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BUS RAPID TRANSIT
Synthesis of Case Studies

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ABSTRACT

Bus rapid systems have grown in popularity in recent years. Spurred by Federal initiatives, the spiraling cost of rail transit, and market realities, a growing number of cities have installed or are planning BRT. This paper presents a synthesis of current experience, drawing upon ongoing research conducted in the project TCRP A-23. The paper describes the nature of BRT; where BRT operates; key features such as running ways, stations, vehicles, ITS, and service patterns; performance in terms of ridership, travel times and land development; and the emerging implications for new systems. It is important to match transit markets to rights-of-way; achieve benefits in speed, reliability, and identity, minimize adverse impacts to street traffic, property access, and pedestrians; and obtain community support throughout an open planning process.

I. INTRODUCTION AND CONTEXT

Transportation and community planning officials throughout the world are examining improved public transportation in addressing their urban mobility issues. Their renewed interest in public transportation reflects concerns arising from environmental protection to the desire for alternatives to clogged highways and urban sprawl.

These concerns have prompted many transit agencies to re-examine existing technologies and to embrace creative ways of improving service quality in a cost-effective manner. As a result, bus rapid transit systems have been built throughout the world. BRT systems have operational flexibility, and can be built quickly, incrementally, and economically. These advantages underlie the growing popularity of BRT in the United States. BRT development in the US has also been spurred by the Federal Transit Administration (FTA) BRT initiative.

The Transit Cooperative Research Program (TCRP) project A-23 was initiated in response to the need for better information on the role of BRT; and the features, designs, and implementation of bus rapid transit projects. Products from this study include a brochure “BRT – Why More Communities Are Choosing Bus Rapid Transit”, a report on “Case Studies in Bus Rapid Transit” that is being published, and “Planning and Implementation Guidelines” that is forthcoming.

This paper summarizes the key findings of the analysis conducted for the case studies report.[1] It describes the nature, features, and effectiveness of bus rapid transit, as well as the planning, design, and operational implications of current BRT experience. The case studies were selected to reflect geographic diversity and a range of BRT applications.

A. What is Bus Rapid Transit?

FTA defines bus rapid transit as “a rapid mode of transportation that can combine the quality of rail transit and the flexibility of buses”.[2] A more detailed definition, which was developed as part of TCRP A-23, is that “BRT is flexible, rubber tired rapid transit mode that combined stations, vehicles, services, running ways, and intelligent transportation system (ITS) elements into an integrated system with a strong positive image and identity. BRT applications are designed to be appropriate to the market they serve and their physical surroundings and can be incrementally implemented in a variety of environments”. In brief, BRT is an integrated system of facilities, services and amenities that collectively improve the speed, reliability, and identity of bus transit.

BRT, in many respects, is rubber-tired light rail transit (LRT) but with greater operating flexibility and potentially lower capital and operating costs. Often a relatively small investment in special guideway (or “running ways”) can provide regional rapid transit. The research conducted in TCRP A-23 indicates that:

- Where BRT vehicles (buses) operate totally on exclusive or protected rights-of-way, the level of service provided can be similar to that of full Metro rail rapid transit.
- Where buses operate in combinations of exclusive rights-of-way, median reservations, bus lanes, and street running, the level of service provided is similar to light rail transit.
- Where buses operate mainly on city streets in mixed traffic, the service provided is similar to a tram or streetcar system.

BRT systems may provide line-haul transport, and they may serve as feeders to rail transit lines. The principal features include running ways, stations, vehicles, route structure, fare collection, and ITS. Carefully and collectively applied, these elements can improve speed, reliability, and identity.

B. Where Bus Rapid Transit Operates

The locations, urban populations, rail transit availability and development status of the 26 case study cities are shown in Table 1. They include 12 cities in the United States: Boston, Charlotte, Cleveland, Eugene, Hartford, Honolulu, Houston, Los Angeles, Miami, New York, Pittsburgh, and Seattle; two cities in Canada – Ottawa and Vancouver, Canada; three cities in Australia – Adelaide, Brisbane and Sydney; three in Europe – Leeds, Runcorn, and Rouen; and five in South America – Belo Horizonte, Bogotá, Curitiba, Quito and Sao Paulo. Most of these BRT systems are found in cities with populations of over 700,000. Many of the locations also have rail transit. Twenty-one systems are in revenue service, and five are under construction, development or planned. Nine of the 14 systems in the United States and Canada are in urban areas near a downtown employment center that exceeds 85,000.

C. Why Implement Bus Rapid Transit

Based on input by transit agencies that have implemented BRT systems, the main reasons reported for implementing BRT were its lower development costs and greater operating flexibility as compared with rail transit. Other reasons that were cited include that BRT is a practical alternative to major highway reconstruction, it can be an integral part of the city’s structure, and it can serve as a catalyst for redevelopment. A 1976 study in Ottawa, for example, found that a bus-based system could be built for half the capital costs of rail transit, and it would be 20% cheaper to operate.[3] In Boston, BRT was selected because of its operational and service benefits, rather than its cost advantages alone.

