Division 44
Environment and Infrastructure
Sector project: "Transport Policy Advice"

Sustainable Transport:
A Sourcebook for Policy-makers in Developing Cities
Module 3b:

Bus Rapid Transit

Deutsche Gesellschaft für
Technische Zusammenarbeit (GTZ) GmbH

OVERVIEW OF THE SOURCEBOOK

Sustainable Transport: A Sourcebook for Policy-Makers in Developing Cities

What is the Sourcebook?

This *Sourcebook* on Sustainable Urban Transport addresses the key areas of a sustainable transport policy framework for a developing city. The *Sourcebook* consists of 20 modules.

Who is it for?

The *Sourcebook* is intended for policy-makers in developing cities, and their advisors. This target audience is reflected in the content, which provides policy tools appropriate for application in a range of developing cities.

How is it supposed to be used?

The *Sourcebook* can be used in a number of ways. It should be kept in one location, and the different modules provided to officials involved in urban transport. The *Sourcebook* can be easily adapted to fit a formal short course training event, or can serve as a guide for developing a curriculum or other training program in the area of urban transport; avenues GTZ is pursuing.

What are some of the key features?

The key features of the *Sourcebook* include:

- A practical orientation, focusing on best practices in planning and regulation and, where possible, successful experience in developing cities.
- Contributors are leading experts in their fields.
- An attractive and easy-to-read, colour layout.
- Non-technical language (to the extent possible), with technical terms explained.
- Updates via the Internet.

How do I get a copy?

Please visit www.sutp-asia.org or www.gtz.de/transport for details on how to order a copy. The *Sourcebook* is not sold for profit. Any charges imposed are only to cover the cost of printing and distribution.

Comments or feedback?

We would welcome any of your comments or suggestions, on any aspect of the *Sourcebook*, by email to sutp@sutp.org, or by surface mail to:

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Modules and contributors

Sourcebook Overview, and Cross-cutting Issues of Urban Transport (GTZ)

Institutional and policy orientation

1a. *The Role of Transport in Urban Development Policy* (Enrique Peñalosa)
1b. *Urban Transport Institutions* (Richard Meakin)
1c. *Private Sector Participation in Transport Infrastructure Provision* (Christopher Zegras, MIT)
1d. *Economic Instruments* (Manfred Breithaupt, GTZ)
1e. *Raising Public Awareness about Sustainable Urban Transport* (Karl Fjellstrom, GTZ)

Land use planning and demand management

2a. *Land Use Planning and Urban Transport* (Rudolf Petersen, Wuppertal Institute)
2b. *Mobility Management* (Todd Litman, VTPI)

Transit, walking and cycling

3a. *Mass Transit Options* (Lloyd Wright, ITDP; GTZ)
3b. *Bus Rapid Transit* (Lloyd Wright, ITDP)
3c. *Bus Regulation & Planning* (Richard Meakin)
3d. *Preserving and Expanding the Role of Non-motorised Transport* (Walter Hook, ITDP)

Vehicles and fuels

4a. *Cleaner Fuels and Vehicle Technologies* (Michael Walsh; Reinhard Kolke, Umweltbundesamt – UBA)
4b. *Inspection & Maintenance and Roadworthiness* (Reinhard Kolke, UBA)
4c. *Two- and Three-Wheelers* (Jitendra Shah, World Bank; N.V. Iyer, Bajaj Auto)
4d. *Natural Gas Vehicles* (MVV InnoTec)

Environmental and health impacts

5a. *Air Quality Management* (Dietrich Schwela, World Health Organisation)
5b. *Urban Road Safety* (Jacqueline Lacroix, DVR; David Silcock, GRSP)
5c. *Noise and its Abatement* (Civic Exchange Hong Kong; GTZ; UBA)

Resources

6. *Resources for Policy-makers* (GTZ)

Further modules and resources

Further modules are anticipated in the areas of *Driver Training*; *Financing Urban Transport*; *Benchmarking*; and *Participatory Planning*. Additional resources are being developed, and an Urban Transport Photo CD (GTZ 2002) is now available.

Module 3b:

Bus Rapid Transit

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GTZ Transport and Mobility Group, 2003

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Acknowledgements

The Institute for Transportation and Development Policy (ITDP) is an international non-governmental organisation dedicated to the promotion of transport options that are environmentally, economically and socially sustainable. ITDP's Bus Rapid Transit Programme provides assistance to municipalities, non-governmental organisations, and other stakeholders in order to realize fully implemented BRT systems. ITDP helps to provide the technical and informational resources that allow municipalities to develop BRT.

Mr. Wright directs the Latin American activities of ITDP. He also directs the organisation's International Bus Rapid Transit Programme. He has also worked with the International Institute for Energy Conservation, the US Environmental Protection Agency, the US Agency for International Development, and the United Nations on transport and environmental issues. He was also previously a fellow with the US-Asia Environmental Partnership in Bangkok, Thailand. Mr. Wright is currently working towards a PhD in Urban Transport Planning at University College London. He also possesses an MSc in Environmental Assessment from the London School of Economics, an MBA from Georgetown University, and a BSc in Engineering from the University of Washington.

1. Introduction

Bus transport in most of the world today does not inspire a great deal of customer goodwill. Bus services are too often unreliable, inconvenient and dangerous. In response, transport planners and public officials have sometimes turned to extremely costly mass transit alternatives such as rail-based Metros. However, there is an alternative between poor service and high municipal debt. Bus Rapid Transit (BRT) can provide high-quality, metro-like transit service at a fraction of the cost of other options (Figure 1).

The origins of Bus Rapid Transit can be traced back to Latin American planners and officials seeking a cost-effective solution to the dilemma of urban transport. The rapid growth of Latin America urban centres beginning in the 1970s placed a heavy strain upon urban transport service providers. Facing high population growth from a citizenry dependent upon public transport and having limited financial resources to develop car-based infrastructure, Latin American municipal planners were challenged to create a new transport paradigm. One ingenious response was Bus Rapid Transit, a surface metro system that utilizes exclusive right-of-way bus lanes. The developers of the Latin American BRT systems astutely observed that the ultimate objective was to swiftly, efficiently, and cost-effectively move *people,* rather than *cars*.

Today, the BRT concept is becoming increasingly utilised by cities looking for cost-effective transit solutions. As new experiments in BRT emerge, the state of the art in BRT continues to evolve. In general, BRT is high-quality, customer-orientated transit that delivers fast, comfortable and cost-effective urban mobility. BRT is also known by other names in various places, including High-Capacity Bus Systems, High-Quality Bus Systems, Metro-Bus, Express Bus Systems, and Busway Systems. BRT systems incorporate most of the high-quality aspects of underground metro systems without, fortunately, the high costs. BRT systems are thus also known as "surface metro" systems.

The main characteristics of BRT systems include:

- Segregated busways
- Rapid boarding and alighting
- Clean, secure and comfortable stations and terminals
- Efficient pre-board fare collection
- Effective licensing and regulatory regimes for bus operators
- Clear and prominent signage and real-time information displays

BRT systems around the world, and key MRT system comparisons

For a survey of Bus Rapid Transit systems worldwide, and a comparison of BRT with other mass transit systems according to parameters such as cost, speed, passenger capcity, poverty reduction, environmental impact and others, please see Module 3a: *Mass Transit Options*.

Fig. 1

Bus Rapid Transit provides a sophisticated, metro-quality transit service at a cost that most cities, even developing cities, can afford.

Photo courtesy of Advanced Public Transport Systems

- Transit prioritisation at intersections
- Modal integration at stations and terminals
- Clean bus technologies
- Sophisticated marketing identity
- Excellence in customer service.

In Latin America, BRT systems have been delivered at a relatively low cost: US$1 million to US$5.3 million per kilometre. This compares to costs between US$65 and $207 million per kilometre for underground metro systems. Additionally, once constructed, BRT systems are typically fully self-financing, with fares in Latin America often under US$0.50 per trip. Such systems also provide passenger capacities that are typically greater than light rail systems and comparable with urban rail systems. Using express lane and passing lane systems, passenger flows of over 35,000 passengers per hour per direction have been achieved in cities such as Sao Paulo, Brazil and Bogotá, Colombia.

Under present trends, public transport's future is increasingly in doubt. The private vehicle is winning the mode share battle. As incomes rise in developing nations, private vehicles are gaining usage while public transport's ridership is almost universally declining. The *Mobility 2001* Report of the World Business Council for Sustainable Development (www.sustainablemobility.org) indicates that the public transit systems in the world's major cities are typically losing between 0.3% and 1.2% ridership each year (Table 1).

BRT is public transport's response to this decline, with an attempt to provide a car-competitive service. With the introduction of the TransMilenio BRT system in Bogotá, Colombia, public transit ridership increased from 67% to 68% when the system had only opened two out of 22 planned lines. This increase occurred during the system's first year of operation, from January to December 2001. Curitiba's BRT witnessed a similar increase when initially opened, and was able to increase ridership by 2.36% a year for over two decades, enough to maintain the public transit mode share when every other Brazilian city was witnessing significant declines.

"Political will is by far the most important ingredient"

The reasons for public transport's demise are not difficult to discern (Figure 2). Poor transit services in both the developed and developing world push consumers to private vehicle options. The attraction of the private car and motorcycle is both in terms of performance and image. Public transport customers typically give the following reasons for switching to private vehicles:

1. Inconvenience in terms of location of stations and frequency of service;
2. Fear of crime at stations and within buses;
3. Lack of safety in terms of driver ability and the road-worthiness of buses;
4. Service is much slower than private vehicles, especially when buses make frequent stops;
5. Overloading of vehicles makes ride uncomfortable;
6. Public transport can be relatively expensive for some developing-nation households;

Table 1: Changes over time in daily average public transport trips, selected cities (includes bus, rail and paratransit).

