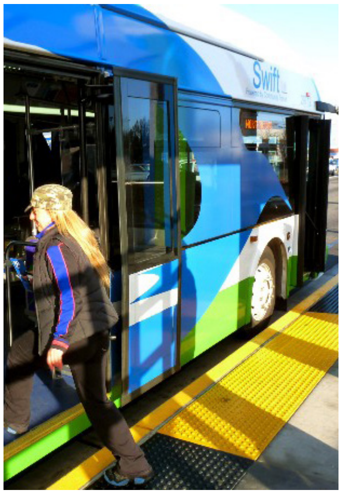
KANE COUNTY
RANDALL/ORCHARD ROAD CORRIDOR
BUS RAPID TRANSIT FEASIBILITY STUDY

APPENDIX C:
Bus Rapid Transit Primer
OCTOBER 2010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SUMMARY

Kane County has embarked on this study to assess the future viability of implementing Bus Rapid Transit (BRT) in the Randall/Orchard Road Corridor. The project will identify future conditions needed to successfully accommodate BRT along the corridor in the 2040 timeframe, and will examine the potential benefits attainable from investing in an enhanced transit system and supporting land uses.

Incremental or phased implementation of BRT, along with transit-supportive land use and development are among several options for reducing vehicle travel demand that have been recommended by past long-range plans in Kane County. One motivation for reducing travel demand is the projected 2030 severe traffic congestion that would remain even after $3.3 billion of arterial roadway projects, far in excess of available funding. Around the U.S., jurisdictions are recognizing the need to adapt transportation corridors for a broader conception of local and regional mobility and pursuing transit system development as a key element of such efforts. Kane County envisions using BRT as a mechanism for transforming Randall Road from an auto-dominated commercial corridor to a pedestrian-friendly, multi-modal corridor while promoting economic development in the corridor.

The purpose of this BRT Primer is to support an informed visioning and decision-making process for the Randall/Orchard Road BRT Task Force, providing appropriate background and context to position the project to make implementation recommendations appropriate to achieve the County's and local municipalities' goals for the Randall/Orchard Road corridor.

What are the General Characteristics of BRT?

Bus Rapid Transit (BRT) is a high quality transit service that integrates a variety of strategies aimed at improving transit travel speed, reliability, passenger comfort, and transit identity over traditional fixed-route bus service. These strategies include:

- Dedicated running ways and/or transit signal priority – roadway and intersection improvement allowing transit vehicles to bypass congestion.
- Enhanced stations – high amenity stations including customer convenience, quick passenger loading and unloading, and BRT service branding elements.
- Specialized vehicles – unique buses with customer amenities, high passenger-carrying capacity, and stylized to promote BRT service.
- High quality transit service – service that is competitive with automobile travel including reduced transit travel times, long spans of service, high frequency of service, and connections to destinations off of BRT corridor.
- Enhanced fare collection systems – innovative fare collection tools and methods that reduces passenger boarding times and therefore reducing delays as stops.
- BRT branding – unique designs and promotion to separate BRT from local bus service and highlight as quality service.

BRT systems throughout North America employ a broad spectrum of these strategies based on available resources, corridor constraints and benefits desired. BRT systems are commonly differentiated by the range of strategies employed, falling into one of two primary categories: Full BRT and Rapid Bus. Full BRT employs many or all of the enhanced characteristics, most notably an exclusive or even segregated running way, while Rapid Bus is typically less capital intensive, applying only targeted strategies. For a frame of reference, Pace's plans for Arterial Rapid Transit will operate more like Rapid Bus.

BRT has operating costs on par with local bus service. Operator labor costs may be slightly higher if high-capacity or sophisticated vehicles are used, or if senior operators are assigned to BRT services. These potential increases are typically offset by increased ridership (lowering the cost per rider) and by improved reliability (eliminating costs to run extra buses due to poor schedule adherence stemming from congestion). As with local service, BRT operations are typically funded from local revenues (primarily sales tax and fares in Kane County).

Capital costs for BRT service vary based on the strategies used. Dedicated running ways, high-end vehicles, sophisticated fare systems and full-feature stations have significant on-time costs associated them. Capital costs are often offset by federal grants, but a number of systems often compete for these funds.

What are Conditions for Successful BRT Projects?

Successful BRT systems are often associated with the four following conditions:

- Transit supportive land uses – mixed-use developments (commercial, residential and other uses) to support high levels of dwelling units, employments opportunities and personal trip destinations near BRT station areas. Greater pedestrian and bicycle connections are offered within station areas.
- Branding and marketing plan – coordinated program to brand BRT service and all of its physical elements (vehicles, stations, signage etc.) to differentiate it from traditional bus service and promote it as a convenient and fast alternative to driving alone.

Source: Lane Transit District

There is a mutually supportive relationship between land use, access and system integration, and service quality from which community benefits from transit are derived.

Station Typology	Station Area Description
Core	• CBD-like land uses and development patterns • Able to sustain job and housing growth • Well-connected multimodal street grid and inviting pedestrian environment • High transit connectivity, including at least two HCT modes
Mixed Use Employment Center	• Adequate mix of zoning capacity to support vibrant mixed use • Provides a regional employment base or draw, typically function as a distinct residential or employment district • Bicycle and pedestrian friendly streetscape • At least 2 modes of 18 – 24 hour transit service
Mixed Use Residential Village	• Some but not all have zoning capacity necessary to achieve social and environmental goals • Smaller centers within the urban area, and no regional draws • Some but not all have high street connectivity • Secondary modes of frequent, high quality transit service are not readily available and residents of the village station area make up the ridership base
Commuter	• Lack of zoning capacity, street connectivity or civic amenities • Peripheral station areas; often serve as transit line terminus or stop along the corridor • Often placed along freeway corridors or areas that make residential development difficult or unattractive • Park and rides are the key multimodal facility and feeder service is the key connective service into HCT
Destination	• Refers to an attraction that creates a large, single user base (such as hospitals, universities, large employment campuses) • Large variance in physical character and performance (density and zoning capacity) • Street connectivity varies by the type of attraction • Transit service varies by use (i.e. universities often exhibit bell service, while employment campuses have frequent peak hour transit service)

- Multimodal connectivity – accessibility to BRT from all modes of travel including: good transit connections between BRT station of other destination off of the corridor; convenient and safe bicycle / pedestrians paths and amenities.
- Competitive with automobile travel – investments in transit speed and reliability to assure that BRT vehicles can bypass congested roadways and intersections while also accessing desired destinations.

Transit supportive land uses are the most critical condition. Research and experience have shown that increased development activity with access to quality transit service results in a greater use of transit, pedestrian and bicycling modes of travel. In addition, average trip lengths in these mixed-use, Transit Oriented Developments (TODs) decrease for all modes, including auto travel. For BRT systems, transit supportive developments are best focused around each station. These station areas are typically developed radially one-half mile around the station – the distance potential riders will walk for high-quality transit service.

Station area developments are best thought of as having a unique character or focus. The notion of station typologies helps create a vision for each station area and helps balance the types and scale of uses throughout the many stations planned in a BRT corridor.

Who has built Bus Rapid Transit and why?

In many of the North American case studies, Bus Rapid Transit was implemented not only to satisfy goals for mobility and greater level of service, but to leverage broader policy goals such as economic development, increased sustainability, and promotion of livable communities. This Primer analyzes BRT systems in seven cities, documenting the goals for BRT in each situation, the characteristics of each system and findings from each case study.

Why agencies chose BRT?

Pittsburgh West Busway
- Manage and bypass congestion
- Increase potential for TOD and economic revitalization

Cleveland HealthLine
- Generate ridership through higher levels of service
- Stimulate development and modify corridor land uses
- Connect employment centers

LTD EmX Green Line (Eugene, OR)
- Improve level of service
- Increase ridership and carrying capacity
- Reduce operating cost

Ottawa Transitway
- Focus land development along BRT trunk lines
- Provide high quality regional transit service
- Reduce operating cost

Community Transit Swift (Snohomish County, WA)
- Improve level of service
- Reinvent transit's image
- Leverage existing transit priority infrastructure and high ridership

Los Angeles Metro Orange Line
- Offer connective service between transit hub and major employment center
- Link Downtown LA and San Fernando Valley with High capacity link
- Provide congestion management and relief along local streets

MBTA Silver Line (Boston)
- Revive a key connective service into Downtown Boston
- Improve level of service

Results included:

- Substantial time savings relative to conventional bus service
- Substantial increases in transit ridership
- Upzoning of land uses around station areas
- Increased development around stations

What are the benefits of BRT?

Experience and research highlight a number of community benefits associated with the implementation of BRT service including:

- Congestion mitigation – increased ridership on BRT lines promotes the shifting of some trips from automobile use to transit, freeing up roadway capacity for remaining drivers and for the movement of freight. Similarly, development of transit supportive land uses results in shorter trips for all modes – reducing vehicle miles traveled per capita
- Cost effectiveness – higher capacity BRT vehicles lower the operating costs per rider.
- Economic Development
  - Increased economic productivity – personal and employee time savings resulting from time not spent idly in traffic.
  - Improved economic opportunities – increased mobility options expand employment opportunities and reduce commuter transportation costs.
  - Revitalization –TOD development around stations can revitalize aging commercial areas creating economic opportunities and enhancing tax revenues for local jurisdictions.
  - Increased land values - investments in high-capacity transit stations and other infrastructure improve access, attract development, and increase land values.
  - Job creation – capital investments in BRT infrastructure support local construction, planning and design jobs.
- Air quality – by shifting trips to transit of shortening trip lengths, the combination BRT and transit supportive land uses reduces tail pipe emersions per capita, improving air quality and reducing greenhouse gas emissions
- Community Health – BRT and station areas incorporating TOD concepts support active living goals by encouraging bicycling and walking to reach transit or for entire trips.

Based on the desired benefits, Bus Rapid Transit can employ a variety of technology and amenity packages ranging from Rapid Bus to Full BRT components. Whatever transit strategies are employed to serve the Randall/Orchard Road Corridor, BRT, in conjunction with coordinated land use planning, can help build thriving, livable communities.

Depending on the level of investment, Bus Rapid Transit can attract and relieve congestion by increasing use of public transit, promote economic development, and improve public health.

Source: National Bus Rapid Transit Institute (top and middle), Flickr user San Joaquin RTD, http://creativecommons.org/licenses/by-nd/2.0/deed.en

WHY A BRT PRIMER?

Kane County has embarked on this study to assess the future viability of implementing Bus Rapid Transit (BRT) in the Randall/Orchard Road Corridor. The project will identify future conditions needed to successfully accommodate BRT along the corridor in the 2040 timeframe, and will examine the potential benefits attainable from investing in an enhanced transit system and supporting land uses.

Incremental or phased implementation of BRT, along with transit-supportive land use and development are among several options for reducing vehicle travel demand that have been recommended by past long-range plans in Kane County. One motivation for reducing travel demand is the projected 2030 severe traffic congestion that would remain even after $3.3 billion of arterial roadway projects, far in excess of available funding. Around the U.S., jurisdictions are recognizing the need to adapt transportation corridors for a broader conception of local and regional mobility and pursuing transit system development as a key element of such efforts. Kane County envisions using BRT as a mechanism for transforming Randall Road from an auto-dominated commercial corridor to a pedestrian-friendly, multi-modal corridor while promoting economic development in the corridor.

The purpose of this BRT Primer is to provide appropriate background and context to position the project and to support an informed visioning and decision-making process for the Randall/Orchard Road BRT corridor Study. The BRT primer is organized to answer the following questions:

- What are the general characteristics of BRT, including elements, conditions for success, and costs?
- What conditions are associated with a successful BRT system?
- Who is building BRT and why?
- Why focus on BRT and how does it compare to other modes?
- What are the benefits of BRT?
- How is BRT funded and implemented?

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WHAT ARE THE GENERAL CHARACTERISTICS OF BRT?

Bus Rapid Transit (BRT) is a high quality transit service that integrates a variety of strategies aimed at improving transit travel speed, reliability, passenger comfort, and transit identity over traditional fixed-route bus service. BRT is often designed to mimic light rail transit in look and in some cases travel times and operating speeds, at a fraction of the required infrastructural investment. In fact, BRT is often used as an incremental shift towards other capital intensive modes like light rail transit and commuter rail. However, BRT systems do not necessarily incorporate all the available strategic elements, and numerous combinations of improvement strategies can generate a variety of benefits needed to improve service quality for the transit dependent, attract captive riders, and retain high levels of ridership.

In general, there are two levels of BRT service: Full BRT and Rapid Bus. Full BRT is typically considered a higher capital investment with exclusive and often segregated running ways, rail platform-style stations, and specialty BRT vehicles (see Figure 1 and the following sections). While some may debate the classification of Rapid Bus as BRT, Rapid Bus seeks to improve transit's level of service and image using many of the key BRT elements, while forgoing the capital intensive technology and infrastructure investments. Rapid Bus often operates within mixed traffic and relies on transit priority treatments like queue jump lanes, to reduce delay and increase average travel speeds. For a frame of reference, Pace's plans for Arterial Rapid Transit will operate more like Rapid Bus.

Figure 1 Typical Characteristics of Full BRT and Rapid Bus

BRT Element	Full BRT	Rapid Bus
Running Way	Exclusive	Mixed Traffic; Queue Jump Lanes
Station Investment	High	Low to High
Vehicles	Articulated; Stylized	Standard or Articulated; Stylized
Technology (ITS)	Precision Vehicle Docking; Real-Time Arrival Display; AVL; APC	Automatic Vehicle Location (AVL); Automatic Passenger Counters (APC)
Service Frequency	5 – 15 minute peak service	10 – 30 minute peak service
Fare Collection	Off-board fare collection (Proof-of-Payment)	On-board fare collection
Branding	Vehicle, marketing materials, logo, stations	Vehicle, marketing material, logo, stations

Note: This is a general summary of elements commonly used in Full BRT and Rapid Bus operation. Actual elements employed by BRT service delivery models will vary by agency and corridor constraints.

Running Way and Right-of-Way Requirements

The most important factor influencing travel time savings and service reliability is the type of running way used to operate a Bus Rapid Transit line. Running ways can take the form of permanent guideways dedicated for bus-only operation, mixed traffic operation where buses share travel lanes with automobiles and other vehicles, and/or a mixture of both. Running ways can also be located on-street or off-street and fully separated from vehicular traffic along a corridor. When interacting with other vehicular traffic (i.e. not operating in a dedicated and separated guideway) BRT can operate with varying levels of transit signal priority to reduce intersection delays. Employing BRT in a corridor allows tremendous flexibility in facility design; a single corridor may use separated right-of-way and mixed traffic designs adjusting to localized conditions. BRT service along Randall Road must take into account these variations as they will ultimately affect project cost, as well as operating speeds and ridership. Some of the more common running way combinations that could be implemented along the Randall Road corridor include:

- Mixed flow lanes – In this scenario, BRT service operates mixed with traffic traveling on the corridor's existing general purpose lanes. This model is often utilized when congestion levels do not warrant dedicated transit lanes throughout the corridor, the right-of-way is space constrained, or if current funding only allows for minimal capital investment. Intelligent transportation systems (ITS) such as signal priority treatments combined with intersection design features provide priority for transit vehicles at congested intersections; without these features mix flow operation would provide little to no travel time improvements over traditional local or commuter bus service. Wider station spacing is another common feature used to reduce corridor delay and improve BRT operating speeds.

Metro Rapid Route operating within mixed traffic in Downtown Los Angeles

Source: Payton Chung, Creative Common Attribution License 2.0

- Queue jump lanes –Queue jumping offers a bypass option for BRT vehicles approaching congested intersections. In this type of running way, which is a common priority treatment used in Rapid Bus service, BRT vehicles operate in general purpose lanes until they arrive at an intersection. In order to bypass congested intersections, the vehicle travels along a queue jump lane that is typically supplemented by a dedicated transit signal and a merge lane to reintegrate into mixed traffic. Transit signal priority is given to the transit vehicle offering travel time savings and an opportunity to bypass congestion.

  These lanes can facilitate access to stations and reduce station dwell times if provided in conjunction with transit priority traffic signals. Queue jump lanes are not considered exclusive because they usually allow for right turning vehicles to access the lane to make their turn movement.

- Exclusive transit only lanes – Transit-only lanes are on-street travel lanes to be used exclusively by BRT vehicles except at intersections to allow for right turn vehicle movements. The primary goals of developing transit only lanes are to establish transit priority along a corridor and to provide uninterrupted travel, except at stations or intersections. These exclusive right-of-ways are typically designated by lane markings, painted buffers, signage, and sometimes curb separation or some other form of physical barrier. Transit only lanes can be structured to operate only during peak hour travel (typical Rapid Bus strategy) or function all day (indicative of Full BRT). Curbside transit lanes are frequently shared with right turning vehicles, particularly on corridors where there are business access driveways. These are often called Business Access Transit (BAT) lanes.

Queue jump lane along a major arterial in Portland, OR

Source: Nelson\Nygaard

Exclusive transit only lane in Cleveland, OH (left) and typical peak hour bus lane signage (right) seen through the Los Angeles region.

Source: Nelson\Nygaard

- Separated at-grade transitways – These are exclusive bus lanes that are fully segregated from general traffic via physical curb separations. Although vehicles still traverse intersections along a corridor, BRT vehicles can be equipped with transit signal priority technology for seamless, near uninterrupted travel. Vehicle interaction with intersections requires a higher investment in safety features such as crossing devices, signage, and additional traffic signals.[1] Depending on the right-of-way widths, an at-grade busway can provide either bi-directional service for higher service frequency or uni-directional peak hour service.

  The enhanced level of investment seen in transitways has a positive effect on passenger psychology. Passengers are more likely to ride (and continue riding) if the service appears to have some degree of permanence.

- Exclusive grade-separated transitways – Grade-separated busways also provide exclusive bus right-of-way to circumvent congestion; however, buses are able to bypass intersections using underpasses and overpasses. BRT vehicles are able to operate at consistently high speeds throughout the corridor with little to no conflicts, which yields greater reliability and faster service than any of the other running way types. Grade separation requires significant capital investment and could create considerable visual impacts to the surrounding neighborhood.

  As discussed before, exclusive transitways featuring grade separation infers some level of permanence, which can attract captive riders and improve the image of transit.

Physical separation, as detailed in the last two bullet points, is the primary strategy that delineates Full BRT from Rapid Bus service delivery. BRT operation along Randall Road may utilize several different running way types. Land use, station suitability, right-of-way widths, and congestion points are all factors that inform the most appropriate choice of running way. If corridor congestion is greatest at a select few intersections, Rapid Transit might be the appropriate mode to invest in because it operates most effectively within mixed traffic with queue jumping opportunities at those congested intersections. If the goal of BRT in Kane County is to provide travel times that mirror LRT and compete with automobile travel, the corridor may operate best on a separated running way with exclusive BRT signal phases using transit signal priority.

1Characteristics of Bus Rapid Transit for Decision-Making, 2009. Federal Transit Administration.

Station Design

Stations are the first-line interface between passengers and BRT service. By enhancing stop amenities and aesthetics, BRT is easily identified as a premium service. Because BRT operates on high-demand corridors with greater stop spacing, station investment can be funneled to offer a maximized level of passenger amenities and comfort at strategic locations. Station design elements focus on rider comfort, safety, and convenience and can include:

Common BRT Station Amenities	
• Shelters and awnings (open or enclosed)	• Signage and station beacons
• Seating and leaning rails	• Windscreens and heated shelters
• System map and route schedule	• Public art
• Real-time arrival displays	• Pedestrian lighting
• Ticket vending machines (TVM)	• Emergency call boxes, CCTV monitoring

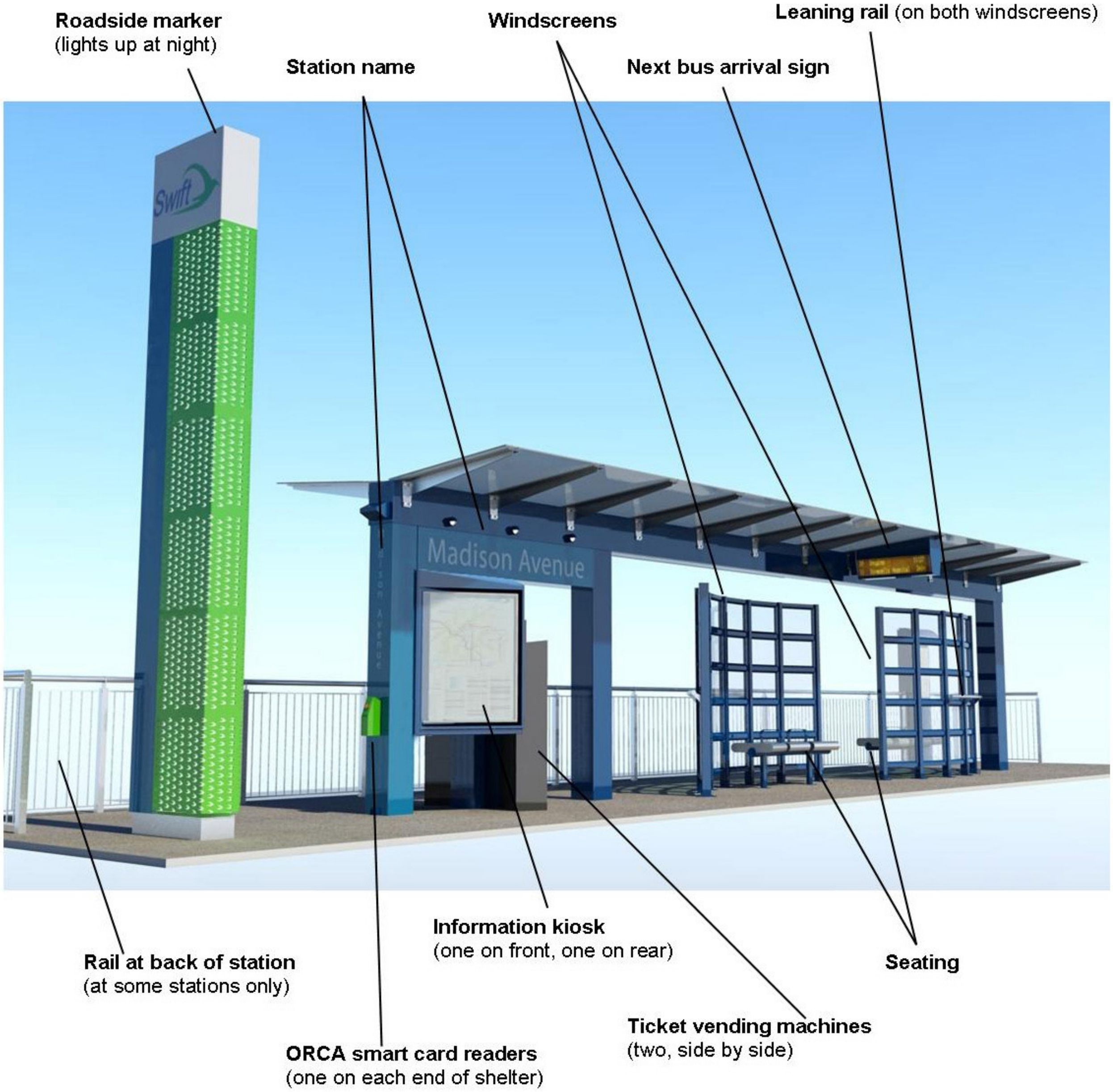
LA Metro's Orange Line operates on an at-grade, exclusive right-of-way

Source: neighborhoods.org, Creative Commons Attribution License 2.0

One of many bus only ramps that serve exclusive busways in the Seattle area

Source: Nelson\Nygaard

A defining characteristic of many BRT stations is high curb design, which allows for low-floor vehicles to seamlessly dock to station platforms and facilitate quick boarding and alighting, especially for riders with mobility aids or strollers. Station platforms can also be extended length-wise to allow for multiple vehicle, or articulated vehicle docking.



