bus rapid transit

an urban form of mobility

mayank patel

university of california, davis | landscape architecture | senior project

2009

bus rapid transit

an urban form of transportation

A senior project presented to the faculty of the Landscape Architecture Program at the University of California, Davis in partial fulfillment of the requirement for the degree of Bachelors of Science in Landscape Architecture.

Accepted & Approved By:

Mark Francis, Faculty Senior Project Advisor & Committee Member

Stephen Wheeler, Faculty Committee Member

Richard Coss, Committee Member

By
Mayank Patel
June 12, 2009

abstract

The transition into the 21st century places us in a precarious situation. With rapid global changes in progress, smarter planning, sustainable practices, conscious applications, and a modified lifestyle become necessities. Transportation is one of the primary contributors to harmful global change. The objective of this project is to examine a particular form of transportation, Bus Rapid Transit (BRT), and analyze whether or not it addresses current issues (congestion) and at the same time, serves as a promising measure for the future. The significance of this study is to a) realize the impact transportation and transportation systems have in urban planning and design, and b) learn how public transportation influences or dictates social welfare.

The project is divided into four parts. First, I discuss BRT to provide a comprehensive understanding of the functionality and application of the system. Thereafter, in order to grasp what may or may not be successful, I refer to existing case studies of cities (Curitiba & Los Angeles) that have implemented BRT. Then, I discuss the lessons learned about BRT, as a system and its application, in an effort to answer the question: How is BRT successfully employed? And finally, I propose a set of general design guidelines tailored for novice planners and designers, which can help with the implementation of BRT.

acknowledgements

maharaj & swami

my success is the result of Your blessing

committee

your guidance, advice, and insight got me through this endeavor

faculty

you are more than teachers, you are educators

family

you are the backbone that supports my every move

friends

you are the memorable experiences and lessons outside the academic walls

table of contents

list of figures
& figure source

[all figures, images, diagrams, charts, etc. are created by mayank patel, unless noted otherwise]

1.3 | VEHICLES

1.4 | SERVICE

figure 1.41a	http://thecityfix.com/category/brt/
figure 1.41b	http://www.urbanjacksonville.info/category/transit/
figure 1.42a	http://vancouver.ca/engsvcs/transport/rto/canadaline/index.htm
figure 1.42b	http://www.i-595.com/improve.aspx
figure 1.42c	http://en.wikipedia.org/wiki/Viva_(bus_rapid_transit)

1.5 | INTELLIGENT TRANSPORTATION SYSTEM (ITS)

figure 1.51a	http://lmr-mc-database.daap.uc.edu/brt2/what.php
figure 1.51b	http://www.nbrti.org/media/gallery/busway/busway-pics.htm
figure 1.51c	http://www.nbrti.org/media/gallery/Vancouver/Vancouver.htm
figure 1.52a	http://www.path.berkeley.edu/PATH/Research/Featured/111805/ITS-WOCO.html
figure 1.52b	http://www.nbrti.org/media/gallery/vegas/maxset.htm
figure 1.52c	http://www.fta.dot.gov/assistance/technology/research_4333.html
figure 1.53a	http://commons.wikimedia.org/wiki/File:Downsview_Vivastation.jpg
figure 1.53b	http://www.citytransport.info/Buses03.htm
figure 1.54a	http://www.weatheredkings.com/downloads/directions.php
figure 1.54b	http://www.citytransport.info/Buses03.htm
figure 1.54c	http://www.service2media.com/home/news/5487
figure 1.54d	Screen shot taken by Mayank Patel
figure 1.55a	http://www.nbrti.org/media/gallery/vegas/maxset.htm
figure 1.55b	http://www1.messeberlin.de/vip8_1/website/MesseBerlin/htdocs/www.innotrans.de/en/Ausstellerservice/InnovationReport2008/index.jsp

chapter 2 | case studies

2.1 | CURITIBA, PANARA-BRAZIL

2.2 | LOS ANGELES, CALIFORNIA-UNITED STATES

chapter 3 | lessons learned

3.1 | COMMUNITY INVOLVEMENT

3.2 | COOPERATIVE PLANNING

3.3 | LONG-TERM VISION

chapter 4 | design guidelines

4.1 | RUNNING WAYS

figure 4.11	http://www.nbrti.org/media/gallery/civis/civis.htm
figure 4.12	http://richmondva.wordpress.com/2007/06/08/more-on-richmond-transit-improvements/
figure 4.13	http://english.sina.com/p/1/2008/0115/141848.html
figure 4.14	http://www.streetsblog.org/2009/02/24/brt-rail-and-new-york-city-a-conversation-with-walter-hook/
figure 4.15	http://richmondva.wordpress.com/2007/06/08/more-on-richmond-transit-improvements/
figure 4.16	http://www.streetsblog.org/2009/02/26/brt-and-new-york-city-part-3-ingredients-of-a-great-brt-corridor/
figure 4.17	http://english.sina.com/p/1/2008/0115/141848.html
figure 4.18	http://www.bristol.gov.uk/ccm/content/press-releases/2008/jan/cyclists-pedestrians-and-passengers-can-co- exist-on-shared-path.en

4.1 | STATION STOPS/SHELTERS

figure 4.21	http://www.metrojacksonville.com/article/2007-may-bus-rapid-tragedy-strikes-again
figure 4.22	http://www.berkeleydailyplanet.com/issue/2007-07-27/?status=301.html
figure 4.23	*Bus Rapid Transit-Stations & Shelters*
figure 4.24	*Advance Network Planning for Bus Rapid Transit-The "Quickway" Model as a Mode Alternative to "Light Rail Lite"*
figure 4.25	http://www.flickr.com/photos/wei/2087024682/in/photostream/
figure 4.26	*Advance Network Planning for Bus Rapid Transit-The "Quickway" Model as a Mode Alternative to "Light Rail Lite"*
figure 4.27	*Advance Network Planning for Bus Rapid Transit-The "Quickway" Model as a Mode Alternative to "Light Rail Lite"*
figure 4.28	*Advance Network Planning for Bus Rapid Transit-The "Quickway" Model as a Mode Alternative to "Light Rail Lite"*

preface

The advent of exponential global climate changes and the energy crisis calls for extensive discussion regarding the impact that civilization will leave on the planet. It is clear that the world cannot afford to continue to blindly embrace the idea of the "American Dream." And those of us who do dare dream it, awake to the bleak reality of our circumstances. Change is overdue. Now, we must take control of the reins and use our education to plan for a healthier tomorrow.

Where do we begin? I argue we must start with something that is embedded into the activities of everyday life—transportation. The global economy depends on the movement of people and goods from one location to another. The ease at which people and goods are transported is the hallmark of a developed state, thanks to the "snap-of-the-finger" availability of fossil fuels. Our effort to modify transportation systems and provide the public with more transportation options can have a drastic effect on our environment, which can ultimately lead to a healthier lifestyle. If we can improve our form of mobility—in all its aspects—we hold a better chance at minimizing our ecological footprint, and potentially, prolonging the lifespan of our planet. Stepping back to examine daily urban activities we see a pattern that depends heavily on transportation. It is safe to say that these activities are the leading cause of climate change, and transportation takes credit for being the largest energy user.

Reports, scientific findings, and statistics all acknowledge that automobiles and other forms of transportation are the leading contributors of green-house gases (GHG), but we should also remember that vehicles do not operate on their own (Chisholm-Smith, 2009). Today, we witness car companies making an effort to create fuel-efficient, "eco-friendly" cars in hopes of saying, "Look, we can be green too!" But, that is not enough. If we really want to help reduce GHG, we ought to step out of our cars and hop onto a bus, ride a bike or simply walk. Unfortunately, we are devoutly wedded to our cars. The automobile is an enduring icon of the American culture; for that reason, I feel Americans fear a change in their individual travel behavior because it a) asks us to forgo certain luxuries and b) requires us to build patience. The shift to a lifestyle oriented around public transportation might be bumpy at first, but once we learn the road, the ride is pleasurable.

Individual travel behavior starts with planning, policies, and design. Our decision of how much to drive, where to drive, and when to drive is contingent on the surrounding environment, available transportation options, and land-use policies. It is rare to find individuals who live, work, dine, shop, and recreate in close proximity. New urbanism and smart growth principles promote compact, mixed-use developments that fully integrate pedestrian, bicycle, and transit facilities to better serve the public. Adapting such models can serve as an incentive for an environmentally conscious community. However as Chisholm-Smith (2009) argues, if "funding policies favor road capacity expansion and single-use development with plentiful parking over compact mixed-use developments and public transportation, then higher levels of single-occupancy vehicle use are inevitable" (Chisholm-Smith, 2009, p. 2). As this report supports, there is a clear relation between transportation and land use planning; proper administration and coordination regarding the two can channel positive results. Therefore, it is critical for planners, designers, and legislature to work cohesively in order to establish a well-functioning community.

Figure 01

The push towards using public transportation as depicted by the specialized logos and livery on a low-boarding BRT vehicle.

introduction

what is bus rapid transit?

Sitting in traffic is not a picnic. During those grueling hours spent in traffic, I wish teleporting were an option. Although such technology has yet to be invented, we must tackle the problem of traffic congestion in a creative, yet practical way using the technology we possess today. Bus Rapid Transit (BRT) is a viable response to the problems we face with traffic congestion. A well-designed BRT system takes into consideration many variables including population growth, commuter demands, rider safety, time efficiency, accessibility, and environmental responsibility.

What exactly is BRT? The Transportation Research Board defines BRT as "a rubber-tired rapid-transit mode that combines stations, vehicles, services, running ways, and Intelligent Transportation System (ITS) elements into an integrated system with a strong positive identity that evokes a unique image" (Levinson, et al., 2003, p. 9). The Federal Transit Administration views BRT as "an enhanced bus system that operates on bus lanes or other transitways in order to combine the flexibility of buses with the efficiency of rail" (United States Department of Transportation, Federal Transit Administration, 2008). Some even see BRT as simply "light rail on rubber tires." What is important to note is that BRT dons many definitions relative to the individual describing it, be it a planner, designer, engineer, or politician. For the purpose of this project, I give BRT a two-fold definition: A) In practice, BRT is an efficient, cost-effective hybrid transit system that incorporates aspects of light rail and the conventional bus system while integrating technology, aesthetics, efficiency, reliability, and connectivity to pedestrians and bicyclists, and B) In theory, BRT is an impetus for positive change towards remediating environmental and social conditions.

Many regard BRT as a foreign concept and a fairly recent phenomenon. However, the idea of bus rapid transit is not new. It just so happens that over these past couple of decades, the idea of BRT was "re-discovered" and has induced new inspiration as a result. The notion of using rubber-tired vehicles to provide rapid transit service originated in the 1930s (Levinson, et al., Bus Rapid Transit, Volume 1: Case Studies in Bus Rapid Transit, 2003). The City of Chicago proposed rudimentary BRT plans in 1937 and others cities like Washington D.C. and St. Louis developed BRT plans in the mid-to-late 1950s. (Levinson, et al., Bus Rapid Transit, Volume 1: Case Studies in Bus Rapid Transit, 2003). Even so, the first implementation of a "BRT" occurred outside of the U.S.

As mentioned, the concepts revolving around BRT have been around for many years. Today, ideas like express services, dedicated running ways, faster travel time, reduced dwelling time, signal priority, and ITS are at the heart of the BRT planning and advocacy. Despite this shared vision, there is still uncertainty in understanding of BRT in the planning and transportation arena. Because of that disunity, the question of "what is BRT?" becomes difficult to answer. In addition, BRT's extensive nature and malleability to its surroundings adds to the difficulty of providing just one definition.

chapter 1 | major elements

the five elements

The identity and quality of BRT is at the mercy of a handful of elements which encourage the rapid aspect of rapid transit. Authorities list a little less than a dozen elements, however, for the purpose of this project, I focus on five elements that I see as most important. Below, I discuss the five major elements (see Diagram 1) that increase the favorability of BRT. The information comes from a number of sources such as the Transportation Research Board (http://www.trb.org/default.asp), Federal Transit Administration (http://www.fta.dot.gov/research_4240.html), and the National BRT Institute (http://www.nbrti.org/). But the primary source I use to explain the information is the Characteristics of Bus Rapid Transit for Decision-Making, compiled by Roderick B. Diaz and team.

You will find that some of the areas intertwine both descriptions and suggestions/guidelines. However, Chapter 3 only provides a set of guidelines. Although all five elements are crucial to the principle and practice of BRT, designers may prioritize them differently. I examine these elements as a designer, thus some elements are discussed in greater length more than others.

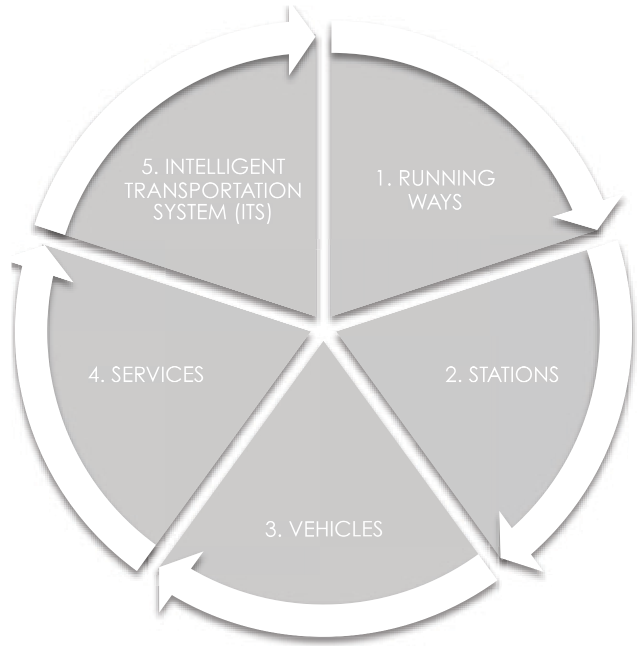
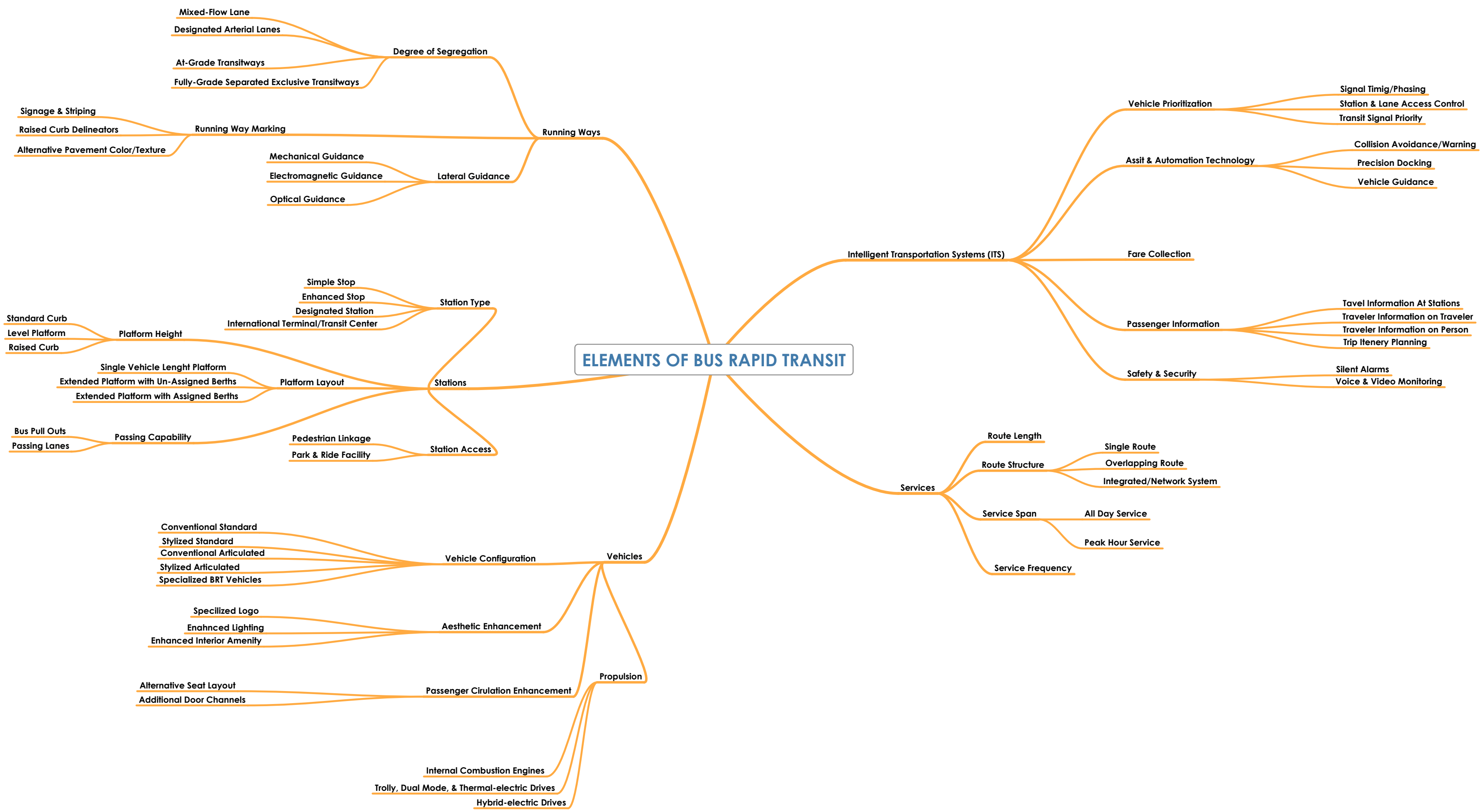


Diagram 1: Five Major BRT Elements
All five elements need to work together in order for BRT to function as a successful unit.

***NOTE: For a quick and complete overview, please refer to the following page, which shows the network of BRT elements.**



ELEMENTS OF BUS RAPID TRANSIT
Running Ways
Degree of Segregation
Mixed-Flow Lane
Designated Arterial Lanes
At-Grade Transitways
Fully-Grade Separated Exclusive Transitways
Running Way Marking
Signage & Striping
Raised Curb Delineators
Alternative Pavement Color/Texture
Lateral Guidance
Mechanical Guidance
Electromagnetic Guidance
Optical Guidance
Stations
Station Type
Simple Stop
Enhanced Stop
Designated Station
International Terminal/Transit Center
Platform Height
Standard Curb
Level Platform
Raised Curb
Platform Layout
Single Vehicle Lenght Platform
Extended Platform with Un-Assigned Berths
Extended Platform with Assigned Berths
Passing Capability
Bus Pull Outs
Passing Lanes
Station Access
Pedestrian Linkage
Park & Ride Facility
Vehicles
Vehicle Configuration
Conventional Standard
Stylized Standard
Conventional Articulated
Stylized Articulated
Specialized BRT Vehicles
Aesthetic Enhancement
Specilized Logo
Enahnced Lighting
Enhanced Interior Amenity
Passenger Cirulation Enhancement
Alternative Seat Layout
Additional Door Channels
Propulsion
Internal Combustion Engines
Trolly, Dual Mode, & Thermal-electric Drives
Hybrid-electric Drives
Intelligent Transportation Systems (ITS)
Vehicle Prioritization
Signal Timig/Phasing
Station & Lane Access Control
Transit Signal Priority
Assit & Automation Technology
Collision Avoidance/Warning
Precision Docking
Vehicle Guidance
Fare Collection
Passenger Information
Tavel Information At Stations
Traveler Information on Traveler
Traveler Information on Person
Trip Itenery Planning
Safety & Security
Silent Alarms
Voice & Video Monitoring
Services
Route Length
Route Structure
Single Route
Overlapping Route
Integrated/Network System
Service Span
All Day Service
Peak Hour Service
Service Frequency

1.1 | running ways

Automobiles depend on roadways. Rail transit systems depend on tracks. What does BRT depend on? The answer is running ways. Running ways are one of the most distinguishing and expensive elements of BRT. Aspects such as reliability, travel speeds, and the identity of BRT heavily rely on running ways. Running ways should attempt to avert interference from the general traffic by marking a strong, clear presence. The primary purpose of a running way is to establish an environment free of delays (Levinson, et al., Implementation Guidelines, 2003). There are three primary characteristics to running ways: 1) degree of segregation, 2) running way marking, and 3) lateral guidance (Diaz, et al., 2004). The Characteristics of Bus Rapid Transit for Decision-Making (CBRT) report discusses the three characteristics in great length. A summary is shown below.

CHARACTERISTIC 1: DEGREE OF SEGREGATION

The separation between regular traffic and BRT vehicles significantly impacts the success, reliability, and favorability of BRT. However, separation is not mandatory. A marketable trait of BRT lies in the number of options regarding its running ways types. Decision-makers have the freedom to choose what is most appropriate based on their financial capacity, general plan guidelines, potential development opportunity, demand, feasibility, and constituent approval. Typical BRT running way options consist of mixed-flow lanes, designated arterial lanes, at-grade transitways, and fully grade-separated exclusive transitways (Diaz, et al., 2004).

Option 1: Mixed-Flow Lanes

Type A- Unimproved mixed-flow lanes

We witness and experience type A on a day-to-day basis. This type of mixed-flow lane is the most elementary form of a BRT running way. Due to the lack of recognizable segregation between regular traffic and BRT vehicles, travel delays, and perhaps even congestion, are inevitable.

Type B- Improved mixed-flow lanes consisting of queue jumpers

A queue jumper is "a designated lane segment or traffic signal treatment at signalized locations or other locations where traffic backs up. Transit vehicles use this lane segment to bypass traffic queues (i.e., traffic backups). A queue jumper may or may not be shared with turning traffic" (Diaz, et al., 2004, p. 254). Typically, queue jumpers work best in the company of signal priority. This combination grants BRT vehicles with access through intersections prior to other vehicles with the help of special signals. Incorporating queue jumpers does not necessarily eliminate delays, but it definitely reduces travel time through busy intersections during peak hours. If faced with a limited budget, this option is beneficial because it allows BRT vehicles to bypass congested areas.

Figure 1.11: Mixed Flow Traffic Lane in China

Option 2: Designated Arterial Lanes

Designated BRT lanes may be a better alternative to mixed-flow lanes when circumstances permit. This option works especially well in corridors that house existing arterial roadways. Designated arterial lanes prohibit non-BRT vehicles from using the BRT assigned lane. However, the question of, "how is this regulated" arises. There are a couple of ways to enforce this scheme. The first is with barriers (concrete, or otherwise). And the second is to have police monitor and cite violators. However, the FTA reports a few cases where specified classes of vehicles have been allowed to share the lane with BRT vehicles. Allocating designated lanes for BRT vehicles is of utmost importance. Lane(s) dedicated to BRT vehicles not only help reduce travel time, but they avoid congestion. As a result, the overall reliability of BRT strengthens.

Figure 1.12: Designated Arterial Lanes

Option 3: At-Grade Transitways

At-grade transitways call for roadways exclusive to BRT vehicles and that is what makes this option costly. But, if new development or the construction of infrastructure is out on the horizon, cities may want to take advantage of the opportunity to integrate transitways into those particular plans. However, if no such plans are in play, if budget constraints exist, or if right-of-ways can only accommodate for a certain amount of space, modifications can be made. For instance, a bi-directional lane can be a great substitute for a standard lane on a transitway (Diaz, et al., 2004). A bi-directional lane is a single lane that supports BRT vehicles traveling in either direction. This works essentially in the same fashion as a standard lane at low frequencies. At higher frequencies, "sophisticated signal systems and coordinated schedule may be required to ensure safe and unimpeded operation of BRT vehicles" (Diaz, et al., 2004, p. 47). At-grade transitways significantly increase speed and safety since barriers/markings do not allow the general traffic to penetrate into the transitway. This, in turn, reassures the reliability of BRT service. Though a bit pricey, at-grade transitways are a wonderful asset for BRT.

Figure 1.13 At-Grade Transitway in Orlando

Option 4: Fully Grade-Separated Exclusive Transitways

This is the most expensive measure because it offers the greatest degree and most distinct level of separation. Usually, fully grade-separated exclusive transitways take one of two forms: stand-alone transitways or transitways on major freeways. Stand-alone transitways can evolve from unused railroad tracks. That is, cities can utilize space occupied by idle railways to instate BRT transitways to save costs. Transitways on major freeways can run parallel to the freeway, along the median, on elevated structures, or underground. Areas that experience high frequencies may require multiple lanes to increase capacity and/

or allow other BRT vehicles to pass. Exclusive transitways ensure the greatest degree of safety along with the most reliable and fastest travel time.

Figure 1.14: Grade-Separated Transitways in Pittsburgh

CHARACTERISTICS 2: RUNNING WAY MARKING

Running way markings indicate the travel path of BRT vehicles. Their primary purpose is to help commuters, other vehicles, and the general public identify where BRT services operate. Running way markings can be expressed in a variety of ways including "pavement markings, lane delineators, alternate pavement texture, alternate pavement color, and separate rights-of ways"(Diaz, et al., 2004, p. 45). However, there are three dominant techniques for running way markings: signage and striping, raised lane delineators, and alternate pavement color/ texture.

Technique 1:Signage and Striping

This is most basic of running way markings. This technique uses "diamond" shaped symbols to avert the general traffic from using the BRT service lane. For major streets/arterials, signage at interactions is a nice way to differentiate BRT lanes from regular traffic lanes.

Figure 1.15: Simple Signage & Striping in Phileas

Technique 2: Raised Lane Delineators

Bumps, bollards, colored line, or raised curbs all represent a form of delineators.

Figure 1.16: Raised Lane Delineators in Mexico City

Figure 1.17: Alternative Pavement Color

Technique 3: Alternate Pavement Color/Texture

The application of colored or textured asphalt serves as the most conspicuous means to distinguish a difference between general traffic and BRT service lanes. Therefore, this technique further reduces potential conflicts between BRT vehicles and the general traffic.

CHARACTERISTIC 3: LATERAL GUIDANCE

Lateral guidance "controls side-to-side movement of vehicles along the running way similar to how a track defines where a train operates" (Diaz, et al., 2004, p. 49). Most BRT services rely on an individual to operate and steer the vehicle. Nonetheless, where needs and desires are different, the option of lateral guidance is taken into consideration. Although later guidance is costly, it allows for no-step boarding and alighting, reduces right-of-way requirements, provides smoother rides, and facilitates "precision-docking" at stations (Diaz, et al., 2004). The type of lateral guidance corresponds to the technology being used, so depending on the technology, the guidance type can be mechanical, electromagnetic, or optical.

Type 1: Mechanical Guidance

As defined by CBRT (2004):

Mechanical guidance requires the highest running way investment of all guidance options, but the lowest requirement for complex vehicle systems. Vehicles are guided by a physical connection from the running way to the vehicle steering mechanism, such as a steel wheel on the vehicle following a center rail, a rubber guide wheel following a raised curb, or the normal vehicle front wheels following a specifically profiled gutter next to station platforms (Diaz, et al., 2004, p. 49).

Type 2: Optical Guidance

As defined by CBRT (2004):

Optical guidance systems involve special optical sensors on the vehicles that read a marker placed on the pavement to delineate path of the vehicle. In this guidance option, the only running way requirement is to have large double striped lines in the center of the respective lanes. Complex electronic/mechanical systems are required for each vehicle (Diaz, et al., 2004, p. 49).

Essentially, optical guidance involves the use of vision cameras to "read" and recognize painted surfaces in order to keep the vehicles within bounds.

Type 3: Electromagnetic Guidance

As defined by CBRT (2004):

Electromagnetic guidance involves the placement of electric or magnetic markers in the pavement such as an electro-magnetic induction wire or permanent magnets in the pavement. Sensors in the vehicle read these markers to direct the path of the vehicle. This type of guidance requires significant advanced planning in order to embed the markers under the pavement (Diaz, et al., 2004, p. 49).

1.2 | stations

Stations influence how individuals perceive BRT and public transit systems in general. Because stations and their components represent the public face of BRT, their design calls for close attention. The purpose of BRT stations is to bolster connectivity among the BRT system itself, its customers, and other forms of public transportation. Spacing between stations can vary greatly, and is affected by the type of running way and the context. For instance, spacing between stations on a freeway or busway can range from 2,240ft. to 5,540ft.; along an arterial street or major corridor it can range from 1,000ft. to 4,000ft. (Levinson, et al., Bus Rapid Transit, Volume 1: Case Studies in Bus Rapid Transit, 2003). Typically, the spacing between BRT stations is greater than that of conventional bus stations. The Transportation Research Board recommends greater distance between stations in order to limit the amount of stops required. One consequence of having limited stops is greater concentration of passengers at those particular stations. The combination of longer distance between stops and limited amount of stations prevents delays and allows vehicles to maintain high travel speeds between stations more consistently. Fast travel time is emphasized in order to compensate for the time required to walk or drive to transit stations (Diaz, et al., 2004).

In addition, stations also offer the opportunity to design BRT waiting areas such that their identity is distinguished from other means of transportation. This is accomplished by designating a theme and palette of color and materials that both stations and running way furnishings adhere to. While research tells us that station design clearly affects the aesthetics of the environment, it also impacts its users psychologically. Therefore, it is in the best interest to install weather-protected waiting areas with seating that creates an ambiance of comfort and safety. More importantly, while it is advised to establish a well-defined, consistent identity for BRT, it is crucial that BRT stations correspond to the larger urban fabric. Cautious integration of BRT into the urban realm initiates the opportunity to enhance the streetscape. Decision-makers can also take advantage of proposing greenbelts or trails, which connect to BRT services. Successful stations demand a high-quality design coupled with qualitative amenities. Both the Transportation Research Board and the Federal Transit Administration recommend addressing a handful of aspects when designing BRT stations. They are: 1) station type, 2) platform height, 3) platform layout, 4) passing capability, 5) and station access.

STATION TYPE

For the most part, BRT serves major arterials or demanding corridors and the number of stops on the route is limited. Given the limited amount of stops, it makes sense that the number of customers using each stop would be considerably higher than a conventional bus stop. According to the CBRT report, BRT stops can range from "simple stops with well-lit basic shelters to complex intermodal terminals with amenities such as real time passenger information, newspaper kiosks, coffee bars, parking, pass/ticket sales and level boarding" (Levinson, et al., Implementation Guidelines, 2003, p. 55). Figures 1.21A-1.21D highlight the different classification of stops as mentioned by CBRT.

Figure 1.21A: Simple Stop
Information below is based on the data contained in *CBRT* (2004).

- Most basic, "off-the-shelf," type of stop
- Offers passengers a sheltered waiting area
- Least amount of amenities

Figure 1.21B: Enhanced Stop
Information below is based on the data contained in *CBRT* (2004).

- Bus stops designed to hold distinct identity and stand out amongst other transit stops
- Enhanced shelters equipped with high-quality finishes and better materials, often glass or some form of transparent material
- Amenities consist of seating, lighting, pay phones, trash cans, etc.

Figure 1.21C: Designated Station

Information below is based on the data contained in *CBRT* (2004).

- Forms connection between platforms where grade separated run ways occur
- Includes level passenger boarding and alighting
- Amenities range from retail service to passenger information
- Ridership dictates the size of the station and scope of services offered

Figure 1.21D: Transit Center

Information below is based on the data contained in *CBRT* (2004).

- Most complex and costly station type
- Provides a host of amenities
- Accommodates transfers from BRT services to forms of public transportation such as, rail transit and local or inner-city bus services

PLATFORM HEIGHT

Platform height plays a vital role in the accessibility of passengers, especially those who are mobility-impaired. Traditionally, passengers board vehicles by climbing the steps of the vehicle. Recently, however, vehicles that require steps to board have become practically obsolete. Instead, a huge shift towards adopting low-level/floor-level vehicles is in place in order to make boarding easier for passengers. The CBRT (2004) notes that if the platform height matches the vehicle's floor height, a reduction in dwell times is likely. It is safe to assume that the "no-gap, no-step" principle will also increase the safety of passengers when boarding the vehicle. Figures 1.22A, 1.22B, and 1.22C provide a visual of platform heights.

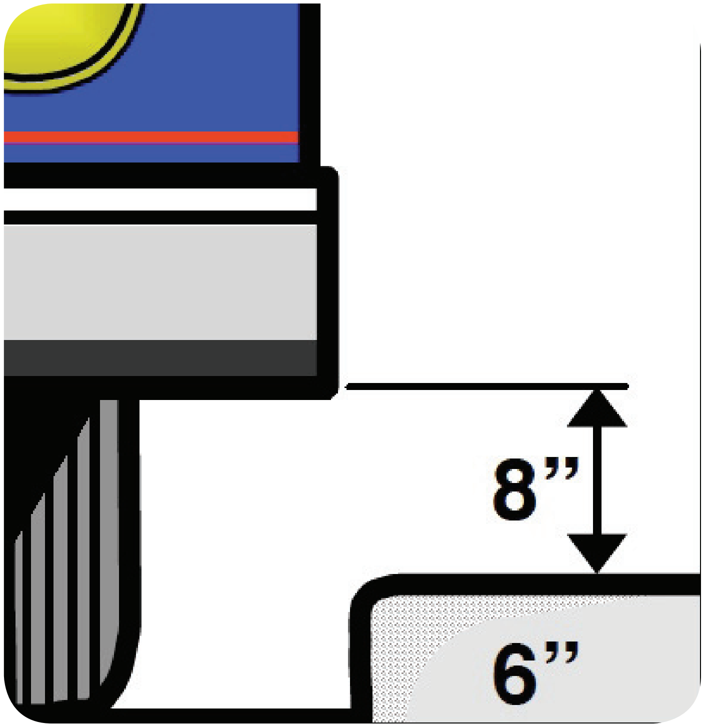


Figure 1.22A: Standard Curb

Information below is based on the data contained in *CBRT* (2004).

- Causes vertical gap between station platform and floor/entry step of vehicle
- Requires passengers to use steps in order to board or exit the vehicle
- Standard curbs are used when the station right-of-way cannot be altered

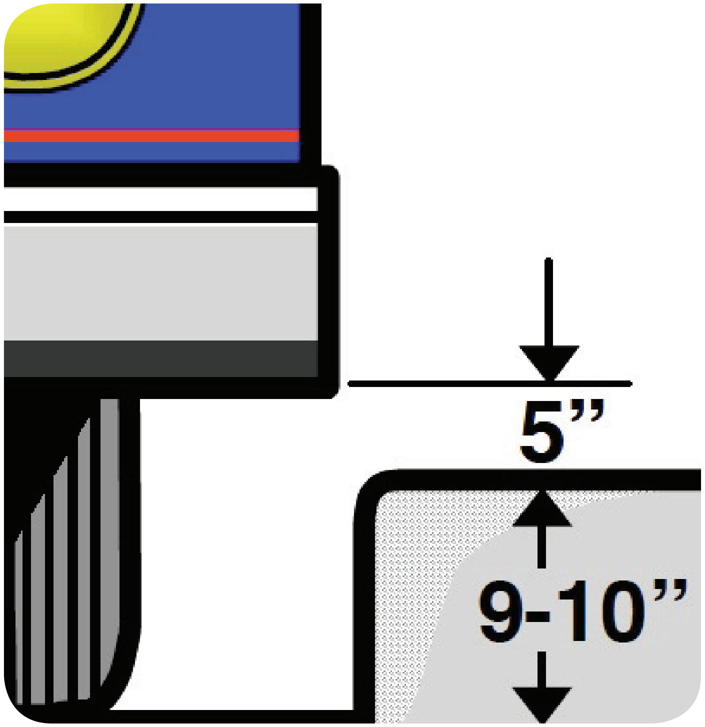


Figure 1.22B: Raised Curb
Information below based is on the data contained in *CBRT* (2004).

- Closes in on the vertical gap between station platform and vehicle floor/step
- Raised curb should not be more than 10" above the BRT running way or the arterial street on which BRT operates
- Preferred treatment over standard curb

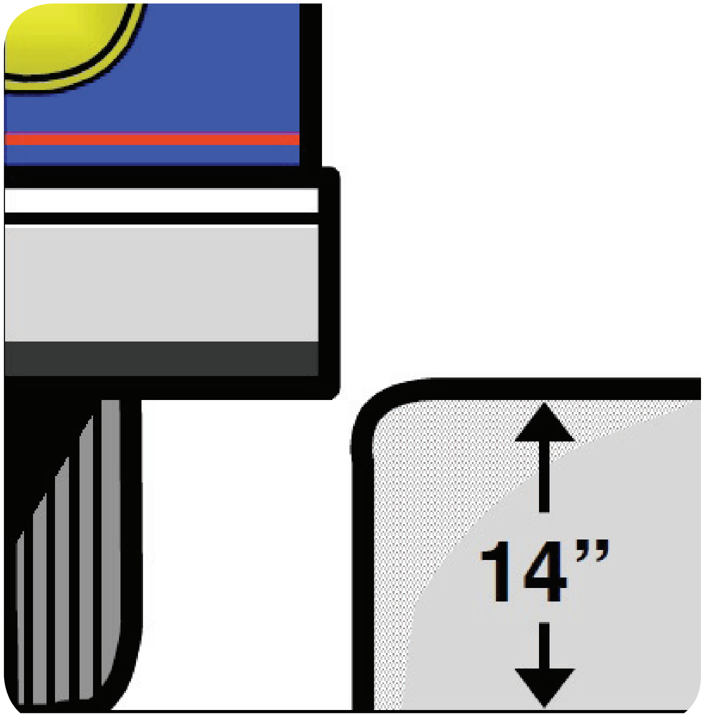


Figure 1.22C: Level Platform
Information below is based on the data contained in *CBRT* (2004).

- Safest, easiest, most efficient method for customer boarding
- Approximately 14" above the pavement for low flooring vehicles
- Ideal treatment because it creates a seamless transition for passengers

PLATFORM LAYOUT

Platform layout helps accomplish a couple of things. First, it helps identify where and how passengers are to arrange themselves in order to board the vehicle. Second, platform layout represents the berthing area for vehicles. The length and extent of platforms depends on the volume of buses and the length of the bus. Thus, platform layout design controls how many vehicles (simultaneously) can serve one particular stop. Please refer to Figures 1.23A, 1.23B, and 1.23C for platform layout types.

Figure 1.23B: Extended Platform Without Assigned Berths
Information below is based on the data contained in *CBRT* (2004).

- Accommodate no less than two BRT vehicles
- Allow multiple BRT vehicles to load/unload passengers--simultaneously

Figure 1.23A: Single Vehicle Length Platform
Information below is based on the data contained in *CBRT* (2004).

- Minimum length that allows BRT vehicles to enter/exit one at a time

Figure 1.23C: Single Vehicle Length
Information below is based on the data contained in *CBRT* (2004).

- Reaps the same benefits as the extended platform without assigned berths
- Assigns BRT vehicles a berthing position based on specific routes the buses run
- Longest platform layout option

Figure 1.24A: Bull Pullouts
Information below based is on the data contained in *CBRT* (2004).

- Permits buses to pull over and stop at stations without blocking the running way
- Enables other vehicles to pass

Figure 1.24B: Passing Lanes at Stations
Information below is based on the data contained in *CBRT* (2004).

- Allows express service vehicles to pass through stations without reducing their speed
- Gives vehicles the freedom to pass/overtake parked vehicles

PASSING CAPABILITY

Passing capability plays an integral role in reducing delays. The implementation of passing lanes maximizes travel speed and reduces delays, namely at station points. Passing lanes are especially important where there is a high frequency of vehicles and where travel times fluctuate immensely. Passing lanes are also important where multiple types of routes share a common running way. According to the CBRT report, passing capabilities can be integrated in several ways. Figure 1.24A and 1.24B illustrate these measures.

STATION ACCESS

Station access translates into ridership. If access to BRT services is poor, chances are ridership will be low too. Thus, access correlates with passenger use. Depending on the marketing strategy and whom decision makers wish to target, access can be geared towards the local community, or it can try to capture the regional population. Land uses adjacent to BRT service will help establish where and how to form pedestrian connections. Land use should also be analyzed to determine the form and extent of parking facilities. Making sure parking is offered at the appropriate locations (stations) can save travel time for customers. As summarized in Figures 1.25A and 1.25B, the Transportation Research Board and the CBRT report focus on two station access options in particular: pedestrian linkages and park-and-ride facilities.

Figure 1.25A: Pedestrian Linkages
Information below is based on the data contained in *CBRT* (2004).

- Sidewalks, overpasses and other forms of pedestrian connections are important to BRT services and adjacent uses

Figure 1.25B: Park & Ride Facilities
Information below is based on the data contained in *CBRT* (2004).

- Park and ride facilities allow BRT to extend its service at a regional level
- Especially beneficial to stations that are not anchored around developed areas; park and ride will help attract passengers from outside locations

1.3 | vehicles

The process of vehicle selection should not be desultory. Vehicles not only impact the attractiveness of BRT services, but they also impact operating and maintenance costs. The most substantial reason to be selective towards vehicles is their ability to influence public perception of BRT. Reports state that if the public perceives BRT positively, ridership is likely to increase. Thus, public perception of BRT and ridership has a direct correlation. It is also important to note that vehicles make an impression on both, users and non-users (or potential customers). And, for non-users, vehicles are the most visible of all BRT elements (Diaz, et al., 2004).

BRT vehicles should also respect the environment in terms of emissions. Ensuring fast travel speeds and avoiding delays helps achieve this. For instance, the less time a vehicle remains "stuck" on a running way (e.g., in traffic congestion, or experiencing delays), the less pollutants it emits into the atmosphere. One of the core ideas behind BRT is to provide frequent service. To uphold that aim, some transitways have as many as 150-200 BRT vehicles servicing certain routes or sections per hour (Levinson, et al., Implementation Guidelines, 2003). This is more often the case for central business districts. That type of high frequency demands special measures to maintain low levels of emission and noise. This can become a great difficulty, but both European and American manufacturers have taken responsibility to design vehicles that will have a softer touch on the environment (Levinson, et al., Implementation Guidelines, 2003).

Vehicle noise, vibrations, "grooming," aesthetics, cleanliness, maintenance state, and emission levels should also be taken into great consideration. It is safe to assume that passengers spend a majority of their time on vehicles (compared to the rest of the BRT elements). For that reason, it is critical that BRT vehicles address and meet passenger needs at a reasonable level. Below, I examine the top four characteristics (as suggested by the CBRT report) that make for sound BRT vehicles. They are vehicle configuration, aesthetic enhancement, passenger circulation enhancement, and propulsion systems.

VEHICLE CONFIGURATION

Vehicle configuration includes the shape, size, and type of a bus; it defines the physical structure of a BRT vehicle. Vehicle configuration can vary, depending on the type of market being catered to. Things such as demand, ridership, and frequency can guide vehicle choice. For the most part, BRT bus lengths comes in two-options: 40ft-45ft, which is the most common option, and a 60 foot articulated bus, which is used for routes with good patronage (Kittelson & Associates, Inc.; Herbert S. Levinson Transportation Consultants; DMJM+Harris, 2007). Other sizes include 30-35 feet buses that serve as feeder buses, and some as large as 80 feet, which are coined double-articulated buses. The flexibility of BRT makes it easy to switch between bus sizes (if or when necessary). Figures 1.31A through 1.31E illustrate the different types of vehicle configuration.

Figure 1.31A: Conventional Standard
Information below is based on the data contained in *CBRT* (2004).

- 40-45' in length, and possess a "boxy/squarish" shape
- Low floors, 14" above pavement
- Consists of 2 doors & a deployable ADA ramp
- Capacity: 40' Bus: 35-44 sitting, 50-60 sitting/standing; 45' Bus- 32-52 sitting, 60-70 sitting/standing

Figure 1.31B: Stylized Standard
Information below is based on the data contained in *CBRT* (2004).

- 40-45' in length, and possess a modern/aerodynamic design
- Low floors, 14" above pavement
- Consists of 2 doors & a deployable ADA ramp
- Capacity: 40' Bus: 35-44 sitting, 50-60 sitting/standing; 45' Bus- 32-52 sitting, 60-70 sitting/standing

Figure 1.31C: Conventional Articulated
Information below is based on the data contained in *CBRT* (2004).

- Longer in length
- Consists of 2-3 doors
- Higher carrying capacity; up to 50% more; holds anywhere from 31-65 people (80-90 sitting & standing) depending on the amount of doors

Figure 1.31E: Specialized BRT Vehicles
Information below is based on the data contained in *CBRT* (2004).

- Design strives to emulate rail vehicles with a modern, aerodynamic body & structure
- Employs sophisticated propulsion systems & incorporates advance technology

Figure 1.31D: Stylized Articulated
Information below is based on the data contained in *CBRT* (2004).

- Long in length like conventional articulated
- Has at least 3 doors
- Low-level boarding with 2 double stream & quick deploy ramps
- Modern, sleek design aims to cut dwelling times

AESTHETIC ENHANCEMENT

As stated earlier, aesthetic enhancement is integral to increasing ridership. Aesthetic enhancement requires the "beautification" of BRT vehicles in terms of their physical structure. A modern and futuristic body type is highly encouraged. In some cases, the front end of the bus is configured to resemble rail vehicles with the application of cone-shaped design. The interior design of buses demands just as much attention. It is beneficial to include large-frameless-windows in order to maximize light and visibility. On the other hand, sun guards and/or tinted windows will keep the sun off the eyes and provide a cooler ride. Other ideas include comfortable seating with a high back design, small, foldable worktables, wider aisles, added legroom, and a well-lit interior (Kittelson & Associates, Inc.; Herbert S. Levinson Transportation Consultants; DMJM+Harris, 2007). Overall, high quality materials and finishes balanced with nice amenities will generate a lot of passenger appreciation. Figure 1.32A, 1.32B, and 1.33C emphasize several measures that lead to aesthetic enhancement.