World Business Council for Sustainable Development, 2001

	Earlier Year				Later Year			
City	Year	Population (million)	Public Transport Trips/day	Percent of All Trips	Year	Population (million)	Public Transport Trips/day	Percent of All Trips
Mexico	1984	17.0	0.9	**80**	1994	22.0	1.2	**72**
Moscow	1990	8.6	2.8	**87**	1997	8.6	2.8	**83**
Santiago	1977	4.1	1.0	**70**	1991	5.5	0.9	**56**
Sao Paolo	1977	10.3	1.0	**46**	1997	16.8	0.6	**33**
Seoul	1970	5.5		**67**	1992	11.0	1.5	**61**
Shanghai	1986	13.0	0.4	**24**	1995	15.6	0.3	**15**
Warsaw	1987	1.6	1.3	**80**	1998	1.6	1.2	**53**

7. Lack of an organised system structure and accompanying maps and information make the systems difficult to use; and
8. Low status of public transit services.

BRT attempts to address each of these deficiencies by providing a rapid, high quality, safe and secure transit option. Figure 3 presents images of Bogotá, Colombia before and after the development of its TransMilenio system.

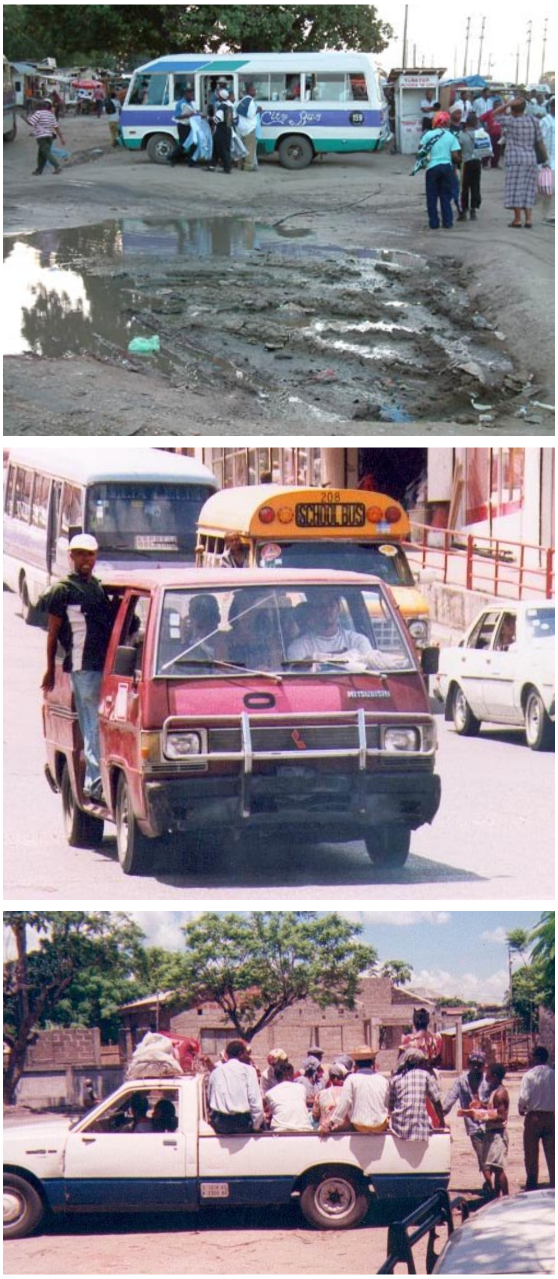


Fig. 2
Public transport in many developing countries means hardship and danger.
Lloyd Wright

2. Planning for BRT

When measured in terms of economic, environmental and social benefits, BRT's track record provides a compelling case for more cities to consider it as a transit priority. However, as a new concept, there remain several barriers that have prevented wider dissemination of BRT. Specifically, these barriers include:

- political will
- information
- institutional capacity
- technical capacity
- financing
- geographical / physical limitations.

Political will is by far the most important ingredient in making BRT work. Overcoming resistance from special interest groups and the general inertia against change is often an insurmountable obstacle for mayors and other officials. However, for those public officials that have made the commitment to BRT, the political rewards can be great. The political leaders

Fig. 3
The TransMilenio BRT system has played a central role in transforming Bogotá into a more liveable city.
Lloyd Wright

behind the BRT systems in cities like Curitiba and Bogotá have left a lasting legacy to their cities, and in the process, these officials have been rewarded with enormous popularity and success.

Even with political will, though, there are other obstacles to overcome. This module on BRT planning outlines much of the information to help build institutional and technical capacity as well as highlight financing options. This module provides an overview of the structure and contents of a BRT plan. While these planning elements have been extracted from some existing BRT plans, it must be recognised that planning practices vary greatly by location and circumstances. Thus, actual BRT plans in a particular developing city may necessitate other elements which are beyond the scope of this *Sourcebook*.

"A focused BRT planning process can be reasonably accomplished in 12 to 18 months"

The sharing of BRT planning documents from other cities, though, does present an opportunity to greatly reduce planning costs. The outline of BRT planning elements may help reduce some upfront consulting costs and thus permit municipalities to focus efforts and funds on targeted areas of need. It is also hoped that a planning template will help reduce the amount of time required to move from the conceptual phase through to implementation. A focused BRT planning process can be reasonably accomplished in 12 to 18 months.

The following planning stages are presented in roughly chronological order. However, it should be noted that there is significant interaction between the different stages, and that some activities must be done simultaneously. For instance, cost data from technology decisions will impact financial analyses and routing decisions will impact busway design options.

2.1. PLANNING STAGE I: PRE-PLANNING ANALYSIS

Prior to the formal development of a Bus Rapid Transit plan, the planning team will require a certain amount of baseline information in order to have a sound basis for decision-making. In most cases, a portion of such information will already be available from previous analyses and planning processes. The following is an outline of the type of pre-planning information that will underpin the development of a BRT plan:

1. Background and situational description:

- Population, population density
- Current mode shares
- Transport costs and tariffs
- Environmental conditions.

2. Stakeholder analysis:

- Existing transport operators, and operators' and drivers' associations (formal and informal)
- Customers (including current transit users, car owners, non-motorised transport users, student travel, low-income communities, physically disabled, elderly)
- Municipal transit departments
- Municipal environmental departments
- Municipal urban development departments
- Traffic and transit police
- Relevant national agencies
- Non-governmental organisations
- Community-based organisations.

3. Origin / destination study

4. Overview study on mass transit options:

- Status quo
- Light rail
- Urban rail
- Bus rapid transit
- Underground metro.

Background and situational analysis

The background and situational analysis will help characterise the existing situation, which will help provide a baseline of data points for later comparison with the new system. The background and situational analysis will also highlight focus areas, such as the reduction of air contaminants in certain zones. Additionally, this analysis may also help identify potential sections of the city, such as rapidly growing areas that will benefit from transit-oriented development.

Stakeholder analysis

The pre-planning period is also an opportunity to begin identifying key groups and organisations that should be included in the planning and development of improved transit services.

Specific agencies, departments and political officials will all have varying opinions and interests with regard to developing a new transit system. Non-governmental and community-based organisations will be important resources to draw upon during later public participation processes.

Origin / destination study

A sound origin and destination (O/D) study is a fundamental basis of any transport planning activity. This study will provide the blueprint of transport patterns throughout the city. The O/D study should ideally not only identify the geographical nature of trips but also note the times of travel and in some case distinguish between trip purposes (work commuting, study, shopping, etc.). It will be from this O/D study that transit corridors will be identified and the location of feeder services will be determined. Figure 4 gives a graphical presentation of data collected during the O/D study in Bogotá, Colombia.

Of course, existing travel patterns are not the only determinants in BRT decision-making. The location of transit services may be both demand and supply driven. Municipalities may wish to place transit corridors in locations to encourage transit-orientated development.

Overview study on mass transit options

The final stage of the pre-planning process is often, although not always, a general study of transit technology options (BRT, light rail, urban rail, metro, etc.). The previous module (Module 3a: *Mass Transit Option*) discusses some of the considerations and trade-offs between each of these options. However, a municipality may also choose to delay a decision on technology until later in the process. The choice of transit technology should be chosen on a range of considerations with performance and cost being amongst the most important. These requirements are ideally derived from an objective analysis of the existing and projected situation.

However, far too often a technology is chosen before such baseline analyses are completed and are based more on reasons of personal biases or industrial policy than on matching customer needs and urban form. The situational analysis and the O/D studies are important starting points that should drive much of the subsequent macro and micro decisions on any new transit service. A planning team may complete other steps in the process (planning stages II, III, and the route elements of stage IV) before committing to a particular technology.

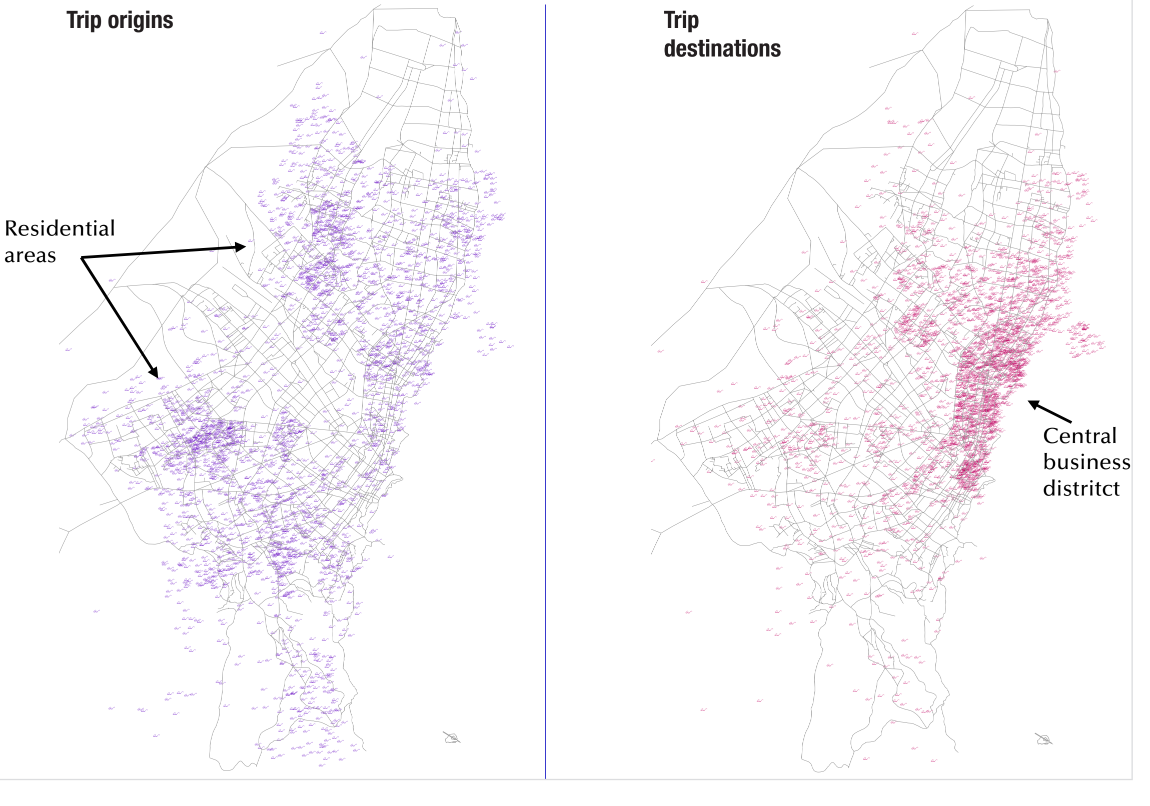


Fig. 4
Illustration of the results of an origin-desination study in Bogotá, Colombia.