II. FEATURES

The main features of bus rapid transit include dedicated running ways, attractive stations, distinctive easy-to-board vehicles, off-vehicle fare collection, use of ITS technologies, and frequent all-day service. Table 2 provides a brief description of each system in the 26 cities analyzed along with its principal BRT features. Table 3 summarizes the BRT features offered by continent (the 29 entries in the table reflect the multiple systems in Los Angeles and New York). Most systems (over 80%) have some type of exclusive running way – either a busy-only road or bus lane; more than three-quarters provide frequent all-day services; and about 2/3 have “stations” rather than stops. In contrast, only about 40% have distinctive vehicles or apply ITS; and only 17% (5 systems) have or will have off-vehicle fare collection. Three existing systems – Bogotá’s TransMilenio, Curitiba’s median busways, and Quito’s Trolebus have all six basic features. Several systems under development (e.g. Boston, Cleveland, and Eugene) will have most BRT elements.

A. Running Ways

Running ways for BRT include mixed traffic lanes, curb bus lanes, and median busways on city streets, reserved lanes on freeways; and bus-only roads and tunnels. Table 4 summarizes the various running ways by continent. Several key observations from the case studies are as follow:

- Busways dominate North American and Australian practice, while median arterial busways are widely used in South America. Reserved freeway lanes for buses (and car pools) are found in the United States and Canada. Figure 1 shows the East Busway in Pittsburgh. Figure 2 shows a median arterial busway in Richmond, British Columbia.

- Existing bus tunnels in Brisbane and Seattle and a bus tunnel under construction in downtown Boston bring a major feature of rail transit to bus operations.

- Running ways are mainly radial, extending to or through the city center. A significant exception is a BRT line in Vancouver, B.C. that is “anchored” at the University of British Columbia.

- Running ways may include elements for optical or mechanical guidance, which may yield benefits in travel speeds, safety and precision docking.

Bus lanes are typically 11 to 12 feet wide. Shoulders are provided along busways where space exists. At busway stations, roadways are widened to about 50 feet. Busway envelopes are about 40 to 50 feet between stations. At stations, the busway envelope (4 travel lanes, plus station platforms) approximates 75 feet. Fences are provided along busway stations in Ottawa.

Arterial median busways in many South American cities provide passing lanes around stopped buses at stations. Typically, the stations platform is offset, thereby resulting in a staggered three-lane road section.

Examples of typical curbside and median running ways are shown in Figures 1 and 2.

B. Stations

BRT station characteristics and features include spacing, length, bypass capabilities, platform height, fare collection practices, and amenities. They vary widely from system to system.

Spacing

Average station spacing by type of running way is shown in Table 5. The spacing of stations along freeways and busways range from 2,000 to 21,000 feet, enabling buses to operate at high speeds. Spacing along arterial streets range upward from about 1,000 feet (Cleveland and Porto Alegre) to over 4,000 feet (Vancouver and Los Angeles). The Runcorn Busway, which operates on an exclusive busway that is partially elevated, has ¼- mile station spacings.

Location

Most stations are located curbside or on the outside of bus-only roads and arterial median busways. However several systems have center island platforms, including Bogotá, a section of Quito’s Trolebus, and Curitiba’s “direct” express bus service.

Length

Station length depends upon bus volumes. Stations typically accommodate two to three buses, although busy stations may accommodate four to five vehicles. Station lengths depend upon the type of buses operated. Boston’s Silver Line, for example, will have 220-foot long platforms that can handle three 60-foot articulated buses. Bogotá’s TransMilenio busway has bus stations ranging up to 500 feet, but this is not typical.

Most BRT stations have low platforms since many are or will be served by low-floor buses. However, Bogotá’s TransMilenio, Quito’s Trolebus, and Curitiba’s all-stop and direct services provide high platforms that allow level passenger boarding and alighting. Each of these systems also has off-vehicle fare collection. These stations function essentially like those along rail rapid transit lines. For example, fare prepayment, along with the use of multi-door buses, reduced dwell time to about 20 seconds per stop in Curitiba.

Design Features

Stations along the case study systems provide a broad range of features and amenities, depending on location, climate, type of facility, and available space. Some are simple, attractive canopies, such as those along Miami's Busway or Los Angeles' Metro Rapid lines. Others, like those along Brisbane's South East Busway (shown in Figure 3), provide distinct and architecturally distinguished designs as well as a full range of pedestrian facilities and conveniences. The "high platform" stations in Bogotá, Curitiba and Quito, contain extensive space for fare payment. Curitiba's distinctive tube stations have become an internationally-recognized symbol.

Overhead pedestrian walks connect opposite sides of stations in Brisbane and Ottawa, as well as busy stations in Pittsburgh. In some situations, access to both platforms is provided from roadway overcrossings of the busway.

C. Vehicles

Conventional standard and articulated diesel buses are widely used in BRT systems. However there is a trend toward innovations in vehicle design, in terms of (1) "clean" vehicles, (2) dual-mode operations through tunnels; (3) low-floor buses; (4) more and wider doors; and (5) the use of dedicated and distinctively designed vehicles. Examples of innovative vehicle designs include:

- Los Angeles' low-floor red-colored CNG vehicles.
- Boston's planned multi-door dual-mode electric and CNG buses.
- Curitiba's double articulated buses with 5 sets of doors and high-platform loading.
- Rouen's Irisbus Civis vehicle–a "new design" hybrid diesel-electric articulated vehicle with train-like features, four doors, the ability to be optically guided, and a minimum 34-inch wide aisle (shown in Figure 4).
- Bogotá's TransMilenio buses also have train-like styling and a futuristic appearance.