Station design, configuration, and passenger amenities can mimic features often seen at rail platforms

Source: Community Transit

Park and ride access is also an important design consideration because it can extend BRT's service area. Park and rides provide access to those that would like to use the service, but live outside of a comfortable walking or bicycling distance from a BRT line. Park and ride integration is typically located in low-density areas that are under developed.

Vehicle Options and Technology

A wide variety of vehicle types can be used in bus rapid transit operations. While some operators use conventional buses, others opt for more advanced "BRT" buses with greater technological benefits and passenger amenities. Vehicles used for BRT typically have some or all of the following characteristics:

- Size – Buses are typically at least 40 feet, and can reach 60 feet with one articulation or eighty feet with two articulations. Articulation is a vehicle feature that uses flexible design to permanently affix a rear body section without giving up the ability for the vehicle to adapt to tight turns or bends in the running way.

  Vehicle capacity depends on the type of vehicle procured for operation, seating configuration, articulation, and market demand. That being said, BRT vehicles in use throughout the U.S. have capacities ranging between 40 and 130 passengers, including both seated and standing passengers. Seated passenger capacity can range between 20 and 65 passengers.

- Easy Boarding and Alighting – Low floor buses can be used to make boarding and alighting easier and to decrease the amount of time it takes for both to occur. This can also be accomplished by matching the heights of the bus floor and station platform.

- Increased Number of Door Channels – Multiple door boarding can be provided to improve boarding and alighting speed, which can reduce station dwell time. Multi-door boarding is usually combined with an off-board payment system.

- Stylizing – Many agencies choose to stylize BRT vehicles like rail transit vehicles—whether for Full BRT or Rapid Bus modes. Because the vehicle provides an immediate visual connection to customers, stylizing can play an important role in BRT's image and identity as a high quality service. Vehicles with unconventional styling, distinctive paint jobs, and different names also help distinguish Bus Rapid Transit from other bus services (See Branding and BRT Image below).

Multiple doors, articulation, and unique styling on the Phileas BRT vehicle

Source: Nelson\Nygaard

Multiple door boarding, as used on Community Transit's Swift BRT service, improves boarding/alighting speed

Source: Community Transit

Sleek styling of the LA Metro Rapid Bus differentiates it from other transit services

Source: Nelson\Nygaard

Figure 2 displays a sampling of typical specifications and capacities seen in North American BRT vehicles as well as representative vehicle models.

Figure 2 Typical BRT Vehicle Specifications

Length	Width	Floor Height	Door Channels	Seats	Maximum Capacity (with standing passengers)	Model Examples
40 ft	96 - 102 in	13 - 36 in	2 - 5	35 - 44	50 - 60	New Flyer Invero, Van Hool A330
45 ft	96 - 102 in	13 - 36 in	2 - 5	35 - 52	60 - 70	NABI 45C-LFW
60 ft	98 - 102 in	13 - 36 in	4 - 7	31 - 65	80 - 90	Iribus CIVIS, New Flyer DE60-LF, NABI 60
80 ft	98 - 102 in	13 - 36 in	7 - 9	40 - 70	110 - 130	APTS Phileas 80

Source: Zimmerman and Levinson (2004); NBRTI Vehicle Catalog (2006)

Interior Design

Within the BRT vehicle, attention to interior design improves passenger comfort, vehicle capacity, and passenger circulation while passengers board and alight the vehicle.

- Passenger Amenities – Amenities to improve the passenger's experience include comfortable seats, air conditioning, on-board media, baggage storage, bright lighting, and large windows.
- Wide Aisles – Strategic seating configuration and experimenting with alternative seating layouts increase passenger comfort and improves circulation within the vehicle.
- Wheelchair Accommodation – Many BRT vehicles provide innovative solutions to wheelchair accommodations such as low floor vehicles that eliminate the need for ramp deployment, wider aisles, rear-facing wheelchair positioning, and designated spaces for wheelchairs. Decals on the outside of the vehicle can also guide passengers to the appropriate door to quickly find wheelchair accommodations.
- Bicycle Storage – Bicycle storage within vehicles is not very common, but a trend that is growing in BRT operations. Amenities like this facilitate multimodal travel by providing a viable option for the "last mile" of a transit trip. One drawback from on-board bicycle storage is that it can take up valuable capacity during peak hour runs. Providing secure, covered bicycle parking at station is an alternative to the on-board option. Bicycle racks on the exterior of vehicles are discouraged due to security issues and to potential for added station dwell time.

Wide aisles offer greater passenger comfort and ability to circulate within BRT vehicles

Source: Oran Viriyincy, Creative Commons Attribution License 2.0

On-board bicycle storage on Community Transit's Swift

Source: Oran Viriyincy, Creative Commons Attribution License 2.0

Propulsion

Bus Rapid Transit buses can use any of the propulsion systems also used in fixed-route local service. These include internal combustion engine (which includes diesel, compressed natural gas, gas, liquefied petroleum gas, ethanol, and biofuels), electric trolley (via catenary tracks), diesel-electric hybrid, and methanol powered vehicles.

Vehicle propulsion system plays a significant role in emission levels and noise pollution. Electric Trolley propulsion offers the cleanest vehicles as well as the smoothest and quickest acceleration. Hybrid-Electric BRT vehicles are a suitable middle ground between electric and internal combustion because it doesn't require the capital investment for electric fueling stations, yet the improvements in fuel efficiency, emission reduction, and vehicle performance are still substantial. A more comprehensive overview of BRT's environmental benefits is documented later.

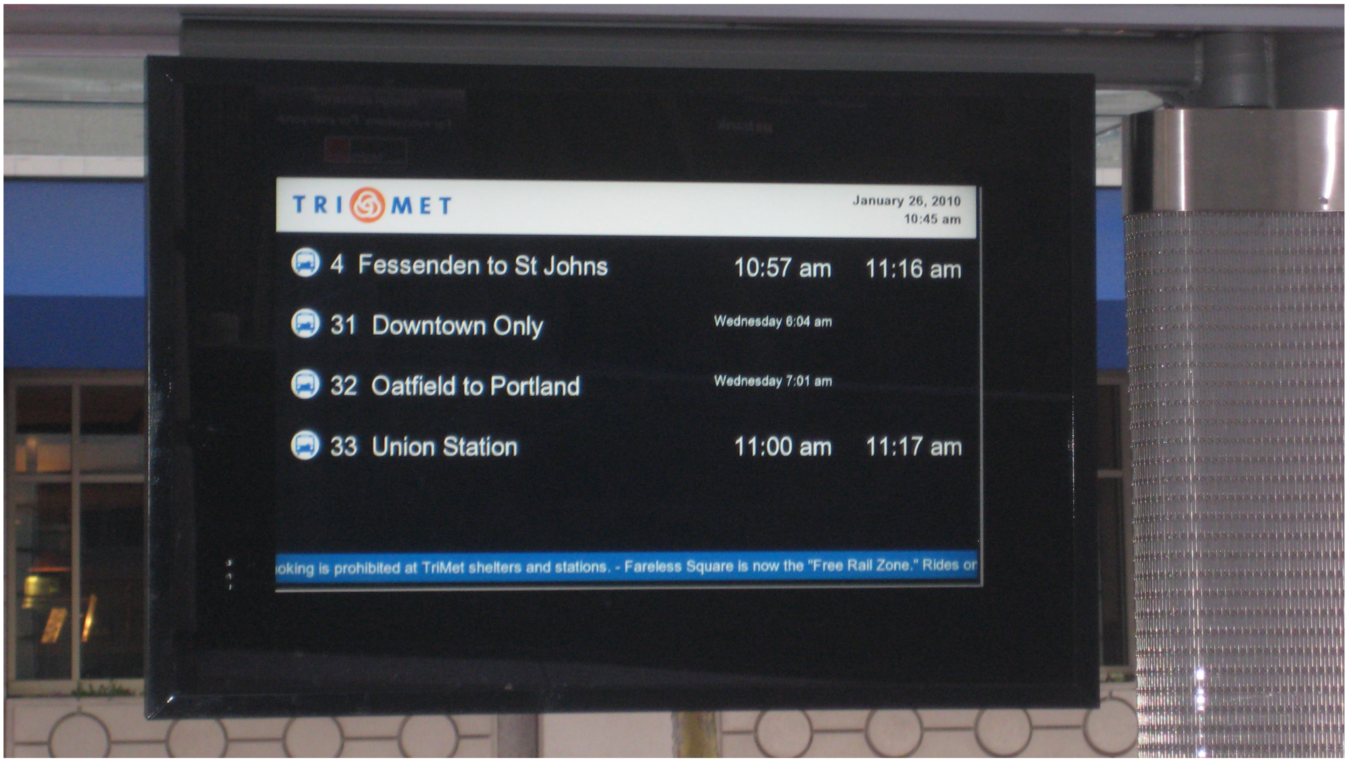
Intelligent Transportation Systems

There are numerous levels of technology integrated into BRT operations that aid in providing faster, more reliable, and more efficient service. Intelligent Transportation Systems (ITS) is the blanket term for the technological packages that offer communication, information, and electronic efficiencies for a transit system. Below is a list of ITS features that are commonly used to enhance service quality.

- Vehicle Assist / Precision Docking – Electronic and mechanical guidance systems may be used to improve performance during station docking. These systems take over for the driver as the bus nears the station and position the bus very close to the station platform, improving boarding and alighting convenience and decreasing station dwell time.
- Transit Signal Priority (TSP) – TSP uses vehicle location trackers and operations center communications (see AVL section) to provide priority treatment to vehicles that are approaching an intersection. This minimizes or eliminates intersections wait time when extended green phases and bus only signals are combined with queue jump or transit only lanes. TSP also improves schedule adherence and could allow for greater service frequency, depending on demand. TSP requires re-timing of signal phases along the corridor in order to ensure efficient flow of all modes as well as installation of transit signal heads (see image).
- Automatic Vehicle Location (AVL) – AVL is a feature that accurately locates the position of vehicles within a system. AVL improves on-time performance and reliability by informing drivers if they are behind schedule or "running hot",

Mechanical docking system guides BRT vehicles for precise in-line boarding.
Source: Nelson\Nygaard (top), NBRTI (bottom)

Bus only "green" phases improve on-time performance in Johannesburg, South Africa.
Source: ITDP, Creative Commons Attribution License 2.0



Example of a real-time electronic display monitor

Source: Nelson\Nygaard

utilizing the BRT fleet more effectively during peak periods, and responding more quickly to congestion and other traffic incidents. Most vehicles employ global positioning system (GPS) tracking equipment to accurately determine location

- Automatic Passenger Counters (APC) – APC sensors track the number of riders boarding and lighting each door on a transit vehicle. APC aids in ongoing service planning efforts by providing precise ridership counts at stop locations and time of day. This technology installed on BRT vehicles would make future BRT operations and transferring to local and regional transit services more efficient.
- Real-Time Travel Information – Real-time vehicle tracking systems accurately pinpoint the expected arrival time for the next arriving bus by displaying information on electronic displays (as opposed the simple display of scheduled arrival information). Additionally, traffic delays and service changes can be monitored and displayed. Real-time information can also be installed on BRT vehicles displaying the next stop, expected arrival times, service delays, and options for transferring. Real-time information requires the installation of AVL technology, prediction software, and electronic displays (at station and/or on-board).

Service and Operating Characteristics

Service and operating elements of BRT distinguish the service from other transit modes in the areas of reliability, travel speed, and passenger wait times. Below are a list of common characteristics that make up BRT's service and operation:

- Route length – Route lengths vary significantly depending on the extent of BRT service; however lengths typically range between 5 to 20 miles. Route length ultimately depends on market demand, land use along a corridor, and the presence of transit generating destinations. Research has shown that in order to provide the most reliable BRT service, runs should not exceed 2-hours, while the maximum route length should not stretch further than 20-miles end-to-end (one-way only)[1].
- Route structure – BRT generally operates on three types of routes: Single Route; Overlapping Service; and BRT with Network Integration:
  - Single routes are simple, direct routing on one corridor that are typically developed along corridors with multiple activity centers and transit generating uses at nearly every stop. One consideration with single route structuring is that it is heavily resource intensive and must extend high quality service during off-peak periods.

1 Characteristics of Bus Rapid Transit for Decision-Making, 2009. Federal Transit Administration

Branching

Branching refers to the strategy of allowing transit lines with different terminus locations to use the same route for the bulk of their run. This is particularly effective where a strong inner line segment exists, but there are multiple options for a line terminus. Branching can eliminate the need to make difficult decisions between relatively equal outer termini markets and can help deliver higher frequency service on inner line segments. Buses are well suited to branching due to the relatively low incremental cost of developing a branch compared to rail modes. Branching can eliminate the need for separate feeder service (and requirements to transfer to the BRT service) when connecting to park-and-ride or downtown locations.

- Overlapping routes are those that offer a base BRT service with variations such as skip stop patterns and express service during peak hours. This type of routing can better allocate resources according to the dual goals of providing access to local services, while improving regional mobility. If BRT service runs on dedicated right-of-ways, this type of route structure might work best with transit passing lanes to avoid delay and congestion.
- Integrated BRT system considers not only the BRT corridor service, but also the supplemental feeder routes that branch from the BRT service or other local fixed route service types that may be overlaid onto the BRT service.

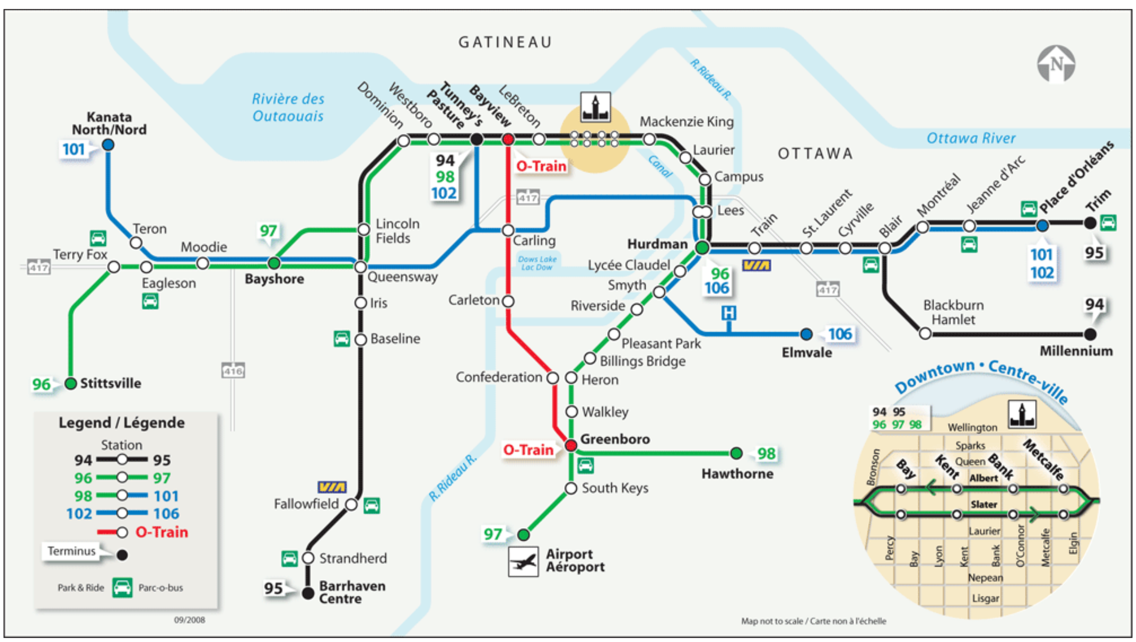
In all, the most important conditions of route structure are that the service patterns are clear and user-friendly, yet allow for consumer choice depending on trip purpose.[2]

- Service span – Service span can range from 18 hours or more to only peak hour service. In general, BRT service operates all day with consistent frequencies during both peak and off-peak service or offer peak-period service where the travel demand and level of service is high. All day service requires a sustained level of service throughout the service span, even when demand is lowest during off-peak hours. Likewise, all day service can signal to customers that the service is the backbone of corridor travel and reinforce the service's reliability.

  Peak-only service is typically implemented in corridors with heavy commuter travel and is more associated with express bus service. These markets don't typically merit the major investments required for Full-BRT service. In addition, if peak-only service is provided, the local service overlay can serve the route with longer headways during non-commute hours. A drawback of this type of service is that a learning curve may be involved in terms of understanding when BRT is in operation. For these reasons, the vast majority of BRT systems currently operating provide some degree of all day service.[3]
- Frequency of service – Also referred to as headways, frequency of service is a result of market demand for service; although more frequent service influences consumer preference

2 Characteristics of Bus Rapid Transit for Decision-Making, 2009. Federal Transit Administration

3 Characteristics of Bus Rapid Transit for Decision-Making, 2009. Federal Transit Administration.



Ottawa's integrated transitway system

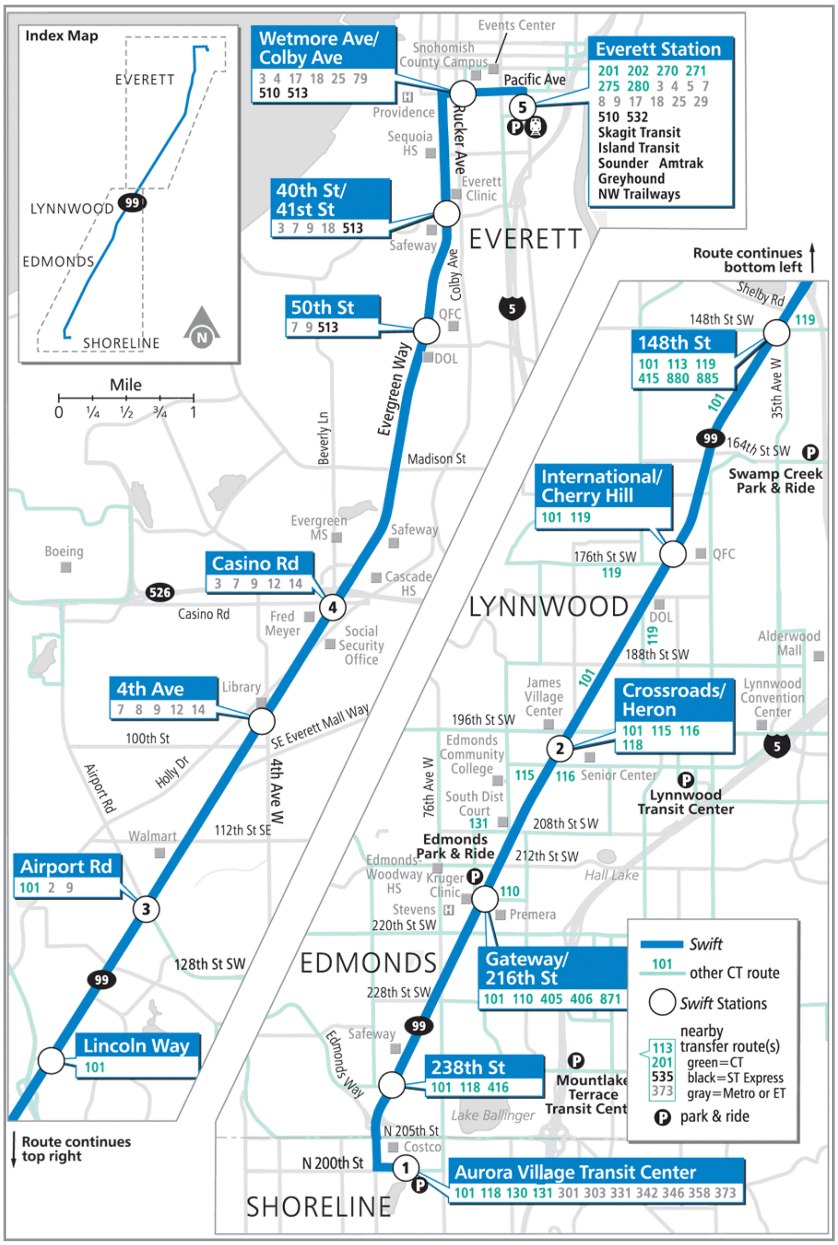
Source: OC Transpo

for transit and can increase demand. That being said, BRT service is typified as a frequent service with headways of 10 minutes or less during peak hour service.[4] High frequency service improves service reliability by minimizing wait times at stations and allowing for "scheduleless" service.