2.2. PLANNING STAGE II: BRT SYSTEM STRUCTURE

The second stage of the planning process seeks to establish the vision and organisational structure of the planned system. At this stage the initial financial feasibility of the system is tested through a costing and revenues analysis. The following is a possible outline of the contents of this planning stage:

1. Statement of vision

2. Work plan and timeline

3. Expected impacts:

- Economic – Impacts of increased mobility, economic efficiency, employment
- Environment – Air quality (local, regional and global pollutants), water contamination, ground contamination, noise
- Social – access to public services, equity issues
- Urban structure – urban structural changes, land-use impacts.

4. Regulatory and legal issues

5. Administrative and business structures:

- Public sector system design and quality control
- Private sector operators and concessions.

6. Tariff structure:

- Subsidy-free operation vs. governmental support
- Revenue distribution options
- Flat tariffs vs. distance-based fares.

7. Cost analyses

- Planning
- Infrastructure
- Operations.

Statement of vision

A vision statement is a political announcement that provides a broad-based perspective on the general goals of the proposed system. This statement provides an important direction and mandate for the planning teams and can also be used to stimulate interest and acceptance of the concept with the general public. The vision statement should not be overly detailed but rather describe the form, ambitions and quality of the intended project.

Work plan and timeline

Once a vision is set for the system, a detailed work plan and timeline on how to achieve the vision will be necessary. By walking through each step of the process, municipal officials and the public will have a better idea of the scope of the project and the necessary activities to make it happen. Invariably, cities underestimate the amount of time needed to complete a full BRT plan. As noted previously, a BRT plan can be reasonably completed in 12 to 18 months. Of course, the actual duration of the planning process will depend greatly upon the complexity of the project and upon other local conditions.

> ***"Sharing the work plan and timeline with politicians, press and the public will help ensure that all parties have realistic expectations of progress with the project"***

Completing the work plan and timeline will help ensure that important elements such as public communication and education are not inadvertently left out. Sharing the work plan and timeline with politicians, press and the public will also help ensure that all parties have realistic expectations of progress with the project.

No matter how well one plans, though, unexpected events will also act to necessitate modifications. Thus, the work plan and timeline should be revisited and revised from time to time during the planning process. Figure 5 provides an example of a BRT timeline.

Expected impacts

Impact analyses are often mandatory by law in terms of measuring the expected economic, environmental and social ramifications of the project. The form of Environmental Impact Assessments (EIAs) is generally well known but the practice of such assessments is still in its infancy in some nations. Public transport projects typically bring positive environmental impacts through the reduction of private vehicle use and subsequent associated emissions. However, the construction process can entail some environmental impacts that must be mitigated to the greatest degree possible.

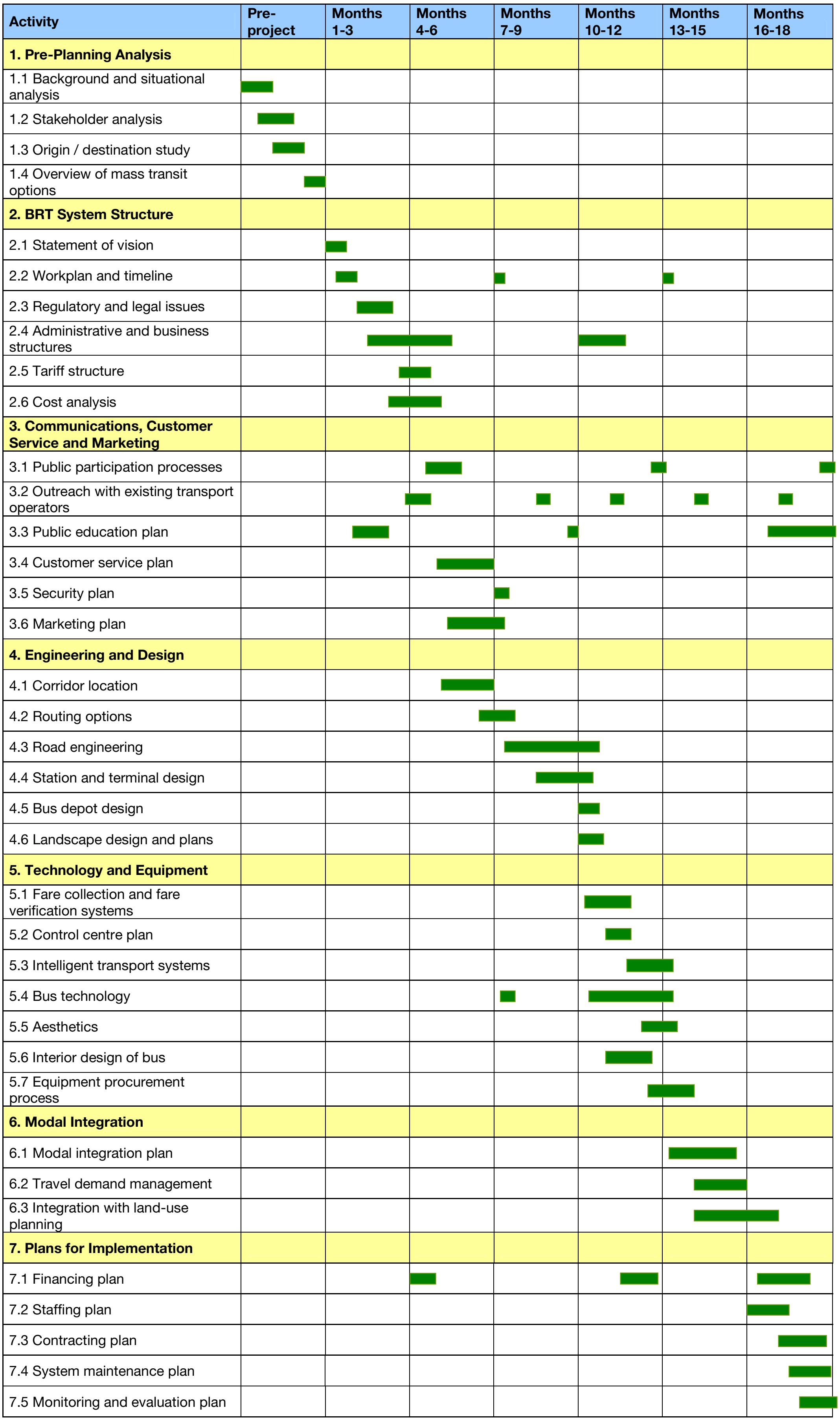


Fig. 5

An illustrative timeline for a Bus Rapid Transit project.

Table 2: BRT and emission reductions.

Emission reduction mechanism	Description	Measurement technique
Mode shifting and mode retention	By offering a superior public transport service, BRT helps to keep existing customers as well as encourage new customers, many of whom would be otherwise using higher-emitting individual transport.	Before & after surveys of mode changes; emission factors for the various modes.
Bus capacity	One articulated BRT vehicle often replaces 4 to 5 mini-buses.	Fuel economy per passenger comparisons
Land use changes	Urban structural changes may occur around BRT corridors; such changes may reduce the number of trips, the length of trips, and the types of mode used to make a trip.	Before and after land use comparisons or modelling
Segregated busways	Operating buses in segregated lanes rather than mixed traffic reduces congestion and improves fuel economy, not only for the buses but also other traffic.	Fuel economy comparisons
Stopping distance	Existing mini-bus drivers often operate much like taxi services and stop frequently and over short distances. The BRT dedicated stations means that buses have formal stops in the area of every 500 metres, and thus achieve higher fuel efficiencies.	Fuel economy analysis
Dwell times	The rapid boarding and alighting associated with BRT means that there is less idling time at stops and thus better fuel efficiency performance.	Fuel economy analysis
Routing efficiency	A more rationalised routing structure can mean shorter travel distances and more efficient use of resources.	Travel distance and fuel economy analysis
Bus propulsion techn. / fuel choice	Lower-emitting propulsion systems and fuels can help reduce emissions.	Fuel economy and emission analyses
Improved bus maintenance	Improved bus maintenance can also help improve fuel economy performance.	Fuel economy analysis

BRT reduces transport-related air emissions in several ways. Table 2 discusses these emission reduction mechanisms along with the potential techniques that are employed to measure the emission reduction impacts.