D. Intelligent Transportation Systems

Selected applications of intelligent transportation system technologies in BRT operations are set forth in Table 6. The applications shown cover (1) automatic vehicle location systems (AVL), (2) passenger information systems (e.g. automated station announcements on vehicles, real time information at stations), and (3) traffic signal priorities.

- BRT systems using AVL include Boston (under construction), Hartford (under development), Los Angeles, Ottawa, Vancouver, Brisbane, Sydney (proposed) and Bogotá.

- Systems with passenger information systems include Boston (recently opened), Hartford (under development), Ottawa, Pittsburgh (some buses), Vancouver, Brisbane, and Curitiba.

- Systems having traffic signal timing priorities or special bus phases include Cleveland (under development), Los Angeles, Vancouver, and Rouen. The Metro Rapid lines in Los Angeles, for example, can get up to 9 seconds additional green time when buses arrive at a signalized intersection. However, at major intersections, advancing and extending the green time for buses can take place only every other cycle. Porto Alegre has a bus platoon dispatching system (Commonor) that is used to increase bus throughput.

E. Service Patterns

Service patterns reflect the types of running way and vehicles utilized. Many systems provide an "overlay" of express (or limited stop) service, as well as all-stop or local service, plus "feeder" bus lines at selected stations. Service in most systems extends beyond the limits of busways or bus lanes, which is an important advantage of BRT. However, the Bogotá, Curitiba, and Quito systems operate only within the limits of the special running ways because of door arrangements, platform heights and/or propulsion systems. These systems actually function similarly to surface rail rapid transit lanes.

Busways – either along separate rights of way or within street medians – have basic "all stop" service with an overlay of express operations, mainly during peak periods. In a few cases, such as Cleveland and Curitiba, the arterial express service is (or will be) provided along nearby parallel streets. A diagram of all stop and express services is presented in Figure 5.

BRT operations in mixed traffic – as in Honolulu, Los Angeles, New York City, and Vancouver- provide "limited stop" service. Local bus service is also operated along the streets as part of the normal transit service. Rouen's TEOR BRT also provides limited stop service along arterial streets.

Buses operating in New York City's reverse-flow expressway bus lanes run non-stop. Buses using median expressway lanes in Charlotte and Houston's HOV lanes also operate without making intermediate stops.

III. PERFORMANCE

The performance of BRT systems can be measured in terms of passengers earned, ridership growth, travel speeds, and travel time savings.

A. Ridership

Ridership for the various BRT case studies was reported in weekday riders, peak hour flows, and increases in ridership. The values and increases in ridership are as follows:

Weekday Riders

The weekday ridership reported for systems in North America and Australia are shown in Table 7. Ridership ranged from about 1,000 in Charlotte up to 40,000 or more in Boston, Los Angeles, Seattle, and Adelaide.

Daily ridership in South American cities is substantially higher. Reported values for specific facilities range from 150,000 in Quito to about 600,000 in Bogotá. Total bus system riders exceed 1 million in Belo Horizonte, Curitiba and Porto Alegre.

Peak-Hour Flows and Riders

The peak-hour, peak-direction bus volumes and riders at maximum load points are shown in Table 8.

Peak-hour, peak direction bus flows (usually at the maximum load point) exceed 650 on the New Jersey approach to the Lincoln Tunnel and the Midtown Bus Terminal. Ottawa's Transitway system reports bus volumes of 180 to 200 along downtown bus lanes. These volumes result from high use of passes, an honor fare system on the busway all-stop routes, and use of multi-door articulated buses.

Peak-hour flows of over 100 buses per hour are found in New York City's Long Island and Gowanus Expressway contra-flow bus lanes. Most other facilities in the United States and Australia have less than 100 buses per hour. Flows of about 50 to 70 buses per hour are typical.

The South American arterial median bus lanes with passing capabilities at stations carry as many as 300 buses per hour one-way at the maximum load point. The Curitiba and Quito systems, which function similar to light-rail, operate at 90 second headways or 40 buses per hour.

The heavier peak-hour, peak-direction passenger flows at the maximum load sections are as follows:

Over 20,000	I-495 on approach to Lincoln Tunnel
	Bogotá's TransMilenio Busway
	Porto Alegre
	Sao Paulo
8,000-20,000	Belo Horizonte
	Ottawa
	Quito
	Curitiba
	Brisbane
	Pittsburgh

These flows equal or exceed the number of rail transit passengers carried in many U.S. and Canadian cities.

Ridership Increases

Reported increases in bus riders reflect expanded service, reduced travel times, improved facility identity, and population growth. Examples of reported ridership gains are:

Houston: 18 to 30% of riders did not make trip before.
Los Angeles: 26 to 33% gain of which 1/3 were new riders.
Vancouver: 8,000 new riders of which 20% previously used cars and 5% represented new trips.
Adelaide: 76% ridership gain.
Brisbane: 42% ridership gain.
Leeds: 50% ridership gain.