Figure 1.32A: Specialized Logo & Livery
Information below is based on the data contained in *CBRT* (2004).

- Used to establish unique identity recognizable by the public
- Uses special colors, materials, logos, and themes to create a "positive image"

Figure 1.32B: Enhanced Lighting
Information below based is on the data contained in *CBRT* (2004).

- Objective: enhance feeling of security; provide an open atmosphere
- Method: Provide large windows and ample lighting to see in and out of the vehicle

Figure 1.32C: Enhanced Interior Amenities
Information below is based on the data contained in *CBRT* (2004).

- Provides comfortable seating and storage space with high-quality materials and finishes
- Better construction with abundant lighting

PASSENGER CIRCULATION ENHANCEMENT

Passenger circulation can either boost or limit the aesthetics of a BRT vehicle. Implementing a design that proposes wider door channels, additional doors, seating space, and sufficient space for wheelchairs to maneuver and secure themselves, are key provisions to make. More specifically, it is better to apply an alternative seating arrangement scheme. Although seating along the length of the bus (perpendicular to the aisle) offers greater carrying capacity, variation is appreciated and beneficial. Gaps, breakage, and diversity of orientation between seats maintain, or perhaps even increase, the comfort level of passengers. In fact, psychology studies show that face-to-face interaction is avoided in crowded situations. If this is true, individuals are more likely to stand perpendicular to one another on a bus, especially when it is crowded. Figures 1.33A and 1.33B shows examples of alternative seat layout and additional door channels respectively.

Figure 1.33A: Alternative Seat Layout
Information below is based on the data contained in *CBRT* (2004).

- Seating along the side of a bus increases aisle space
- Gives the impression of a larger, more open space
- Side layout of seating allows for more standing space; thus more passengers

Figure 1.33B: Additional Door Channels
Information below is based on the data contained in *CBRT* (2004).

- Decreases delays
- Passengers have multiple options of alighting
- Boarding increases BRT flexibility, depending on the type of running-way

PROPULSION SYSTEM

Propulsion systems can come in a number of varieties. They control aspects like speed, acceleration ability, fuel consumption, and most importantly, emissions. Propulsion systems can be a valuable asset for passengers, but are often overlooked by individuals because of their complexity and hidden presence. The importance of quality propulsion systems is realized once the public learns that propulsion systems control the level of vehicle noise, smoothness of ride, vehicle operation and maintenance costs, and of course, reliability. The type of propulsion system (Figures 1.34A through 1.34C) adopted will determine not only BRT's reliability and dwell times, but also the comfort and experience of its passengers.

Figure 1.34A: Internal Combustion Engine
Information below is based on the data contained in *CBRT* (2004).

- Most common form of propulsion system
- Fueled by ultra-low-sulfer diesel (USLD)/ compressed natural gas (CNG) with automatic transmission

Figure 1.34B: Trolly, Dual Mode, & Thermal Electric Drives
Information below is based on the data contained in *CBRT* (2004).

- Uses overhead catenary-delivered power to function
- Usually used in tunnel BRT systems

Figure 1.34C: Hybrid Electric Drives
Information below is based on the data contained in *CBRT* (2004).

- Reduces emissions by offering better fuel usage (saves up to 60%)
- Incorporates on-board energy system
- Provides a smoother ride, with quicker acceleration and “efficient” braking

1.4 services

The amount and quality of services significantly impact customer approval. The role of BRT services is to effectively move passengers from one destination to another. That is why it is important for BRT to offer frequent, direct, and distinct services. Marketing strategies should depict BRT as a distinguished form of transportation that provides its passengers with proper amenities and excellent service. At the same time, decision makers should not hesitate to shape marketing tactics that try to adapt to any additional or special constituent demands. The flexibility of BRT permits service plans to meet the specific needs of each BRT environment and the variety in the public desires. A major advantage for BRT service is its ability to offer "one-seat rides" (Levinson, et al., Implementation Guidelines, 2003). This means that unlike rail systems, BRT does not serve large units, which makes it easier for BRT services to provide frequent trips that have minimal transfer requirements. Below, we take a look at route frequency, span, length and structure, the primary characteristics that make BRT services comfortable and convenient, rapid and reliable, and safe and secure.

ROUTE LENGTH

Route length informs passengers how far BRT extends its service. It also tells them whether or not transferring at specific stations is necessary. Market demands and the urban context influence route length, therefore route lengths may vary across different areas. The FTA recommends that long routes should be avoided because long routes require more capital, but they also reduce transfer rates. On the other hand, short routes increase reliability but also increase the amount of transfers required. Before constructing routes, it is important to compare the difference in distance between regular roadways and BRT running ways. The distance of a BRT running way should not exceed more than 20% of the regular roadways on which automobiles operate. For instance, if a car and bus are traveling from the same location (point A) to reach the same destination (point B), the bus running way should not be significantly longer. Round-trips should take about two hours, but should definitely not exceed three hours (Levinson, et al., Implementation Guidelines, 2003). Routes that adhere to that recommendation range from 10-20 miles.

SERVICE FREQUENCY

Service frequency conveys waiting time. It tells passengers how long or little they have to wait. Usually, frequency is determined by the context along and around where BRT operates, meaning areas such as central business districts will tend to have higher frequencies than residential areas. Moreover, higher frequencies give the impression of a more reliable service (Diaz, et al., 2004).

SERVICE SPAN

Service span means the range of hours that BRT operates and is used to inform the public when and how long BRT operates. The services can run either one of two ways: all day or peak hours only (see Figures 1.41A & 1.41B). The targeted market is a good indicator of what type of service span to apply. Peak hour service might limit the amount of ridership, as it will not consider passengers who might use BRT before or after peak hours (e.g., individuals who work swing or graveyard shifts). On the other hand, all day services do not discriminate against varying schedules, thus all day services might attract more passengers.

Figure 1.41A: All Day Service
Information below is based on the data contained in *CBRT* (2004).

- Runs all day, from morning to evening (evening hours can vary)
- Maintains same headways, irrespective of time of day
- Beneficial to offer weekend services

Figure 1.41B: Peak Hour Service
Information below is based on the data contained in *CBRT* (2004).

- Offers high quality & high capacity service only during peak hours
- Regular service may take place during off-peak hours

ROUTE STRUCTURE

Route structure entails the actual configuration of the route and the shape and form of the path of travel. The more clear and direct a route structure is, the easier it is for passengers to comprehend the service. Successful BRT routes are structured to run through the heart of urban areas such as downtown, business districts, and commercial districts. Simple, linear routes usually work the best. The following figures depict the different types of route structure.

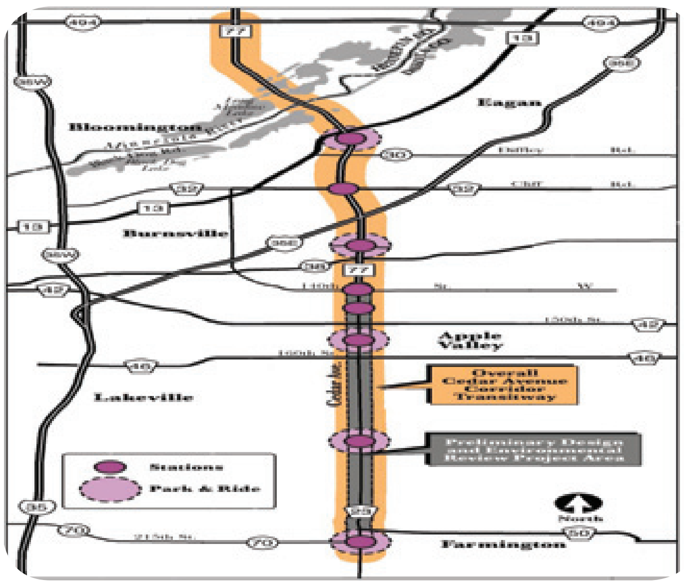


Figure 1.42A: Single Route
Information below is based on the data contained in *CBRT* (2004).

- Simplest and easiest to understand
- Works best along major corridors that have high activity

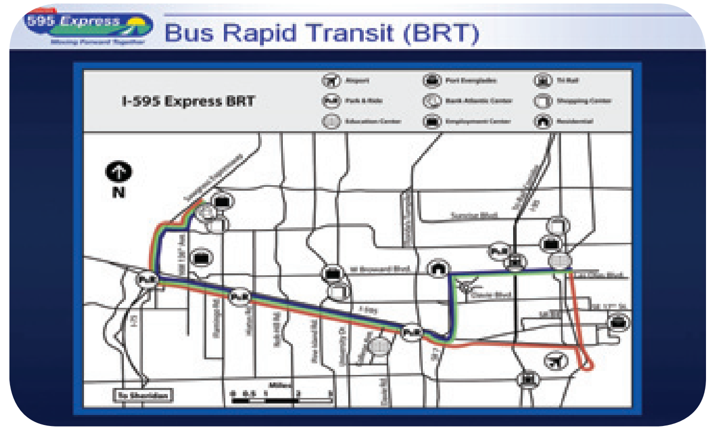


Figure 1.42B: Overlapping Route with Express Service
Information below is based on the data contained in *CBRT* (2004).

- Advantage of express or skip-stop service
- Works best with passing lanes at stations
- May be confusing for passengers

Figure 1.42C: Integrated or Network System
Information below based is on the data contained in *CBRT* (2004).

- Most comprehensive route structure
- Most likely to provide "one-seat ride," but also likely to cause confusion with the hierarchy of systems

1.5 | intelligent transportation systems

Intelligent transportation system has a very broad spectrum and is used across a variety of fields. However, for the purpose of this project, we examine ITS in terms of its relation to BRT. Of the five major BRT elements, I find intelligent transportation systems (ITS) to be the most intriguing. Although aspects of it are complicated and technical, it fosters the way BRT functions. I feel ITS is the element that gives BRT a modern, sophisticated look; it is the "icing on the cake." The goal of BRT is to provide fast, reliable, and convenient service that is comfortable and easily comprehended by passengers; BRT utilizes ITS to accomplish that goal. The integration of ITS into BRT accommodates a number of useful things. For instance, ITS is very useful to chart the location and timing of buses, monitor vehicles to ensure safety and security, and expedite travel time. How exactly does ITS work? Well, first, ITS uses complex technological systems to gather and process information. It then transmits the data to dedicated communication networks/servers, which then relay the information back to operating agencies, vehicle operators, and most importantly, passengers (Diaz, et al., 2004). It may be easier to think of ITS as a toolbox and the variety of technologies that make up ITS as the tools inside that toolbox. Decision makers then have an option of which tool(s) to choose in order to construct a BRT system that best meets their needs. However, some "tools" are used more frequently than others and we explore those tools below. The list includes: automatic vehicle location, vehicle prioritization, assist and automation technology, fare collection, passenger information, and safety and security. It is essential to use a combination of these technologies or "tools" collectively and effectively.

AUTOMATIC VEHICLE LOCATION (AVL)

AVL can be thought of as an advance notification system. In order for AVL to function properly, it mandates three things: "1) a method for determining vehicle location, 2) a means of communicating the vehicle's location to a main center, and 3) a central processor to store and manipulate the information" (Levinson, et al., Implementation Guidelines, 2003, p. 139). Although it is mainly used to pin-point vehicle location, AVL also serves many other purposes. For example, AVL makes it possible for bus drivers to communicate with personnel at the central operating agency or hub, to inspect and survey mechanical conditions of vehicles, and to re-route vehicles in the case of dilemmas. More importantly, AVL presents dynamic, real-time schedule updates at stations, on the Internet, and on cell phones (incase buses experience delays, accidents, or mechanical problems). AVL's highest appreciation comes in the event of an emergency, in which case AVL acts immediately and allows for a quicker response. Currently, a lot of transit operators and decision makers are embracing AVL not only because it significantly contributes to the transit rider's experience, but also because the cost of installing AVL is rapidly dropping (United States Department of Transportation, Federal Transit Administration, 2008).

VEHICLE PRIORITIZATION

Vehicle prioritization is used to give BRT vehicles a preference, or "priority," at intersections or areas where they encounter signals. The purpose behind prioritization is to reduce travel time and delays by means of traffic signals. Vehicle prioritization allows BRT to better abide by the assigned schedule or headways. Figures 1.51A, 1.51B, and 1.51C look at the different options for vehicle prioritization.

Figure 1.51A: Signal Timing/Phasing
Information below is based on the data contained in *CBRT* (2004).

- Involves and requires lots of traffic studies, an understanding of traffic patterns, and simulation of models
- Optimizes traffic signals along travel path to take advantage of green lights

Figure 1.51B: Station & Lane Access Control
Information below is based on the data contained in *CBRT* (2004).

- Involves control gates, control systems, and signs that allow BRT vehicles to enter and exit
- Requires monitoring or surveillance

Figure 1.51C: Transit Signal Priority (TSP)
Information below is based on the data contained in *CBRT* (2004).

- TSP is different than signal timing/phasing
- TSP gives BRT vehicles priority, not preemption
- TSP adjusts to traffic signals to better accommodate BRT vehicles
- Great tool to reduce travel time, maintain consistency, improve transit efficiency

ASSIST & AUTOMATION TECHNOLOGY (A & A TECHNOLOGY)

Assist and automation technology is an ITS feature that helps operators control and maneuver BRT vehicles. These technologies can help guide vehicles along running ways or allow for precision docking. A & A technology is especially useful because it can be utilized as needed. A & A technology can also be installed along the width of the running way or it can be used at narrow points of running ways, specific stations/stops, or through tunnels. A & A technology consists of collision avoidance technologies which increase the level of safety considerably in terms of accidents and collisions. Figures 1.52A, 1.52B, and 1.52C summarize a few of these technologies.

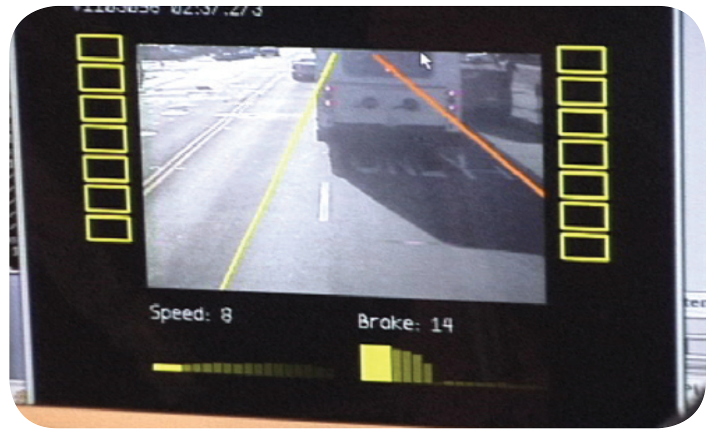


Figure 1.52A: Collision Avoidance/Warning
Information below is based on the data contained in *CBRT* (2004).

- Collision sensor helps avoid running into obstacles
- Systems (infrared, cameras) inside vehicle informs driver of pedestrian, vehicle, or other obstacle interference

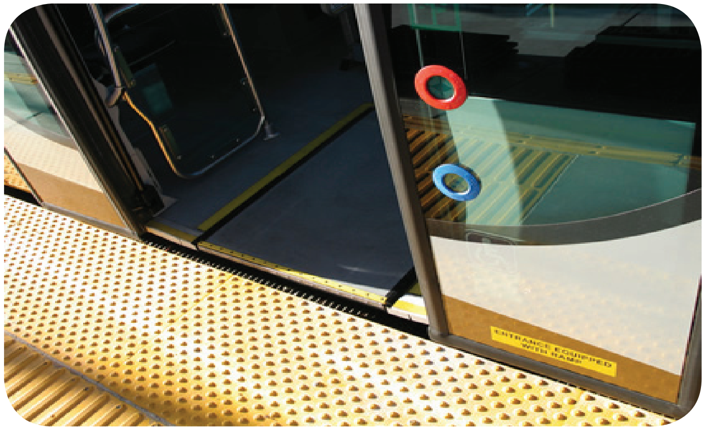


Figure 1.52B: Precision Docking
Information below is based on the data contained in *CBRT* (2004).

- Assists drivers to dock vehicles appropriately and precisely at platforms or station using either magnetic or optical guidance
- Requires markings on pavement (paint/magnet) that vehicles "read"

Figure 1.52C: Vehicle Guidance
Information below is based on the data contained in *CBRT* (2004).

- Allows vehicles to maintain high speeds in a controlled fashion
- Guidance options include: optical, magnetic, and GPS-based
- Requires special treatment on paving and vehicles (paint, magnets, sensors [on top of the bus in image above])

FARE COLLECTION

Fare collection systems are given considerable attention since they are generally one of the leading determinants of how fast or slow passengers board vehicles. Successful fare collection systems support rapid boarding and multiple stream boarding where service demand is high. In other words, fare collection systems should be direct, clear, and user-friendly. Most of all, fare collection systems should process information efficiently since passengers appreciate systems that are not time consuming.

According to CBRT, fare collection systems can be manual, mechanical, or electronic. CBRT also mentions three key features of fare collection systems. The first is the fare collection process (Figures 1.53A & 1.53B), which determines how payments are made. Common fare collection processes include on-board payments, conductor-validated systems, barrier enforced systems, and barrier free/proof of payment systems. Design plays a major role in the latter two options because aesthetics (look and feel) and comfort (easy to use) are an important criterion for customers. The type of fare collection process employed can influence operating costs, and of course, dwelling time. The second feature is fare media, which defines how the fare transactions take place. Typical fare media options include cash, paper media, and magnetic stripe cards. However, a not-so-typical form of fare media is gaining preference, one that is known as "smart cards." Smart cards are replacing stripe cards simply because smart cards have more to offer. Smart cards resemble credit cards and, as Casey, R.F. describes it, are "equipped with a programmable memory chip that performs several functions: holding instructions, holding value, self-monitoring, and creating an electronic billing record" (Levinson, et al., Implementation Guidelines, 2003, p. 151). The last key feature is fare structure. Fare structure denotes whether the service will implement a flat rate policy or one that varies based on the distance of the trip. Factors such as public demand, ridership, network type, and long-term plans/goals help resolve fare structure (Diaz, et al., 2004).

Figure 1.53A: Pre-Boarding Fare Collection System

Figure 1.53B: On-Board Fare Collection System

PASSENGER INFORMATION

Any transportation service must necessarily keep passengers informed. However, the method(s) in which information is dispensed to customers may vary. For example, some services may only offer printed pamphlets that include the schedule and timing; others may go as far as providing up-to-date audible announcements. In order to truly emulate rail systems, ITS and passenger information need to be applied and emphasized, respectively. ITS increases the feasibility of providing dynamic information to BRT passengers at multiple points (at stations, on the vehicle, and at stops). As the technological age continues to strengthen, expanding BRT service information such as schedules, updates, special announcements, etc., to the Internet and mobile devices has become increasingly advantageous. Nonetheless, a well-designed system with a conscious passenger information structure utilizes both static (telephones, kiosks) and dynamic (electronic signage, radio/television broadcasts, cell phones) methods (Levinson, et al., Implementation Guidelines, 2003). The availability of travel information through multiple means presents passengers with the opportunity to plan and schedule trips accordingly. Figures 1.54A through 1.54D display the different passenger information options.

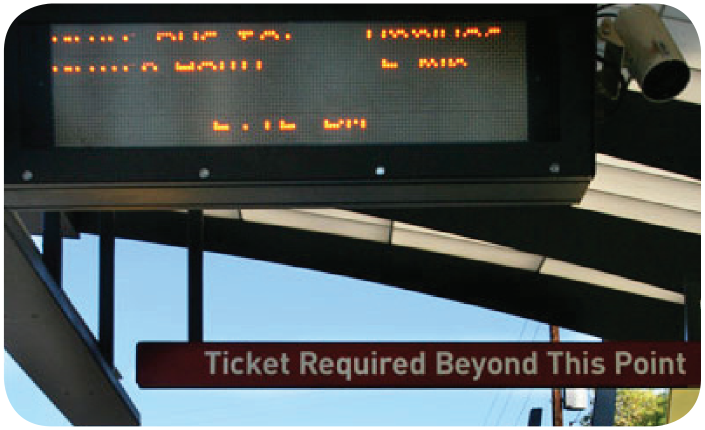


Figure 1.54A: Travel Information at Station
Information below is based on the data contained in *CBRT* (2004).

- Provides passenger with bus information
- Requires methods to predict bus timing/delays/arrival

Figure 1.54B: Travel Information on Vehicle
Information below is based on the data contained in *CBRT* (2004).

- Provides passengers on vehicles with expected arrival, next stop, vehicle schedule, etc.
- Requires methods to predict bus timing/delays/arrival

Figure 1.54C: Travel Information on Person
Information below is based on the data contained in *CBRT* (2004).

- Provides passengers with bus schedules on the Internet and mobile devices
- Requires special software to implement

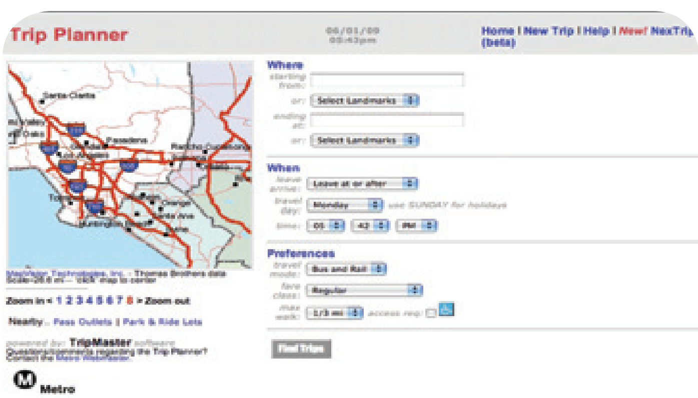


Figure 1.54D: Trip Itinerary Planning
Information below is based on the data contained in *CBRT* (2004).

- Allows passengers to plan trips
- Allows passengers to specify special needs/equipment

SAFETY & SECURITY

Safety and security are the predominant concerns of an individual deciding to take public transportation. As a young child living in downtown Atlanta, Georgia, public transportation was my way of getting around; I hated waiting at bus stops where fights broke out and riding on a bus that was full of drunk people. It was a nerve wrecking experience each and every time. In those moments, the only thing I cared about was reaching home safely. To prevent the type of experiences I encountered, safety and security must be placed at the forefront of the decision making process. It is imperative for policy makers and designers to understand that safety and security are essential ingredients to a successful public transportation recipe.

As service providers, transportation agencies take responsibility for their passengers because a single sign of uncertainty can inevitably reduce an individual's willingness to use their service (Loukakos & Blackwelder, 2000). A large list of undisciplined actions classifies as "transit crime." Loukakos and Blackwelder refer to *Synthesis of Transit Practice 21, Improving Transit Security* in order to give us a better explanation. "Crimes committed in transit systems include disorderly conduct, public drunkenness, non-payment of fares, theft, harassment/threat, narcotics, weapons violation, purse snatching, simple assaults and batteries, robberies and attempts, aggravated assaults, sexual assaults, rapes and attempts, and homicide and attempts" (Loukakos & Blackwelder, 2000). Based on that information, we know that individuals are vulnerable at stations and onboard vehicles. Because the nature of "crime" is extensive and can unfold in many ways, it is obligatory to integrate advance technologies with BRT in order to monitor misconduct. ITS offers a couple of preemptive tools that might increase the level of safety and security as indicated in Figures 1.55A and 1.55B. Chapter 3 examines and discusses other measures and design aspects that ameliorate the environment in terms of safety and security.

Figure 1.55A: Silent Alarms
Information below is based on the data contained in *CBRT* (2004).

- Allow driver to trigger alarm incase of emergency/danger
- Messages like "Call 911" display on the exterior of vehicles

Figure 1.55B: Voice & Video Monitoring
Information below is based on the data contained in *CBRT* (2004).

- Cameras and microphones provide surveillance
- Transmits data to operations center/hub

In this chapter, I discuss two cities (Curitiba, Panara-Brazil and Los Angeles, California-United States) that have launched BRT; these two cities were ideal points of focus since both are the quintessence of functional and pragmatic BRT design. To learn about the implementation process, I refer to and summarize existing case studies conducted on these two cities. Unlike the previous chapter, this chapter does not cover technical aspects. Instead, this chapter concentrates on the design scheme of running ways and station stops. At the end of each section, I give my opinion and present others' opinions about whether or not the discussed design has been successfully employed and effectively utilized.

chapter 2 | case studies

2.1 | curitiba,panara-brazil

Curitiba, the "poster-child" city of Brazil, takes much of the credit for triggering the "bus rapid transit phenomenon." Curitiba's transportation scheme is highly revered among designers, planners, and city leaders. As such, Curitiba is largely responsible for causing the surge for bus rapid transit as a viable transportation model for cities around the globe.

BACKGROUND

Situated in the mountains of southern Brazil, Curitiba is the capital city of Panara. Compared to other cities in Brazil, Curitiba enjoys higher per-capita income and a relatively a higher standard of living (Leroy W. Demery, 2004). The city is also recognized for its cleanliness and innovative planning strategies, which is why many are attracted to Curitiba. Curitiba experienced tremendous population growth between the 1940s-1970s and the rapid raise in population called for a new planning initiative. Although Curitiba had a plan set out since the mid 1940s, the plan did not fulfill the demands of the changes taking place. Then, in 1964, the City of Curitiba adopted a new plan—the Preliminary Urban Development Plan—that later evolved to become the Curitiba Master Plan (Transportation Research Board, 2003). To this day, the Curitiba Master Plan serves as the leading guide for development and planning projects. The plan follows an integrated, enlightened approach for sensitive issues such as environmental regulations, housing policies, social concerns, and transportation measures.

A little over thirty-five years ago, Curitiba city leaders faced a huge dilemma in deciding what type of transportation system to implement. In 1972, Jamie Lerner, the Mayor of Curitiba (and an architect by trade), proposed an "above ground subway system." Originally, city leaders and planners had been probing the idea of developing a subway system, the construction of which would have cost over $90 million per kilometer, versus only 200,000 per kilometer for Lerner's proposed BRT system (Grossman). Compared to the subway system, BRT served as a highly economical solution. Decision makers quickly acted on their decision to implement the BRT system, and the first BRT service became effective in 1974 (Transportation Research Board, 2003). The following section discusses the successful aspects of Curitiba's transportation system.

DESIGN

In this section, I explore the keys to Curitiba's success in employing an effective BRT system. In order to explain this success, I focus on the design of Curitiba's running ways and station stops.

Running Ways

Since the first launch of BRT in 1974, the service has both evolved and expanded incrementally. Curitiba exercises a hierarchical system of bus services. Feeder buses take neighborhood residents to the conventional bus lines, which operate on the city's outer limits. Those buses in turn carry passengers to the BRT buses, which transport them to the city center. BRT service functions along five major arteries (Figure 2.11), which follow the "trinary road concept" (Transportation Research Board, 2003). The trinary road concept is a system in which the two outer roads are a mixture of both general traffic and direct high-speed bus services, while the middle road is designated for high-capacity express busways. A typical cross-section of the three-roadway system extends about 85 feet. Figure 2.12 gives us a better idea of the scheme. Passengers are required to make only one payment, which makes transferring between different stations/ services—feeder, trunk, express, and direct express—

Figure 2.11: Major Arteries of Curitiba's bus service systems.

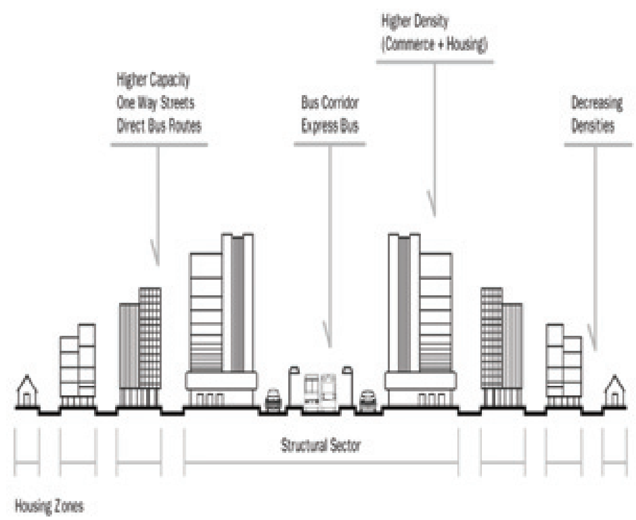


Figure 2.12: Arrangement of structural axes.

more convenient. Over the years, the BRT track-way has grown to cover about 37 miles. Because Curitiba's express service travels through the center of roadways, it is free from traffic delays and the segregation plays a key part in expediting travel time for passengers. The Transportation Research Board indicates that the roadways on which Curitiba's BRT runs do not consist of major traffic. Thus, passenger crossing to and from stations through heavy traffic is limited, and possibly, less dangerous. The running ways are separated with small, yellow islands to emphasize the BRT exclusive lanes.

Figure 2.13: A look at Curitiba's segregated running way.

Station Stops

Curitiba's stations represent an exciting facet of the BRT model. The iconic tube stations, which are spaced every 1/3 of a mile along the busways, are not only considered an innovative design, but they also consist of functional features. The creator of the station stops is none other than Jaime Lerner.

Sitting at a bus stop one day, Lerner noticed that the biggest time drag on his fleet was how long it took passengers to climb the stairs and pay the fare. He sketched a plan for a glass "tube station," a bus shelter raised off the ground and with an attendant to collect fares. When the bus pulls in, its doors open like a subway's, and people walk right on. (McKibben, 1995) A year later, the sketch took life. Today, we see the tube like structure wrapped in Plexiglas and supported by steel ribs as shown in Figure 2.14. The design provides passengers with a sheltered waiting area, but does not consist of seating. Perhaps the high frequency of service [in some cases, as often as every 90 seconds (Federal Transit Administration) makes seating, as an amenity, gratuitous. Because the tube design encompasses raised platforms, the process of boarding and alighting experiences very little dwell time. Level boarding, coupled with the pre-boarding fare system (Figure 2.15) reduces dwell time down to as little as 15 to 19 seconds per stop (Goodman, Laube, & Schwenk). The design also eliminates gaps between the station and vehicle (Figure 2.16). This is achieved by a system that automatically deploys fold-down steps from bus doors as bus doors open (Transportation Research Board, 2003); the fold-down steps are then positioned onto the platform. The tube also corresponds to the number of doors on the buses depending on the type of service in effect (express or trunk). Usually, express services consist of two exit/ entry doorways, while trunk lines consist of up to five doorways. Most importantly, the tube stations also make access easy and comfortable for those with special needs. Individuals who are disabled or require wheelchair use gain access to stations and buses through a mini elevator lift attached to one end of the station (Figure 2.17).

Figure 2.14: The iconic Tube Stop of Curitiba.

Figure 2.15: Pre-boarding fare collection system.

Figure 2.16: Closed gap between vehicle and tube station.

Figure 2.17: Tube accessibility for the disabled.

OBSERVATIONS

The figures and statistics, ridership, cost-effectiveness, public approval, etc. clearly gauge the accomplishment of Curitiba's BRT system. However, I feel some things remain unaddressed. For instance, in terms of station design, we do not have adequate information regarding some important issues. Information on aspects such as lighting, seating capacity, and signage/notifications, is minimal and insubstantial. Reports on safety and security are nonexistent. So, although the tube station design does a commendable job at speeding up travel time, little to nothing is mentioned in terms of its relation to landscape architecture and contextual design. Thus, it is difficult to both learn and give comprehensive commentary on Curitiba's station design.

Despite the lack of actual design information, we know that Curitiba's planning policies teach many things. What was once a stopover town with a population of 150,000 has quickly emerged as one of the world's top livable cities. Now, it is home to over 1.7 million denizens. What led to this drastic change? Long term, environmentally and socially conscious planning, which took an alternative approach to dealing with existing infrastructure rather than the conventional "rip-and-tear" method. The planning process focused on the people, and not the automobiles (McKibben, 1995). Instead of forging development away from the city with the typical concentric circles, city leaders channeled linear growth around the major arteries. And the transportation system became the spine on which these new policies were erected. The first BRT line carried 25,000 passengers per day; today, Curitiba's BRT serves 2.3 million individuals daily (Press, 2009). Without a doubt, BRT is the crown jewel of Curitiba. It is hardly surprising that cities are ready to embrace and emulate Curitiba's BRT paradigm.

Figure 2.18: Bicyclist glances at BRT vehicle.
Many of the running ways in Curitiba integrate pedestrian/bicyclist and BRT access onto one running way.

2.2 | los angeles, california-united states

Los Angeles is the second largest city in the U.S. with a population closing in on four million people. Over the years, it has become a destination point because of its location, resources, and attractions. Public transportation probably does not come to mind when people think about Los Angeles. Hollywood, a glamorous lifestyle, notable sports teams, and the thick layer of smog are more reasonable images. However, the "City of Angels" works assiduously to win the battle over congestion. Recently, it has added BRT to its artillery, and results show that is has been a valuable weapon. As a matter of fact, Los Angeles has designated BRT along several roadways. I focus on only one of them, the "Orange Line." Although known as the most distinct and "accurate" form of BRT in Los Angeles, the Orange Line is often put under the same umbrella as Metro Rapid. The Metro Rapid is the larger "BRT system" that covers greater Los Angeles and expands to many major corridors. Metro Rapid attempts to provide BRT services, but falls short because it does not espouse all its elements.

BACKGROUND

The Orange Line shared a similar origination process as the Curitiba BRT system, in the sense that both were an alternative option to a proposed and long awaited subway system. The story begins in 1980 with Proposition A, which called for a half-cent sales tax increase in order to build a rail system through 13 designated "Prop A" corridors, one of them being where Orange Line operates today (Stanger, 2007). Originally, the plan was to invest in a light rail system, but community opposition quickly stifled that idea. To make matters worse, opponents managed to pass a state law that "prohibited anything other than a deep bore subway from being built, essentially creating an untenable situation" (Hoffman, 2008, p. 74). The following years witnessed tireless planning efforts with many alternatives. All of them were rejected. Opposition of a rail system (heavy, light, monorail, etc.) became the communities' cause, and "NIMBY" (not in my backyard) became the communities' mantra. They feared light rail would lower their property values and create excessive noise (Stanger, 2007). Finally, BRT was proposed, but the community members resisted that as well. After a 15-year battle, constituents finally caved and accepted the BRT concept. Individuals came to realize that a public transportation system was necessary and the implementation of one was inevitable. The Orange Line made its debut in October 2005.

The Metro Orange Line blankets the abandoned Southern Pacific Railroad right-of-way (ROW). The busway parallels Ventura Boulevard as it spans 14.2 miles (Figure 2.21), servicing the east-west corridor in the San Fernando Valley. The eastern end feeds the northern terminal on the Red Line (Northern Hollywood station) and the western end serves Warner Center in Woodland Hills (Gray, Kelley, & Larwin, 2006). The surrounding landscape lacks diversity because the dominating land use is residential, but a glimpse of other uses such as offices, civic centers, and colleges along the service route can be seen. The Orange Line uses 60 foot customized, articulated buses with low level boarding that travel up to 55 mph. It classifies as an "end-to-end trunk line service" that has a scheduled run time of 42 minutes with headways ranging from five minutes during peak time, 10 minutes at mid-day, and 20 minutes in the evening (Stanger, 2007). City planners expected the Orange Line to carry about 9,000-12,000 riders, but today, 26,000-28,000 people ride the Orange Line daily (Eckerson Jr., 2009)—ridership figure projected for the year 2020 (Uranga, 2006).

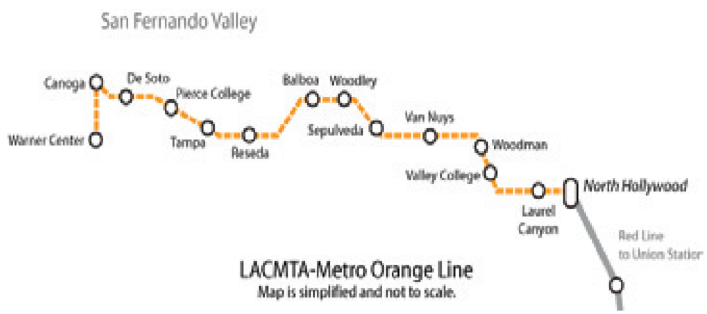


Figure 2.21: Orange Line service map.

Figure 2.22: Passengers on Los Angeles's Metro Orange Line.

DESIGN

Los Angeles's BRT system, starting with the rudimentary Metro Rapid, was galvanized by Curitiba's BRT model. City officials and planners selected a handful of Curitiba's key BRT elements and applied them to the Orange Line. The following information discusses the design tactics employed to the running ways/busways/T-ways and to the station stops.

Running Ways

The Orange Line busway is Los Angeles's first "real" BRT line. Technically, it is termed a "T-Way," which means an "at-grade busway, or one whose operations are determined by grade crossings" (Hoffman, 2008, pp. 3-4). And that is the term I will use henceforth. The biggest advantage to the planning process of the Orange Line was the availability of an unused railroad ROW. The width of the T-way varies greatly, anywhere from 70-200 feet, but for the majority of the length, it spreads out to about 100 feet (Stanger, 2007). The actual "real-estate" where the buses operate consists of two lanes, one lane in each direction, and covers 26 feet. Planners also accounted for other thing like: 1) pullout space necessary for maintenance vehicles to park or service, which are typically 70 feet long and 10 feet deep and 2) an additional 23 feet at the station stops to allow other buses to pass in case of breakdowns (Stanger, 2007), even though not all stations allow for passing (Hoffman, 2008). The nice thing about the Orange Line T-Way is that it incorporates bicycle and pedestrian pathways that run parallel to the T-way and within the ROW. Additionally, a well-designed landscape equipped with sound walls along the ROW mitigates the noise caused by the buses. Figure 2.23 provides a nice visual.

Figure 2.23: Image of the Orange Line T-way.
Image shows the nice landscaping and pedestrian and bicycle pathway (to the left).

Station Stops

Along the 14 miles of the Orange Line, there are 14 specialized stations that space roughly a mile apart. All the stations are adorned with customized branding and livery, distinguishing them from other forms of service. The uniformity anchors the Orange Line's identity and makes the station stops easily recognizable for customers. Each station consists of a canopy to provide shelter and passenger information displays. The combination of sidewalk-level boarding, low-level boarding vehicles, and off-board fare collection system not only makes boarding easier but also decreases dwell time. The stations length accommodates up to two buses and also provides passengers with a number of amenities such as seating/leaning rails, "enhanced paving, artwork, lighting, CCTV cameras, TVMs, emergency and public telephones, system and community maps cases, bicycle racks, and lockers on a separate module"(Gray, Kelley, & Larwin, 2006, p. 38). Stations also offer ADA accessibility.

Figure 2.24: One of the Orange Line stations.
The new 65-foot Metro Liner for the Orange Line in front of a station.

Figure 2.25: Another one of the Orange Line stations.

OBSERVATIONS

Initially, the success of the Orange Line was questionable. But, the result we see today gives us a clear answer. Based on the reports and short films, the Orange Line was not expected to perform at such a high caliber. Those "low expectations," if you will, inflate its achievement. Nevertheless, a few key design features do indeed contribute to the Orange Line's success. Because the design features adhere to the BRT doctrine, officials consider the Orange Line as Los Angeles's first, true BRT system. The most critical design feature of the Orange Line is its T-way. Having an exclusive busway allows buses to avoid street congestion and strengthens BRT's identity. The Orange Line is also granted signal priority, which decreases travel time and, more importantly, allows operators to compensate for lost time in order to match schedules/headways. Another thing that was done right was dressing all the station stops and vehicles in the same attire. The Orange Line is distinct from other, similar bus systems, yet the uniformity within the Orange Line (shared theme between buses and station stops) creates a strong image—an integral aspect for passengers. Moreover, the beautifully landscaped T-way coupled with a designated pathway for bicyclists/pedestrians attracts people to the service. Even if individuals do not use the bus service, they may be compelled to take advantage of the "greenbelt" (bicyclist/pedestrian pathway).

Despite these measures, there are some areas that need improvement or alteration. For instance, not all the station shelters fully protect the passengers from the elements. Looking at the shelter's canopy, it seems passengers are vulnerable to the rain, cold, and wind. Additionally, I prefer platforms that provide level boarding to Orange Line's sidewalk level boarding, even though they are combined with low-level boarding vehicles. Not all the stations consist of passing lanes (Hoffman, 2008), which might be a limiting factor, but perhaps passing lanes are not required at all the stations. Finally, Hoffman feels that the stations do not necessarily fit into the urban context, and that "stations are only peripherally integrated into the surrounding land uses, but many of those land uses are auto-oriented" (Hoffman, 2008, p. 76).

Figure 2.26: Image of an Orange Line station.
Image of what I think is a poor station shelter.

chapter 3 | lessons learned

In this chapter, I apply my research and finding to the broader question: How is BRT employed successfully? That is, what key measures or steps help establish BRT? First and foremost, we must understand BRT should not replace conventional bus systems. Rather, BRT serves as an alternative for light rail. Nevertheless, we cannot simply plop it in places as we please. It stands as a viable option for areas that 1) experience congested roadways, 2) demand or need public transportation, and 3) require revival along disparate, neglected corridors. BRT works best in large cities/metropolitan areas (populations that are at least 750,000 large) or urban settings that consist of high densities, extensively developed downtowns/town centers, low parking availability, limited automobile access, and "sufficient" presence of buses (Levinson, et al., Implementation Guidelines, 2003). BRT brings several advantages to the table like its relatively low cost (compared to light rail), immediate results, greater operating flexibility, and ability to be implemented incrementally. For that reason, more individuals are advocating its presence and pushing for its existence. While we know BRT presents many benefits, it is not suitable across all situations. BRT may not be the best option, or even perhaps a good alternative, but when the opportunity presents itself, BRT definitely deserves consideration. Based on the reports and case studies mentioned earlier, I believe several factors encourage and help secure the implementation of BRT.

3.1 | community involvement

The first of these factors is community involvement. As with any proposal, community support plays a pivotal role in moving forward with the planning process, especially for transportation. The public should be involved from the beginning. Early involvement may limit confusion or misunderstanding. And, if resistance does occur, the planning process can be altered to better address the community's demands or needs. Educating constituents about BRT and introducing them to successful models helps avoid any misconceptions and mitigate negative attitudes towards bus systems. Planners and decision makers should also inform the public about the benefits of BRT and how it may or may not affect them. Opening up the planning discussion to community members and, more importantly, getting them engaged, community members them that their opinion is valued. These precautions motivate the public to buy into "the cause."

Figure 3.11: Example of community involvement.
This is a workshop regarding Cleveland's future plans about BRT. The meeting consisted of planners, designers, engineers, city-officials, but it was also open to the public. Workshops are a great tool to raise public awareness.

3.2 | cooperative planning

The second factor is cooperative planning. Unity gets the job done. A clear, definitive vision among the various shareholders and agencies ultimately leads to a successful outcome. Traffic engineers, urban planners, communities, local and state agencies, transit engineers should work together to establish a shared vision. Constant communication among involved parties eliminates fragmentation in the planning process. Regular meetings, following up, and keeping everyone up-to-date expedites the planning and implementing process.

Figure 3.21: Example of cooperative planning.
This is a workshop where various stakeholders and members of the community came together to plan and learn about Berkeley's BRT system.

3.3| long-term vision

Figure 3.31: Example of BRT vision and how it fits in with the surrounding land use.

The third factor is long-term vision. Political will is the strongest asset to have during the BRT planning process. As we learned in Curitiba's case study, Jaime Lerner did not fear the ramifications of pushing for an "above-ground subway system." Lerner and his team had a clear vision for Curitiba. The commendable thing is that Lerner and his team did not care what the polls said. They were not afraid to sacrifice their popularity for a good cause. This sort of political commitment from leaders sustains the planning process and inspires others to promote the positive change.

Long-term vision should also incorporate land use planning. Combining land use planning with BRT planning results in many benefits because their integration creates the opportunity to build high-density housing, business districts, commercial centers, etc. Mixed-use developments will encourage individuals to live, work, and recreate in the same place. The availability of public transportation will decrease the need for automobiles. Moreover, long-term vision also allows city officials and planners to generate growth in desirable directions, and "rightful" land use along the BRT corridor channels economic development.

3.4 | ensuring safety & security

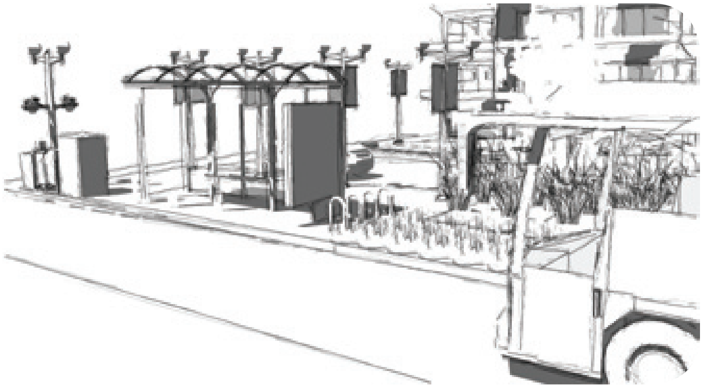
The forth factor is ensuring safety and security. This factor applies more towards station design. Fast service, "sexy" buses, and convenient schedules are great, but in the absence of safety and security, they are trivial. The lack of safety and security, actual or perceived, destabilizes the value of BRT. This affects not only passengers, but also the entire system. Employees suffer as workdays are lost, revenues decrease and prices increase to make up for the loss, and areas are abandoned (Needle & Cobb, 1997). If people do not feel safe at stations or on vehicles, they are more reluctant to consider public transportation, no matter how great the service. Because stations are exposed to the public throughout the entirety of the day, their design should be vandal proof. Some stations might be unattended for long periods of time, which makes them even more vulnerable to vandalism; however, certain design measures help reduce these risks. For instance, lighting is an important attribute to safety. Well-lit shelters, pedestrian pathways, platforms, and parking facilities generate and increase the feeling of safety. "Lighting on open platforms should be in the range of 5 footcandles, with areas beneath canopies increased to 10 to 15 footcandles" (Levinson, et al., Implementation Guidelines, 2003, p. 99).

The public should have an unobstructed view of stations at all times. Stations should not be hidden, covered, or tucked away. Furthermore, it is necessary for individuals to see their surroundings and be seen in those surroundings because "visibility is the single most important attribute of security" (Levinson, et al., Implementation Guidelines, 2003, p. 100). Given that, station shelters and walls should be transparent so individuals have a clear view of what is taking place in and around stations. Situating stations or station platforms in close proximity of streets (enough setback for safety) decreases the amount of harmful or suspicious activity. More importantly, landscape elements should not impede, limit, or obscure visibility. In addition, dead-ends, sharp turns, hidden or tucked away corners should be avoided. For full BRT services, it is beneficial to have security officers or staff who monitor stations to prevent destructive or harmful activity in order to ensure customer safety.

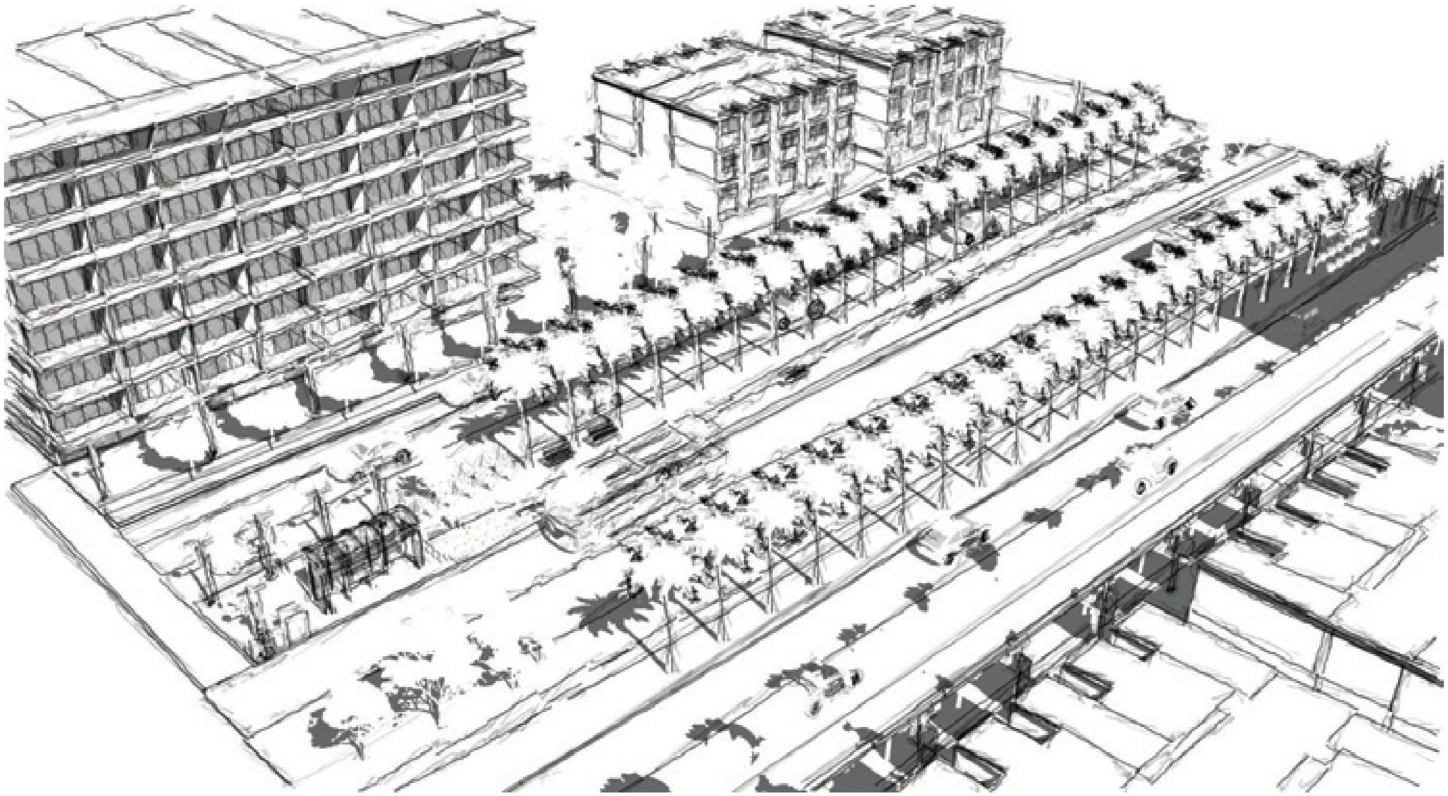
chapter 4 | design guidelines

This chapter surveys the practical aspect of BRT for designers based on the material covered thus far. It is important to realize that each situation presents different opportunities and constraints and we should accept the fact that no singular solution exists; there is no magic formula. We will experience discrepancies in tactics, measures and methods, and implementation practices as we move from one situation to another. Hence, the circumstances should guide how and what type of BRT system to adopt. The ideas that I present are not my independent, innovative ideas; however, they are an amalgamation of my research, existing ideas, and my personal view(s). The Transportation Research Board and Federal Transit Administration have worked extensively to provide comprehensive guidelines for BRT in several documents. The information I have collected over the course of my research has aided me in developing general running ways and station stops/shelters design guidelines, which are geared towards the novice designer. Additionally, I have created a hypothetical design of what I believe to be an "ideal" BRT system using the guidelines I proposed.

Hypothetical Design
Black & white rendering of the back of the station stop.



Hypothetical Design
Black & white rendering of the front of the station stop.



Hypothetical Design
Black & white rendering of an aerial view of the busway and station.

4.1 | running ways

figure 4.11

1. Running ways should be--separated--from the general flow of traffic and traffic interferences.

figure 4.12

2. Running ways must establish a strong and distinct identity for BRT. BRT services should be iconic. For that reason, I recommend central/median busways whenever feasible.

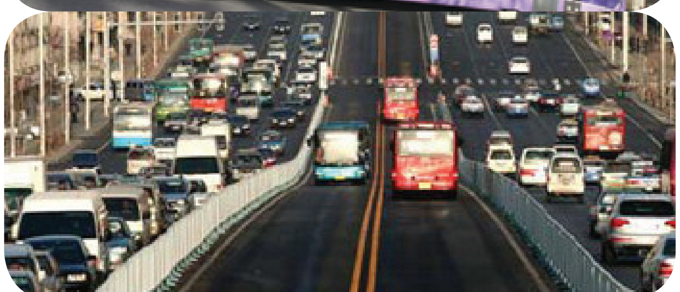


figure 4.13

3. Running ways/route structure should be direct, linear, and turn-free as much as possible. BRT should take advantage of free-flowing roadways.

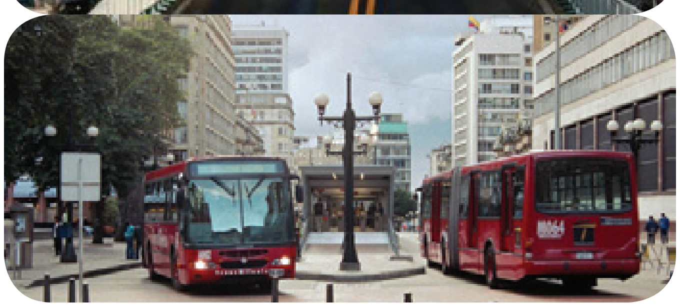


figure 4.14

4. Running ways should serve major travel markets, central business districts (CBDs), commercial districts, and other venues that attract a lot of public.

5. Running ways should accommodate or cater to adjacent land use. Meaning, running ways should be “shaped” to meet the requirements of surrounding land use.

figure 4.15

6. Running way design should allocate enough space for buses, general traffic, bicyclists, and pedestrians to move/maneuver around safely.

figure 4.16

7. Running ways should include simple, clear, and easy to understand signage/markings.

figure 4.17

8. Running ways should integrate pedestrian/ bicycle paths or trails and incorporate landscaping/ vegetation when possible.

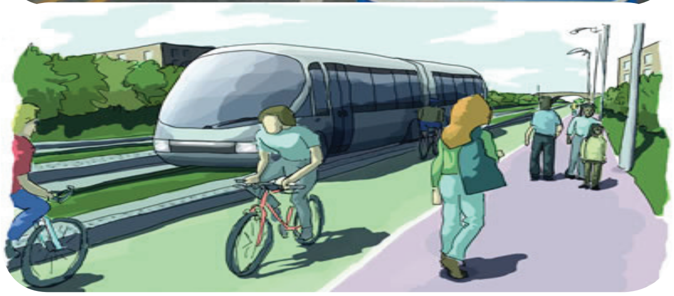


figure 4.18

4.2 | station stops/shelters

figure 4.21

1. Stations should offer seating/leaning rails with sheltered waiting areas that are accompanied by vegetation/landscaping.

figure 4.22

2. Stations should consist of appropriate amount of lighting and transparent materials (structure) to increase passenger safety and visibility.

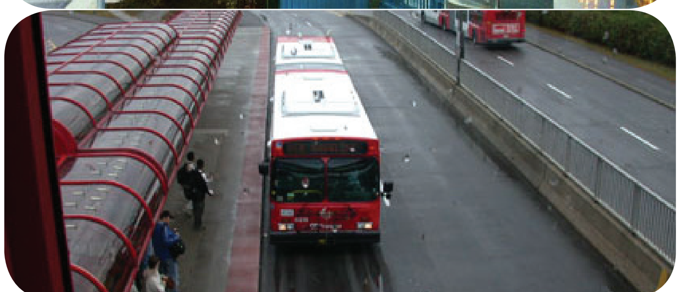


figure 4.23

3. Stations should allow passing capabilities whenever/wherever possible.

figure 4.24

4. Stations should provide passengers with adequate information systems (ITS) regarding bus timings, schedules, delays, etc.

5. Stations should adopt a theme and be distinct from conventional bus lines. Station imagery and livery should be easily recognizable and clearly visible.

figure 4.25

6. Stations should provide level boarding when possible. When this is not possible, either the vehicle or station should accommodate for individuals with disabilities.

figure 4.26

7. BRT stations should be sparsely spaced (between 1/2-1 mile). Authorities should use their discretion along major arterials/corridors that consist of high densities, and/or surrounding land use.

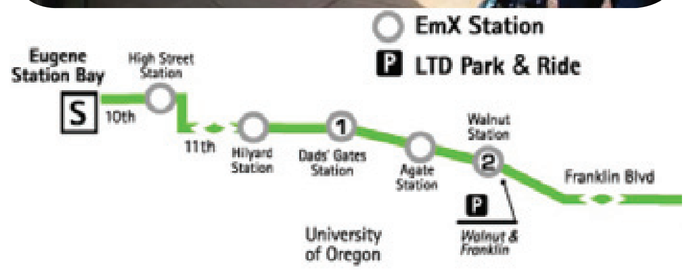


figure 4.27

8. Major stations/stops should provide customers with amenities (vandal free) like public phones, receptacle, pre-boarding fare collection system, lockers, bicycle racks, news stands, drinking fountains, restrooms, ATM, etc.

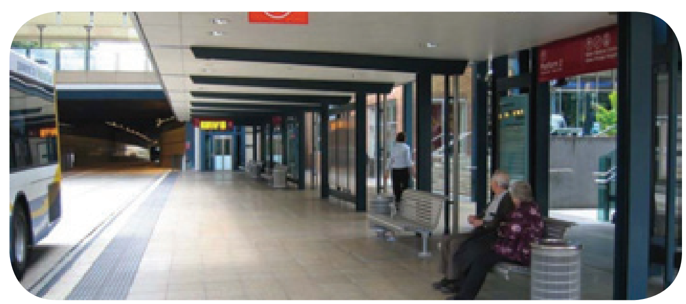


figure 4.28

4.3 | hypothetical design | running way

The image below is my design of a BRT running way. The design incorporates the design guidelines mentioned in the previous section (4.1). The numbers on the image correspond to the design guideline.

RUNNING WAY DESIGN GUIDELINE REFERENCE

1. Running ways should be--separated--from the general flow of traffic and traffic interferences.

2. Running ways must establish a strong and distinct identity for BRT. BRT services should be iconic. For that reason, I recommend central/median busways whenever feasible.

3. Running ways/route structure should be direct, linear, and turn-free as much as possible. BRT should take advantage of free-flowing roadways.

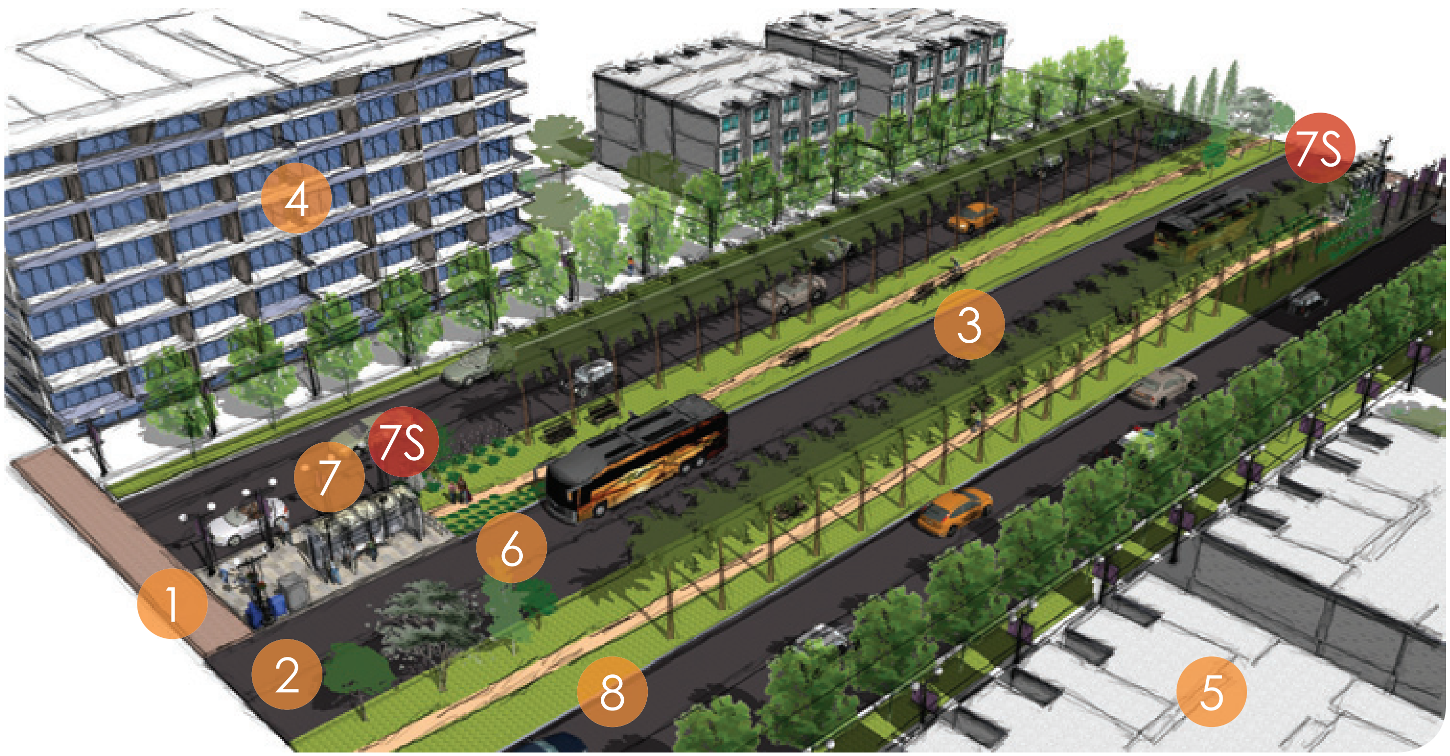
4. Running ways should serve major travel markets, central business districts (CBDs), commercial districts, and other venues that attract a lot of public.

5. Running ways should accommodate or cater to adjacent land use. Meaning, running ways should be "shaped" to meet the requirements of surrounding land use.

6. Running way design should allocate enough space for buses, general traffic, bicyclists, and pedestrians to move/maneuver around safely.

7. Running ways should include simple, clear, and easy to understand signage/markings.

8. Running ways integrate pedestrian/bicycle paths or trails and incorporate landscaping/vegetation when possible.



4.3 | hypothetical design | station stops/shelters

The image below is my design of a BRT station stop/ shelter. The design incorporates the design guidelines mentioned in the previous section (4.2). The numbers on the image correspond to the design guideline. For number 7, please refer to the previous page/ design.

STATION STOP/SHELTER DESIGN GUIDELINE REFERENCE

1. Stations should offer seating/leaning rails with sheltered waiting areas that are accompanied by vegetation/ landscaping.

2. Stations should consist of appropriate amount of lighting and transparent materials (structure) to increase passenger safety and visibility.

3. Stations should allow passing capabilities whenever/ wherever possible.

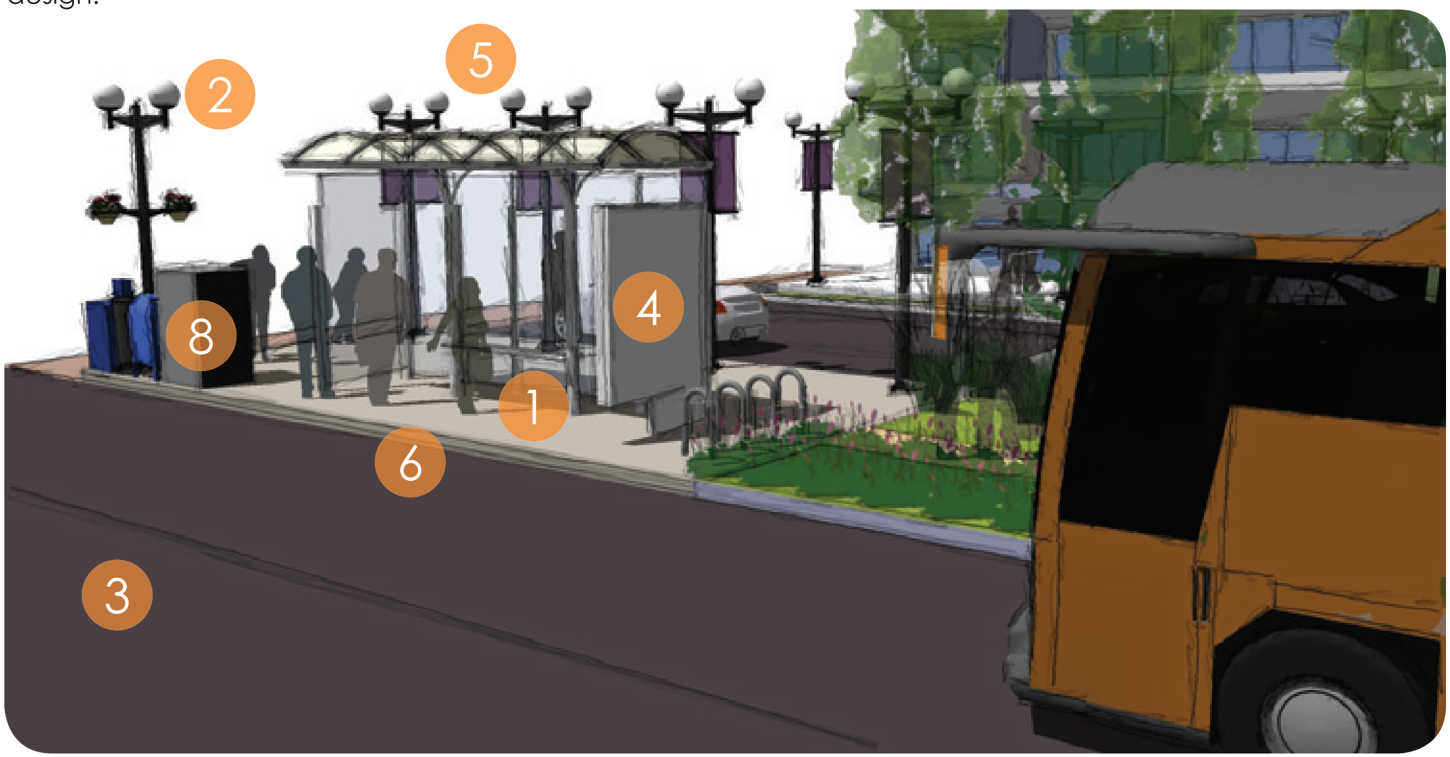
4. Stations should provide passengers with adequate information systems (ITS) regarding bus timings, schedules, delays, etc.

5. Stations should adopt a theme and be distinct from conventional bus lines. Station imagery and livery should be easily recognizable and clearly visible.

6. Stations should provide level boarding when possible. When this is not possible, either the vehicle or station should accommodate for individuals with disabilities.

7. PLEASE REFER TO PREVIOUS DESIGN (RUNNING WAY) FOR THIS GUIDELINE ILLUSTRATION. IT IS NOTED "7S."
BRT stations should be sparsely spaced (between 1/2-1 mile). Authorities should use their discretion along major arterials/corridors that consist of high densities, and/or surrounding land use.

8. Major stations/stops should provide customers with amenities (vandal free) like public phones, receptacle, pre-boarding fare collection system, lockers, bicycle racks, news stands, drinking fountains, restrooms, ATM, etc.



conclusion

summary

Bus rapid transit is a global phenomenon that has very recently caught America's attention. Currently, planners and designers have begun to explore BRT more extensively as a sufficient alternative to light rail. Although BRT is not limited to a single definition, most definitions describe BRT as simply, light rail on rubber tires. We learned BRT consists of diverse, dynamic options and applications. However, a handful of core elements (dedicated running ways, articulated vehicles, enhanced stations, specialized services, ITS) and practices ultimately determine its success. The case studies (Curitiba & Los Angeles) told us that some of the greatest advantages of BRT are operation flexibility, incremental implementation, and its ability to be built quickly. The biggest merit of BRT is that it is relatively economical. More importantly, the case studies taught us that BRT influences growth patterns, land use planning, and potentially, lifestyles. Finally, we analyzed BRT from a designer's perspective to tackle the question: How can BRT be employed successfully? The answer: BRT's success relies on community involvement, cooperative planning, long term-vision, and ensured safety and security. We should not hastily label BRT as a solution, instead we should recognize it as a procedure that relieves and alleviates pressing issues. BRT is an impetus for fostering a better lifestyle—a lifestyle that takes us one step closer to being a "solution."

the greater cause

As we look forward to the future, it is safe to say that the technological age we find ourselves in will create many more transit options and the variety of options will be useful for communities that experience day-to-day traffic congestions. The fate of BRT, and public transportation in general, lies with us. Public transportation is more than just about providing mobility, it is about providing individuals with opportunities; the opportunity to get an education, work, and build a life. Many equate public transportation with poverty and low socio-economic status, which is an irrational correlation and a stereotype that must be dispelled. As a society, especially in America, we should forgo certain luxuries. This idea of "sacrificing" our lifestyle postpones our decision to act promptly. The request to modify deeply-rooted habits, lifestyles, and attitude leaves us debating, thinking, and debating some more. It is definitely a daunting change, but it is also a necessary change.

With the application of innovative technology systems, planners, designers, and decision-makers can establish BRT as a reliable, safe, high-speed form of quality service. But, online forums, groups, articles, and organizations depict the constant bashing towards BRT by those fighting for light rail. Then the obvious happens, BRT patrons retaliate. I do not understand the animosity between light rail proponents and BRT advocates. Unlike them, I do not prefer one system to another, and the fuss about one being better than the other is gratuitous and senseless. Public transportation system is a tool used to ease congestion and provide transportation for those who either a) do not own, or b) wish to use an automobile. The method in which traffic congestion is relieved (light rail, BRT, or some other environmentally-friendly alternative), does not matter as long as congestion is addressed effectively and reasonably. Therefore, designers should analyze social and environmental issues carefully and only then prescribe the necessary treatment.

Lastly, we cannot treat the environment as an expendable aspect of our life. We have done a great deal for human rights. Now we must act rightfully as humans. The betterment of our environment is a process, not an overnight change. Awareness is the first step. Our unflinching determination and will to try different measures in order to protect, harness, and enhance our environment is the real testament to human dignity.

definitions

termdefinition

Alighting "When a passenger exits a vehicle" (Diaz, et al., 2004, p. 249)

Automated Vehicle Location (AVL) "Technology used to monitor bus locations on the street network in real-time. AVL is used to improve bus dispatch and operation, and allow for quicker response time to service disruptions and emergencies" (Diaz, et al., 2004, p. 249)

Bus Rapid Transit (BRT) "A rubber-tired rapid-transit mode that combines stations, vehicles, services, running ways, and Intelligent Transportation System (ITS) elements into an integrated system with a strong positive identity that evokes a unique image" (Levinson, et al., 2003, p. 9). The Federal Transit Administration views BRT as "an enhanced bus system that operates on bus lanes or other transitways in order to combine the flexibility of buses with the efficiency of rail" (United States Department of Transportation, Federal Transit Administration, 2008). I give BRT a two-fold definition: A) In practice, BRT is an efficient, cost-effective hybrid transit system that incorporates aspects of light rail and the conventional bus system while integrating technology, aesthetics, efficiency, reliability, and connectivity to pedestrians and bicyclists, and B) In theory, BRT is an impetus for positive change towards environmental and social conditions.

Branding "The use of strategies to differentiate a particular product from other products, in order to strengthen its identity. In the context of BRT systems, branding often involves the introduction of elements to improve performance and differentiate BRT systems such as the use of vehicles with a different appearance from standard bus services, distinct station architecture and the use of distinct visual markers such as color schemes and logos" (Diaz, et al., 2004, p. 249).

Busway "A busway is a special roadway designed for the exclusive use of buses. A busway can be in its own right-of-way, or in a railway or highway right-of-way. Short stretches of streets designated for exclusive bus use are sometimes also called busways" (United States Department of Transportation, Federal Transit Administration, 2008).

Demand "The actual number of passengers attracted to use a BRT system" (Diaz, et al., 2004, p. 250)

Designated lane "A lane reserved for the exclusive use of BRT or transit vehicles. Dedicated lanes can be located in different positions relative to the arterial street…" (Diaz, et al., 2004, p. 251).

Dwell time "The time associated with a vehicle being stopped at a curb or station for the boarding and alighting of passengers. BRT systems often intend to reduce dwell times to the extent possible, through such strategies as platform height, platform layout, vehicle configuration, passenger circulation enhancements, and the fare collection process" (Diaz, et al., 2004, p. 251)

Headway "Public transit jargon for "the time between buses or trains on the same line". You could say that it's the pulse of a transit route" public transit jargon for "the time between buses or trains on the same line". You could say that it's the pulse of a transit route" (Hughes, 2007).

Intelligent Transportation System (ITS) "Advanced transportation technologies that are usually applied to improve transportation system capacity or to provide travelers with improved travel information. Examples of ITS applications with relevance to BRT systems include vehicle prioritization, driver assist and automation technology, operations management technology, passenger information, safety and security technology, and support technologies" (Diaz, et al., 2004, p. 252).

Level boarding "An interface between station platform and vehicle that minimizes the horizontal and vertical gap between the platform edge and the vehicle door area, which speeds up passenger boarding/alighting times and does not require the use of wheelchair lifts or ramps. Level boarding is often done through the use of station platforms and low-floor vehicles" (Diaz, et al., 2004, p. 252).

Livery "A special design and color scheme used on vehicles, air crafts, or products, of a particular company" (Oxford Dictionary).

Low floor vehicle "A vehicle designed with a lower floor (approximately 14 inches from pavement), without stairs or a wheelchair lift. Use of low floor vehicles could be done in combination with station platforms to enable level boarding, or could be done stand-alone such that passengers are required to take one step up or use a wheelchair ramp to board the vehicle" (Diaz, et al., 2004, p. 252).

Passing capability "The ability for vehicles in service to pass one another. Bus pullouts and passing lanes at stations are two primary ways to enhance passing capability for a BRT system" (Diaz, et al., 2004, p. 253).

Precision docking system "A guidance system used to accurately steer vehicles into alignment with station platforms or curbs. These may be magnetic or optical-based, and require the installation of markings on the pavement (paint or magnets), vehicle-based sensors to read the markings, and linkages with the vehicle steering system" (Diaz, et al., 2004, p. 253).

Queue jumper "A designated lane segment or traffic signal treatment at signalized locations or other locations where traffic backs up. Transit vehicles use this lane segment to bypass traffic queues (i.e., traffic backups). A queue jumper may or may not be shared with turning traffic" (Diaz, et al., 2004, p. 254).

Running time "Time that vehicles spend moving from station to station along the running way. BRT systems are designed to reduce running times to the extent possible, through such strategies as running way segregation, passing capability, station spacing, ITS, and schedule control" (Diaz, et al., 2004, p. 254).

Running way "The visible differentiation of the running ways used by BRT vehicles from other running ways. Signage and striping, raised lane delineators, and alternate pavement color/texture represent three major techniques" (Diaz, et al., 2004, p. 254).

Service frequency "The interval of time between in-service vehicles on a particular route. Determines how long passengers must wait at stations, and the number of vehicles required to serve a particular route. Service frequencies for BRT systems are typically high relative to standard bus services" (Diaz, et al., 2004, p. 255).

Service span "The period of time that a service is available to passengers. Examples include all day service and peak hour only service" (Diaz, et al., 2004, p. 255).

Smart Card A fare collection system replacing magnetic stripe cards. As referenced by (Levinson, et al., Implementation Guidelines, 2003, p. 151): "The cards look similar to standard credit cards and are equipped with a programmable memory chip that performs several functions: holding instructions, holding value, self-monitoring, and creating an electronic billing record (Casey et al., 2000)."

Transit Signal Priority (TSP) "Adjustments in signal timing to minimize delays to buses. Passive priority techniques involve changes to existing signal operations. Active priority techniques involve adjustments of signal timing after a bus is detected (i.e., changing a red light to a green light or extending the green time)" (Diaz, et al., 2004, p. 256).

T-Way Term "proposed for an at-grade busway, or one whose operations are determined by grade crossings" (Hoffman, 2008, pp. 3-4).

Trunk Line Main line/route on which BRT operates.

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