Too often the entire focus of emission reduction efforts is placed on bus propulsion technologies and fuel choice. While such options as natural gas, alcohol fuels, hybrid-electric systems, and fuel-cell systems can play an important role in an overall emission reduction strategy, an exclusive focus on tailpipe emissions can obscure the even larger emission reductions that can be achieved through some of the other mechanisms. This point is noted by the analysis of the International Energy Agency (IEA, 2002):

> Regardless of whether a bus is "clean" or "dirty", if it is reasonably full it replaces anywhere from 10 to 40 other motorised vehicles (including 2-wheelers as well as cars; in some developing cities the primary displacement is of 2-wheelers). The consequent fuel savings, CO_2 reductions, and pollutant reductions can be large – our scenario analysis suggests that they can be much larger than the potential benefits of making a fuel or technology upgrade to the bus itself. So getting buses on the road, and getting riders onto buses (mainly by offering a service that riders want) is the best strategy for providing efficient, sustainable transportation systems.

Economic impacts include employment impacts, both during system construction and operation, as well as general efficiency gains from a more coherent transport system. Social impacts are also generally positive, as lower-income groups gain more access to services and opportunities.

Regulatory and legal issues

In many developing cities, licensing is geared toward individual operators on prescribed routes. An integrated, city-wide system such as BRT will require licensing and regulatory reforms.

Administrative and business structures

This initial stage is also the time to consider whether the system will be publicly or privately operated, or a mix of both public and private sector elements. The administrative and organisational structure of the system will have profound implications for the system's efficiency, operation, and costing. There is no single correct solution, though most municipalities today do make use of private sector involvement in order to make such projects financially feasible. On the other hand, successful systems still also include an oversight and quality control role from public officials (see further Module 3c: *Bus Regulation and Planning*). Bogotá's TransMilenio provides an example of a mixed system (both public and private) that attempts to secure the best qualities of each sector.

Figure 6 shows the overall structure of the TransMilenio system, with a publicly-owned company (TransMilenio SA) having overall responsibility for system management and quality control. However, TransMilenio SA itself is an organisation of only approximately 70 people, with oversight for a system in a city of seven million inhabitants. Private sector concessions are used to deliver all other aspects of the system, including fare collection and bus operations. The director of TransMilenio reports directly to the Mayor's office. Thus, TransMilenio and the municipal government are able to leverage private sector investment and defer a large portion of the financial risks while retaining overall control on the shape of the system. In the case of TransMilenio, the private sector operators were responsible for purchasing the buses, thus allowing the public sector to focus its financial resources on the provision of infrastructure.

"Systems in cities such as Bogotá and Curitiba depend upon a strict calculation of operating costs in order to properly distribute revenues"

Tariff structure

Tariff levels, of course, will greatly determine the ultimate size of the customer base and the segments of society that can afford to use the system. The structuring of the tariffs will also greatly influence the behaviour of the system operators. One advantage of BRT systems in comparison to other mass transit systems is that operating subsidies are typically not necessary. The avoidance of public subsidies can greatly simplify system management as well as reduce the continual need to justify a system's continued financing with public officials and the electorate.

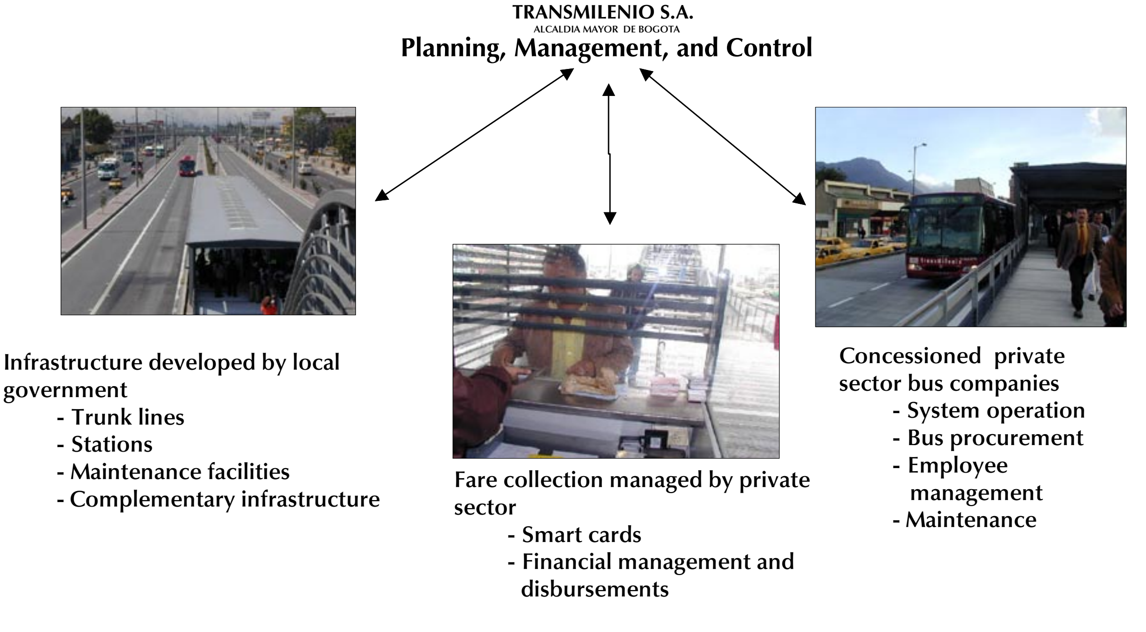


Fig. 6
Organisational structure of Bogotá's TransMilenio system.

In developing countries, existing public transport systems often operate more like private taxi services than coordinated systems. The existing incentives mean that the income of operators and drivers depends directly upon the number of passengers collected. The result is a system in which drivers compete fiercely to take passengers from other drivers. To do so, drivers will stop indiscriminately, drive recklessly at high velocities, and work dangerously excessive hours. Prior to the TransMilenio system, many of the drivers in Bogotá would work as much as 16 hours per day. Now, they can earn even greater incomes during just six-hour shifts (Figure 7). The difference is due to the structuring of the revenue distribution. Instead of earnings being based exclusively on the number of passengers collected, drivers and operators now earn based on a formula which is based not just on the number of passengers, but is largely determined by the number of kilometres travelled. The number of kilometres travelled is largely fixed by the system's scheduling. Thus, the operators now have no reason to speed or drive dangerously. Instead, they have an incentive to provide good customer service to the benefit of everyone. Ending the "battle over customers" in favour of a kilometres travelled approach is a "win" for the drivers and operators, a "win" for municipal officials, and a "win" for customer safety and satisfaction.

From a customer perspective, tariffs can be set either as a flat fare or as a function of distance travelled. In most Latin American cities, tariffs are set as a flat fare. There are several reasons for this preference. First, a flat fare allows for much greater simplicity in the fare collection system, and can substantially reduce both the capital and operational costs associate with fare collection. For example, flat fare schemes imply that simpler ticket-less technologies such as coin operated fare gates can be employed. With distance-based systems, more costly magnetic strip or smart card technologies must be utilised. Second, a flat fare system can be a mechanism to ensure greater social equity within public transport services. In Latin America and other parts of the developing world, poorer segments of society often live farther from the city centre and face long and costly commutes. This situation means that lower-income groups incur the greatest costs in terms of seeking employment and accessing public services. A flat fare system generates a cross-subsidy designed to assist these lower-income groups.

Fig. 7 ▲
These "before and after" photos of TransMilenio show the dramatic improvement in the quality of work life for Bogotá's transit operators.
Lloyd Wright

However, there are also arguments in favour of distance-based fare structures. Most importantly, distance-based fare structures most closely mirror actual operating costs and thus provide a truer measure of expenses for system operators.

Cost analysis

This stage of the planning process also provides an early opportunity to examine the overall financial feasibility of the system through an initial costing analysis. This section examines both capital costs and operational costs. Additionally, the costs involved with the planning process itself must be considered. While such costs are discussed in this section, an approximation of and commitment to such costs must obviously be made before the planning process begins.

The cost of BRT planning processes can vary from $500,000 to over $3 million, depending upon the internal capabilities of the municipal planning team as well as the degree to which outside consultants are employed. Current international efforts, from such organisations as ITDP and GTZ, are underway to help reduce these planning costs. By sharing the planning experiences of cities such as Bogotá, Colombia, these organisations hope that other cities will be able significantly reduce the costs of developing a BRT system.

As noted in Module 3a: *Mass Transit Options*, BRT is a low-cost option for providing cities with a quality transit solution. Latin American systems have been constructed at a cost of $1 million to $5 million per kilometre, which is a fraction of the cost of rail options. The capital cost of construction is typically borne by the public sector, just as such costs are publicly funded for car-based infrastructure. Table 3 identifies the principal cost categories for system infrastructure and sums up these capital costs for the initial lines of the TransMilenio system.

The calculation of system operating costs holds significant importance not only for determining tariff levels but also for defining incentives and profitability with operators. Systems in cities such as Bogotá and Curitiba depend upon a strict calculation of operating costs in order to properly distribute revenues between operators, fare collection firms, and system administrators.

There are two types of tariffs used in the calculation process. The Technical Tariff reflects the actual cost per passenger of operating the system, plus a profit margin. The Customer Tariff, which is the fare paid by passengers, is 0.5% higher than the Technical Tariff in Bogotá's TransMilenio system, since it includes an additional 0.5% Contingency Fund payment. The Contingency Fund is designed to handle unexpected events such as unusually low levels of service demand, extended hours of operation, terrorism and vandalism, and problems associated with hyper-inflation.

The Technical Tariff is the basis for the distribution of funds to the various actors contracted to the system, as represented in the following formula:

Fares sold x Technical Tariff = Remuneration of system actors

For TransMilenio (Figure 8), most of the revenues are distributed to the concessioned private operators who are providing either trunk line (65.5%) or feeder services (20%). The fare collection company responsible for the collection of funds from the customer and distribution of fare cards receives 11% of the technical tariff revenues. TransMilenio SA, the public company with overall management responsibility for the system, receives 3%. Finally, a Trust Fund Administrator receives 0.5% of the technical tariff revenues. This Trust Fund Administrator is responsible for managing the incoming assets as well as distributing the funds to the other entities.

Table 3: BRT construction cost breakdown, Bogotá's TransMilenio.

Component	Total Cost (US$)	Cost per km (US$)*
Trunk lines	94.7	2.5
Stations	29.2	0.8
Terminal	14.9	0.4
Pedestrian overpasses	16.1	0.4
Bus depots	15.2	0.4
Control centre	4.3	0.1
Other	25.7	0.7
Total	198.8	5.3

* The initial lines of TransMilenio total 37 kilometres

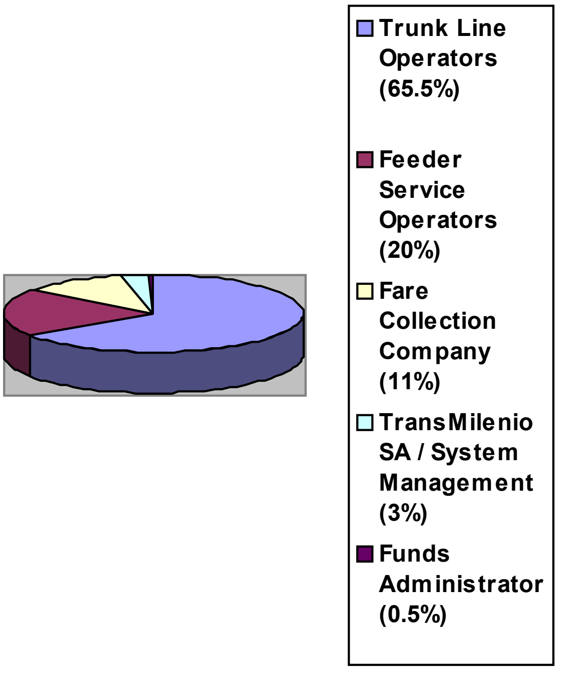


Fig. 8 *Distribution of TransMilenio system revenues.*

Mechanisms are also established to adjust these percentages on a monthly basis. The adjustments are needed to account for variations in kilometres travelled by the different companies.

System designers must be explicitly aware of the magnitude of operational cost components in order to properly set fare levels. Otherwise, bus operators may lack the appropriate incentives to participate. Operating costs can be divided into both fixed and variable components. The fixed portion includes the cost of capital and the depreciative value of the rolling stock (buses) assets. Additionally, there will be fixed costs associated directly with system operation such as the salary of drivers, mechanics, and administrative staff. Variable costs will include such operational consumables as fuel, tires, and lubricants, as well as maintenance items. Table 4 provides a summary of operational cost components along with sample values from Bogotá's TransMilenio system. (Values will vary greatly depending on local circumstances.)

Table 4: Operational cost components of BRT.

TransMilenio SA, Bogotá, Colombia, June 2002

Item	Measurement units	Consumption per vehicle
Repayment of Capital		
Vehicle depreciation	% of value of vehicle / year	10%
Cost of capital	Effective annual interest rate on invested capital	15%
Fixed Operating Costs		
Driver salaries	Employees / vehicle	1.62
Salaries of mechanics	Employees / vehicle	0.38
Salaries of administrative personnel and supervisors	Employees / vehicle	0.32
Other administrative expenses	% of variable costs + maintenance + personnel	4.0%
Fleet insurance	% of value of vehicle / year	1.8%
Variable Operating Costs		
Fuel	Gallons of diesel / 100 km m^3 of natural gas / 100 km	18.6 74
Tires - New tires - Retreading	 Units / 100,000 km Units / 100,000 km	 10.0 27.6
Lubricants - Motor - Transmission - Differential - Grease	 Quarts of gallon / 10,000 km Quarts of gallon / 10,000 km Quarts of gallon / 10,000 km Kilograms / 10,000 km	 78.9 4.5 5.8 3.0
Maintenance	% of value of vehicle / year	6.0%

The values in Table 4 are used to calculate an overall operating cost per kilometre for the system operators. This value is the basis for the remuneration of the concessioned operators.

When comparing such operating cost values between mass transit modes (e.g., BRT with rail), one must be certain that a "like for like" comparison of variables is being made. BRT systems typically amortise vehicle purchase costs within the operating cost calculation, while rail systems sometimes list rolling stock as a capital cost. Further, because of rail's high cost structure, certain maintenance and replacement part items are sometimes capitalised. To make a correct comparison, adjustments will need to be made to ensure capital and operating costs are appropriately categorised.

> *"Perhaps the most fundamental difference between BRT and standard bus services is BRT's principal focus on customer service"*

Rail systems do have an apparent operational labour cost advantage, specifically with regard to the cost of a driver. Bus coaches each require a driver while several connected rail coaches only requires a single driver. However, in developing cities lower wage rates mean that this advantage is largely overwhelmed by other cost components.

2.3 PLANNING STAGE III: COMMUNICATIONS, CUSTOMER SERVICE AND MARKETING

Perhaps the most fundamental difference between BRT and standard bus services is BRT's principal focus on customer service. Systems are designed around the needs and wants of the customer; all other details such as technology and structure follow from this simple customer predilection. As noted previously, bus systems today are often losing mode share because customer concerns about convenience, safety, and comfort are not being addressed. This planning stage discusses methods for engaging the public in the design process as well as the key attributes in providing a customer-friendly service. The following is a possible outline of the contents of this planning stage:

1. Public participation processes

2. Communications and outreach program with existing transit operators

3. Public education plan

- Basic system facts
- How to use the system
- Implications of the system.

4. Customer service plan

- Driver courtesy and professionalism
- Signage
- System maps
- Cleanliness plan for buses, stations and terminals
- Staff uniforms.

5. Security plan

- Buses
- Stations and terminals

6. Marketing plan

- Identification of customer base
- System name
- Logo
- Positioning of brand
- Advertising strategy
- Publicity campaign through the media.

Public participation processes

Typically, the greatest barrier to the actual implementation of a BRT system is neither technical nor financial in nature. Most often, it is the lack of communication and participation of key actors that ultimately undermines a project's progress. Such communications are not only important in terms of obtaining public approval of the project but also provide the design insights of the people who will be using the system. Public inputs on likely corridors and feeder services can be invaluable. Incorporating public views on design and customer service features will also help ensure that the system will be more fully accepted and utilised by the public.

Professional planners and engineers obviously do play a key role in system design, but often such "professionals" do not frequently use public transport systems, and thus do not possess some of the design insights of the general public. Some cities are now requiring public officials to use public transport each day in order to retain a better understanding of the daily realities.

Managing and fostering wide public involvement can be a challenge to agencies and departments unaccustomed to public processes. Non-governmental organisations are sometimes better equipped to manage such processes. Consultants are another possibility. Third party management of the public participation process can also be an effective mechanism to achieve an independent and objective viewpoint on design issues. In some cases, community members may be more comfortable expressing opinions to local organisations rather than exclusively to public officials.

Communications and outreach with existing transport operators

"Taking the initiative in introducing a new form... is very difficult and dangerous, and unlikely to succeed. The reason is that all those who profit from the old order will be opposed to the innovator, whereas all those who might benefit from the new order are, at best, tepid supporters of him"

Niccolo Machiavelli

As Machiavelli noted in the 16th Century, change is never easy and likely will be resisted regardless of the intended benefits. BRT can improve profits and working conditions for existing operators and drivers. However, in many countries, the sector is unaccustomed to any official involvement and oversight, and operators often distrust public agencies. In cities such as Belo Horizonte, Brazil and Quito, Ecuador, proposed formalisation of the transport sector has sparked violence and civil unrest.

Ideally, the existing operators can come to view BRT as a positive business opportunity and not as a threat to their future. How this key sector comes to view the concept, though, largely depends on the circumstances and manner in which BRT is introduced to them. The municipality will wish to carefully plan an outreach strategy that will build a relationship of openness and trust with the existing operators.

Public education plan

BRT will hopefully introduce a range of customer service innovations that will provide a dramatically improved transit experience for the public. To prepare the public for BRT, an educational campaign will be necessary. This plan is in part designed to secure support and approval for BRT, but also to better prepare the public so they know how the system will be used.

Thus, the public education process starts well before the system goes into operation. Information kiosks such as those shown in Figure 9 are effective means of reaching out to potential customers. Ottawa's TransitWay system maintains a permanent information outreach office located at a highly accessible shopping mall in the city centre. Public outreach workers such as those utilised in Honolulu and Bogotá (Figure 10) are a very personal and thus effective means of reaching consumers. In each case, the system developers do not merely assume that "if one builds it, the customers will come."

Customer service plan

Unlike many existing bus services in developing-nation cities, BRT places the needs of the customer at the centre of the system's design criteria. The quality of customer service is directly related to customer satisfaction, which ultimately determines customer usage and long-term financial sustainability.

Unfortunately, unclear maps and schedules, unclean buses, and uncomfortable rides have been all too frequently the obligatory price to be paid for utilizing public transport. Public transit and para-transit operators sometimes give scant attention to customer service, assuming instead that their market is predominated by captive customers who have few other options. Such an attitude, though, can lead to a downward spiral, in which poor services push more commuters toward two- and four-wheeled motorised alternatives. In turn, the reduced ridership curtails public transport revenues and further diminishes quality of services, which again leads to a further erosion of the passenger base.

Customer service is fundamental at each level of operation. Are drivers courteous, professional and well-presented? Are the stations and the buses clean, safe and secure? Is the morning commute a pleasant and relaxing experience or is it traumatic? Customers probably do not care about the type of engine propulsion technology; they do care greatly about the simple customer service features that directly affect their journey comfort, convenience and safety.

Many of the informal and paratransit systems in the developing world follow informal and flexible routings that required a seasoned system insider to fully understand and utilise. Many such systems are incomprehensible to potential new users, those with occasional transport needs, and temporary visitors to the city. BRT systems in cities such as Bogotá and Quito emulate the better underground systems of the world by providing clear system maps both at stations and on-board buses (Figure 11). A good

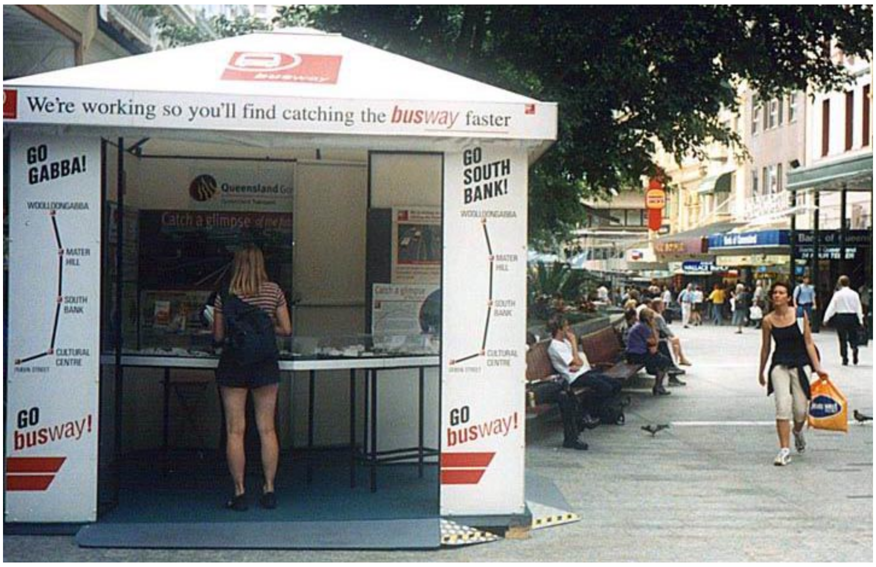


Fig. 9

Information centres in Brisbane and Ottawa.

L. Wright (right); K. Fjellstrom (above) test of a system's user-friendliness is to determine whether a person who does not speak the local language can understand the system within two minutes of looking at a map and information display. It is possible to achieve this level of simplicity in conveying the system's operation, but, unfortunately, most bus systems today do not even make the attempt. Colour-coding schemes are also used in some systems to allow customers to readily differentiate between multiple routes.

Additionally, real-time information displays that inform passengers when the next bus is due can be particularly effective at reducing "waiting anxiety", which often affects passengers who are not sure when or if a bus is coming. This feature allows customers to undertake other value adding activities to make best use of the time, rather than nervously waiting and standing with close attention to the horizon.

The presence of friendly transit staff at stations also helps overcome customer uncertainties. Providing such staff with smartly-styled uniforms helps raise the public's perception of system quality and professionalism. Strict daily cleaning and maintenance practices keep the stations and buses very clean, and thus again reinforce consumer confidence in the system. Exceptional cleanliness can also be a determining factor in dissuading problems of crime and graffiti. Individually, each one of these features may appear to be insignificant measures, but their combined effect can result in dramatically improved levels of customer satisfaction and market penetration.

While these design and service features have helped to make dramatic improvements in system effectiveness and customer satisfaction, each is relatively low-cost to implement and relatively low-tech in nature. Thus, another lesson from BRT is that simple, ingenious, low-technology solutions are often of much greater value than more complex and costly alternatives.

Security plan

Like any public place with large quantities of persons, buses can attract undesirable elements. The close confines of crowded conditions provide the perfect environment for pick-pocketing and other assaults on person and property. Fear

Fig. 10 ▲
Public outreach workers in Bogotá and Honolulu.
Photos courtesy of Fundaciun Ciudad Humana (Bogotá) and the Honolulu Dept. of Transport Services

Fig. 11 ▼
System map of TransMilenio.
Photo courtesy of TransMilenio SA, Municipality of Bogotá, Colombia

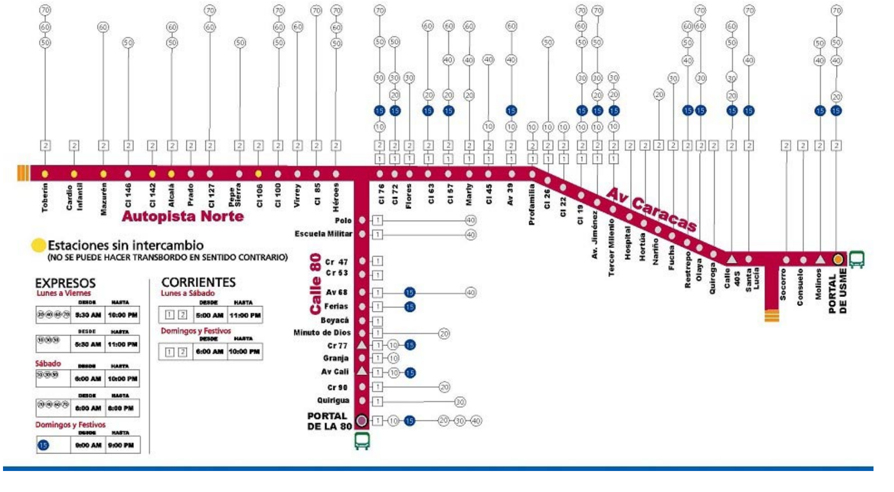


Fig. 12 ▲
Emergency call box in Ottawa, Canada.
Lloyd Wright

of crime and assault is a highly motivating factor in the movement towards more private modes of transport, especially for women, the elderly and other vulnerable groups.

However, crime and insecurity can be overcome with the strategic use of policing and information technology. Uniformed security personnel at stations and on buses can dramatically limit criminal activity and instil customer confidence. Security cameras and emergency call boxes (Figure 12) both permit more rapid response to potential threats as well as deterring crimes.

Marketing plan

Bus Rapid Transit is not just another bus service. However, communicating this effectively to the public is not easy. The negative stigma of existing bus systems is a formidable barrier to overcome in selling the BRT concept. The right marketing campaign can help put BRT in a new light for the customer.

An effective marketing plan begins with the identification and segmentation of potential user groups. The use of focal groups is a standard market research technique to gain insights into customer impressions. By understanding the needs and constraints of each market segment, tailored marketing strategies can then be designed and employed.

The name and logo of the system is another key starting point to impart the sense of a new type of transit service. Creating the right marketing identity helps create the right image in the customer's mind. Cities that have successfully implemented BRT have developed marketing identities that set their product apart and excite the public's imagination (see Figure 13).

Transit agencies should consider the use of a range of outreach media for their message. The promotional campaign can be communicated in billboards, print advertisements, radio, television, and special events. In many cases, media organisations will donate the cost of the advertising as a public service announcement.

2.4 PLANNING STAGE IV: ENGINEERING AND DESIGN

The location and design of the BRT corridors should flow from the previous work on origins and destinations (O/D studies), as well as from the input of key groups such as customers. The ultimate design of the busways, stations and terminals will need to cater to both existing passenger loads as well as projections for future expansion. Within the various parameters of corridor location, service options, busway engineering, and station and terminal designs, there are many qualitative decisions that will have

Fig. 13 ▶
Creating a marketing identity with the public.

long-term impacts on the shape and effectiveness of the total system. The following is a possible outline of the contents of this planning stage:

1. Corridor location

- O/D study inputs
- Major destination centres (work places, schools, shopping areas, etc.)
- Total system plan and phased construction.

2. Routing options

- Feeder-trunk option
- Convoy option
- Express services.

3. Road Engineering

- Roadway reconfiguration
- Busway design.

4. Station and terminal design

- Station and terminal locations
- Architectural design.

5. Bus depot design

- Depot location
- Maintenance area
- Administrative offices
- Re-fueling facilities.

6. Landscaping designs and plan

Corridor location

The choice of corridor location will not only impact the usability of the BRT system for large segments of the population, but will also have profound impacts on the future development of the city. The starting point for corridor decisions is the origin / destination study, which will help identify the daily commuting patterns in both spatial and temporal terms. Clearly a key consideration is to minimise travel distances and travel times for the largest segment of the population. This objective will typically result in corridor siting near major destinations such as work places, universities and schools, and shopping areas.

Access for special groups, particularly disadvantaged communities, should also be a determining factor. Some systems prefer to develop initial lines around low-income areas in order to demonstrate that BRT is a magnet for positive development.

The relationship between BRT and land use can have long-lasting impacts on the form of the city. Busways can play a catalysing role towards sustained economic development. For example, the BRT stations in Curitiba, Brazil are development nodes, which act to attract commercial and residential development. In fact, the busways and development nodes are mutually beneficial. The strategic siting of BRT stations improves customer access to shopping, employment, and services while the high-density centres ensure sufficient passenger traffic for cost-effective busway operations. Curitiba has also coordinated new residential construction around bus arteries. The end result is that the municipality can deliver basic infrastructure such as water, sewage, and electricity at a significant cost savings to the concentrated and coordinated areas of development. While mixed use, high density planning does not always guarantee a sustainable urban environment, as many Asian cities demonstrate, integrated planning efforts between land use and transport can benefit municipal officials, commercial developers, and residents.

"Corridor plans will evolve, but it is worthwhile to create a city-wide corridor plan that will stimulate political and public support"

BRT systems are typically developed as phased projects. Municipalities are advised to gain experience with it at a demonstration level before committing to a full network. The phased approach is also consistent with the realities of system financing, which is not likely to be immediately available to support a city-wide system. However, while construction may not immediately encompass the entire city, initial corridor planning should provide an expansive vision that goes well beyond the immediate construction cycle. Early in the development process of Bogotá's TransMilenio system, the mayor provided the stated vision of a system that would one day "put 85% of the city's seven million inhabitants within 500 metres of a BRT corridor" (Figure 14). This type of visions sets an important political precedent for the system's ultimate shape. Corridor plans will certainly evolve as experience is gained and as the city's form itself evolves, but it is worthwhile to create a city-wide corridor plan that will stimulate political and public support.

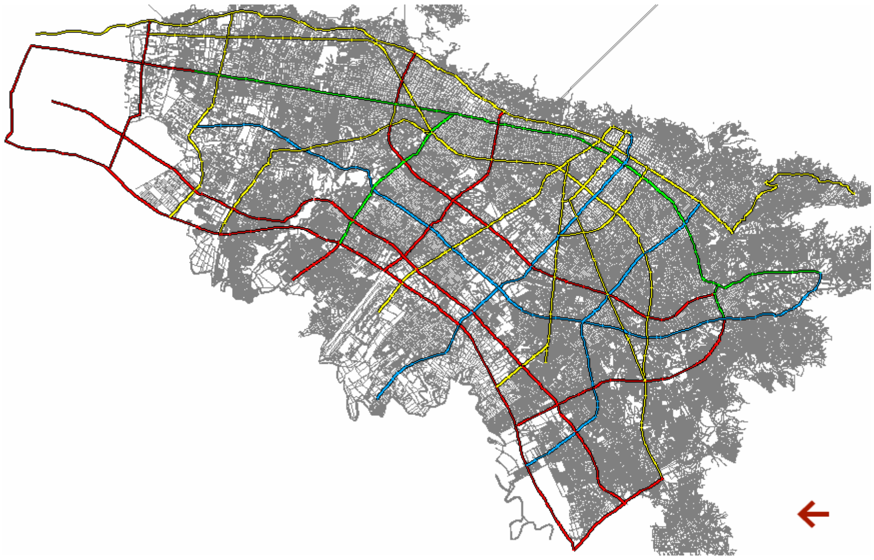


Fig. 14 ▲
Bogotá's vision for a city-wide BRT system includes 388 kilometres of exclusive busways.

Routing options

The relationship between trunk line corridors and feeder lines from smaller communities will also impact the system's routing. Matching route structures to bus and throughput capacities will affect system cost-effectiveness, bus specifications and service frequency. Currently, there are at least two different techniques for servicing trunk line and feeder line areas (Figure 15):

1. Trunk-Feeder technique
2. Convoy technique.

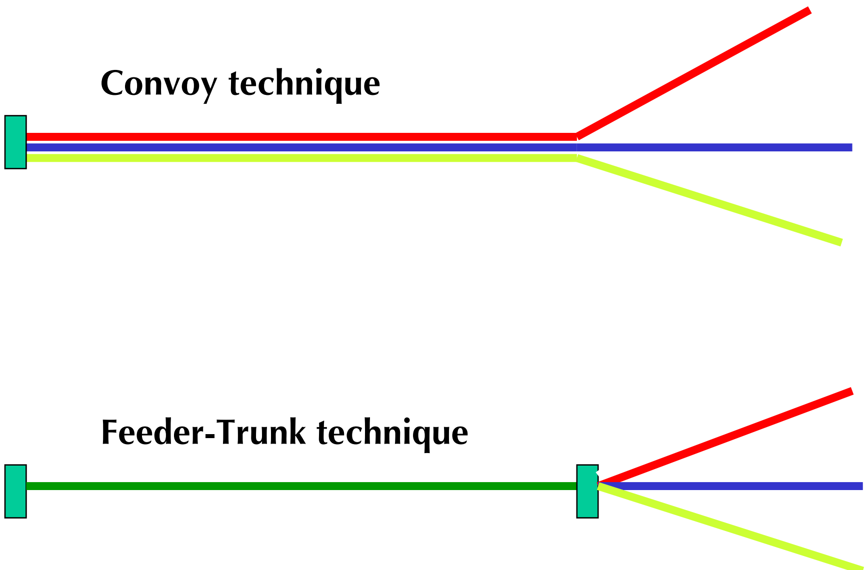
With the Trunk-Feeder technique, larger buses service the principal corridors. At the end of these corridors an integrated terminal station is erected to allow efficient transfers to smaller feeder buses that continue into smaller communities. The principal advantage of this technique is that it allows better matching of bus size to targeted route sizes. The main disadvantage is that customers must transfer, and thus may have a longer commute time than a routing involving a single bus. Most cities today utilise variations on the Trunk-Feeder technique; these cities include Bogotá, Curitiba, Goiania, and Quito.

Alternatively, the Convoy technique does not necessitate the need for transfers at terminal stations. Instead, a convoy of buses with different ultimate routes all ply the same main line corridor. At a certain point, each of these buses leave the main corridor and continue onto individual routes, which may or may not involve segregated busways. The advantage of the Convoy technique is that it provides a concentration of service on high-demand corridors while then permitting differentiated buses to enter smaller communities without incurring a transfer for the customer. The principal disadvantage of this technique is that it may lead to an oversupply of bus seating on the feeder portion of the route, especially if large articulated buses are utilised. Porto Alegre, Brazil utilises the Convoy technique and has been generally successful.

There is no right or wrong answer with regard to routing options, since so much depends on local circumstances such as population density changes within a city. If main line corridors give way to more lightly populated areas, then the Trunk-Feeder technique may produce optimal results. If the population density and thus the spatial changes in trip demand are less variable between main line and feeder areas, then the Convoy technique may be more appropriate.

Other routing variations are also possible. Some cities like Bogotá and Sao Paulo provide "express" services on their main line corridors. Such services permit designated buses to skip intermediary stations to provide more rapid travel from high-demand areas. The principal advantage to "express" services is that it can dramatically reduce travel times, particularly for customers travelling longer distances. The principal disadvantage is that it adds another layer of complexity to the design and operation of the system. Further, sufficient road space must be available for either a second set of exclusive busways or a passing lane at by-passed stations.

Fig. 15 ▼
Two options for structuring BRT routes.



Road engineering

As noted by the capital cost figures for Bogotá's TransMilenio system, road construction and engineering work represents about 50% of the entire system cost. Thus, cost savings in this category will greatly affect the overall financial burden of construction. Roadway design also carries with it significant interplay with existing geographical parameters of the streets and the current use patterns. Existing road widths are especially important, given the space requirements for exclusive busways and their associated stations.

Construction materials and techniques will affect both initial outlays and long-term maintenance costs. Cement is often preferred over asphalt due to its greater durability, especially when the lane is utilised by heavy buses. Additionally, since busways do not require vehicle lane changes, some system developers have elected not to pave the centre of the lane (Figure 16). The resulting savings in construction costs can be substantial. Further, the existence of earth or grass beneath the bus can help absorb engine noise. Noise reductions of up to 40% have been reported using this technique.

The use of coloured emulsions within the cement or asphalt can provide several benefits (Figure 17). First, a smartly coloured busway raises the image of the system as well as allowing the public to attach a greater sense of permanence to the existence of the system. Second, coloured lanes create a psychological advantage over motorists who may potentially block the busway when the lane must cross mixed traffic. Motorists are more likely to recognise that they are committing a traffic infraction by blocking a highly visible bus lane, especially when compared to the crossing of a lane that is indistinguishable from a normal mixed-traffic lane.

System designers sometimes wrongly assume that only major arterial roads are options for exclusive busways. In fact, there is an entire range of corridor options to consider. Major arterial roads typically do provide an economy-of-scale in terms of customer flows since major origins and destinations are often located on principal thoroughfares. However, there may be times

Fig. 16 ▲ ◀

Not paving the centre of the BRT lane can produce substantial cost savings and reduce noise.

Photos courtesy of Lane District Transit (Eugene, USA) and the US Transit Cooperative Research Program (Leeds, UK)

Fig. 17 ▼

Coloured lanes raise the profile of the busways, as can be seen in Rouen, France and Nagoya, Japan.

Photos courtesy of the US Transit Cooperative Research Program

Busways, bus lanes, and grade separation

Physical separation of the bus' space from other traffic is the chief difference between "busways" and "bus lanes". Bus lanes typically are just separated by a painted line while busways are separated from other traffic by raised cement or pylons. Bus lanes often fail due to poor enforcement of preventing traffic entering the system, which undermines the free-flow movement and thus travel-time advantages of the buses. However, both busways and bus lanes may permit access for certain vehicle types. For instance, police vehicles and ambulances can also benefit greatly from the existence of these lanes.

Also, there is a further distinction between "at-grade" busways and "grade-separated" busways. "At-grade" busways must eventually cross signal-controlled intersections, which may greatly reduce the overall potential capacity of the system. "Grade-separated" busways avoid such conflicts by being constructed in a manner completely separated from any conflict with other lanes. Overpasses, underpasses, and tunnels are a few of the options available to create grade separation. In fact, the use of tunnels in cities such as Seattle and Boston has made the terms "surface subway" and "BRT" no longer synonymous (Figure 18). The Boston Silver Line is essentially an underground system that happens to use bus rather than rail technology. Clearly, such designs undercut the cost advantages that surface BRT systems hold over rail, but it does provide further indication of the blurring of the line between bus and rail options. In cities like Quito, Ecuador, the "Trolley-Bus" BRT system makes use of underpasses at key intersections. Given the time savings and congestion avoidance attributed to such underpasses, payback periods may be short.

Fig. 18 ▲

BRT systems can also be constructed underground as practised in cities such as Seattle and Boston.

Photos courtesy of the US Transit Cooperative Research Program

when existing traffic flows may not realistically permit lane conversion to busways. Further, such arterials may not provide easy or safe access for pedestrians to reach the BRT stations. Thus, other alternatives include secondary roads that are parallel to and near a major arterial. Such secondary roads often hold the advantage that they are more "traffic-calmed" for effective busway conversion. In some cases, a secondary road may be entirely converted to BRT use, and thus prohibit access to private vehicles. The feasibility of such as approach depends upon existing use patterns in the area.

The location of the segregated busway is another design decision that holds more options than might be immediately apparent. The most common option is to locate the busway in the centre median or in the centre two lanes (Figure 19). This configuration reduces turning conflicts to the right (in countries that drive on the right-hand side of the street). This configuration also allows for more integration options with busway lines that may cross on a perpendicular street.

Along with a centre lane configuration option, one can opt for either "with flow" or "counter-flow" bus movements. "With flow" means that the buses drive in the same direction as the cars alongside them. "Counter flow" means that the buses drive in the opposite direction of mixed traffic (Figure 20). Counter flow is sometimes used if the doorways on the existing buses require the bus to drive on a certain side. Obviously, it is preferable to adapt the bus to the optimum busway design, but this is not always possible. A major issue is that counter flow arrangements can endanger pedestrians, who will be unaccustomed to looking in the direction of the counter flow lane before crossing the road.

Beyond the centre lane configuration, there are a full range of alternatives that all too often do not receive complete consideration. In Miami, the two busway lanes operate entirely on one side of the roadway while the mixed traffic is given several lanes (in both directions) on the other side (Figure 21). This configuration works well when one side of the road lacks many turn-offs, such as when a roadway runs along a body of water or a large park. In Orlando, USA, a similar concept is used but with a roadway of significantly fewer lanes (Figure 22).

"Beyond the centre lane configuration, there are a full range of alternatives that all too often do not receive complete consideration"

In some cases it may be possible to give over the entire roadway to the BRT system. In Pittsburgh, USA, the East (a former rail corridor) and West busways operate on exclusive

Fig. 22
Busway in Orlando, USA.
US Federal Transit Administration

Fig. 19
Busway located in the centre median.
Photo courtesy of TransMilenio SA, Municipality of Bogotá, Colombia

Fig. 20
Counter-flow busway in Quito, Ecuador.
Lloyd Wright

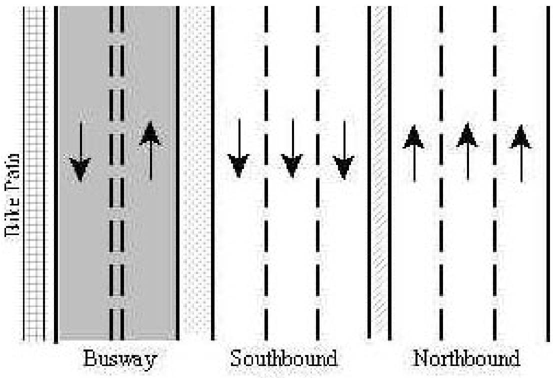


Fig. 21
Both busway lanes located on one side of the road in Miami, USA.
US Federal Transit Administration

road networks that have virtually no interactions with mixed traffic, as does the Brisbane Busway (Figure 23).

A surprisingly rare BRT configuration is the placement of the busway on the sides of the roadway. While this configuration is fairly common with bus lanes, busways do not utilise the design, primarily because of the conflicts with turning traffic. Such a configuration also creates difficulties when trying to allow free-flow transfers between perpendicular lines. To do so would require a rather elaborate set of overhead or underground pedestrian passages to keep the system closed off.

Fig. 23

An exclusive busway in Brisbane, Australia, running under a major hospital complex.

Karl Fjellstrom

Fig. 24

Curitiba utilises a range of busway configurations, depending on the nature and dimensions of the existing roadway.

Karl Fjellstrom, Feb. 2002

"It may be possible to use several different configurations in a single system"

Like many other design decisions associated with BRT, there is no single "correct" solution to roadway configuration. Much depends upon the local circumstances. Additionally, it may be possible to use several different configurations in a single system. Curitiba, Brazil uses centre lanes, both lanes on the side, and streets exclusively for BRT (Figure 24). In most cases the only limitation is to keep the doorway on the same side, so that one has the flexibility to use the same buses on multiple lines. However, even this caveat has been circumvented in some cases; Porto Alegre has buses with doorways on both sides, allowing maximum flexibility.

Station and terminal design

The design and location of the BRT stations will affect system flow capacities as well as key customer service parameters such as safety and convenience. Station location is largely demand driven with access to primary destinations such as shopping complexes, stadiums, major office buildings, and schools being a determining factor. The optimum distance between stations is a trade-off between demand at key locations and the time penalty incurred for each stop added. A standard distance between stations is around 500 metres but can range from 300 to 1000 metres, depending upon local circumstances.

Ease of access to the stations will play a role in determining the size of customer base. The development of pedestrian and bicycle corridors around the station will help ensure that customers are able to conveniently and safely make their way to the station. Recognisable signage in the area will also help to attract customers. Street lighting, adequate sidewalk widths and quality surfaces all contribute to ensuring that customers can confidently utilise the system.

The entry areas, fare sales area, turnstiles and the station structure must all be designed to sufficiently handle projected peak customer flows. Key factors for this determination include the number of bus stopping bays, peak frequency times, and expected bus dwell times. The floor space dedicated to the expected number of waiting customers should be sufficient to avoid user discomfort. Adequate customer space will also help to reduce incidences of pick-pocketing and other crime. However, floor space is limited to an extent by the available street space that may be allocated to the station footprint. Station widths typically vary from 3 to 5 metres. Passenger space in narrower stations can be partially gained by increasing the overall length.

Station design also depends upon an interaction with bus technology decisions. Decisions on the number of boarding doors and the width of the doorways must reflect both passenger flow requirements and the availability of options from bus manufacturers.

The type of ramped entry device will impact the likely dwell times of the buses. BRT systems in cities like Bogotá are able to reduce dwell times to 20 seconds using an array of rapid boarding and alighting strategies. Cities such as Curitiba and Quito utilise flip-down ramps attached to the bus to speed up customer flows (Figure 25). Bogotá's TransMilenio system opted not to utilise flip-down ramps in order to save the few seconds that the flip-down device consumes when opening and closing. Instead, TransMilenio relies upon close alignment between the bus and the station docking area to allow quick access. Optical and mechanical guidance devices can also be utilised to ensure swift and accurate docking. Minimising the bus to station distance is key to the rapid flow of customers as well as making boarding practicable and safe for disabled people.

Bogotá has also made use of sliding doors at the station to bus interface (Figure 26). Automatic station doors give a degree of safety to waiting passengers as well as protection against wind, rain and cold. Additionally, the sliding doors can help prevent fare evaders from entering the system. The disadvantage of the doors is that they are susceptible to mechanical failure and can thus add to system maintenance costs.

Fig. 25 ▲
Flip-down entry ramps in Quito, Ecuador.
Lloyd Wright

Protection from weather is a major consideration in station design. The image of the station as a refuge from the outside world can help attract customers. In many developing cities, high temperatures and humidity are a concern. Passive solar design techniques can help shield the station from direct sun as well as stimulate natural ventilation flows. Air conditioning and ventilator fans are an option to consider, but obviously are a significant cost item. Open designs can be a good option (Figure 27), especially in warm locations, although open designs increase the need for protection against fare evasion.

Architectural considerations are also important from aesthetic, cultural and customer-friendliness perspectives. Many systems opt for a highly modernised appearance, which helps to position BRT as a new class of public transport. However, if the system runs through or along corridors of great historical value, designers may wish to seek congruence with the adjoining architecture.

Fig. 26 ▼
Automated sliding doors protect passengers as buses arrive.
Courtesy of TransMilenio, SA, Municipality of Bogotá

Fig. 27
Open-air station design.
Illustration courtesy of the Municipality of Pereira, Colombia

Terminals involve many of the same design issues as stations. Given the larger number of passengers and transfer options, terminals require more space. Whether or not the system is designed for free fare transfers will have a significant impact on terminal design. Free fare transfers mean that passengers can move from feeder services to trunk line services without an additional fare. If an additional fare payment is required, then space must be given to fare collection and fare verification activities.

Fig. 28
Electronic kiosk in Taipei BRT station.
Photo courtesy of Jason Chang

Fig. 29
Air quality monitoring display at the metro station in Montreal, Canada.
Lloyd Wright

System designers also face decisions regarding the types of services that may be offered within a station. Quito, Ecuador, for example, offers entertainment at stations through video displays. Other systems offer information displays and even internet access. Terminals may include restrooms and other customer services such as information kiosks (Figure 28). Some systems use BRT stations and terminals as venues to publicise or implement other programs of public interest, such as recycling facilities and air quality monitoring (Figure 29).

Commercial establishments within terminals are possible, but can create many complications, including litter and security issues. Food and beverages should be kept out of the system to the extent possible, since their presence adds to maintenance costs and ultimately lead to a premature aging of the infrastructure. Some systems intentionally elect not to provide additional services. These system designers feel that the most important task is to keep passengers moving through the system, and that additional services are an impediment to that over-arching goal.

Station advertising, in moderation, can be a revenue source, but also carries with it complications. Too much advertising will detract from the visual clarity of the system and can lead to customer confusion, especially when system maps and other key information displays are difficult to find due to visual clutter.

Bus depot design

Bus depot areas are used for an array of purposes, including parking for buses not in use, re-fuelling facilities, maintenance areas, and office space for bus operators (Figure 30). The location of a bus depot is ideally within close proximity to the actual system, since operators will want to have the ability to rapidly introduce additional buses to meet peak demand. However, since bus depots can consume considerable space, the location is often dependent upon the economical acquisition of sufficient property.

The type of re-fuelling facilities will depend on current and future fuel types to be utilised in the system. Bogotá, Colombia provides facilities for both clean diesel and compressed natural gas (CNG) since the operators have decision-mak-

Fig.30

Bus depot and maintenance area in Bogotá.

Photo courtesy of TransMilenio, SA, Municipality of Bogotá

ing control over fuel selection, provided given emission standards are met. Maintenance areas should provide operator personnel the ability to easily access the bus chassis from below in order to fulfil both repair and inspection activities.

Landscape designs and plan

BRT systems should enhance rather than detract from the aesthetic value of a city's public spaces. All efforts should be made to retain existing green spaces. If the centre median is utilised as the location of the stations, the existing landscape can be left significantly intact. Only the station footprint may require landscape alterations. The other areas can be enhanced with additional plantings. Greenery may also be an option as a divider between the BRT system and other traffic lanes. Trees and plants can also provide climatic protection to pedestrian and bicycle corridors linking with the BRT system.

2.5 PLANNING STAGE V: TECHNOLOGY AND EQUIPMENT

It is not by coincidence that technology and equipment decisions are listed later in the BRT planning process, well after decisions on routing, customer service, and tariff structures. Technology and equipment should be responsive to customer needs rather than the other way around. Too often, municipal officials make a decision at the outset of the process on a particular bus manufacturer, and thus force the design of the system to match the demands of a bus manufacturer above those of the customer. Certainly, there is a degree of interplay between the available products on the market and how a system is designed, but ideally a system is largely led by customer needs rather than arrangement of a special relationship with a supplier. