place to guide the setting of service frequencies that are planned and provided. The policies should be coordinated with the standards that are already in place for other rapid transit lines (especially rail, to help ensure that BRT is not perceived as inferior to rail) and for conventional transit services.

The most common approach is to have one set of rules to fix a minimum frequency of service (which can vary, for instance by time of day or by direction) and a second set of rules to establish when and by how much the service should operate more frequently than the minimum (for instance, when ridership reaches a certain level). Typically, the frequencies for off-peak times are based on the minimum standards (although some midday frequencies are higher), while those during peak times most often exceed the minimum standards and are determined by ridership demand.

### 5.2 Minimum service levels (policy frequencies)

Minimum service levels are intended to give a guaranteed level of convenience for customers, even at times when ridership is low. Because the BRT system is intended to be a higher-order service than local routes, it would normally have a minimum service level that is more frequent than the minimum for local routes.

In the U.S., in order to qualify as a Small Start under FTA guidelines, a corridor-based bus project is required to offer as a minimum 10-minute service during peak periods and 15-minute service during off peak times, for at least 14 hours per day in total. This is typical of most BRT systems in the U.S. and Canada, but with actual peak period frequencies usually being higher, based on ridership demand (see Section 6.3, “Service capacity standards”).

The minimum service level can vary by time of day and by day of the week, if desired. A further consideration should be how the minimum service levels for the BRT service coordinate with parallel local routes, intersecting main routes and timed transfers. Also, if off-peak demands can justify significantly higher frequencies, there may be a good case for using higher-capacity vehicles, such as articulated buses.

Saturday frequencies are usually similar to those of weekday off-peak times, while Sunday frequencies typically range between Saturday and evening frequencies. Bringing Sunday frequencies closer to Saturdays is becoming more prevalent due to a greater tendency of retail and other activities to be open on Sundays.

During times of very low demand, such as late nights and early mornings on weekends, service on the BRT corridor can be provided by parallel local services. This is often preferable to operating BRT at a low frequency (e.g., every 30 minutes), which could be considered contrary to the basic principle of not allowing BRT to operate at less than a suitable “rapid transit” frequency.

**Table 3** shows samples of minimum service levels for BRT service.

**TABLE 3**  
BRT Minimum Service Levels

Minimum Service Levels	Ottawa	York Region Viva	Pittsburgh East Busway	Seattle RapidRide
Early morning (before 6 a.m.)	30 minutes	None <sup>1</sup>	15 minutes	
Weekdays (18 hours)	15 minutes	15 minutes	15 to 20 minutes <sup>2</sup>	10 minutes
Saturdays (15 to 18 hours)	15 minutes	15 minutes	15 to 20 minutes <sup>2</sup>	10 to 15 minutes
Sundays (15 to 18 hours)	15 minutes	15 minutes	15 to 30 minutes <sup>2</sup>	10 to 15 minutes
Late night (after midnight)	30 minutes	None <sup>1</sup>	None <sup>3</sup>	

1. Service provided by parallel local service.  
 2. 15 minutes daytime, 20 or 30 minutes late evenings.  
 3. Service operated until 1 a.m.; some local service operated until 2 a.m.

### 5.3 Service capacity standards

During peak periods in particular, service frequencies are usually greater than the minimum standards and are driven by ridership demand. Service capacity standards can be developed to guide the frequency of service based on expected or observed ridership levels, usually at the peak load point on a route.

These standards can also be used to establish the starting frequency of service, and thus to determine the initial fleet size, when planning a new line. They can be used to predict and determine when ridership is increasing enough that service should be made more frequent and when service could be reduced, in times of ridership decline or budget reductions.

Some considerations when setting service capacity standards include the following:

- vehicle type
- vehicle configuration (number of seats, amount of standing space)

- whether some customers will be required to stand
- route length and speed (whether standees would be desired on long routes and/or operating at highway speeds)
- whether room should be allowed for ridership growth before the next scheduled or budgeted service increase and before the next acquisition of vehicles
- how wheelchairs and other mobility devices are handled on board
- whether bicycles are carried inside buses

Service capacity standards can vary in several ways, including the following:

- among different types of vehicles (e.g., lower on low-floor buses, higher on high-floor buses)
- by day of the week (e.g., lower on weekends)
- by the time of day (e.g., lower at off-peak times)
- according to frequency of service (e.g., lower when service is less frequent than every 10 minutes)

Where service capacity standards are used to make decisions on service increases, lower standards will lead to service increases under conditions such as these. **Table 4** shows service capacity standards for BRT service in Ottawa. All the numbers are compared to the average number of customers observed onboard buses, averaged over the busiest hour.

**TABLE 4**  
Ottawa Service Capacity Standards

Bus type	Maximum average number of riders on each bus	Seated customers	Standing customers
<b>Peak periods/peak direction</b>			
Low-floor 60-foot bus	70	54	16
Low-floor 40-foot bus	45	41	4
Standard 40-foot bus	45	45	0
<b>Off-peak times/direction</b>			
Low-floor 60-foot bus			
• Normal standard	54	54	0
• Short distances or frequent service	60	54	6
Low-floor 40-foot bus	40	40	0
Standard 40-foot bus	40	40	0

In this example, the service capacity standards are higher for articulated buses than for 40-foot buses, higher during peak periods than at off-peak times, and during off-times higher for short distances (for 10 minutes or less) or when service is very frequent (every five minutes or less).

Note that a certain number of standees are expected on certain bus types. In addition to those standees expected in the average over the hour, the busier trips in that hour will have more standees, and the lighter trips in that hour may have some open seats at the peak point.

A decision could be taken to have service capacity standards lower on BRT than on conventional service, either to increase comfort or to ease the justification for service improvements. Or a decision could be taken to have service capacity standards higher on BRT than on conventional service, to take account of a different vehicle type or a higher ride quality.

## 5.4 Examples of service frequencies

**Table 5** gives examples of the frequencies of service that are currently provided during weekdays on a selection of BRT systems within the United States and Canada. This helps to illustrate how in most cities service frequencies will be greater than the minimum policy frequencies, especially during peak periods, and in cities with high ridership or mature BRT systems, service levels may be well above the minimums at most times of the day or week.

**TABLE 5**  
Frequencies of Service (in minutes)

BRT Service	Peak	Midday	Early Evening	Late Evening
Transitway (Ottawa)	1+	2	3	5
Silver Line (Boston)	4	8	10	12
98-B Line (Vancouver)	5+	6	12	15
Orange Line (Los Angeles)	4	10	20	20
Viva (York Region)	5-10	15	15	15
East Busway (Pittsburgh)	4+	18+	20	20
South Busway (Miami)	6+	15+	15	30
EmX (Eugene, Ore.)	10	10	20	—
MAX (Las Vegas)	12	12	20	—
San Pablo (Oakland)	15	15	20	20
MAX (Kansas City)	9	15	30	30
Metro Rapid (Los Angeles)	6-10	15-20	20	—
MetroLink (Halifax)	10	30	30	30

+ Indicates additional routes augmenting a core service on the BRT facility.

## 6. Approaches to scheduling and operations

### 6.1 Creating reliable schedules

As a higher-order service, there is a higher expectation for reliability on BRT than on conventional transit. A service designed to change people’s habits from driving to transit use must be reliable in order to entice new customers to the system.

Notwithstanding what can be achieved with ITS technology (e.g., automated vehicle location and computer-aided dispatch), service reliability needs to be a major consideration when developing service schedules. Usually, recovery time is built into the routes to maintain reliable service, which results in at least some increase in both capital costs (more vehicles) and operating costs (more service hours). Because of the cost impacts, it is important to have an achievable schedule but not one with excessive time built in to it, which can result in slower service or having several buses sitting idle at a terminal. ITS technology can also allow tighter schedules to be built by using the technology to track vehicle locations and manage headways, resulting in both lower costs and faster service.

Where possible, recovery time should be scheduled at endpoint terminals rather than midroute stations. An exception is a busy midroute transfer station where it may be desirable to have the bus lay over to make connections with other routes. However, if an excessive amount of recovery time is inserted into the schedule midroute, it can result in buses sitting idle at midroute stops, unnecessarily delaying passengers and also potentially impeding traffic and/or transit vehicle flow along the corridor.

It is also imperative to test the schedules thoroughly prior to opening the system to the public. While modeling and historical data can provide insights into how a schedule might run, there is no substitute for real-world testing. In preparation for the launch of MetroLink service in the Halifax region, Metro Transit staff conducted approximately 20 trials for each time period of service. This allowed staff to refine the schedules and achieve reasonable reliability without unnecessary recovery time.