B. Speeds and Travel Times

Operating speeds reflect the type of running way, station spacing, and service pattern. Reported speeds by type of running way and geographic area are shown in Table 9. Typical speeds are as follows:

- Freeway-Busway: Non-Stop: 40-50 mph
  All-Stop: 25-30 mph

- Arterial Streets*:* Express, Bogotá, Curitiba: 19 mph
  Metro bus, LA Ventura Blvd., 19mph
  Metro bus, LA Wilshire Blvd. and Wilshire Blvd, L.A.: 14 mph
  All-Stop – Median Busways, South America: 11-14 mph
  Limited Stop Bus Service – New York City: 8-14 mph

Reported travel time savings are as follows:

- Busways, Freeway Lanes: 32-47%
- Seattle's Bus Tunnel: 33%
- Bogotá: 32%
- Porto Alegre: 29%
- Los Angeles Metro Bus: 23-28%

Busways on essentially grade separated right-of-way generally save 2 to 3 minutes per mile. Bus lanes on arterial streets typically save 1 to 2 minutes per mile. Savings are greatest where buses previously experienced major congestion.

IV. BENEFITS AND COSTS

Bus rapid transit systems – largely as a result of faster journey times – have resulted in lower operating costs, less fuel consumption, greater safety, and land development benefits. Table 10 summarizes some of the benefits reported for selected systems.

A. Land Development

Reported land development benefits are similar to those experienced along rail transit lines. An analysis of the Ottawa Transitway indicated that the system contributed to about $675 million ($U.S.) in new construction around transit stations. Similarly, a study by the Port Authority of Allegheny County found that Pittsburgh's East Busway resulted in $302 million in new and improved development. Property values near Brisbane's South East Busway were reported to grow by 20%. In several cities (e.g. Ottawa) land development policies have concentrated major activities along busways.

B. Costs

Facility development costs reflect the time, type, and complexity of construction. Reported median costs were $272 million per mile for bus tunnels (2 systems), $7.5 million per mile for busways (12 systems), $6.6 million per mile for arterial median busways (5 systems), and $4.7 million per mile for guided bus operations (2 systems), and $1 million per mile for mixed traffic or curb bus lanes (3 systems).

Operating costs for BRT service are influenced by wage rates and work rules, fuel and electricity costs, operating speeds and ridership. Operating costs for Pittsburgh's East and South busway (1989) averaged $0.52 per passenger trip. Costs per trip for light rail lines in Buffalo, Pittsburgh, Portland, Sacramento, and San Diego averaged $1.31; the range was from $0.97 (San Diego) to $1.68 (Sacramento). These comparisons, although limited, suggest that BRT can cost less per passenger trip than light rail transit.[4]

V. IMPLICATIONS

Each city has a unique set of circumstances that will influence the need for, and the planning design, and operations of BRT. Within this context, many common lessons and implications emerge from an analysis of the case studies. While several of these implications are common to rapid transit, many also apply to rapid transit in general, most are unique to BRT.

A. Development Process

BRT system development should be an outgrowth of a planning and project development process that addresses demonstrated needs and problems, rather than solution advocacy. This open and objective process should be undertaken throughout all phases of BRT development.

Early and continuous community support from elected leaders and citizens is essential. Public decision makers and the general community must understand the nature of BRT and its potential benefits. BRT's customer attractiveness, operating flexibility, capacities, and costs should be clearly and objectively identified, usually through an alternatives analysis that considers other options as well.

State, regional and local agencies should work together in planning, designing, implementing and operating BRT. This requires close cooperation of transit service planners, city traffic engineers, urban planners, and police. Metropolitan planning agencies and State DOT's should be major participants.

B. Market Considerations

BRT should serve demonstrated markets. Urban areas with more than a million residents and a central area employment of at least 80,000 are good candidates for BRT. These areas generally have sufficient corridor ridership demands to allow frequent all-day service. BRT works especially well in physically constrained environments where hills, tunnels, and water crossings result in frequent traffic congestion.

It is essential to match markets with rights-of-way. The presence of an exclusive right-of-way, such as along a freeway or railroad corridor is not always sufficient to ensure effective BRT services. This is especially true where the rights-of-way are removed from major transit markets and stations are inaccessible. Ideally, BRT systems should be designed to penetrate major transit markets. BRT systems are flexible enough to allow for service design that connects to major transit markets.

C. System Development

The key attributes of rail transit should be transferred to BRT wherever possible. These include segregated or prioritized rights-of-way, attractive stations, off-vehicle fare collection, easily accessible multi-door vehicles, and clear, frequent, rapid service. A successful BRT project requires more than merely providing a queue bypass, bus lane, or dedicated busway. It requires the entire range of rapid transit elements, and the development of a unique system image and identity, and a sense of permanence, speed and reliability are essential.

Incremental development of BRT may often be desirable. This will demonstrate BRT's potential benefits as soon as possible to riders, decision makers, and the general public, while still enabling expansion and possible upgrading of systems.

Within this context, BRT systems should be reasonable in terms of usage, travel time savings, costs, development benefits and traffic impacts. Therefore corners should not should not be cut.

D. Integration with Land Use

BRT and land use planning in station areas should be integrated as early as possible. Adelaide, Brisbane, Ottawa, Pittsburgh, and of course, Curitiba, have demonstrated that BRT can have land use benefits similar to those resulting from rail transit. Close working relationships with major developers may be necessary in addressing issues of building orientation, building setbacks and connections to stations.

Parking facilities should complement, not undercut BRT. Adequate parking is essential at stations along high-speed transitways in outlying areas. It may be desirable to limit downtown parking space for employees, especially where major BRT investments are planned, or in service.

E. Design and Operations

Bus rapid transit should be rapid. This is best achieved by operating on exclusive rights-of-way wherever possible, and by maintaining wide spacing between stations. Separate rights-of-way can enhance speed, reliability, safety and identity. They can be provided as integral parts of new town development or as an access framework for areas that are still undeveloped. Bus tunnels may be desirable where congestion is frequent, bus volumes are high, and street space is limited. Where possible, busways should be grade separated, especially at major intersections. This will improve both travel times and safety.

The placement, design, and operation of bus lanes and median busways on streets and roads must take into account and balance the diverse needs of buses, delivery vehicles, pedestrians, and the general traffic flow. Curb bus lanes allow curbside boarding and alighting, but they may be difficult to enforce. They also pose conflicts for right turns and as such may not be practical for urban corridors with many access points for adjacent land uses.

Median busways provide good identity and avoid curbside interferences, but they may pose problems with left turns and pedestrian access. Moreover, they require wide streets, generally about 75 feet or more from curb-to-curb. They may be developed on narrower streets where left turns are limited, and where general traffic is in a single lane each way.

Coordinated traffic engineering and transit service planning is essential in designing running ways, locating bus stops and turn lanes, applying traffic controls, and establishing traffic signal priorities for BRT.

Vehicle design, station design and fare collection procedures should be coordinated. Stations should be accessible by bus, car, and/or foot; provide adequate berthing capacity, passing lanes for express buses (or busways), and suitable amenities for passengers. Buses should be distinctively designed and delineated, and provide sufficient passenger capacity, multiple doors and low-floors for easy passenger access, and ample interior circulation space. Off-vehicle fare collection is desirable, at least at major boarding points. Achieving these features calls for changes in operating philosophies and practices of many transit agencies. More focus should be placed on reducing dwell time. ITS and smart card technology applied at multiple bus doors may expedite on-board payment without losing revenues.

F. Service and Design

BRT services should be keyed to transit markets. The maximum number of buses during peak hour should meet ridership demands and simultaneously minimize bus-bus congestion. Generally, frequent all-stop trunk-line service throughout the day should be complemented by an “overlay” of peak period express service to and from specific markets. During off-peak periods, the overlay service could operate as feeders (or shuttles) to BRT stations. BRT service can extend beyond the limits of dedicated running ways where a reliable, relatively high-speed operations can be sustained. Outlying sections of BRT lines and downtown distribution can use bus lanes or even operate in the general traffic flow.

VI. CONCLUSIONS AND DIRECTIONS

There is a growing number of bus rapid transit systems throughout the world. A review of these experiences indicates that BRT can reduce saving times, attract new riders, and induce transit-oriented development. It can be more cost effective and provide greater operating flexibility than rail transit. BRT can also be a cost extension of rail transit lines. And it generally can provide sufficient capacities to meet peak-hour travel demands in most U.S. corridors.

There is, however, a need for improvements in vehicle design and system identity. There remain missing elements in many BRT systems, often a result of cost-cutting measures made during the development process. Other considerations include maintaining high average trip speeds. High speeds can be best achieved when a large portion of the service operates on separate rights-of-way. In addition, major BRT investments should be reinforced by transit supportive land development and parking policies.

More cities can be expected to implement BRT systems in the future. There will be a growing number of fully integrated systems, and even more applications of selected elements. These efforts will lead to substantial improvements in transit access and mobility.

TABLE 1: BRT CASE STUDIES

CITY	URBANIZED AREA POPULATION (MILLIONS)	RAIL TRANSIT IN CITY
U.S. AND CANADA		
Boston[2]	3.0	X
Charlotte	1.4	
Cleveland[2]	2.0	X
Eugene[2]	0.2	
Hartford[2]	0.8	
Honolulu	0.9	
Houston	1.8	
Los Angeles	9.6[1]	X
Miami-Dade	2.3	X
New York City	16.0	X
Ottawa	0.7[2]	X
Pittsburgh	1.7	X
Seattle	1.8	[4]
Vancouver	2.1	X
AUSTRALIA		
Adelaide	1.1	X
Brisbane	1.5	X
Sydney[2]	1.7	X
EUROPE		
Leeds, U.K.	0.7	
Rouen, France	0.4	X
Runcorn, UK	1.7	
SOUTH AMERICA		
Belo Horizonte, Brazil	2.2	X
Bogotá, Columbia	5.0	
Curitiba, Brazil	2.6	
Porto Alegre, Brazil	1.3	X
Quito, Ecuador	1.5	
Sao Paulo, Brazil	8.5	X

(1) Los Angeles County only
(2) Under Development
(3) Excludes Holl, Quebec
(4) Seattle has limited commuter rail service

TABLE 2: BRT SYSTEM FEATURES

City	Urbanized Area Population	Facility Description	Running Way	Stations	Distinct-ive Easy-to Board Vehicles	Off-Vehicle Fare Collect.	ITS	Frequent All Day Service
1. Boston	3.0	Silver Line – Bus Tunnel, Lanes	x	**x**	x	x	x	x
2. Charlotte	1.4	Independence Blvd. Freeway Busway	x	x				
3. Cleveland	2.0	Euclid Ave – Arterial Median Busway	x	x	x		x	x
4. Eugene	0.2	Eugene-Springfield Arterial Median Busway	x	x	x		x	x
5. Hartford	0.8	Hartford-New Britain Busway	x	x			x	
6. Honolulu	0.9	City and County Express (Mixed Traffic)	x	x	x			x
7. Houston	1.8	High Occupancy Vehicle Lane System	x	c	e			
8. Los Angeles	9.6	Harbor Freeway HOV/Busway San Bernardino Freeway HOV/Busway Wilshire-Whittier & Ventura Metro Bus (Mixed Traffic)	x	x	x		x	x
9. Miami	2.3	Miami-S. Dade Busway	x	x				x
10. New York City	16.0	I-495 NJ, I-495 NY, Gowanus AM Contra-Flow Lanes Arterial Limited Stop Service	x	x				x
11. Ottawa	0.7	Transitway System (Busway, Bus Lanes)	x	x			x	x
12. Pittsburgh	1.7	South, East, West Busways	x	x				x
13. Seattle	1.8	Bus Tunnel	x	x				x
14. Vancouver	2.1	Broadway & Richmond “B” Lines (Mixed Traffic)	a	x	x		x	x
AUSTRALIA								
15. Adelaide	1.1	O-Bahn Guided Busway	x	x				x
16. Brisbane	1.5	South East Busway	x	x			x	x

City	Urbanized Area Population	Facility Description	Running Way	Stations	Distinct-ive Easy-to Board Vehicles	Off-Vehicle Fare Collect.	ITS	Frequent All day service
17. Sydney	1.7	Liverpool-Parramatta Busway – Bus Lanes	x	d			x	d
EUROPE								
18. Leeds (UK)	0.7	Superbus Guided Bus System	b	d				x
19. Rouen (France)	0.4	Optically Guided Bus – Bus Lanes	x	x	x	G	x	x
20. Runcorn (UK)	0.1	Figure 8 Busway	x	x				x
SOUTH AMERICA								
21. Belo Horizonte (Brazil)	2.2	Avenida Christiano Median Busway	x	c				x
22. Bogotá (Columbia)	5.0	TransMilenio Median Busway	x	x	x	x	x	x
23. Curitiba (Brazil)	1.6	Median Busway System	x	x	x	x	x	x
24. Porto Alegre (Brazil)	1.3	Assis Brasil & Farrapos Median Busways	x	d				
25. Quito (Ecuador)	1.5	Trolebus Median Busway	x	x	x	x	x	x
26. Sao Paulo (Brazil)	8.5	9 De Julho & Jaraquara Median Busways	x	f				x

Notes:

(a) Has a short median busway.
(b) Queue bypasses at congested locations.
(c) Four terminal stations.
(d) Not specified.
(e) Uses over-the-road coaches.
(f) Median bus stops.
(g) Limited.
(h) Where all day limited-stop service is provided.

Source: TCRP A-23, Individual Case Studies

TABLE 3: NUMBER OF FACILITIES WITH SPECIFIC FEATURES

FEATURE	US/ CANADA	AUSTRALIA /EUROPE	SOUTH AMERICA	TOTAL	% (OF 29 SYSTEMS)
Running Way	13	5	6	24	83
Stations	12	4	3	19	65
Distinctive Vehicles	7	1	3	11	38
Off-Vehicle Fare Collection	1	0	3	4	14
ITS	7	1	3	11	38
Frequent All-Day Service	11	5	6	22	76
TOTAL SYSTEMS	**17**	**6**	**6**	**29**	**100**

TABLE 4: RUNNING WAY CHARACTERISTICS

LOCATION	BUS TUNNEL	BUSWAY (Separate Right-of-Way)	FREEWAY BUS LANES	ARTERIAL MEDIAN BUSWAYS	BUS LANES	MIXED TRAFFIC
North America	Boston, Seattle	Charlotte, Hartford, New Britain, Miami, Ottawa, Pittsburgh	Houston, Los Angeles, New York City	Cleveland, Eugene, Vancouver	Vancouver	Honolulu, Los Angeles, Vancouver
Australia	Brisbane	Adelaide[1], Brisbane, Sydney				
Europe		Runcorn			Rouen[2]	Leeds[1]
South America				Belo Horizonte, Bogotá[3], Curitiba[3], Porto Alegre, Quito[3], Sao Paulo		

[1] O-Bahn Guided Bus
[2] Guided bus with queue bypass
[3] Optically Guided Bus – High platform station with fare prepayment

TABLE 5: STATION – SPACING BY TYPE OF RUNNING WAY (FEET)

LOCATION	BUS TUNNEL	SPACING (feet)	BUSWAY/ FREEWAY	SPACING (feet)	ARTERIAL BUSWAYS/ BUS LANES	SPACING (feet)
North America	Boston	2,170	L.A.-San Bernardino	21,200	L.A.-Ventura	5,630
	Seattle	3,870	L.A.-Harbor Busway	7,200	L.A.-Wilshire-Whittier	4,580
			Ottawa	6,980	Vancouver	4,190
			Hartford – New Britain	4,200	Cleveland	1,230
			Pittsburgh	4,200		
			Miami	2,890		
Australia			Adelaide	13,020	Sydney	2,870
			Brisbane SE Busway	5,540		
Europe			Runcorn	1,390	Rouen	2,470
South America					Bogotá	2,110
					Curitiba	1,410
					Porto Alegre	1,005
					Quito	1,640
					Sao Paulo	2,000

TABLE 6: APPLICATION OF INTELLIGENT TRANSPORTATION SYSTEM (ITS) TECHNOLOGIES
(Selected Systems)

CITY	SYSTEM	AUTOMATIC VEHICLE LOCATION (AVL)	TELEPHONE INFO / STATIONS	PASSENGER INFORMATION AUTOMATED STATION ANNOUNCEMENTS ON VEHICLE	REAL TIME INFO AT STATIONS	TRAFFIC SIGNAL PRIORITIES
U.S./CANADA						
Boston	Silver Line	X	X	X	X	
Charlotte	Independence Corridor	X				
Cleveland	Euclid Ave					X
Hartford	Hartford-New Britain Busway	X	X	X		
Los Angeles	Wilshire-Whittier & Ventura BRT	X				X
Miami	Miami-S. Dade Busway		X			Removed
Ottawa	Transitway	X	X	X	X	
Pittsburgh	South-East-West Busways		X	Some buses	Selected locations	
Vancouver	Broadway and Richmond "B Lines"	X			X	X
AUSTRALIA						
Brisbane	South East Busway	X		X	X	
Sydney	Liverpool Parramatta BRT	X			X	
EUROPE						
Rouen	Optically Guided Bus	X		X		X
SOUTH AMERICA						
Bogotá	TransMilenio	X				
Curitiba	Median Busway System			X		

Notes: (1) GPS and Control Center
Source: Individual Case Studies

TABLE 7: REPORTED DAILY RIDERSHIP ON SELECTED BUS RAPID TRANSIT FACILITIES

System	City	Daily Ridership
Bus Subways	Boston	40-78,000(e)[1]
	Seattle	46,000
Busways	Ottawa	200,000
	Brisbane	60,000
	Pittsburgh	48,000
	Adelaide	30,000
	Hartford	20,000
	Sydney	18,000(e)
	San Bernardino (L.A.)	18,000
	Miami	12,000
	Harbor (L.A.)	9,400
	Charlotte	1,000
Arterial Streets	Wilshire (L.A.)	40,000[2]
	Cleveland	29,500(e)
	Vancouver	20,000-22,000
	Ventura (L.A.)	9,000[2]

Notes:
e - estimated
[1] higher values estimate for future
[2] excludes local bus riders on same street

TABLE 8: PASSENGER VOLUMES AND BUS FLOWS ON SELECTED FACILITIES

City	Facility (System)	Reported AM Peak-Hour Bus Flows and Passenger Volumes at Maximum Load Sections	
US/CANADA		**Bus**	**Riders**
Boston	Silver Line Bus Tunnel/Lanes	75	4,500
		115	8,600
Charlotte	Independence Blvd. Busway		
Cleveland	Euclid Ave. Median Busway		
Hartford	Hartford-New Britain Busway	20-24	1,000+/-
Houston	HOV System KATY	48	2,100
	I-45 North	63	3,300
	Northwest	34	1,500
	Gulf	21	1,200
	Southwest	54	
	Easter	22	1,150
Los Angeles	Harbor Bus HOV Way	40(e)	1,800(e)
	San Bernardino Bus HOV Way	70	2,750
	Wilshire-Whittier Metro Bus	30	1,500
	Ventura Blvd. Metro Bus	15(e)	750(e)
Miami	Miami- S. Dade Busway	20(e)	800(e)
New York City	I-495 (NJ) Contra-Flow Lane	650-830[1]	25,000-35,000[1]
	I-495 (LI) Exp. Contra-Flow Lane	125	5,240
	I-278 Gowanus Contra-Flow Lane	175	6,180
Ottawa	Transitway System	180-200	10,000
Pittsburgh	South Busway	50	2,000
	East Busway	110	5,400
	West Busway	40	1,700
Seattle	Bus Tunnel	70	4,200(e)
Vancouver	Broadway “B” Line	15	1,000(e)
	Richmond “B” Line	15	1,000(e)

City	Facility (System)	Reported AM Peak-Hour Bus Flows and Passenger Volumes at Maximum Load Sections	
AUSTRALIA			
Adelaide	O-Bahn Guided Busway		4,000
Brisbane	South East Busway	150	9,500
Sydney	Liverpool-Paramatta Busway/Lanes		
SOUTH AMERICA			
Belo Horizonte	Avenida Christiano Machado Median Busway	N/A	16,000
Bogotá	TransMilenio Median Busway	N/A	27,000[2]
Curitiba	Median Busway System	40	11,000
Porto Alegre	Assis Brasil Median Busway Farrapos Median Busway	326 304[3]	26,100 17,500
Quito	Trolebus	40	8,000
Sao Paulo	9 de Julio Median Busway Jabaquaro Median Busway	220+	18-20,000

[1] Facility operates only during AM Peak
[2] Total peak hour route ridership is 45,000
[3] PM Peak hour
e – estimated
N/A – not available

TABLE 9: BUS SPEEDS (MILES PER HOUR)

Type of Facility	City	Express	All Stop
Freeway or Busway	**U.S./Canada**		
	Hartford	38	30
	Houston	54	
	Los Angeles Harbor Busway		35
	San Bernardino		43
	Miami	18	12-14
	New York City (NJ) I-495 Contra-Flow Lane		35
	Ottawa	50	24
	Pittsburgh (3 busways)	40	30
Bus Tunnel	Seattle		13
Arterial	Cleveland		12
	New York City (limited stops)		8-14
	South America		
	Belo Horizonte		17
	Bogotá	19	13
	Curitiba	19	13
	Porto Alegre		11-14
	Sao Paulo		12-14

TABLE 10: REPORTED BENEFITS SELECTED SYSTEMS

1. LAND DEVELOPMENT BENEFITS

City and Facility	Benefit
Pittsburgh East Busway	59 New developments within a 1500 ft radius of station. $302 million in land development benefits of which $275 million was new construction. 80% clustered at station.
Ottawa Transitway System	$C 1 billion in new construction at Transitway stations.
Adelaide Guided Busway	Tea Tree Gully area is emerging into an Urban village.
Brisbane South East Busway	Up to 20% gain in property values near busway. Property values in areas within 6 miles of a station grew 2 to 3 times faster than those at greater distances.

2. OTHER BENEFITS

City and Facility	Benefits
Ottawa Transitway	150 fewer buses, with $58 million C savings in vehicle costs and $28 million C in operating costs.
Seattle Bus Tunnel	20% reduction in surface street bus volumes. 40% fewer accidents
Bogotá TransMilenio Median Busway	93% fewer fatalities. 40% drop in pollutants.
Curitiba Median Busway	30% less fuel per capita.

FIGURES

Figure 1: Martin Luther King Jr. East Busway, Pittsburgh, PA

Source: Port Authority of Allegheny County, PA

Figure 2: Median Arterial Busway in Richmond, British Columbia

Source: Greater Vancouver Transportation Authority

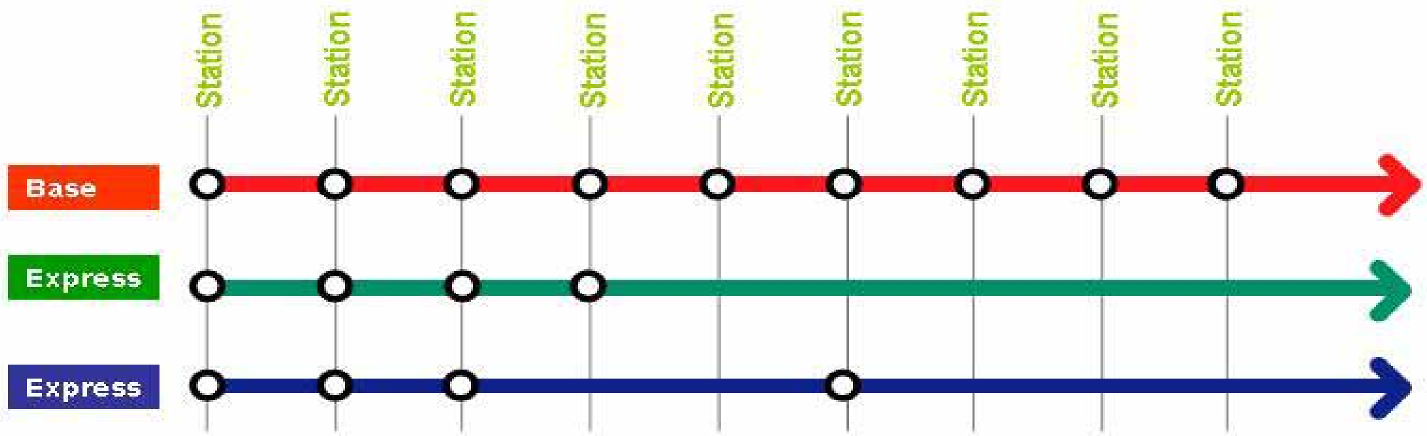
Figure 3: Griffith University BRT Station, Brisbane Australia

Source: Derek Trusler

Figure 4: Irisbus Civis Vehicle, Rouen, France

Source: Irisbus N.A.

Figure 5 – Example of All-Stops and Express Service Route Patterns



Source: DMJM+Harris

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