- Stop spacing – One of the most important features that affect BRT operating speeds is stop spacing. Longer stop spacing contributes to predictable high speeds for longer periods of time—especially along a dedicated right-of-way. Less frequent stops concentrates passengers at a limited number of stations which cuts corridor travel time compared to local bus routes with frequent stops. Each stop entails time to decelerate, board and alight passengers (dwell time), and accelerate back up to travel speeds. Figure 3 demonstrates conceptually how stop spacing and operating speeds interact along different Bus Rapid Transit corridors. As vehicles approach downtowns, central business districts (CBD), or other activity centers, stops become more frequent as transit demand increases. Limited stop service usually consists of frequent stop service in neighborhood centers and long distance travel without stops into a downtown or major activity center. Ideal stop spacing can range between .5 and 2 miles depending on land use, running way, and primary mode of station access. Stations in a central business district (CBD) or commercial center may allow for .33 to .5 mile stop spacing because of their strong transit market and better pedestrian connections to the service.[5]

4 Bus Rapid Transit Practitioner's Guide, TCRP Report 118

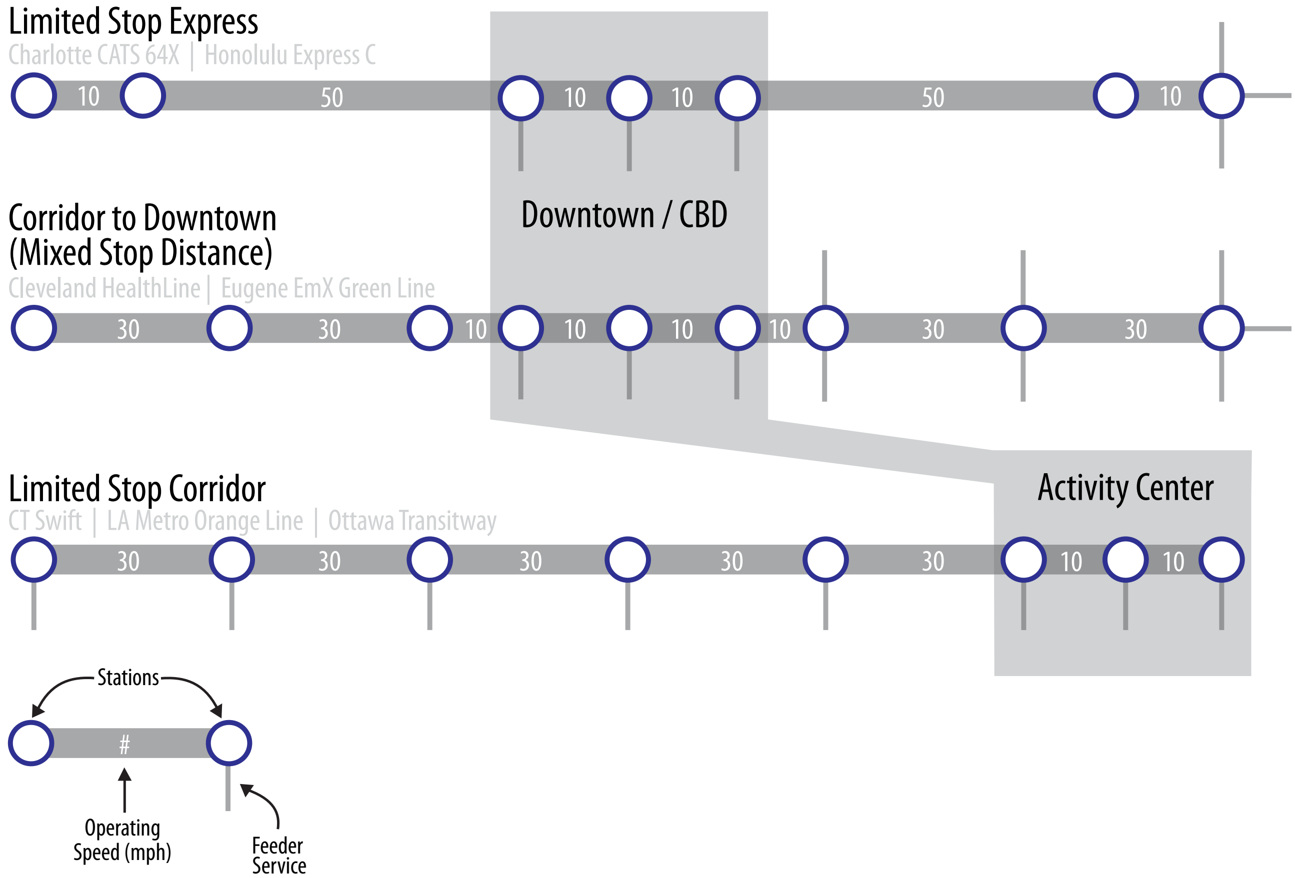
5 Bus Rapid Transit Practitioner's Guide, TCRP Report 118



Single route corridor BRT service in Snohomish County, WA

Source: Community Transit

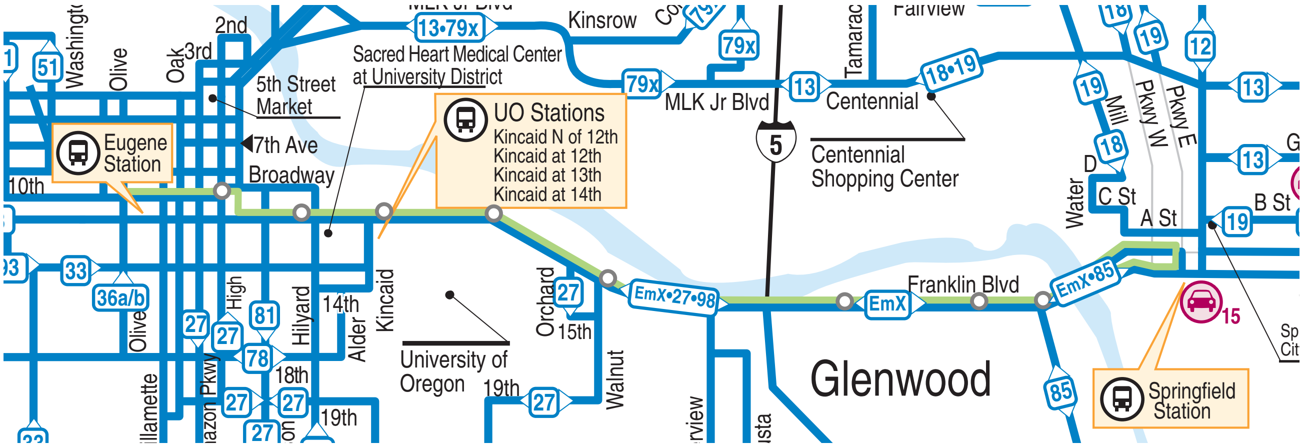
Figure 3 Station Spacing and Operating Speed



Source: Nelson\Nygaard

- Transferring – A key objective of BRT is to minimize regional travel times, including the time it takes to transfer to/from local connecting bus service. BRT service often operates with local service overlays to fill in the gaps of limited stop service. Transfer opportunities also arise with feeder buses serving into the BRT route. Service frequency and transferring must be coordinated to maximize customer satisfaction and reliability. Wait time is perceived by passengers to be threefold as burdensome relative to in-vehicle travel times.

  BRT improves the transfer experience through its relatively fixed high speeds, shorter service frequency, and longer stop spacing, as well as station amenities like real-time arrival information and system maps and schedules.



Eugene's EmX has transfer opportunities with feeder service at nearly every station.

Source: Lane Transit District

Fare Collection

Innovative fare collection tools and methods are being developed to speed up boarding procedures and minimize station dwell time. Off-board fare collection is a critical strategy used to improve travel time savings. Off-board fare collection is typically based upon the “proof-of-payment” concept where those that board are assumed to have paid the fare to ride. Ticket inspectors are used at random to enforce fare payment and penalize fare jumpers. Equally, some transit systems invest in barriers and ticket validators that only allow paying customers to pass through to the platform. The alternative is the conventional on-board payment process where drivers physically validate the fare. This creates significant dwell time, especially during peak hour travel when passenger queues are at their greatest.

In order to facilitate off-board fare collection, stations must be equipped with ticket vending machines (TVM) and ticket validators for those with prepaid tickets. Fare media may include dispensed tickets, magnetic stripe fare cards, smart card technology.

Efficient boarding processes such as: off-board fare payment (up to 38 percent reduction in boarding time); and multiple door boarding (between a one and two second savings in boarding time per passenger) can improve dwell time by several seconds per passenger.

Ticket Vending Machines (top) and Smart Card Technology with Validators (bottom) are used for “Proof-of-Payment” fare collection
Source: Nelson\Nygaard (top),
Oran Viriyincy, Creative Commons Attribution License 2.0 (bottom)

Swift BRT vehicles
Source: Community Transit

Branding and BRT Image

Eye-catching branding is an integral element of reinforcing BRT's identity as a high quality transit service and an attractive alternative to automobile travel. The most common strategy to distinguish BRT as a unique and high quality service is through a stylized vehicle design. Other common branding strategies include distinct names, logos, color schemes, typography, station signage, and marketing materials. Branding strategies like these are developed for customers to identify the BRT operation as an elevated tier above local service, in terms of quality of service.

Branding and the image of BRT are very important to customer perception. Across nearly all agencies that operate BRT, the majority of customers perceive the service as attractive or favorable, directly correlating to the service's brand and identity.

There are two broad levels of BRT branding: 1) how the system is presented to the public; and 2) what individual branding elements are used to reflect system presentation. There are a variety of branding strategies used to develop BRT's identity. Common branding elements identified in agency BRT marketing and communication plans include:

- Naming – A unique name that makes clever use of acronyms or some form of a locally significant landmark, cultural feature or even a native animal is a common feature used to identify BRT as an enhanced service. Examples include Community Transit's Swift, Lane Transit District's Emerald Express (nicknamed EmX), and Greater Cleveland RTA's HealthLine.
- Logo – A visual emblem usually in the form of an icon signifying the service's unique and advanced performance. Logo colors typically relate to a consistent color scheme seen at stations and on vehicles. Logos can also retain some connection to the agency's brand or identity. Logos are often accompanied by some form of marketing slogan that reinforces the service's speed, cleanliness, and quality.
- Color palette – Provides an additional element that distinguishes BRT from other transit modes or services. The color palette is used consistently on vehicles, station signage and marketing materials.
- Consistent typography – BRT system signage and marketing materials typically will use typography distinct from local and express bus routes. The graphic elements associated with typography such as italicizing often signal the service as faster or more exclusive than traditional service.
- Signage and station beacons – Signage and stop beacons typically follow the same color scheme and incorporate the system logo into their design. Signage and beacons must clearly transpose information and maintain a clean look.
- Marketing materials – Information dissemination is often the first media that influences consumer choice. Marketing materials utilize most aspects of the BRT brand including logos, slogans, colors, and clean / legible maps. Examples of where the BRT brand and aesthetic are employed include website design, information kiosks and publications, as well as route timetables and maps.

EmX Green Line BRT vehicles

Source: Lane Transit District

Separate from the branding effort, physical BRT design contributes to the mode's identity. BRT features including enhanced pedestrian access, pre-paid fare collection and TVM, ITS features, vehicle aesthetic (actual vehicle design, not the color palette), and station design all contribute toward a real and perceived improvement in consumer convenience, reliability, and fast service. Integrating all the identity and branding components discussed above with the features of BRT is a critical step for capturing greater ridership potential. Better integration will not only attract riders by improving transit's image, but the enhanced service quality and passenger amenities will retain the new ridership.

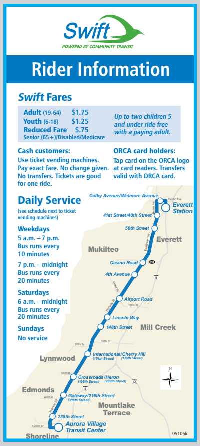
Figure 4 displays the range of branding strategies used by Community Transit's Swift BRT service in Snohomish County Washington.

Figure 4 Example of Coordinated Branding Features

Attractive vehicle styling improves the vehicle customer interface

Clear signage and station beacons with consistent color scheme

BRT stations and vehicles integrate branding elements



Logo, color palette, and clever naming develop BRT's identity

Consistent typography and font color distinguish BRT's service from other transit services

Clean graphics and readible conceptual route maps on marketing materials increase customer convenience

Image Sources: Community Transit

Summary of BRT Characteristics and Performance

Each of the BRT elements described in the sections above yields direct positive performance in the areas of travel time improvements, ridership, reliability, person capacity, image and safety/security. Perhaps the most effective elements of BRT operation that improves performance are service frequency and running the service along a separated busway or dedicated transit only lane. Figure 5 summarizes many of the elements of BRT and indicates how each element affects system performance according to various performance characteristics.

Figure 5 Elements of BRT and their Effect on System Performance

	BRT Performance Characteristics					
BRT Element	Travel Time	Ridership	Reliability	Capacity	Image / Identity	Safety
Running Way						
Mixed Flow Lanes						
Queue Jump Lanes	++	+	++	+	+	+
Exclusive Transit Lanes	+++	+++	+++	+++	+++	++
Station Design/Access	+	++		++	++	
Service/Operating Characteristics						
Service Frequency	+	+++	+++	++	+++	
Stop Spacing	+++	+	+			
Vehicle Options/Technology*	+	++		+++	+++	+
Intelligent Transportation Systems	+++	+	++	++	++	++
Off-Board Fare Collection	++		++			
Branding		+			+++	

Source: FTA Characteristics of Bus Rapid Transit for Decision-Making (2009); TCRP Report 118 (2007)
+++ = High effect relative to local bus service
++ = Moderate effect relative to local bus service
+ = Slight effect relative to local bus service
*Includes exterior and interior design, as well as propulsion

Cost to Implement and Operate BRT

Operational Costs

For any transit mode, operating cost is determined by the number of hours and miles operated, and by the cost for a unit (usually an hour) of operation. On any fixed distance line, the level of service (headway) and achievable operating speed are the direct influences on operating cost. The cost per hour is unique to the operator providing the service and reflects prevailing wage rates, current fuel/energy costs, and maintenance needs.

Urban transit operating funds in the United States are generated almost exclusively locally, and are typically the greatest funding challenge for any operating agency. Consequently, strategies for keeping operating cost low are critically important. Policy makers should be aware that:

- Transit delay is costly. Rapid Bus needs more service hours and funding to maintain service levels than those with exclusive right-of-way (Full BRT). Right-of-way treatments including exclusive running ways and signal priority treatments can be critical in protecting public investment in BRT service.
- Operator pay and benefits is the largest element of transit operating cost. Given demand exists for the service, higher capacity vehicles/modes are more cost effective because fewer operators are needed to service the same number of people. Nationally, wages and benefits account for two-thirds of all operating costs. That being said, additional costs must be considered such as non-revenue travel and layover requirements (these are paid operator times when the vehicle is not producing service revenue). Hired fare inspectors are additional operating costs needed for "proof-of-payment" fare collection systems.

Figure 6 Sample BRT Operating Cost Measures

System	Operating Cost per Hour	Operating Cost Per Mile
Pittsburgh, West Busway	$81.90	$6.40
MBTA Silver Line, Washington Blvd.	$109	$17
LA Metro Orange Line (2007)	$243.18	$14.53
LA Metro Rapid	$117.12	$9.57

Source: FTA (2009); Vincent and Callaghan (2007); Niles and Jerram (2010)

- Fuel and energy cost is the other major driver of operating costs. Material and supply costs, including fuel, typically constitute 10 to 15 percent of operating costs. Shifting away from diesel-operated vehicles toward hybrid-electric vehicles can prove far more cost effective, while alternative fuel use can generate a higher per vehicle mile cost.

Figure 6 below compares operating costs measures for BRT lines that operate on different running ways. Pittsburgh's West Busway operates on an off-street and grade separated right-of-way, while Boston's Silver Line runs operates in mixed traffic for portions of line and as well as in several miles of transit only lanes.

Capital Costs

Like all transit services there is some level of capital investment required to implement Bus Rapid Transit along a corridor. The level of infrastructure needed for BRT depends on the intended service goals, but BRT's capital requirements are generally higher than local fixed route service, yet less than rail-based modes like streetcar and light rail transit. Below is a list of major capital cost compo¬nents as part of BRT service:

- Right-of-Way and Running Way. Most BRT routes operate in existing right-of-way and often in mixed flow traffic. However, some BRT systems have acquired right-of-way exclusively for that service or developed infrastructure for dedicated or separated running ways. Depending on the area, right-of-way acquisition costs can be a major capital cost element.
- Vehicle Costs. The cost of vehicles is considered a major capital cost, especially for rapid transit modes. The cost of BRT vehicles varies significantly but ranges from about $500,000 for a stylized, standard-length vehicle to $1,000,000 or more for a stylized, articulated vehicle. The number of vehicles required is based on the operating characteristics of the service—most notably frequencies, route length, and service span. Spare vehicles are also necessary in case of breakdowns or during peak periods where operating capacity is reached.
- Infrastructure Improvements. This includes improvements to bridges, underground or at-grade utilities or other improvements that are required to operate a transit service. This element is typically required for rail modes only, however higher quality BRT service may require grade or curb separation and restructuring of stormwater facilities like gutters and culverts in more rural areas to accommodate stations or running ways.
- Stations. BRT stations typically require a higher level of investment than traditional bus stops in order to present itself as a high quality service. Station facilities may include elements such as signage, benches, information kiosks, shelters, off-board fare collection systems, and pedestrian access features like level boarding facilities, curb extensions, sidewalks, wheelchair ramps, pedestrian guard rails.
- System Elements and ITS. In the case of BRT, this cost element can include any ITS feature such as automatic passenger counters, automatic vehicle location with GPS, and transit priority systems and signal re-phasing.
- Professional Service. This cost element can be as much as 30% of total capital costs, especially for rail modes. Services such as preliminary engineering, final design, project management, insurance and permitting should be estimated.
- Unallocated Contingency. Another 30% of total capital costs are usually reserved for a contingency in the case of unexpected costs.
- Maintenance Base and Storage Requirements. As is typical with rubber-tire modes, BRT does not require a special maintenance facility and can utilize the operator's existing facility. It should be noted that buses typically require non-revenue routes to reach a maintenance facility. Therefore, existing maintenance sites should be located as close as possible to the revenue route or it may be useful to construct a new storage and maintenance facility to cut down on operating costs.

Figure 7 provides high-level cost ranges for the key BRT elements, which can vary significantly between implementations depending on specific agency goals.

Figure 7 Estimated Capital Costs

		Capital Cost Range	
Cost Element	**Unit**	**Low**	**High**
Running Way*	Per lane mile	$0 (Mixed Traffic)	$10 million (At-Grade Separated)
Stations	Per station	$15,000 (Simple Shelter)	$2,000,000 (Enclosed Station)
Vehicles	Per vehicle	$500,000 (Stylized, Standard-Length)	$1,000,000 (Stylized, Articulated)

*Source: Federal Transit Administration (2009); NBRTI (2006). Note: * Does not include ROW acquisition costs*

WHAT ARE CONDITIONS FOR SUCCESSFUL BRT PROJECTS?

Although there is no definitive standard characterizing the perimeters for BRT implementation and performance, there are several conditions that drive successful BRT projects around the world. The following sections provide detail on four common conditions of implementing and operating a thriving BRT corridor.

Condition #1: Transit-Land Use Connection

A mutually supportive relationship exists between land use, transit service quality, and transit accessibility and is an essential condition for providing a ridership base for BRT systems and a means for BRT to foster further development at station sites. This relationship is critical for a community to maximize mobility, economic, social and environmental benefits from investment in BRT. The relationship is summarized in Figure 8 below and can be described as follows:

As density increases, more potential riders are given access to transit. Assuming streets and stops are designed to invite passengers, increased density will drive ridership higher. As the level of transit patronage increases in a corridor, transit providers will look to offer more frequent service, and to improve the speed and reliability of service for passengers. High quality, permanent transit service makes an area more attractive to residents, signaling to developers that the market is good for dense housing. This relationship builds over time as long as transit is able to respond to growing demand.

A more detailed discussion of each of these elements follows.

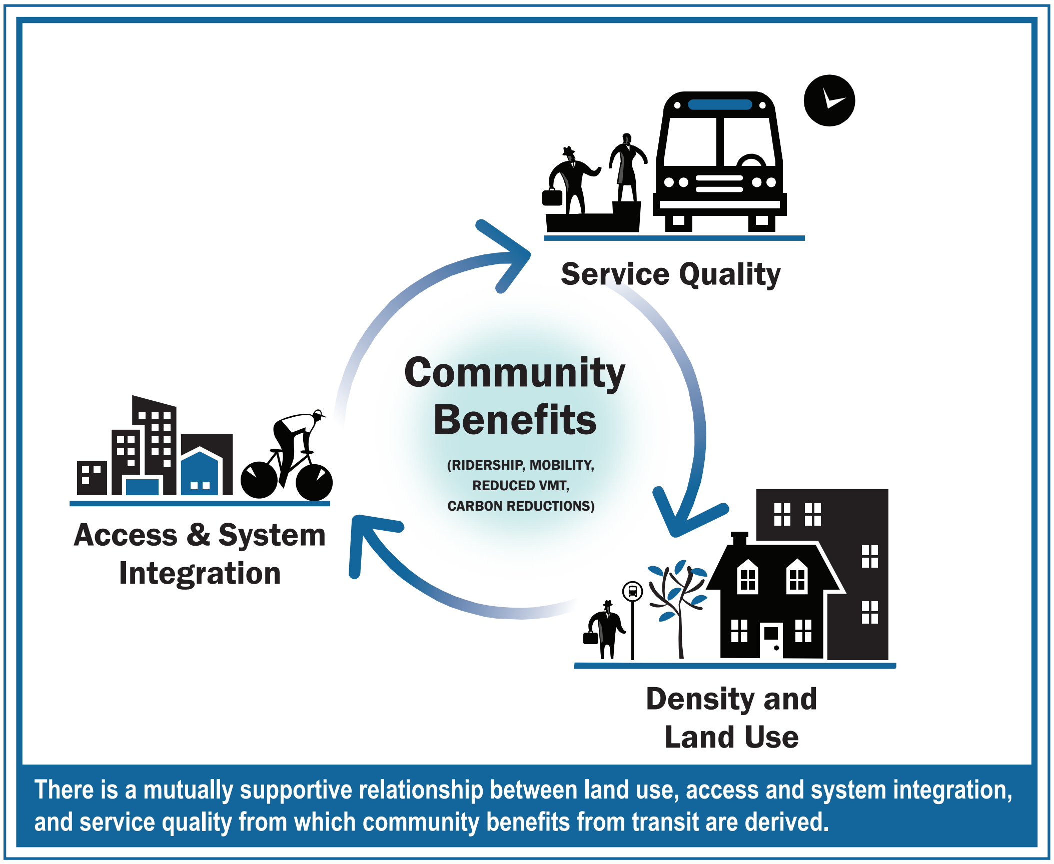
Density and Land Use

Density and land use are perhaps the most critical features in building transit ridership and realizing transit's full benefits. This is certainly true regarding bus rapid transit as it is a higher capacity transit mode that requires an accessible transit market for high quality regional service. More than any other two factors, high density living and land use designed to encourage transit use will ultimately lead to a lifestyle where transit is the most convenient mode available.

Impacts of Intense Development

Based on a detailed regression analysis conducted in the Portland region, population and employment density was shown to predict 80% of transit demand in an area. In other words, where density and jobs are high, so too will be the demand for transit service. Higher density also reduces per capita vehicle miles of driving, which in turn can satisfy multiple policy goals such as greenhouse gas reductions, increased options for healthy living, improved roadway operations and reduced capital construc-

Figure 8 Community Benefits of Rapid Transit



KEY INGREDIENTS FOR SUCCESSFUL STATION AREAS

In order to create vibrant transit-oriented communities, local jurisdictions must reflect several land use, design and mobility related considerations in local planning processes prior to the development of Bus Rapid Transit in the Randall Road corridor. Key ingredients for successful station area development include:

Density—Modest increases in residential and employment density at station areas can reduce automobile use and expand BRT's ridership base. Density increases also create an embedded retail market with the ability to attract local and national retailers because of the availability of a constant customer base. Higher densities also reduce the need to provide costly parking especially at station areas.

Land Use Diversity—In order to promote vibrant communities with easy access to transit, stations must provide retail options that are located within walking distance from jobs and residences. A supplementary benefit from mixed land uses is the ability for residents and visitors to link errands into one trip within a walkable distance of their home or BRT station. Included within this ingredient is diversity in housing types. Station areas should not look solely at increasing density, but integrating a variety of housing types to create vibrant neighborhoods.

Multimodal Access and Intermodal Connections—Offering safe and convenient pedestrian and bicycle connections throughout station areas is critical to support non-motorized internal circulation and promote access to transit. Circuitous bicycle and pedestrian networks should be avoided and existing gaps in the bike/ped networks should be addressed. Park and ride lots also play an important role in intermodal travel; however park and ride access should be focused only at key stations where access to connective transit service is limited. Feeder service goals should seek efficient, timed transfers and offer service to destinations that link to the limited number of BRT stations.

Urban Design and Placemaking Features—Station areas should merge meeting mobility needs with providing a sense of place. Station areas can be transformed into livable communities by integrating public space, active retail frontages, and pedestrian amenities such as benches, shade trees, pedestrian scaled lighting, café seating, public art and landscaping. Internal streets should include traffic calming features to reduce vehicle speeds and manage vehicular volumes. In order to implement these design features, local jurisdictions will need to develop urban design guidelines for station areas.

This Fruitvale, CA station development (left) merges density, mixed land uses and walkability. Dense single-family residential housing (right) is located across from the rail station providing a variety of housing types.

Source: Nelson\Nygaard

tion and preservation costs. Figure 9 below shows the impact residential density has had on annual VMT per household in the San Francisco, Los Angeles and Chicago metropolitan areas. To achieve the dramatic drop in per capita vehicle miles traveled (VMT) that occurs as urban neighborhoods transition from 8 to 40 households per acre, high quality transit service (defined below) and quality pedestrian access must be in place for these benefits to be realized.

In fact, recent empirical research confirms that clustering development around high capacity transit station areas reduces vehicle trip generation, increases the propensity for transit use, and reduces the parking requirements of traditional development patterns.[1] Increased transit use is observed in both highly urban and medium to low density suburban station areas.

In addition to mixing retail and employment uses, a diversity of housing types will increase the demand for transit. Residential densities in most neighborhoods surrounding the Randall Road corridor sit at or near the vertical axis on this graphic, meaning moderate increases in density could lead to significant changes in travel behavior.

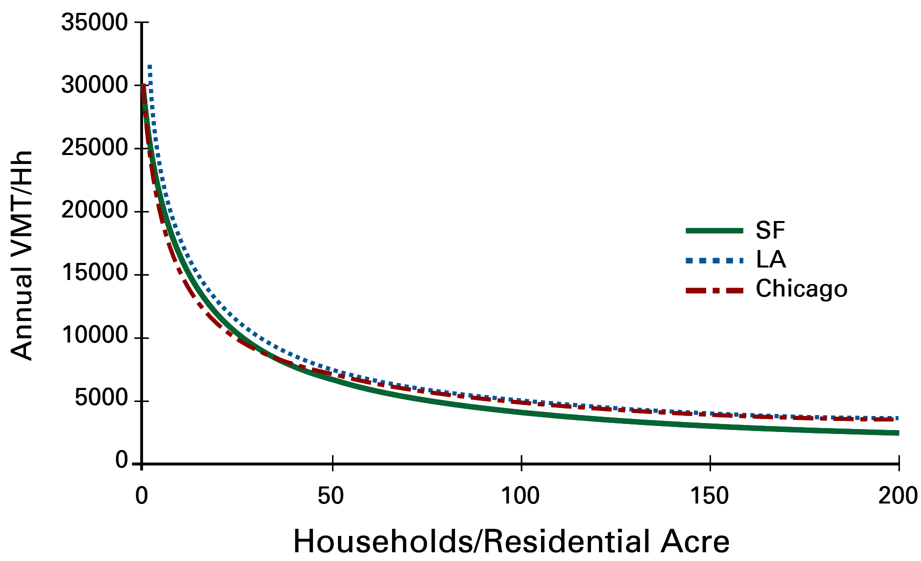
1 Cervero and Arrington (2008)

Nearly every study of transit ridership has provided evidence that density is the primary determinant of transit ridership. Noted transportation researcher Robert Cervero and others conclude that in rough terms, a 10 percent increase in population and employment densities yields anywhere between a 5 and 8 percent increase in transit ridership, controlling for other factors (such as lower incomes, restricted parking, and better transit services generally associated with more compact settings). As evident in Figure 10, transit supportive land use combined with quality transit service, decreases automobile usage and VMT, while increasing transit mode share.

Density Targets

Figure 11 below, which is based on a synthesis of national research and practical experience, illustrates average household and employment density targets along corridors for several transit modes. It is worth noting that there are successful transit services that operate in corridors with lower density land uses than indicated in the graphic; however, those cases typically have excellent pedestrian access, frequent service and high quality passenger amenities.

Figure 9 Vehicle Miles Traveled vs. Residential Density



Source: Holtzclaw, J. Et Al (2002) Location Efficiency: Neighborhood and Socioeconomic Characteristics Determine Auto Ownership and Use - Studies in Chicago and San Francisco. Transportation Planning and Technology, Vol. 25.

Figure 10 Mode Share by Transit and Land Use Characteristics, Multnomah County, OR

	Mode Share						
Land Use Type	Auto	Walk	Transit	Bike	Other	VMT per Capita	Auto Owner-ship per House-hold
Good transit / Mixed use	58.1%	27.0%	11.5%	1.9%	1.5%	9.8	0.93
Good transit only	74.4%	15.2%	7.9%	1.4%	1.1%	13.28	1.5
Remainder of county	81.5%	9.7%	3.5%	1.6%	3.7%	17.34	1.74
Remainder of region	87.3%	6.1%	1.2%	0.8%	4.6%	21.79	1.93

Note: The base example for good transit and mixed use is Multnomah Village, a small community within Portland, OR.
Other modes include vanpool and carpool

Source: Reconnecting America (2009)

Figure 11 Minimum Target Corridor Densities for Transit Modes

Note: Figures represent average corridor densities; station area housing units and employment densities should be higher to support a vibrant, transit-oriented neighborhood.

It is also important to note that a mixture of household and employment density is another important component of a frequent bus rapid transit line. Planned population and employment density at BRT station areas could make up for a lack of total density along a corridor, depending on the level of development envisioned. This depends on the whether the service is envisioned as a regional high capacity service that connects activity centers, or if it is intended to stimulate development at strategic station areas. For reference, current density hot spots along the Randall Road corridor currently range between 10 and 25 persons per acre and 1 and 75 jobs per acre. Assuming that BRT will organize development at nodes where access to BRT is at its greatest, the Randall Road corridor will need to increase densities in order to support a frequent BRT service. Most importantly, corridor communities will need to focus residential, commercial, and office growth in a relatively small number of nodal centers with a mix of land uses and organized to support internal walking and walk access to station areas.

Station Area Anchors and Access to Regional Destinations

Access to regional destinations is another important land use-oriented condition found in successful BRT corridors. The mix and intensity of trip generators is positively correlated with greater transit use and decreased vehicle miles traveled along a corridor. The major questions that need to be answered before BRT operation is implemented include:

- What travel markets is the transit route connecting?
- What are the key anchors?
- Are there convenient connections (feeder service, pedestrian, bicycle) between the BRT service and corridor activity centers / anchors?

Ensuring reasonable connections to regional destinations is a key determinant in inducing mode shift and ridership increases. If regional destinations are difficult to access via BRT relative to automobile travel, mode choice will likely skew towards the automobile. Similarly, BRT has proven to stimulate land development around station areas. BRT's impact on corridor growth requires strategic land use planning to concentrate development and ensure relative land use mixing in order to support destination accessibility. The presence of strong anchors or employment activity centers in walkable proximity to BRT termini or station areas provides significant incentive to use the service. Typical anchors seen in BRT projects include shopping and employment centers, park and ride lots, hospitals, central business districts, and other employment centers.

Corridors and Development Patterns

Not all transportation corridors develop equally. Corridors can develop vastly different urban or suburban forms. Some corridors are supplemented by continuous urban development providing a consistent ridership pool along its path. Other suburban corridors are densely packed with commercial development throughout, yet concentrate residential land uses at strategic nodes. And still, some rural corridors take a more nodal form where activity centers or concentrated development is separated by miles of rural land uses. The type of corridor that BRT runs along will greatly impact service goals and characteristics, ridership potential, modes of access to station areas, and station area amenities (i.e. park and ride access).

Figure 12 illustrates how BRT organizes development along a corridor compared to other modes. Whereas local bus service benefits residents and businesses located roughly one-quarter mile from many bus stops, BRT benefits development up to one-half mile from fewer station locations.

Figure 12 How Modes Impact Development

STATION TYPOLOGIES

Station area development is always unique and never follows a prefabricated mold. The key ingredients for successful station area development detailed above can be applied in various intensities and levels of investment. Figure 13 provides a comparative framework for different station types and their typical land use, function, levels of connectivity and transit characteristics and connections. Future stations along the Randall Road corridor should provide a variety of functions ranging from the vibrant, self-sustaining community to the institutional destination.

Figure 13 Station Typologies

Station Typology	Station Area Description
Core	• CBD-like land uses and development patterns • Able to sustain job and housing growth • Well-connected multimodal street grid and inviting pedestrian environment • High transit connectivity, including at least two HCT modes
Mixed Use Employment Center	• Adequate mix of zoning capacity to support vibrant mixed use • Provides a regional employment base or draw, typically function as a distinct residential or employment district • Bicycle and pedestrian friendly streetscape • At least 2 modes of 18 – 24 hour transit service
Mixed Use Residential Village	• Some but not all have zoning capacity necessary to achieve social and environmental goals • Smaller centers within the urban area, and no regional draws • Some but not all have high street connectivity • Secondary modes of frequent, high quality transit service are not readily available and residents of the village station area make up the ridership base
Commuter	• Lack of zoning capacity, street connectivity or civic amenities • Peripheral station areas; often serve as transit line terminus or stop along the corridor • Often placed along freeway corridors or areas that make residential development difficult or unattractive • Park and rides are the key multimodal facility and feeder service is the key connective service into HCT
Destination	• Refers to an attraction that creates a large, single user base (such as hospitals, universities, large employment campuses) • Large variance in physical character and performance (density and zoning capacity) • Street connectivity varies by the type of attraction • Transit service varies by use (i.e. universities often exhibit bell service, while employment campuses have frequent peak hour transit service)

In order to better visualize what station typologies look like in practice, it is important to identify what functions can apply to each station type. Different intensities of commercial retail, employment and entertainment districts, housing, and institutional uses can be more applicable in certain station types than others. Figure 14 identifies which functions and their varying levels of intensity are more conducive to each station area type. It should be noted that this matrix takes a general view of districts and their functions. This is not to say that one use will not entirely work within a station area type.

Continued on next page

STATION TYPOLOGIES (continued)

Figure 14 Station Typologies and their Functional Application

Function	Commercial		Entertainment		Residential		Employment Centers	Hospital (Emp. subset)	Institutional
Intensity ▶ Typology ▼	Large Scale	Small Scale	Attraction (i.e. Larger retailers, theaters, etc.)	Cafes / Coffee Shops	Traditional Neighbor-hood Devel-opment	Compact Develop-ment (condos, townhouses)	Intensity (Campus, Clusters, Minimal)	Intensity	Gov't Offices, Post Office, Schools
Core	XX	XX	XX	XX	-	XX	Job Cluster	XX	XX
Mixed Use Employment Center	XX	XX	X	XX	X	XX	Job Cluster	X	XX
Mixed Use Residential Village	-	XX	-	XX	XX	XX	Local Retail/Office Cluster	-	X*
Commuter	X	X	X	-	-	-	Minimal	XX	-
Destination**	X	-	XX	X	-	-	Campus	XX	XX

++ = Highly applicable to typology

\+ = Moderate applicable to typology

\- = Not applicable to typology

* Village station types are highly conducive to small scale school development.

** Due to the primary use nature of the Destination station types, there is usually only one highly applicable function type.

Service Quality

Service Quality

Quality transit service on BRT not only attracts new riders and keeps people riding, but enhances the ability to impact density and land use and justifies the need to improve access to transit service. Choice riders, those with mode options, need to perceive transit as convenient, reliable, safe, and enjoyable mode of transportation and BRT is capable of meeting all these attributes. Many of the previously discussed BRT characteristics result in high levels of service quality including:

- High frequency of service to minimize wait times
- Roadway improvements to improve transit speed and reliability
- High-capacity vehicles to meet peak demands
- High-amenity vehicles and stations to enhance the overall “transit experience”

Access and System Integration

Access & System Integration

No matter how frequent, comfortable, and well-planned transit service is, passenger experience and ridership will suffer if it is difficult, time-consuming or uncomfortable to get to and from stations. Safe and direct access to station areas by pedestrians and cyclists is a key component to ensure high quality service, offers additional convenience for those with longer commutes. Ultimately, jurisdictions’ decisions to support different modes of access also determine the success of common goals such as easing traffic congestion, reducing emissions, and catalyzing land development in a corridor or station area.

A successful BRT system must allow people to travel where they want, when they want, with assurance that they won’t be met with unreasonable delays or breaks in service. This necessitates an approach in which access and system integration with BRT service is paramount along the Randall Road corridor. In other words, if investment in BRT threatens transit access or system integration, its overall value should be considered carefully. Pedestrian and bicycle access will be discussed in further detail in a later section (Condition #3).

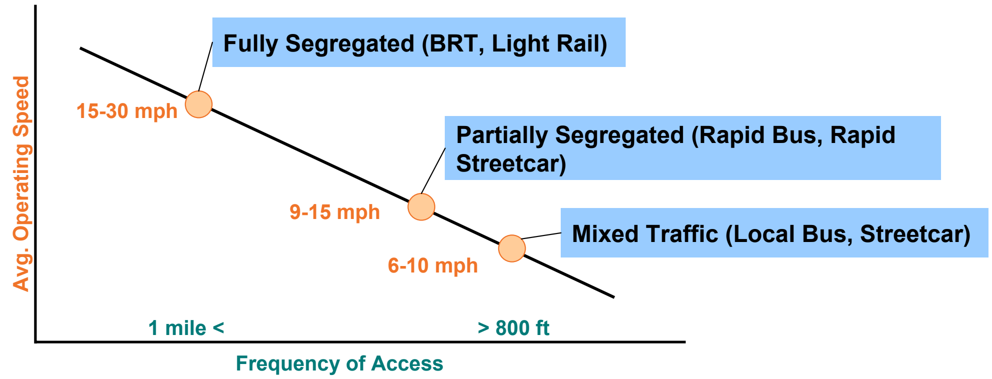
Integration with Supporting Transit Networks

Any successful BRT line must integrate with the local and regional transit networks, providing customers seamless connections and a standardized experience. For optimal connectivity, any new transit delivery mode should:

- Provide direct service to major transit hubs whenever possible. Most transit services converge at a few key transit hubs around Kane County and any BRT line would be more effective by serving one or more of these hubs. One major transit and employment hub is located at the Big Timber Metra Station, less than half-mile from the Randall Road corridor.
- Maximize the ease of transferring. Transfer distance and route clarity are important. If a customer is forced to walk more than a block or two to transfer between services, or if clear wayfinding does not exist, the extra time and inconvenience spent transferring to or from the BRT service could be enough to prevent them from using transit to make the trip altogether.
- Integrate wayfinding and information. Clear wayfinding improves system legibility by guiding riders between transit systems and points out nearby attractions and services, enhancing and simplifying the overall user experience.

Transit wayfinding enhances and simplifies the transit experience.
Source: Nelson\Nygaard

Figure 15 Average Speeds Relative to Stop Spacing



This diagram is conceptual; average travel speeds are based on peer systems operating in North America.

Access versus Transit Speed and Reliability

Transit speed and reliability must be balanced with access. As Figure 15 demonstrates, there is a direct tradeoff between service access and operating speed, since lines that stop less have less delay. Local transit routes that stop as often as one to two blocks provide excellent access but slow service. In a well connected neighborhood, switching from two to three block stop spacing has limited impact on walk or bike distances to transit, but can significantly improve transit speeds. Service design should seek the sweet spot between service speed and access, or the maximum distance that passengers will comfortably walk to access BRT. In general, passengers will tolerate a longer walk or bike distance for BRT or rail service compared to local bus, but this ultimately relates more to the frequency and reliability of many rapid transit modes than the vehicle itself.

Condition #2: Branding and Marketability

As previously mentioned, branding is common strategy used in BRT systems around the world as a tactic for reinforcing BRT as a "premium" transit service. The success of BRT (measured here in terms of ridership and resulting farebox revenue) is positively associated with a consumers' reaction or preference toward BRT's identity over other modes. Marketing BRT as a distinguished high quality transit service is a key strategy of attracting ridership and improving the outlook towards transit performance and service quality. A positive product identity is one that reinforces immediate attraction, distinction as a marquee transit mode, and easily distinguishable route and station design.

Branding generates a buzz around a BRT system by treating the system as a high-end product is a coordinated approach involving multiple design and marketing elements. An enhanced image for a new service may be lost on the public if the vehicles still look like traditional bus and stations are indistinguishable from the surrounding development or look like unfriendly bus stops. The branding should also incorporate a theme relative to the BRT system's strengths (such as speed) and/or some local attraction or icon. The branding and marking plan can also coordinate with local priorities such as healthy living or sustainability initiatives.

Condition #3: Multimodal Connectivity around Stations

Almost all transit trips start and end with a walk or bicycle trip. The importance of excellent access to transit cannot be overstated. Typically, streetcar and local bus service provides easy access since they have frequent on-street stops; these services rely on the existing pedestrian environment to ensure good access to transit. However, since Bus Rapid Transit limits the number of stations, stops and stations can only be as effective as the streets and sidewalks that lead to them. Thus, BRT typically concentrates greater investment in access to fewer stations and rely on feeder transit service. Below summarizes the three key components of enhancing access to Bus Rapid Transit. Figure 16 displays how access levels affect corridor development.

Pedestrian Connectivity

Research clearly identifies connectivity, route directness, and availability of pedestrian facilities as factors that influence trip choice.[1,2,3] Pedestrians are generally willing to walk 10 minutes, or ½ mile, to access transit and other basic services such as retail and health care. Sidewalk completeness, average block size, and intersection density are three indicators influence the ability and willingness of people to walk to transit.

Sidewalk coverage refers to the percent of streets within a ½-mile of a station that has sidewalks on both sides of the street. An acceptable target for sidewalk coverage is 67%. Average block size, or the average area a block takes up, directly influences how "permeable" a station area is and the number of routes a pedestrian can take to access transit. Typically, 4 acres or less is an optimal average block size to facilitate pedestrian movement. Intersection density per acre (typically quantified as the number of 4-way intersections per acre) indicates the density of connections for an area and relates to route directness. Suburban road networks consisting of a large number of street ends (i.e. cul-de-sacs) greatly reduce the convenience to walking and bicycling to destinations by increasing travel distances. This should be avoided in station areas.

Bicycle Access

Transit operators everywhere are realizing that transit and bicycles are highly compatible, and facilitating bicycle access to transit facilities can increase transit's market considerably. Providing direct, safe routes to stations with dedicated bike lanes and allowing for bikes to be carried on BRT vehicles is very important, particularly for routes that carry longer distance trips and collect from lower density neighborhoods. While all modes can be designed to accommodate bikes, BRT systems typically do not use exterior racks due to time delays and have less interior space than rail cars. One exception to this rule is the new on-board bicycle rack used in Community Transit's (Snohomish County, WA) Swift BRT service. Bike storage at stations and innovative seating configuration aboard BRT vehicles that accommodate greater bicycle storage can mitigate any transit-bicycle capacity issues and promote multimodal corridor travel.

Secure bicycle storage at BRT stations is a critical amenity that goes hand-in-hand with bicycle access.
Source: Nelson\Nygaard

Transfers

Providing efficient timed transfers is a critical component of BRT access. Ideally, customers traveling to BRT stations via local feeder service should only have to wait 7.5 minutes before transferring to the BRT route.[4] Transfer wait time is considered roughly two times the relative importance that actual in-vehicle travel time. Thus, BRT's reputation as a reliable and high quality transit service must be extended to its feeder routes through route design and schedule coordination. This is especially important if "schedule-free" travel is being sought for the Randall Road corridor. In addition, by allowing local routes to access transit only lanes used for the BRT running way, Pace could provide single-seat rides that do not require transfers.

1 Dill (2004)

2 Moudon et al. (1997)

3 Frank et al. (2005)

4 7 – 7.5 minutes is considered the threshold at which transfer wait time becomes punitive (TCRP 95—Ch. 10).

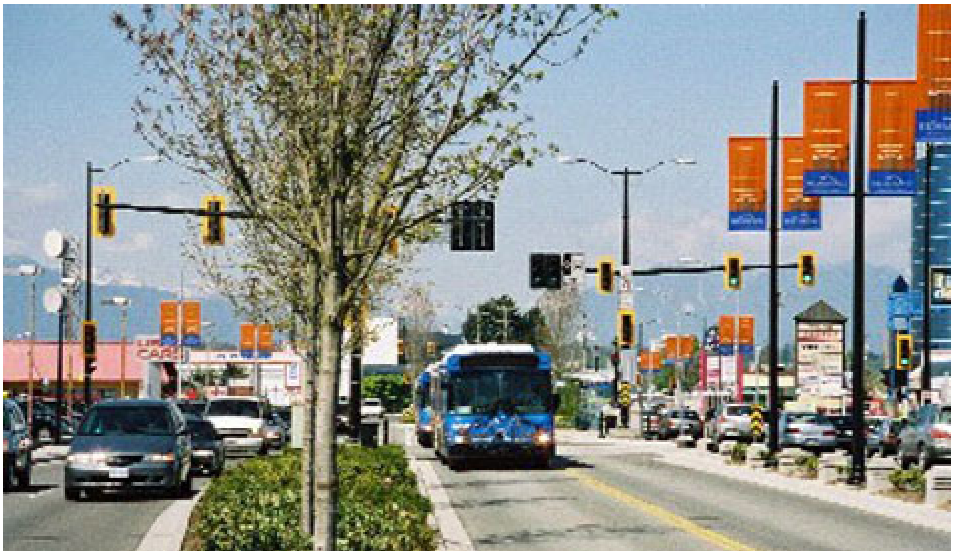
Figure 16 Varying Levels of Multimodal Access

Access Type	Typical Distance	Characteristics	Best	High	Medium	Low
Pedestrian Access	0.25 – 0.5 miles	Continuous sidewalks, pedestrian cut-throughs, barrier free, crosswalks, low vehicular speeds, appropriate scale and aesthetics.	Complete pedestrian system and aesthetics	Good system; some factors need improvement	Some factors present	Poor pedestrian system, walking is a challenge
Bicycle Access	0.5 to 5 miles	Local bicycle access facilities and trail connections, street crossings. Wide shoulders, continuous bike lanes, direct routing, gentle grades, low auto speeds, bicycle racks and lockers	Complete bicycle system; good connectivity with all factors present	Good system but some elements needing improvement	Some factors present; limited connectivity; usable	Poor system; bicycling is a challenge and/or unsafe
Transit Access	1 mile or more	Feeder service to stations from local routes or park-and-ride facilities, connections to Fox Valley downtowns, timed transfers, system clarity through wayfinding signage and passenger information	Seamless transfers with all factors present	Good system; some factors need improvement	Some factors present; many are deficient	Access into BRT stations is poor; significant wait times for transfers

Condition #4: BRT Must Compete with Automobile Travel

Travel time is the single most important factor in encouraging choice ridership. If transit service is slow, customers will opt to drive to make their trip (if they have the means, that is). Higher operating speeds, reduced station dwell time, and minimal passenger wait times gives the sense that BRT service is "on-demand" and can compete with automobile travel. BRT marketing should also promote relative time savings if BRT access eliminates the need to hunt for parking or park in off-site lots.

The out-of-pocket costs for BRT travel should be less than those for automobile travel where possible. This may be easier when the cost of fuel is high. Urban areas can include the cost of parking into the equation, but free parking in suburban markets does not make this possible. Employer or development subsidized BRT fares can also help automobile travel seen less attractive.



Separated running ways compete with automobiles and can bypass peak hour congestion.

Source: NBRTI

WHY FOCUS ON BRT AND HOW DOES IT COMPARE TO OTHER MODES?

The working premise of this study is that the quality and flexibility aspects of BRT make it the appropriate mode to meet the County's goals given the challenges of transforming the Randall/Orchard corridor to make it possible to provide a high quality transit service for the use of County residents, employees, and visitors.

Today, fixed-route transit service in Kane County today is primarily provided by Metra Commuter Rail and Pace buses. Augmenting these services, the Federal Transit Administration defines bus rapid transit as a "rapid mode of transportation that can provide the quality of rail transit and the flexibility of buses." The table below summarizes the advantages of BRT in comparison to both rail and traditional bus service.

This section places BRT in the context of other common transit modes. Figure 17 identifies the three modes that will be discussed in this section: fixed-route local bus, BRT, streetcar, and light rail. Three other high capacity transit modes are not considered, commuter rail (e.g., Metra) because the corridor lacks existing rail infrastructure, rapid or heavy rail (e.g., CTA trains) because of the high cost and density requirements and streetcar because of the length of the corridor and unlikelihood for high-density development along most of the corridor (as opposed to at specific nodal developments). Neither of these modes would integrate easily with the land use environment along Randall Road and thereby help achieve the land use goals for the corridor.

Compared to rail, BRT:

- Is a more cost-effective means of improving transit service and performance
- Can be built in stages, with shorter planning and construction time frames
- Can be structured to provide feeder service from lower density areas

Compared to traditional bus, BRT:

- Can provide a higher quality transit experience competitive with the automobile
- Can enhance the image of bus transit
- Provides potential for redevelopment

Figure 17 Comparison of Transit Modes

Rubber-Tire	Fixed-Route Bus. Fixed-route local bus service is the most widely used form of transit in the United States and the most flexible. Buses typically operate on regular streets with other traffic. Local buses can provide short distance travel between neighborhoods, circulation functions, or feed passengers into a larger rapid transit system (e.g. Metra). Frequent service implies buses arriving at least every 15 minutes. Express buses may provide longer distance travel with limited stops and may utilize high-occupancy vehicle (HOV) lanes. Frequent/express bus features begin to blend into BRT.
	Bus Rapid Transit. BRT is an operating concept used to make bus transit more like fixed rail service through the use of different technologies, running ways, and operating strategies. The term is flexible and can describe many different types of operations. Rapid Bus utilizes some BRT elements but is more similar to frequent local bus service. The "Rapid" in BRT is perhaps its most critical distinction with local bus service and is achieved using priority traffic treatments, limited stops, and/or prepaid boarding. "Full" BRT has many of the features of rail transit, such as dedicated running ways, prepaid boarding, and multiple vehicle doorways.
Rail	Light Rail. Light rail is a medium-performance transit mode, between streetcar and bus service and rapid (heavy) rail transit or commuter rail. It is a very flexible mode of transit and thus is hard to define. Light rail operating with at-grade intersection crossings is similar to a mixed flow streetcar, while light rail operating in fully exclusive, grade-separated right-of-way is very similar to rapid transit.

Photo Sources: Nelson\Nygaard (top), Oran Viriyincy, Creative Commons Attribution License 2.0 (middle), Nelson\Nygaard (bottom)

The table below summarizes the advantages of BRT in relation to rail and bus transit modes. These benefits will be discussed in detail in this section of the report.

Figure 18 BRT in Relation to Rail and Other Bus Modes

Advantages in Common with Light Rail Transit	Advantages in Common with Standard Bus Mode
• Increased ridership. Rail modes generally attract at least 15-50% more riders than bus routes operating in the same area. In Toronto, where streetcar service replaced a nearly identical bus service, ridership increased between 15-25%. BRT utilizes common elements of rail systems to realize comparable ridership benefits. • Visibility and easily understood routing. Rail systems in general provide a physical presence on the street that is easy to comprehend. Riders can stand at a stop and literally see where the line comes from and where it is going. Visitors and occasional users in particular are more inclined to use them than local bus routes, which are more likely to deviate from a straight path. Although BRT does not have the same physical street presence as rail tracks (with the exception of dedicated busways), branded BRT stations and vehicles are more distinctive and recognizable than local buses. • Attracting private funding. Property owners are often willing to financially contribute to a rail system because they realize the increased values that it brings to their property and to the neighborhood, such as through fees or benefit districts. The ability of BRT systems to attract private investment is generally linked to the level of investment in facilities. • Ability to catalyze and organize development. LRT lines have historically been an organizing principle behind new development. Public investment in light rail lines can help foster private infill development and create dense pedestrian environments where local stops are easily accessible by foot. In contrast, bus routes are typically added once an area has developed and demand is in place. BRT implementations have increasingly demonstrated the ability to similarly focus development.	• Flexibility. Rail vehicles cannot maneuver away from obstructions in the track, such as a stalled vehicle or traffic congestion blocking mixed flow or even dedicated right-of-way, special events, delivery vehicles or construction. BRT has the flexibility of standard buses, which can easily be temporarily re-routed if necessary. • Efficiency in lower-density environments. Rail services operate best where there is consistent intensive development along a line with strong anchors on both ends. In suburban areas where land uses densities are lower and there is a lack of anchors sufficient to create high levels of all day transit demand, buses have the benefit of being able to branch to serve multiple low density neighborhoods on different routes. • Lower capital investment. Due to the higher capital costs associated with trackwork and overhead wire, rail systems cost significantly more per mile to implement than bus systems. BRT systems have higher development costs and lead times for running way, vehicles, stations, and marketing and branding materials than standard bus service, but still significantly less than rail. • Does not require a unique maintenance facility or staff. For an agency that does not have existing infrastructure, rail systems require investment in unique maintenance facilities and equipment, including trackwork and overhead wire, whereas BRT vehicles can often be housed at an existing transit garage. The unique vehicles for BRT may impose one-time or higher ongoing costs compared to a standard bus system, however the requirements are significantly less than for rail. • Does not require special operator training. BRT vehicles can generally be driven by bus operators with minimal need for additional training. • Suitable for steep grades. Rail vehicles require gentle grades to operate and have more difficulty climbing steep hills (over 6% grades). Buses perform much better in these environments. • No overhead visual impact. Unlike streetcar or light rail vehicles, buses don't require overhead wires which can be unsightly. • Other perceived advantages include. Rail tracks can create crossing difficulties for bicycles and necessitate a safety education effort. Rail construction also can be difficult for local businesses, whereas with the exception of exclusive running ways, minimal street closure is typically necessary for BRT system construction.

Summary of Operating Characteristics

Figure 19 below compares the operating characteristics of BRT and similar travel modes. Several of these characteristics are contrasted in more detail in subsequent sections.

Figure 19 Operating Characteristics by Transit Mode

	Local Bus	BRT	Light Rail
Vehicle Capacity	Low-medium capacity, depending on size of bus. Includes small shuttles, standard 40-foot bus (35-42 seats) and articulated 60-foot bus (60-64 seats).	Medium capacity, with most systems using at least some articulated buses. Up to 160 passengers in dual-articulated buses	Medium-to-High Capacity
Flexibility	Most flexible, can easily move around obstructions.	Same flexibility as bus, but may have additional station infrastructure (e.g., fare collection)	Less flexible than bus. Cannot go around temporary obstructions and track/overhead wires are expensive to move.
Right-of-Way	Generally operates in shared ROW, but can utilize exclusive ROW.	Can operate in either shared on exclusive ROW, depending on implementation.	Typically operates in exclusive ROW but can also utilize non-exclusive ROW.
Station or Stop Spacing	3 blocks is typical; 600-foot minimum spacing recommended	Typically ½ to 1 mile, in some cases as little as ¼ mile and longer for some express services	Comparable to BRT
Fare Collection	Typically on-board vehicles	May be on or off-board vehicles, often with proof-of-payment. Some systems, mostly outside U.S., have enclosed stations to enforce off-board fare purchase.	Generally off-board vehicles, often with proof-of-payment
Operating Speed	Low	Medium to high; depends on right-of-way and stop spacing	Medium to high; depends on right-of-way and stop spacing
Optimal Markets	Suited to diverse markets, including local trips and circulation, feeding higher-capacity transit, and longer -distance commuter trips. Suited to areas without well-established travel demand patterns.	Short, local trips for service in CBDs and as well as limited stop corridor service.	Service connecting and serving major nodes in a city and region

* Listed for comparison purposes but is not considered

ROW = Right-of-Way

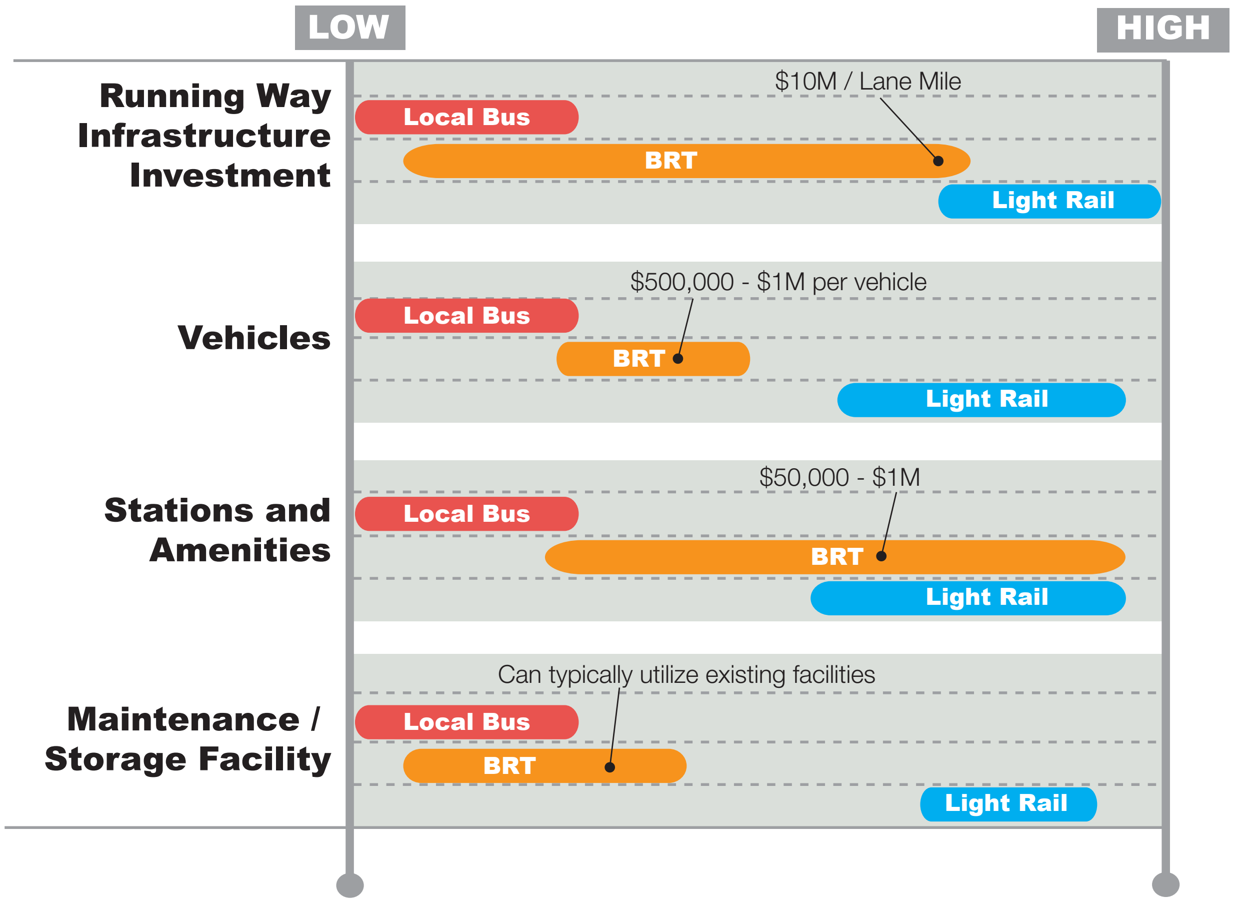
Cost Comparisons

This section compares the capital and operating costs of BRT to other similar transit modes. Figure 20 provides a summary. Figure 21 shows typical BRT capital costs relative to those for other modes.

Figure 20 Operating and Capital Costs by Mode

	Bus	BRT	Light Rail
Capital Cost	Lowest capital cost. Typically basic and enhanced stops along routes and transit centers at key nodes. Typically does not have major investments in running way improvements	Medium capital cost, generally between local bus and light rail modes. Can have significant running way improvement, station and vehicle costs based on specific applications.	Highest cost, with most developed stations, expensive vehicles and running way investments..
Operating Cost	Lowest operating cost; Pace averages $100/Hour, typical of large operators.	Comparable to bus on a per-hour basis, but may have a lower per-passenger cost due to higher capacity vehicles.	Slightly higher than other modes due to need for specialized personnel, but a large system can have scale efficiencies and lowest per-passenger cost due to highest capacity vehicles.

Figure 21 Capital Cost Summary



As shown in Figure 22, operating costs for BRT systems are comparable or lower than the overall average for bus systems. Figure 23 shows that nationally light rail has lower operating costs than bus service on a per-trip basis given the typically high level of ridership on this mode. Systems operating high-capacity BRT vehicles are able to achieve a comparable operating cost per trip, typically with a much lower capital cost.

Land Use (Density) Requirements by Mode

Figure 11, included in the earlier in-depth discussion of land use, illustrates typical density requirements to support different transit modes. The sample densities shown can be satisfied by either residential or employment density, although a mix of uses provides the strongest transit market. The density required to support BRT is higher than for frequent bus service but less than light rail. Depending on the specific service design, BRT and streetcar modes may have comparable density requirements.

Figure 22 Comparative Operating Cost Per Service Hour

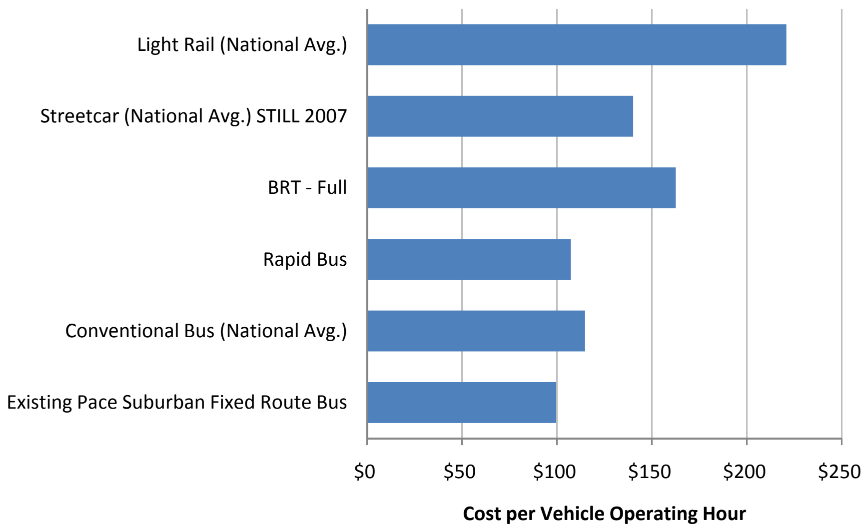
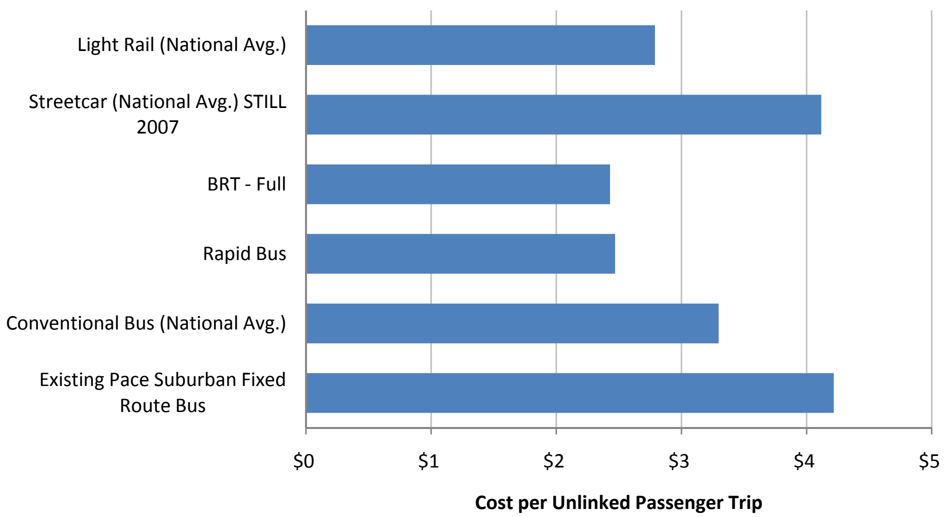


Figure 23 Comparative Operating Cost Per Trip



WHO HAS BUILT BUS RAPID TRANSIT AND WHY?

In many of the North American case studies, Bus Rapid Transit was implemented not only to satisfy goals for mobility and greater level of service, but to leverage broader policy goals such as economic development, increased sustainability, and promotion of livable communities (See Callout).

The following series of case studies highlight successful BRT investments and detail each of their project goals (i.e. economic development, stimulate ridership, congestion mitigation, etc.), current and planned land use and development patterns, visioning aspirations, funding strategies, and how local transit service adapted to the new service. Some key lessons learned are described as well. Figure 24 compares service characteristics and basic performance data to better understand how different agencies structure BRT operations.

WHY AGENCIES CHOSE BRT?

Pittsburgh West Busway
- Manage and bypass congestion
- Increase potential for TOD and economic revitalization

Cleveland HealthLine
- Generate ridership through higher levels of service
- Stimulate development and modify corridor land uses
- Connect employment centers

LTD EmX Green Line (Eugene, OR)
- Improve level of service
- Increase ridership and carrying capacity
- Reduce operating cost

Ottawa Transitway
- Focus land development along BRT trunk lines
- Provide high quality regional transit service
- Reduce operating cost

Community Transit Swift (Snohomish County, WA)
- Improve level of service
- Reinvent transit's image
- Build upon existing transit priority infrastructure and high ridership

Los Angeles Metro Orange Line
- Offer connective service between a transit hub and major employment center
- Link Downtown LA and San Fernando Valley with High capacity transit service.
- Provide congestion management and relief along local streets

MBTA Silver Line (Boston)
- Revive a key connective service to Downtown Boston
- Improve level of service

West Busway, Pittsburgh

Source: National Bus Rapid Transit Institute

KEY RESULTS:

- Offers 25 – 26 minute inbound AM peak period travel time savings
- 2.4 mph average increase in speed for all routes now using the busway
- Exhibited a 135% increase in ridership between August 2000 (pre-Busway) and October 2002

While Pittsburgh's West Busway broke ground in 2000, the city was one of the early adopters of the Bus Rapid Transit concept in the 1980's. Responding to increasing congestion, Pittsburgh's Port Authority of Allegheny County primarily developed the Full BRT operation along 5.1 miles of the Parkway West corridor as way to manage congestion during peak travel periods and market the service as a congestion bypass using dedicated and grade-separated guideways.[22] Transit oriented-development and economic revitalization initiatives were launched later as new development markets were opened along the former railroad corridor, which is largely surrounded by residential and abandoned commercial and industrial land uses. Due to the corridor's topographical features and historic industrial presence, promoting transit-supportive land uses is a challenge. However, local and county-wide land use planning is currently underway to gear policy toward denser, mixed use, and pedestrian-friendly development around stations.[23,24] Secondary and tertiary project goals include increased job access and reduce energy costs and regional air pollution.

High operating speed and reliability are largely achieved by a separated running way developed out of old freight rail corridors. Another important feature of the West Busway is the ability of feeder routes to access the busway to provide "one-seat rides" to destinations along the busway corridor. Some of the key takeaway lessons include:

- Economic development can occur even along corridors where current conditions make attracting investment difficult
- Operating speeds for existing routes that are re-routed to use the busway increased on average 2.4 mph, which saw average travel time reductions of 20 minutes during peak travel periods
- Ridership increased 135% between August 2000 and September 2002
- Use of limited stops, enhanced bus stations, transit signal priority, use of abandoned rail right-of-ways can be used successfully in corridors elsewhere[25]

The West Busway was largely funded (80%) by Section 5309 "New Starts" funding from the FTA for major investment in a new fixed guideway system. The remaining 20% of the project cost was covered by state and county funding. The project cost roughly $325 million; a major capital investment largely due to the cost of exclusive right-of-ways and engineering requirements for difficult terrain.

22 FTA (2003)

23 PAAC (2006)

24 Allegheny County Comprehensive Plan, Allegheny Places

25 FTA (2003)

HealthLine, Cleveland

Gaining its name from a partnership between Cleveland Clinic and the University Hospital system, Cleveland's HealthLine is a 7.1-mile Bus Rapid Transit line that replaced local routes along the Euclid corridor and marketed itself as a high quality rapid transit service for the most heavily traveled corridor in the region. Other local routes were located on parallel streets to provide access to destinations between BRT stations. HealthLine is unique in that it operates as Full BRT along exclusive median transit lanes for roughly 2/3 of its route, and then operates more as a Rapid Bus mode along 2.7 miles of mixed traffic operation.

BRT was developed for three primary reasons. First, the Greater Cleveland Regional Transit Authority (RTA) sought to improve the speed and reliability of service to increase ridership. BRT was also used to stimulate land use change around station areas and spur economic development where automobile oriented land uses had taken away the corridor's vitality. Bus Rapid Transit was the key driver to connect the region's two largest employment centers—the central business district and the University Circle area.

The project also included the development of a downtown Transit Zone. This Transit Zone was designed to enhance transit connections, improve the pedestrian environment that connects to transit, and maximize transit speeds using exclusive transit only lanes. The Transit Zone was essentially recalibrated from being a primary traffic corridor to accommodating all modes equally. Cleveland is now planning additional BRT lines to create an integrated rapid transit system.[8]

Some of the key lessons learned from developing BRT along the Euclid Corridor include:[9]

- Land use planning and BRT development must be coordinated concurrently to ensure that policy and service goals are mutually supportive
- Arterial streets with wide right-of-ways (like the 100-foot wide Euclid Corridor) should dedicate more space to transit and pedestrians where vehicle capacity allows
- Early community buy-in and project understanding is essential to maintain fluid progress and ensure that the project represents the community's needs and values
- Enforcement of transit only lanes must be seriously considered in the operational planning for BRT

KEY RESULTS:

- 8 minute end-to-end travel time savings compared to previous corridor service[5]
- 26 percent improvement in travel time relative to pre-BRT services[6]
- Creation of Transit Zone to improve land uses around and access to stations[7]

The project cost just under $170 million, half of which was funded by FTA New Starts money. The rest of the funding was covered by Ohio DOT ($50 million), the RTA ($17.6 million), the City of Cleveland general fund ($8 million), and the Northeast Ohio Areawide Coordinating Agency ($10 million), the region's metropolitan planning organization ($10 million).[10]

5 TCRP Report 90 (2003), Case Studies

6 FTA, Characteristics of Bus Rapid Transit for Decision-Making (2009)

7 RTA Transit 2025 (2004)

8 www.rtahealthline.com/project-overview.asp

9 TCRP Report 90 (2003), Case Studies

10 http://www.rtahealthline.com/project-overview-funding.asp

Source: Greater Cleveland Regional Transit Authority (RTA)

EmX Green Line, Eugene (OR)

The Emerald Express (EmX) Green Line provides enhanced connective service along the 4-mile stretch between downtown Eugene and downtown Springfield along the Franklin Corridor. This was already the highest ridership corridor in the Lane Transit District system with two large transit markets—the University of Oregon and Sacred Heart Medical Center—and relatively high population and employment density. The original project goals were to increase the corridor's transit level of service (frequency and speed), increase ridership and person carrying capacity, while reducing operating costs. Passenger type began to change as the new corridor service attracted a large amount of choice riders (roughly 16% who previously used private automobiles for similar trips prior to EmX). Supplemental to this, the line was designed to support mixed use districts around stations and enhance the surrounding streetscape with an attractive median busway coupled with bicycle and pedestrian facilities. Once implemented, EmX replaced the existing high performing corridor service (Route 11), and restructured local service to feed into the corridor.

Lane Transit District (LTD) identified several key lessons learned throughout the planning and implementation phases of EmX development, but two are of particular importance. Political and jurisdictional acceptance, particularly a local political champion would have been a vital tool for community acceptance and a smooth planning process. Without political backing, the project ran into several speed bumps that delayed progress. Visioning was the second key lesson learned and ties in with political buy-in. LTD did not only seek community buy-in, but rather motivation to achieve project completion as the community could now visualize the end product and its benefits.

KEY RESULTS:

- Reduced average end-to-end travel times from 16 minutes on the previous corridor service to 15 minutes.
- 50% increase in ridership over conventional bus service

The capital cost of EmX was approximately $25 million. Of this price tag $5 million was covered by local fund sources while the majority of the project was funded through federal dollars. New Starts funding covered $13.3 million of the federal share, while the remainder was comprised of FTA urbanized area formula grants. Future BRT expansion along corridors will be evaluated and selected according to planned nodal development and population / employment clustering.

Source: Functoruser, CC2.0

Ottawa Transitway

The Ottawa Transitway is one of North America's most advanced BRT systems serving as the city's high capacity transit spine since 1983. OC Transpo, Ottawa's transit authority, operates a 30.8-mile bus rapid transit network with service running in a combination of mixed traffic, dedicated bus lanes and grade-separated transitways. The system is set up to be adaptive and flexible to the commuting needs of passengers. There are two BRT trunk lines with local feeder routes that provide transfer opportunities. Peak hour express routes utilize the Transitway and enter park-and-ride facilities and local stops via special access ramps. The Transitway links the city's key residential and commercial development nodes to downtown, as well as provides valuable intermodal connections to rail, airports, and inter-city bus.

KEY RESULTS:

- Reduced average end-to-end travel times from 16 minutes on the previous corridor service to 15 minutes.
- 50% increase in ridership over conventional bus service

Project goals for BRT development were outlined in the early 1970's. They key goals were to provide cost effective regional high capacity transit, increase the region's proportion of transit mode share, and structure new community development around BRT trunk lines—all of which are continually satisfied and reinforced as the system expands.

Ottawa's Transitway has generated upwards of $1 billion (Canadian) in investment at station areas. Development includes vast residential development, a hospital, and several commercial shopping centers. Being one of the pioneers of BRT, OC Transpo offers several key lessons learned. Some of the most pertinent to the American context include:

- Integrating feeder service into the Transitway can eliminate the need for transfers and allow for "single-seat" rides
- Image of BRT is highly linked to system clarity, effective fare collection procedures, and attractive station design
- Integrating land use policy and parking management in areas surrounding stations can stimulate higher ridership
- Effective BRT systems do not need capital-intensive transitways to be effective; dedicated transit lanes can offer nearly identical travel speeds when coupled with signal priority

Ottawa's Transitway cost an estimated $415 million (U.S. dollars) over several phases of construction. Funding sources are not provided due to the differences in funding structure between Canada and the U.S.

Source: NBRTI

Swift, Community Transit (Snohomish County, WA)

In November 2009, Community Transit (CT) began operating Swift along the Highway 99 corridor. Located only 11 miles from downtown Seattle, Swift offers a regional high capacity transit connection between the cities of Everett and Shoreline. The new service also links Snohomish County with King County Metro's regional transit service, providing a more efficient transit connection into downtown Seattle. Swift covers a 16.7-mile route and stops at 15 stations along its course. It runs entirely within mixed traffic, although 7 miles of the corridor contain curb separated Business Access and Transit (BAT) lanes that force non-transit vehicles to turn right at intersections.

An important characteristic of the line is that it acts as a service overlay on top of existing local fixed route service. In other words, Swift supplements existing local routes by providing longer stop spacing for increased travel speeds and frequencies. Although the existing CT Routes 100 and 101 combined to offer 15 minute peak service frequency, BRT presented a strategic opportunity to make service more frequent, attractive and reliable, even during peak periods.

Swift was chosen over other transit modes because the Highway 99 corridor combines an existing well-developed transit market, high transit productivity, high residential and employment densities at various nodes along the corridor, relatively mixed uses, connectivity with designated Regional Growth Centers (especially Everett and Lynnwood), and existing transit priority infrastructure of transit only/BAT lane facilities supportive of higher transit speeds and reliability.

Several cities are actively conducting land use studies in order to accept more density along the Highway 99 corridor. The general objective for updating development code and design guidelines is to create TOD nodes that support higher densities and better accommodate pedestrian movement. An exemplary local land use planning effort was conducted in the City of Lynnwood at the southern end of the corridor where the City independently adjusted land uses around BRT station calling for transit-oriented "Gathering Places". The corridor's existing land use environment consists of commercial strip malls, car dealerships, and other various automobile-oriented uses. To enhance the land use connection to BRT, the city initially adopted economic development strategies for the Highway 99 corridor and amended them into their comprehensive plan in February 2008—prior to Swift's completion.[22] Some of the key land use and transportation objectives identified during this planning process included:

- Increasing density and introducing mixed uses in conjunction with BRT
- Concentrating housing within walking distance to BRT stations
- Co-locating housing and commercial uses
- Enhancing pedestrian access to BRT
- Encouraging a variety of local businesses to locate along the corridor

The project's total capital infrastructure costs amounted to $28.4 million, while CT projects that Swift's annual operation will cost $5 million. The Swift BRT project was not given New Starts funding likely because it would not operate on a separated right-of-way. $11 million of federal funding was used to purchase vehicles. Outside of federal sources, the project utilized a mix of state Regional Mobility funds and local revenue streams. Partnership funds between Community Transit and Everett Transit—the city of Everett's transit provider—made up the remainder of the project's funding. Initial operating costs are divvied up by federal JARC grant funds, a state regional mobility grant, and partnership funding.[23] Partnership funding will likely sustain future BRT operation along the corridor.

KEY RESULTS:

- Carries 80,000 people per month with hourly productivity that exceeds CT's system average
- Ridership has exceeded CT's opening year goal after only six months of operation

22 City of Lynnwood Highway 99 Corridor Study Adopted Strategies, City of Lynnwood Highway 99 Corridor Study Adopted Strategies, 2008

23 From interview with Community Transit Project Manager

Source: Oran Viriyincy, Creative Commons Attribution License 2.0

Orange Line, Los Angeles

LA Metro's Orange Line is a 14.5-mile BRT line that predominately uses a former railroad right-of way as an exclusive busway with passing lanes. The corridor connects two major transit hubs and employment centers—the Warner Center and North Hollywood, which links into Metro's subway system. The Orange Line also connects into the Metro Rapid Ventura Line providing access to the area's primary commercial corridor, while several local routes were re-routed to feed into the busway. No local service was replaced because there was no route that ran along this corridor prior to the Orange Line.

Key project goals identified by Metro include connecting the Warner Center, one of the region's largest employment centers, with the North Hollywood transit hub, providing a high capacity link into downtown Los Angeles, congestion relief along local streets, reduced travel times compared to private automobile and similar Rapid Bus transit services. Another project goal was to stimulate transit-oriented development at strategic activity centers using a high capacity transit line. $3.6 million in renovations have already been committed to revitalize the historic North Hollywood station area and many real estate developers have expressed interest in developing large mixed use districts, largely due to the Orange Line's momentum.[22]

Several important issues arose during the initial operating period that may provide a transferable lesson in other corridors. Safety issues at intersections needed to be mitigated by experimenting with traffic control and signal priority features. There were also noise complaints launched by residents living adjacent to the busway. Noise was mitigated using sound walls and rubberized asphalt to block noise and limit and tire to surface friction.

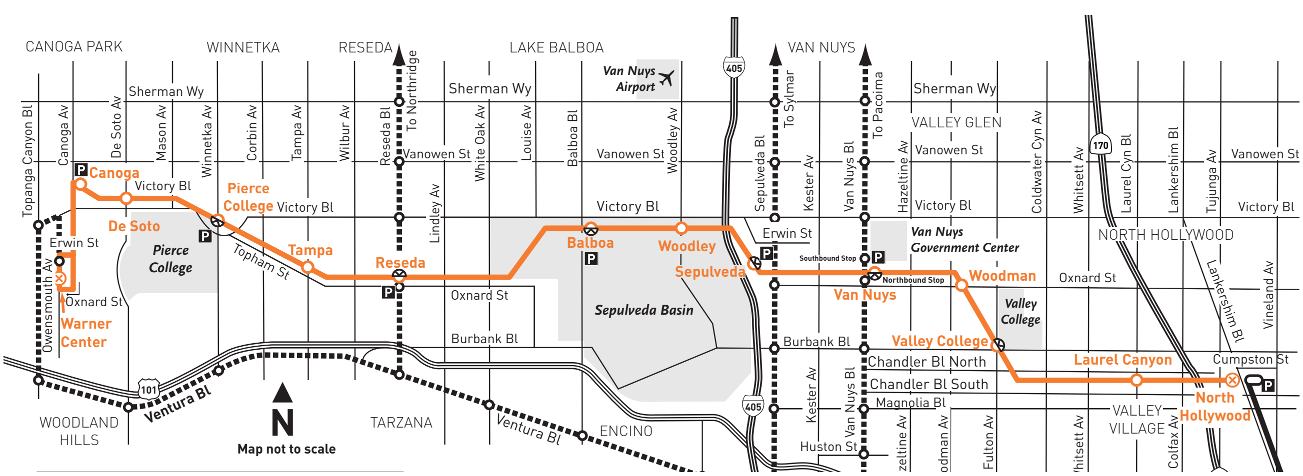
KEY RESULTS:

- 18 percent of passengers are captive riders, previously taking the same trip by car
- 16 percent improvement in travel time relative to pre-BRT services[19]
- 2 million square feet of mixed use development will be constructed at several stations

The BRT option was deemed as more appropriate mode than the subway and BRT Lite alternatives because it was more politically viable and cost-effective on a cost per passenger mile basis. Due to the route length and level of guideway investment, the Orange Line capital cost amounted to $350 million. This was largely funded by Proposition A, a county-wide ½ cent sales tax dedicated to transportation projects. Other capital costs like vehicle procurement and station construction were funded by federal New Starts dollars (Section 5309). A future Orange Line extension will be funded by a new county-wide sales tax initiative.

22 Vincent and Callaghan (2007)

19 FTA, Characteristics of Bus Rapid Transit for Decision-Making (2009)



Orange Line route map

Source: LA Metro

Silver Line, Boston

Boston's Silver Line, operated by the Massachusetts Bay Transportation Authority, is a 2.4-mile Rapid Bus project that replaced a popular local fixed route service (Route 49). The Silver Line runs along the Washington Street, a dense residential and commercial corridor with existing land uses that could support a frequent high capacity transit line.

The Silver Line's key project goal was to provide a higher quality connection between Dudley Station in Roxbury and downtown Boston. Some of the main objectives to reach this goal were to increase travel speeds using a dedicated transit only lane, to create attractive stations, and improve reliability using real-time travel information and increased frequency. Residents along the corridor made it clear that they did not want "just another bus stop."[22]

When the Silver Line began service, it replaced the high ridership and frequent service Route 49. After the service initiated, the 16.6% of passengers were captive riders who either drove or walked for similar trips pre-implementation. However, it is unclear whether service was trying to attract choice riders. Land uses along this corridor are dense, but had patches of disinvestment. As a result of the Silver Line, parts of the South End and Roxbury underwent significant redevelopment and private investment.[23]

Throughout the project planning and early operating phases of the Silver Line, several key lessons were ascertained. These include: [24]

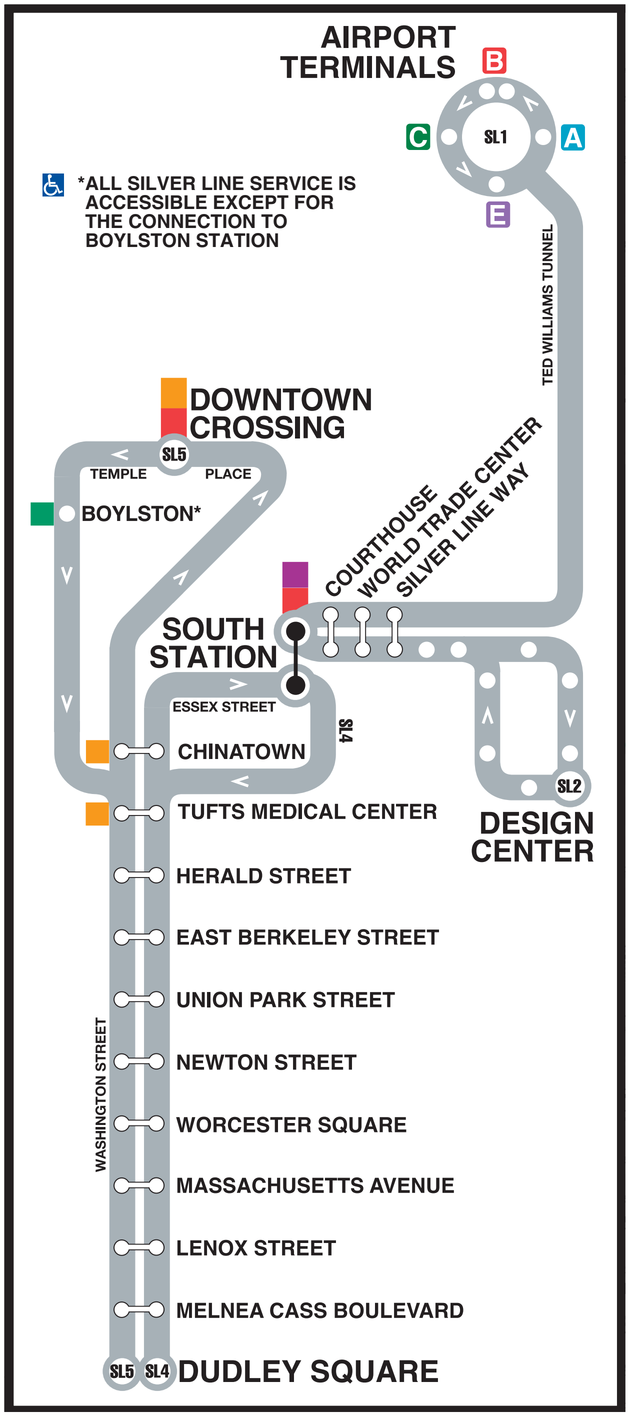
- New vehicles (especially low level and stylized articulated) are an essential component of improving transit's image. MBTA found that the vehicle choice resonates with the community and identifies the service as high quality and fast when compared to conventional vehicles.
- MBTA had difficulty operating their real-time passenger information and AVL system package; these ITS features are still not operational.
- Off-board payment created station dwell time delay when compared to peer systems that used the proof-of-payment method.
- MBTA suggests that early project consensus over service quality goals (i.e. avoiding the "just a bus" plan) was responsible for successful BRT system planning.

The Silver Line project cost $50 million in capital installations including vehicle procurement, station and roadway construction, ITS improvements. No information is available regarding how the project was funded.

22 Federal Transit Administration (2005)
23 Federal Transit Administration (2005)
24 Federal Transit Administration (2005)

KEY RESULTS:

- Reduced corridor travel time by 25% in the PM peak period (compared to previous service)
- 96% increase in average weekday ridership between 2001 (pre-Silver Line) and 2005 (post-implementation)
- $1.2 billion in real estate development created along the Silver Line



Source: MBTA

Figure 24 Bus Rapid Transit Case Study System Characteristics







	Snohomish Co. (WA)	Eugene	Boston	Cleveland	Los Angeles	Pittsburgh	Ottawa
	Swift	EmX Green Line	Silver Line (Washington St.)	HealthLine	Orange Line	West Busway	Transitway
Full or Rapid BRT	Rapid	Full	Rapid	Full/Rapid	Full	Full	Full
Routes	1	1	1	1	1	1	3
Route Length	16.7 miles	4 miles	2.4 miles	7.1 miles	14.5 miles	5.1 miles	30.8 miles
Running Way (miles)	On-Street	On-Street	On-Street	On-Street	On/Off-Street	Off-Street Only	On/Off-Street
Mixed Flow Lanes	9.7 miles	1.4 miles	0.2 miles	2.7 miles	1 mile	-	2.1 miles
Exclusive Bus Lanes (Transit Lanes)	7 miles	2.5 miles	2.2 miles	4.4 miles	-	-	9.9 miles[1]
At-Grade Transitway	-	-	-	-	13.5 miles	-	-
Grade-Separated Transitway	-	-	-	-	-	5.1 miles	18.8 miles
Service Frequency (Peak)	10 minutes	10 minutes	4 minutes	5 minutes	4 minutes	1.33 minutes	3 – 12 minutes
Service Frequency (Off-Peak)	15 – 20 minutes	20 – 30 minutes	12 minutes	15 minutes	10 minutes	N/A	4 – 30 minutes
Service Span	19-Hour Service	All Day	All Day	All Day	All Day	All Day	All day (some routes)
Number of Stations	15	18	22	58	28	13	68
Station Spacing (Average)	1 mile	0.44 miles	0.22 miles	0.42 miles	0.75 miles	0.83 miles	0.6 – 1.3 miles
Fare Collection	Off-Board	Off-Board	On-Board	Proof-of-Payment	Proof-of-Payment	On-Board	Proof-of-Payment
Vehicle Type	Stylized Articulated; Low	Stylized Articulated; Low	Stylized Articulated; Low	Stylized Articulated; Low	Stylized Articulated; Low	Standard & Articulated	Standard & Articulated

Figure 24 Bus Rapid Transit Case Study System Characteristics (continued)

							
	Snohomish Co. (WA)	**Eugene**	**Boston**	**Cleveland**	**Los Angeles**	**Pittsburgh**	**Ottawa**
	Swift	**EmX Green Line**	**Silver Line (Washington St.)**	**HealthLine**	**Orange Line**	**West Busway**	**Transitway**
ITS Features	TSP, Info (V)	AVL, Info (V)	TSP, AVL, Info (V+S)	Precision Docking, Info (S)	AVL, APC, Info (S)	TSP (at one intersection)	TSP, AVL, APC (10% of vehicles), Info (V+S)
Parallel Service?	Yes; Replaced 1of 2 Local Routes	No; Replaced Local Route	No; Replaced Local Route	No; Replaced Local Route	Yes; Service Overlay	No	Yes
Average Daily Boardings	2,660[2]	N/A	14,102	N/A	62,597	9,000	97,739 (3 routes)

1 1.2 miles are on off-street reserved bus lanes.
2 With aggressive changes to land use, zoning, and density, ridership is projected to reach 13,500 average daily riders by 2015.
Acronyms: N/A = Not Available; TSP = Transit Signal Priority; AVL = Automatic Vehicle Locator; APC = Automatic Passenger Counter; Info = Real Time Travel Information; V = In Vehicle Information; S = Station Real Time Display

Source: Federal Transit Administration (2009)

WHAT ARE THE BENEFITS OF BRT?

This section highlights a number of the benefits of Bus Rapid Transit, including research documenting these benefits and comparisons with other modes as applicable. These benefits include: increased ridership (and an associated mode shift away from driving alone); the fostering of livable communities; and expanded economic development including job creation. The Randall Road BRT feasibility study will develop methodologies for quantifying these benefits for the envisioned BRT service in Kane County.

Congestion Mitigation (Ridership)

Similar to rail transit modes, the ability of BRT to reduce congestion relates directly to its capacity and ability to compete with the automobile and attract ridership to the service, over and above local bus service. Several of the key factors in attracting riders to BRT are:

- Speed and reliability improvements
- Connectivity between stations and destinations
- Image and branding influences

BRT systems have attracted up to 50% of riders from private vehicles, as shown in Figure 25.

Figure 25 Share of Ridership from Private Vehicles, Select BRT Systems

BRT System	% of Ridership from Private Motor Vehicles
Boston - Silver Line Washington Street	2%
Boston - Silver Line Airport	19.6%
Boston – Silver Line BMIP	49.5%
Los Angeles Orange Line	33%
Oakland San Pablo Rapid	19%

Source: FTA, Characteristics of Bus Rapid Transit for Decision-Making, 2009.

When combined with mixed-use transit oriented development at the BRT station areas, trips across all modes should be shorter and less dependent on automobile travel. Total vehicle miles traveled (VMT) per capita should be reduced under these circumstances.

Cost Effectiveness

In general, Bus Rapid Transit offers greater performance per capital cost than many other modes including streetcar, light rail and conventional bus. BRT infrastructure typically consists of type and complexity of running way and station construction as well as vehicle procurement. Unlike other rapid transit modes, it is not necessary to construct fully-segregated or grade-separated running ways to produce high levels of service (speed and reliability). In fact, providing higher levels of separation at strategic locations can offer similar performance as rail modes for a fraction of the cost. Similarly, BRT vehicles, whether conventional with some level of stylizing or higher capacity specialized BRT vehicles are far less expensive than streetcars and light rail vehicles, even when life cycle costs and capacity is factored in.[1]

On the operating side, BRT vehicles do not require additional maintenance facilities or specialized maintenance procedures to ensure long-term operation. BRT vehicles can use the same maintenance and storage yards used by conventional Pace local routes. In addition, BRT does not require the use of roadside power supply to power vehicles like other rapid transit modes.

In one of the more successful North American BRT systems, Ottawa's Transitway system out performs the roadway and light rail systems when looking at passengers per kilometer as a performance measure.[2] This is not surprising as Ottawa's residents recognize the Transitway as a high quality transit service and realize the mobility benefits of BRT compared to the aforementioned modes.

Economic Development

What are the economic benefits of BRT?

BRT has similar economic benefits to other high quality transit systems, often achieved at a lower capital cost. These benefits include:

- **Increased economic productivity:** BRT can provide travel time savings or productivity benefits for existing and new transit users, as well as travel time savings for both automobiles and freight as a result of reduced roadway congestion. For every $10 million invested in transit infrastructure, over $15 million is saved in transportation operating costs and congestion for both highway and transit users, according to a 1999 Cambridge Systematics study.[3] In Los Angeles, a before and after study of the Orange Line BRT found that traffic speeds in the morning rush hour on the adjacent US 101 increased by an average of 3 mph, onset of congestion (speeds less than 35 mph) was 11 minutes later, and drivers spent 14% less time in congested conditions.[4]
- **Improved economic opportunities**: A BRT system that provides additional mobility options can expand employment opportunities and reduce transportation costs. Retail establishments and other employers have access to a larger work force and benefit from increased accessibility. Access to public transportation was rated as an extremely important factor in selecting corporate locations according to a recent survey by the real estate services firm

1 TCRP Report 90 (2003)

2 TCRP Report 90 (2003), Case Studies

3 Cambridge Systematics, *Public Transportation and the Nation's Economy*, 1999.

4 VTPI, http://www.vtpi.org/tdm/tdm120.htm (Orange Line Eases A.M. Rush on 101 Freeway)

Jones Lang LaSalle in its Property Futures publication.[5]

- **Revitalization:** Transit-oriented development around BRT stations can be used to revitalize aging downtowns and commercial areas, creating economic opportunities and enhancing tax revenues for local jurisdictions. The cases listed in Figure 26 illustrate the demonstrated development potential of BRT implementations.

5 Hank Dittmar, Prepared Testimony to Senate Subcommittee on Housing and Transportation, http://banking.senate.gov/02_06hrg/062602/dittmar.htm

- **Job creation:** Capital investments in transit infrastructure support jobs in construction, planning, and design. According to an analysis conducted by Economic Development Research Group for the American Public Transit Association (APTA), a $10 million transit capital investment creates about 235 jobs, primarily in the construction and services sectors. For example, recent design and pre-construction work on the Boulder Highway BRT line in Las Vegas (NV) generated nearly 175 job-weeks of work and $300,000 in payroll to the local economy. New transit service also creates ongoing operations and maintenance jobs. The APTA study estimated about 410 jobs per $10 million in operations spending, and a blended average of 365 jobs based on a national ratio of 71% operations and 29% capital spending.

Figure 26 Development Benefits of BRT Systems

BRT System	Development Benefits
Boston - Silver Line	Over $700M in new investment within 2-3 blocks of BRT Line, along reconstructed Washington Street between downtown Boston and Dudley Square. The first phase, along Washington Street, accelerated development with at least $93 million in new construction, including a mix of retail, housing, and institutional uses. (1,3)
Ottawa Transitway	The regional planning department found that between 1996 and 1998, more than $600 million was spent on the construction of 3,211 residential units and 436,858 square meters of institutional and commercial buildings near Transitway stations. From 1988 to 1993, more than 2,300 housing units were built within an 800-meter radius of 14 surveyed Transitway stations. About 1/3 of customers arrive at the St. Laurent Centre via the Transitway, connected by weather-protected walkways; the center completed a major expansion of 80 additional stores concurrent with the station opening in 1987. Six new office buildings, a cinema complex, and a community shopping center have been constructed near Blair station since it opened in 1989. The Riverside Hospital expanded over the Riverside station in 1991, with a pedestrian walkway to connect the station with a new medical office building. (1, 2, 3)
Pittsburgh - Martin Luther King, Jr. East Busway	$302 million in new and improved development along the East Busway, between 1983 and 2000, and over $500 million by 2007, with 80% around stations. 59 new developments within 1,500 feet of stations. (1,2)

Sources: (1) TCRP Report 118, 2007; (2) TCRP Report 90, Volume 2, 2003; (3) FTA, Characteristics of BRT, 2009

Figure 27 Jobs Generated per $10 Million in Public Transportation Spending, 2007

Category	Type of Jobs	Jobs per $10M Capital Spending	Jobs per $10M Operations Spending	Blended Average
Direct Effects	Construction, Manufacturing, Operations	80	210	175
Indirect Effects	Parts Suppliers and Services	80	30	45
Induced Effects	Jobs from Workers Re-spending Wages	75	170	145
Total		**235**	**410**	**365**

Source: Economic Development Research Group, Job Impacts of Spending on Public Transportation: An Update, 2007

What factors affect the economic development potential of BRT?

Since most BRT systems in the United States are relatively new, there is not as much evidence of their economic development impact as is noted for rail systems. However, in studies of both rail and BRT systems, the following factors influence the ability of a BRT system to foster economic development:

- **Permanence**: The level of public investment in BRT stations, vehicles, and running ways creates a greater sense of permanence for BRT in comparison to local bus service, and enables its potential to catalyze and organize development analogous to rail. Conveying a sense of permanence is widely cited as an essential factor in encouraging investment and addressing a major developer concern, and these investments demonstrate a public commitment to provide high quality transit service along a corridor.
- **Quality of Service**: With design features and amenities similar to rail, BRT vehicles and stations provide a superior customer experience to local bus, although the ride is typically not as smooth and comfortable as rail vehicles, which run on tracks rather than pavement and make more gradual and less frequent turning movements.
- **Noise and pollution**: Noise and pollution impacts for BRT are influenced by vehicle and fuel type, and are particularly relevant with an on-street running way. Selecting vehicle and fuel technologies that minimize noise and pollution, discussed in more detail in a subsequent section, are important factors in realizing the economic benefits of BRT. The Boston Silver Line (see Figure 26) exemplifies development benefits of a system that minimized these impacts; the Pittsburgh and Ottawa busways, which use more conventional vehicles but on separated running ways, indicate that development benefits can still be realized given emphasis on station design.[6]
- **Image**: Transit customers and developers often have an aesthetic preference for both rail and Bus Rapid Transit modes over local bus. A study of perceptions of several light rail and BRT lines in Los Angeles found that BRT services were able replicate both the tangible and intangible service attributes of the light rail lines, listed in Figure 28, with a much lower capital investment.

Figure 28 Tangible and Intangible Service Attributes

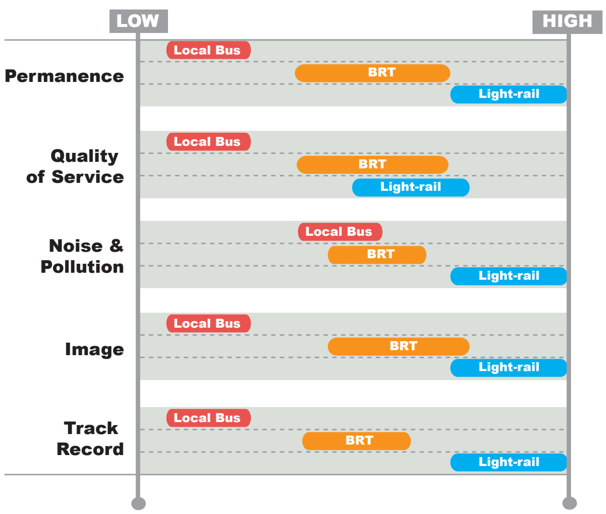
Tangible Attributes	Intangible Attributes
• Travel Cost • Door to door travel time • Frequency of Service • Hours of service • Convenience of service • Reliability of service	• Safety while riding • Safety at the station/ stop • Comfort while riding • Comfort at the station/ stop • Customer service • Ease of service use • Other riders • Avoiding stress/cost of car use

Source: Cain, Flynn, McCourt, and Reyes. Quantifying the Importance of Image and Perception to Bus Rapid Transit, 2009

- **Track Record:** Although rail modes have a stronger track record than BRT in focusing development, the impact of BRT, linked to the level of station investment for particular implementations, is greater than standard bus service and increasingly recognized as competitive with rail.

Figure 29 illustrates BRT's performance relative to other modes for each of these factors that affect economic development potential.

Figure 29 Factors in Economic Development by Mode



6 FTA, Characteristics of Bus Rapid Transit, 2009.

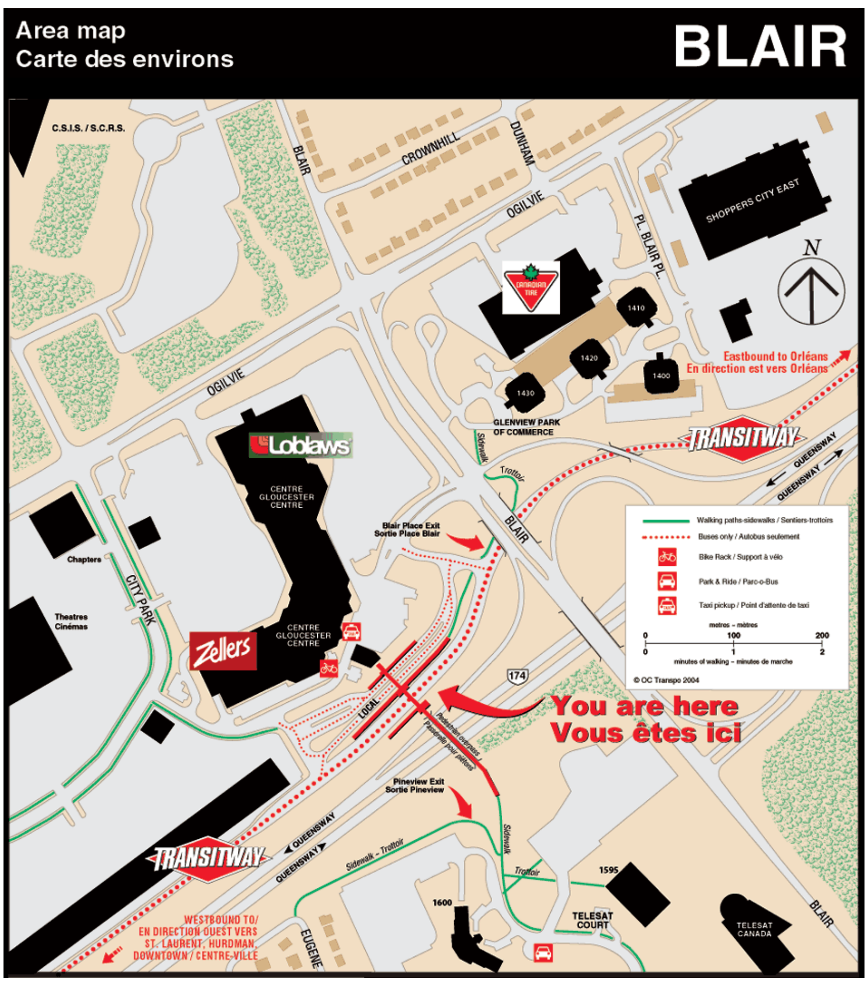
DEVELOPER PERSPECTIVE ON BRT

Surveys of developers along the Boston Silver Line and Ottawa Transitway, two of the cases described in depth above, were conducted to ascertain the factors likely to influence them to develop within walking distance of BRT stations.[1] In Boston, developers identified key development considerations as proximity to stations, supportive zoning, land availability and cost, and real-time passenger information. Some respondents perceived reconstruction of Washington Street, including sidewalks and amenities, to be as important as the transit improvement itself. In Ottawa, where the BRT system operates on a separated running way, the survey results did not indicate significant differences between the impact of light rail and BRT on TOD projects. The image below illustrates the integration of the Blair Station with local businesses.

In addition, a survey of developers along the San Pablo Avenue Rapid BRT line in Oakland (CA) found that simply increasing stop spacing and providing bus priority were not sufficient to attract interest in developing along BRT service, indicating the importance of station infrastructure and a distinctive image.[2] These respondents also emphasized the importance of streetscape improvements and safety.

1 TCRP Report 118, Bus Rapid Transit Practitioner's Guide, 2007.

2 Meijas and Deakin, Redevelopment and Revitalization Along Urban Arterials: Case Study of San Pablo Avenue, California, from the Developers' Perspective, TRR 1905, 2005.



Source: OC Transpo

Figure 30 Land Value Impacts of BR

BRT System	Property Value Effects
Bogota TransMilenio	The rental price of a property decreases between 6.8% and 9.3% for every five minutes of additional walking time to a BRT station (4)
Brisbane, Australia - South East Busway	Property values near stations grew 20% faster than property values in the surrounding area. (2, p.28)
Pittsburgh - Martin Luther King, Jr. East Busway	A property 1,000 feet away from a station is valued approximately $9,745 less than a property 100 feet away. (3)

Sources:
(1) TCRP Report 118, 2007; (2) TCRP Report 90, Volume 2, 2001; (3) Perk and Catala, 2009; (4) Rodriquez and Targa, 2003

DEVELOPER PERSPECTIVE ON BRT

"Next-generation projects will orient to infill, urbanizing suburbs, and transit-oriented development. Smaller housing units – close to mass transit, work, and 24-hour amenities – gain favor over large houses on big lots at the suburban edge. People will continue to seek greater convenience and want to reduce energy expenses. Shorter commutes and smaller heating bills make up for higher infill real estate costs…. Locations near transit corridors are prime."

PriceWaterhouseCoopers and Urban Land Institute, Emerging Trends in Real Estate 2010

How does BRT impact land patterns?

The economic development potential of BRT, as any transit mode, requires land use policies that enable higher density, mixed use transit-oriented development. Several studies have found that policies are as important as permanence in attracting transit-oriented development. In turn, BRT can help catalyze this type of land use environment.

Investments in high-capacity transit stations and other infrastructure improve access, attract development, and increase land values. Higher land values around stations then encourage higher density development to occur. A number of studies have demonstrated increases in both residential and commercial property value along rail lines.[7] In recent years, this effect has increasingly also been demonstrated for BRT, with several examples listed in Figure 30.

7 For example, see literature review provided in Perk and Catala, *Land Use Impacts of Bus Rapid Transit: Effects of BRT Station Proximity on Property Values along the Pittsburgh Martin Luther King, Jr. East Busway,* 2009

Environmental/Climate

Noise

Noise is an important consideration in enhancing the image of transit service, attracting development, and creating livable communities, particularly for an arterial-based service. The key noise-related considerations for BRT include:

- Electric vehicles (rail or electric rubber-tire trolleys) are generally quieter than motor buses; however hybrid-electric engines and other alternative propulsion technologies can reduce noise for buses.
- Larger vehicles as may be used in BRT can have a greater noise impact than smaller vehicles, particularly when accelerating. However, the greater distance between stops in BRT systems reduces acceleration noise compared to local buses which make frequent stops.
- Higher BRT frequencies magnify noise impacts and accentuate the importance of considering noise when selecting vehicle and running way technologies.
- Landscaping and running way materials and design can help mitigate BRT noise impacts.

Reducing Vehicle Miles Traveled and GhG emissions

Transit can reduce Greenhouse Gas (GhG) emissions in the following ways[8]:

Reducing vehicle miles traveled in private vehicles by shifting trips to transit;

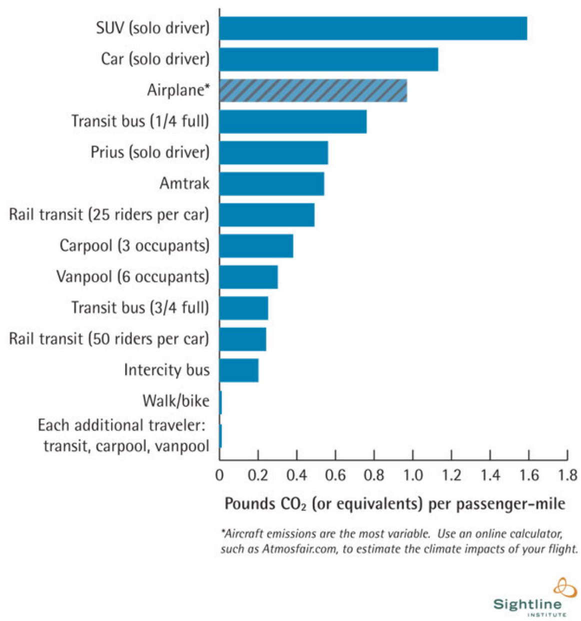
- Reducing congestion, which reduces emissions from vehicles idling or traveling in stop and go traffic conditions; and
- Facilitating compact development patterns that reduce vehicle miles traveled, such as by reducing the length of vehicle trips and allowing some trips to be completed by walking and bicycling.

For each of these effects, discussed in more detail in previous sections, BRT and rail modes would be expected to have a greater impact on development patterns than a traditional bus system and therefore would have a larger impact on reducing emissions by reducing VMT.

Transit's effectiveness in reducing GhG emissions depends on the difference between emissions displaced from passenger vehicles and emissions from transit vehicles and facilities. Major determinants of net emissions reductions from transit are the average passenger load on transit vehicles and the level of emissions from transit vehicles and facilities, which can be reduced through the use of alternative fuels or electricity generated from renewable sources.

Figure 31 illustrates the comparative emissions of passenger vehicles and transit modes for different passenger loads. A bus that is three-quarters full has lower emissions per passenger mile traveled than hybrid cars (Toyota Prius), carpools or vanpools.

Figure 31 Comparative GhG Emissions (grams CO2 by Passenger Miles Traveled)



Source: Sightline Institute, 2008.

8 TCRP Synthesis 84, Current Practices in Greenhouse Gas Emissions Savings from Transit, 2010

The emissions impact of electrified travel modes, including light rail and electric passenger vehicles, depends on the how the electricity is generated. A BRT system in Kane County, particularly using low-emissions vehicles running on alternative fuels, could be expected to have lower per-passenger GhG emissions than a typical transit bus or rail transit. BRT systems in the planning stage are currently pursuing either hybrid-electric, CNG (Compressed Natural Gas), or biodiesel fuels; among 20 planned full BRT systems, nearly two-thirds are committed to hybrid technology.[9]

Findings from research studies include: [10 11]

- BRT can reduce GhG emissions based on low-emission vehicle technology, passenger loads of the same magnitude as light rail, and shifting travel from private vehicles.
- Implementing BRT with bicycle and pedestrian improvements does the most to reduce private vehicle travel and achieves the largest and most cost-effective emissions reductions.
- A 40-mile BRT corridor similar to the Los Angeles Metro Rapid would reduce annual CO2 emissions by 70% to 74%, depending on the fuel technology.
- A study of the Transmilenio BRT in Bogotá, Columbia, found that it reduces emissions by 250,000 CO2-equivalent tons.

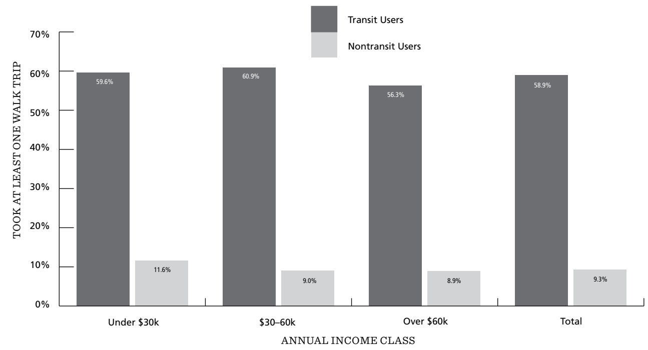
Air Quality

In urban areas, transportation is the primary source of pollutants regulated by the U.S. Environmental Protection Agency (EPA), including ground-level ozone (formed from nitrous oxide and volatile organic compounds), particulate matter, and carbon monoxide. Older diesel buses can increase exposure to pollutants if coupled with transit-oriented development that concentrates population near transit facilities. However, electric trains or buses that use low-emissions technologies can improve local air quality. Recent EPA standards mandate cleaner diesel fuel and engines by 2010, and technologies such as hybrid-electric engines can further reduce emissions.

Environmental analysis for BRT projects has generally shown them to have a small effect (about 1%) on reducing overall emissions of air pollutants, comparable to other high capacity transit. A post-implementation study of Mexico City's Metrobùs BRT found that it would have an average $3 million annual health benefits from reduced emissions between 2005 and 2010.[12]

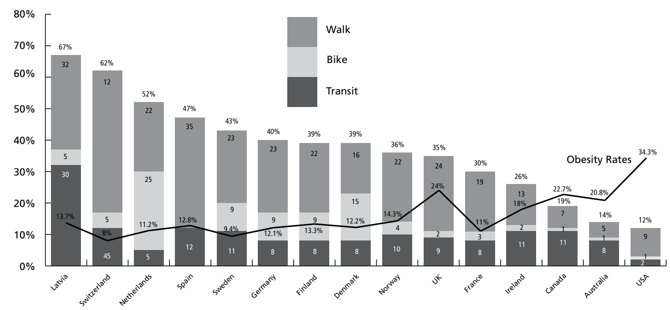
9 Federal Transit Administration. Characteristics of Bus Rapid Transit for Decision-Making, 2008.
10 Vincent and Callaghan Jerram, The Potential for BRT to Reduce Transportation-Related CO2 Emissions, 2006.
11 Federal Transit Administration. Characteristics of Bus Rapid Transit for Decision-Making, 2008.
12 Federal Transit Administration. Characteristics of Bus Rapid Transit for Decision-Making, 2008.

Figure 32 Daily Walking Trips and Transit Use



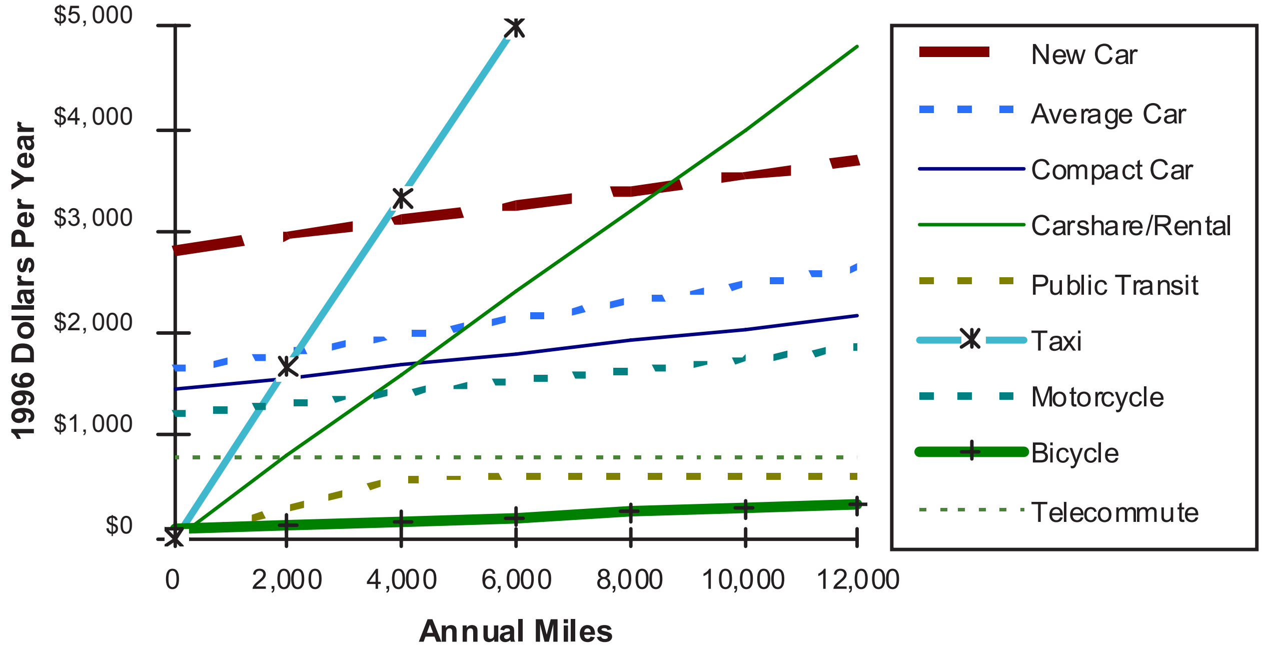
Source: Todd Litman, "Public Transportation and Health" in Healthy, Equitable Transportation Policy.

Figure 33 Walk, Bike, and Transit Use vs. Obesity Rates



Source: Todd Litman, "Public Transportation and Health" in Healthy, Equitable Transportation Policy.

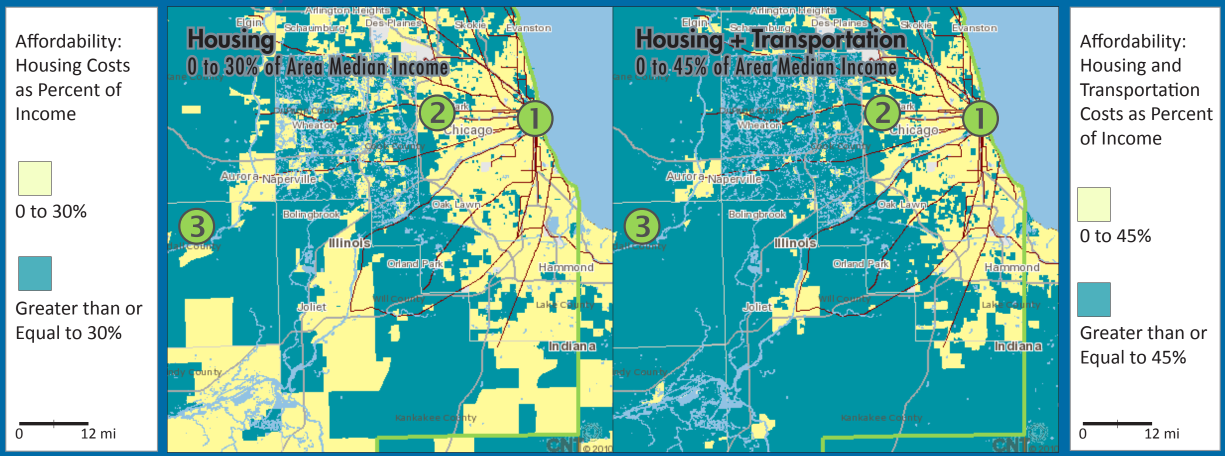
Figure 34 Operating Costs by Mode of Transportation



Source: VTPI, Transportation Cost and Benefit Analysis, 2009.

MEASURING HOUSING AND TRANSPORTATION AFFORDABILITY

The Housing and Transportation Affordability Index (H+T) is a tool for comparing the combined affordability of both housing and transportation costs. A general rule of thumb is that affordable housing should cost no more than 30% of household income, while transportation and housing combined should cost no more than 45% of household income. An analysis of residential locations in the Chicago region using the H+T methodology illustrates that walkable locations with better access to services and transit are more affordable than locations without these characteristics. The yellow-shaded areas in the left pane of the map below indicates areas considered affordable using housing alone, while the right pane shows combined housing and transportation costs, with the yellow-shaded "affordable" area covering a smaller extent of the map.



Source: Center for Neighborhood Technology, Chicago Region Fact Sheet, 2010

Social/Community Benefits

Health Impacts

In addition to health benefits from improved air quality as discussed in the previous section, BRT can create health benefits by encouraging bicycling and walking, known as "active transportation." Public transit and active transportation are complementary, since most public transit trips involve walking on one or both ends of the trip, and an average transit trip involves 5-10 times more walking than an automobile trip, according to travel surveys.[13] Transit facilities at BRT stations can encourage bicycle use by providing facilities such as bicycle racks on buses and secure lockers at stations. Mixed-use, transit-oriented development around BRT stations encourages active transportation for even non-transit trips. Transit users are likely to walk longer distances than non-transit users, and as shown in Figure 32, transit users of all income levels are more likely to make at least one daily walking trip. Figure 33 illustrates that obesity rates are inversely related to the level of walking, biking, and transit use across a range of developed nations.

And as the population ages[14], the region will see increased demand for transit and other non-automobile-based trips increase. BRT is more attractive than local bus service, especially for safety-conscious senior and those who did not previously use transit. Development at BRT station areas also creates opportunities for seniors to meet their mobility needs without traveling long distances.

13 VTPI, *Transportation Cost and Benefit Analysis: Safety and Health Costs, 2009.*

14 The Census Bureau has projected that the number of individuals 65 and older will grow by 36% in the next 10 years and by 79% in the next 20 years. Looking 20 years ahead, the most rapid growth will be in the age 75 to 84 group, which will grow by 89%. The old-old age group of people 85 and older will grow more than the general population in the next ten years, but will not see really rapid growth until the period after 2020.

Personal Transportation Costs

Figure 34 compares the cost of driving to other modes. Owning a car has high fixed costs (e.g., vehicle and insurance) depending on the type and age of the vehicle, but driving has relatively low incremental costs (e.g., gas, maintenance, parking and tolls). Modes such as public transit and bicycles have low fixed and incremental costs for individuals. Compact development patterns, quality transit service and other transportation options can save households money by allowing them to reduce the number of vehicles they own and/or the amount of travel. According to one study, the average potential savings per vehicle can be up to $3500 per year, the average annual cost of an additional vehicle.[15] Household savings on transportation costs translates into money they can spend in the local economy.

Social Interaction and Livability

The redevelopment potential of BRT, comparable to other high quality transit, provides it with the ability to foster the following benefits16:

- Creating places for community life;
- Acting as a catalyst for the renewal and revitalization of neighborhoods and downtowns;
- Creating opportunities for entrepreneurship and local economic development;
- Making communities safer and more comfortable;
- Making connections between neighborhoods, downtowns, and community destinations more accessible and convenient; and
- Shaping community growth.

15 Center for Urban Transportation Research, University of South Florida, Exploration of a Shift in Household Transportation Spending from Vehicles to Public Transportation, 2008

16 TCRP Report 22, The Role of Transit in Creating Livable Metropolitan Communities, 1997.

HOW ARE BRT PROJECTS FUNDED AND IMPLEMENTED?

Funding for transit projects consists of both capital and ongoing operating and maintenance costs. Capital costs are typically provided through a combination of federal and local sources, while operating costs are primarily a local responsibility. There is significant competition among projects for both federal and local capital funds, underscoring the importance of developing a project design that maximizes benefits and fostering corridor land use patterns with strong ridership potential. There are opportunities for public-private partnerships, particularly for infrastructure improvements supporting a transit project.

Figure 35 New Starts Project Evaluation Criteria

New Starts Project Justification Criteria*	Local Financial Commitment
• Mobility Improvements • Environmental Benefits • Operating Efficiencies • Cost Effectiveness • Transit Supportive Land Use Policies • Economic Development	• Share of capital costs from sources other than New Starts • Strength of capital financing plan • Ability to fund ongoing operation and maintenance

Source: Federal Transit Administration.

Federal Capital Funding

The major federal funding source for BRT projects is the New Starts program administered by the Federal Transit Administration (FTA). As shown in Figure 35, the FTA evaluates New Starts projects based on six "project justification" criteria and the level of local financial commitment. The vast majority of BRT projects are funded under Small Starts, a category of the New Starts program for projects requesting up to $75 million in New Starts funding and costing up to $250 million. Small Starts has a less intensive approval and evaluation process, and is not limited to the fixed guideway (running way) portion of a project. The FTA recommended that Congress fund 11 BRT projects under Small Starts in the 2011 fiscal year, covering between 32% and 80% of the total capital cost. The Very Small Starts program is another subset of New Starts for projects costing up to $50 million overall and no more than $3 million per mile.

Local Capital and Operations Funding

The Regional Transportation Authority (RTA) has oversight over transit capital and operations funding for the six-county region that includes Kane County. It allocates federal funds and state/local funds including sales taxes and bonds to capital projects and transit operations. Pace has proposed a network of BRT corridors (called Arterial Rapid Transit) throughout its service area, including Randall Road. The Randall Road corridor would need to demonstrate benefits and ridership potential competitive with the other proposed corridors to be added to the RTA long-range capital plan.

Public-Private Partnerships

The development potential of BRT allows public-private funding strategies to be used to contribute to infrastructure costs and/or BRT capital and operating costs. These strategies include:

- **Tax Increment Financing (TIF).** Property taxes collected on the incremental increase in property values within a defined district and time period (maximum 23 years in Illinois), can be used to finance infrastructure improvements. In Illinois, For example, the Village of Schaumburg created a TIF district in 2009 around a planned STAR Line station area to promote TOD and improve infrastructure.
- **Benefit Assessment Districts.** Properties within the district are assessed a variable fee, typically based on the distance from a station to cover construction, maintenance, or infrastructure improvements. In Denver (CO) rates varied from $.05 to $0.45 and generated $2.2 million in revenues, used to fund ongoing maintenance.[1]
- **Joint Development.** Ground or air rights can be leased around a specific station to provide a revenue stream for operations and/or encourage development around the station. At the Ohlone-Chynoweth light rail station in California's Silicon Valley, the Santa Clara Valley Transit Authority receives $300,000 annually from a 75-year lease of an adjacent mixed-use development.[2]

1 Levinson et al, Bus Rapid Transit, *Volume 2: Implementation Guidelines*, 2003

2 Levinson et al, Bus Rapid Transit, *Volume 2: Implementation Guidelines*, 2003

Land Use and Jurisdictional Coordination

Land use policy and economic incentives are needed to encourage the most intensive development around BRT station areas to assure successful implementation of a BRT project. Given the many jurisdictions along the Randall Road Corridor, all stakeholders must collaboratively identify shared land use and operating goals for the service. Station area land use planning must be consistent throughout the corridor as gaps in transit-supportive land uses at agreed upon development nodes can impact ridership and service quality. A key challenge that must be negotiated is the autonomous willingness to change zoning to allow for denser mixed use districts at station area nodes. Station area density and land use diversity are primary ridership generators and key strategies for ensuring successful BRT implementation. Land developers could be included in the process to identify opportunities for nodal development along the corridor.

Applicable jurisdictions must develop a shared understanding regarding the land use policy and economic incentives to encourage the most intensive development around BRT station areas. Such incentives can be implemented through a transit overlay zoning district. Inter-jurisdictional agreements regarding a comprehensive transit overlay zoning district could facilitate the necessary land use and zoning changes to promote dense, mixed use station area development. This type of overlay zoning district would expand upon land use and zoning regulation by stipulating parking management strategies that promote transit-oriented development (i.e. eliminating minimum parking requirement), urban design guidelines (i.e. site design, streetscape), and policies make the pedestrian and bicycle environment more safe and inviting. All parties need to ensure that future development of commercial and residential centers and major employment hubs are located along the BRT line per an agreed upon vision for the corridor.

Project Phasing

The flexibility of BRT systems allows them to be built in phases. The following are several possible phasing approaches that can be employed in BRT projects generally Because there is no existing transit service on a large portion of the Randall/Orchard corridor, not all phasing options make sense in this case (e.g. vehicles)[3]: Project phases can add specific BRT elements as needed or afforded including:

- Changing from a mixed to dedicated running way in parts of the corridor
- Extending the transit corridor
- Providing transit signal priority at congested intersections
- Adding branches to both extend the corridor and increase service frequency along the core of the corridor
- Increasing the hours of service and/or the days of service
- Providing specialized BRT vehicles

3 Levinson et al, *Bus Rapid Transit, Volume 2: Implementation Guidelines*, 2003

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