## 6.2 Policies affecting speed and service quality

### 6.2.1 Compulsory stop vs. stop-on-request only

Whether vehicles will make every stop along the route or whether they will stop only on request are two different approaches to BRT design and operation, each of which has its advantages. Most customers familiar with rail rapid transit systems will expect vehicles to make every stop and for all doors to open every time, which makes this an appropriate choice if it is important that the BRT service replicate rail rapid transit (although some LRT systems do not make all stops automatically). If priorities are for faster travel times and there is an expectation that customers using the system will be familiar with it, then stopping and opening doors only on request would be an appropriate choice.

Some considerations for whether stops are compulsory or on-request include the following:

- Is boarding or alighting activity regularly occurring at most stations throughout the full service period?
- Do the stops appear to customers as rapid transit stations or as upgraded bus stops?
- Are customer stop request features (stop request buttons and display) available on the vehicle?
- Will boarding be permitted and encouraged at all doors or only at the front door?
- Is a rail rapid transit service already part of the transit system?
- Will deceleration and acceleration at stops where no customers are boarding or alighting add an acceptable length to travel times (there may be a need to slow down at stations for safety reasons)?
- Will customers with visual disabilities know whether the vehicle is stopping?
- Are the station names being announced and/or displayed prior to arrival at the station?
- Do hot or cold climates make it important to keep cool or warm air inside the vehicle?

These decisions may have an impact on vehicle specifications, as additional equipment may be required if a demand responsive approach is taken. The additional vehicle equipment could include stop request buttons/strips/cords, stop request signage and customer door activation on the interior and exterior of the vehicle. Also, a marketing campaign and customer information should be considered if the practice is a unique situation for the system.

### 6.2.2 On-board vs. off-board fare collection

While some BRT systems maintain the conventional transit norm of having fareboxes on the vehicles and requiring fare payment at the front door, several systems have off-board prepayment, just as is done on subways and other higher-order rapid transit. This typically requires the purchase and installation of ticketing and ticket validation equipment at stations and terminals instead of fareboxes on the vehicles. It also requires a comprehensive public education campaign, if this type of fare collection is new to the transit system.

The primary advantage of off-board fare payment is faster travel times (and related cost savings due to lower requirements for vehicles and service hours). This is achieved primarily from allowing boarding at all doors, along with eliminating delays from fare or transfer disputes or when passengers ask questions about fares (which in turn lessens the distractions for drivers). The benefits of off-board payment may be less if a high percentage of riders use pre-paid fare media such as passes or stored-value cards (smart cards).

The main disadvantage of off-board fare payment is the need to have fare inspectors and the costs associated with them, although an offsetting advantage of this can be heightened security if the inspectors are also able to deal with other incidents or if their presence creates disincentives for disruptive behavior. Even with inspectors, some revenue loss due to fare evasion should be expected with off-board payment (approximately 4 to 5 percent). The cost of ticketing equipment is also a factor, although this is mostly offset by not having to purchase fareboxes.

Also, as noted in Section 2, “Routing,” an off-board fare payment system is much less feasible on a BRT system where routes leave the BRT facility to circulate through neighborhoods or access off-corridor destinations, since it would be difficult to justify purchasing and installing ticketing machines at stops along local routes outside the BRT facility. Ticketing equipment could still be installed on the BRT corridor, but the vehicles would need fareboxes, thus adding to the cost; inspectors would still be needed; and there would be a greater likelihood for public confusion from mixing two different fare collection procedures.

### 6.2.3 Accessibility

Full accessibility to customers using wheelchairs or other mobility devices and to people with disabilities in general has become the accepted norm on transit systems. Accommodating mobility devices can, however, have the effect of slowing the service, such as when a wheelchair ramp is deployed. This delay can be reduced considerably through level boarding and vehicle guidance systems at stations (as discussed in the APTA *Recommended Practices Runningways*).

Additional delay can result from having to attach securement belts in forward-facing wheelchair positions. In both Canada and the United States, several systems have successfully used rear-facing positions, where securement is not needed, thus lessening this delay factor.

### 6.2.4 Bicycle accommodation

Accommodating bicycles on BRT can be a feature in attracting ridership but can also add delays to travel time. This is especially the case for exterior bike racks, where the cyclist must lower or extend the rack, put the bike on the rack and properly secure it, as well as carrying out the reverse procedure at the end of the trip. Some systems, such as Vancouver and Ottawa, have found this to have little or no impact on operations and travel times, especially as cyclists become familiar with the procedure and can load or unload their bikes quite quickly.

Eugene’s EmX system is one of several BRT systems that has installed interior bike racks, which, along with having level boarding, have helped reduce this delay. The main disadvantage of interior racks, however, is the loss of vehicle capacity and the inconvenience to other passengers, especially during peak times and high vehicle occupancy, when trying to maneuver the bike on or off the vehicle.

The other approach is not to have bicycles on the vehicle at all, but rather to provide bike racks or bike lockers at stations. This can, however, raise security concerns regarding bicycle theft, which can be lessened with properly designed lockers or if the station or terminal has a full-time staff or security presence.

## 7. Service monitoring and refinement

### 7.1 Performance measures

Performance measurement and monitoring is a critical element of all service design and needs to be considered from the outset of BRT planning and included in the project design and budget (both capital and operating). Policy objectives of the BRT project should guide the selection of performance guidelines and indicators, with consideration also given to data and resource needs for ongoing monitoring and analysis.

#### 7.1.1 Productivity

Productivity objectives are perhaps the most valuable to service design, as they serve as the basis for reallocating or adjusting service levels. Numerous productivity standards are possible; however, two are of particular value: boardings per service hour and load factor (or utilization rate).

**Boardings per service hour** (or per mile or kilometer) is an industry standard indicator for assessing productivity. This provides a means of comparing similar routes (those using the same fleet type), which makes it useful for many BRT systems. However, boardings per hour is an insufficient measure for comparisons between different types of routes (e.g., those with high turnover vs. those with long single seat rides) or transit services with different vehicle types and capacities.

A preferred means of equitably measuring productivity of transit services is **load factor** or utilization rate. Load factor is a measure of the demand compared to the available capacity, which in BRT applications translates best into a ratio of passenger miles/kilometers to seat miles/kilometers. This can guide operational adjustments to better match supply with demand (such as introducing short turns or different sized vehicles).

For illustrative purposes, **Table 6** is a sample of minimum efficiency guidelines for bus services in Vancouver, showing the differing productivity guidelines for B-Line (low-cost BRT) and other bus services. Figures are average percentage of seats occupied over the entire route in the peak direction, measured as passenger-miles divided by seat-miles.

**TABLE 6**  
Minimum Efficiency Guidelines for Vancouver BRT

Service Brand	Weekday Peak Periods	Weekday Midday	Evening	Weekend Daytime
B-Line	50%	40%	30%	30%
Express coach	50%	40%	20%	30%
Bus	30%	25%	15%	20%
Community shuttle	25%	15%	10%	15%

TransLink Transit Service Guidelines (2004)

#### 7.1.2 Reliability

Service reliability is an important measure of both system performance and customer experience. Two key indicators are schedule adherence and headway adherence. **Schedule adherence** is the traditional approach to measuring service reliability. However, on BRT services with high frequencies and without published schedules, **headway adherence** is a much more relevant measure. It can be measured both at the route level, as well as at the individual trip level. Analysis of this sort requires extensive data, reasonably available only through automated collection (e.g., AVL).

If schedule adherence is not being monitored, then an indicator of speed (or delay) should supplement headway adherence measures.

The following example is from San Francisco (SFMTA), which is used for all transit modes and should be applicable for BRT:

- **On-time performance target: 85 percent.** At least 85 percent of vehicles must run on time, with “on time” defined as one minute early to four minutes late.
- **Headway adherence target: 85 percent.** Actual headways must be within the lesser of 30 percent or 10 minutes of the scheduled headway.
- **Service delivery target: 98.5%.** 98.5 percent of scheduled service hours must be delivered and must begin service at the scheduled time.

Examples of on-time performance definitions for various modes are as follows:

- **SFMTA (San Francisco):** one minute early to four minutes late
- **NYMTA (New York):** five minutes early to five minutes late
- **CTA (Chicago):** one minute early to five minutes late
- **LACMTA (Los Angeles):** one minute early to five minutes late
- **WMATA (Washington) Bus:** two minutes early to seven minutes late (all time points)

Examples of headway adherence definitions for various modes are as follows:

- **WMATA (Washington) Rail:** less than two minutes deviation for peak trips; less than 50 percent deviation the rest of the day
- **SFMTA (San Francisco):** within the lesser of 30 percent or 10 minutes of scheduled headway

## 7.2 Data collection and analysis

Extensive data collection will be necessary to support the measurement of these indicators. Traditional manual data collection methods of ride checks and point checks are increasingly being supplemented by automated data sources. The two primary sources of automated data are automated passenger counter (APC) and automatic vehicle location (AVL) systems. In some cases, these can be further supplemented by farebox data.

### 7.2.1 Automated passenger counters

APC systems enable the collection of a high volume of highly detailed passenger data. The systems are comprised of both hardware and software to produce passenger boarding and alighting counts. The count records include time clock, GPS/odometer and other information (e.g., wheelchair ramp deployment).

A wide array of passenger and operational data can be derived from this data, including the following:

- boardings, alightings and load at any given location and place in the system
- arrive and leave times at stops and timing points
- travel speed and travel time between stops
- dwell time at stops

Deployment of APC units over 10 to 15 percent of the entire fleet is considered an industry minimum to reliably gather sufficient data for meaningful analysis. In many systems, there is a move towards a much higher degree of APC deployment on dedicated BRT sub-fleets, with many agencies opting for full (100 percent) APC coverage.

### 7.2.2 Automated vehicle location

AVL systems are complementary to APC data in providing operational data to support service analysis. Detailed operational data that AVL systems can provide include the following:

- constant data stream with the location of all vehicles in real time
- automatically or manually recorded events (stop, door opening, lift deployment, etc.), associated with a trip, time and location
- speed (actual, average, variance)
- headways (actual, average, variance)

As most AVL systems have been designed primarily for real-time applications, they do not necessarily capture and/or archive data that would be valuable for off-line analysis. Those wishing to maintain and analyze AVL data should procure systems with the ability to do so.

Overall, automated systems can provide a far greater amount and detail of information, and with a shorter turnaround time than is possible with manual data collection. The result is the possibility of almost instant extensive data for all trips and time conditions, which is highly reliable and easily accessible to a broad range of users. The challenge is that these applications require a lot of data processing to produce high-quality, reliable data. The data produced by automated systems (particularly APC) needs to be interpreted and transformed to eliminate data error or bias. Of particular concern to BRT systems is the high degree of counting error generated by many APC systems in heavy load situations. Realistically, at least some amount of manual data collection may remain essential to calibrate or supplement the APC results.

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## Definitions

**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.

**dwelt time:** The time a transit vehicle spends at a stop to discharge and take on passengers, including opening and closing doors.

**headway:** The time interval between the passing of successive transit buses or trains moving along the same route in the same direction, usually expressed in minutes. Also be referred to as “service frequency.”

**intelligent transportations systems (ITS):** An umbrella term used to describe the variety of technologies, treatments and strategies that allow improvements to the flow of transit systems. In many cases, insertion of ITS technologies provide transit travel improvements with a minimal of capital investment. In other words, these methods described herein try to extract out efficiencies in a system that is already in place by adding refinements to the system and/or infrastructure rather than major rehabilitation.

**Small Starts program:** The federal government’s primary financial resource for supporting locally planned, implemented and operated major transit capital investments. The New Starts program funds new and extensions to existing fixed guideway transit systems, including commuter rail, light rail, heavy rail, bus rapid transit, streetcars and ferries.

## Abbreviations and acronyms

<b>APC</b>	automated passenger counts
<b>AVL</b>	automated vehicle location
<b>BRT</b>	bus rapid transit
<b>CAD</b>	computer-aided dispatch
<b>CTA</b>	Chicago Transit Authority
<b>EmX</b>	Emerald Express (Eugene, Ore.)
<b>FTA</b>	Federal Transit Administration
<b>ITS</b>	intelligent transportation systems
<b>LACMTA</b>	Los Angeles County Metropolitan Transportation Authority
<b>LRT</b>	light rail transit
<b>NYMTA</b>	New York Metropolitan Transportation Authority
<b>RTC</b>	Réseau de transport de la Capitale (Quebec City)
<b>SFMTA</b>	San Francisco Municipal Transportation Agency
<b>TOD</b>	transit-oriented development
<b>TPM</b>	transit priority measure
<b>TSP</b>	transit signal priority
<b>WMATA</b>	Washington Metropolitan Area Transit Authority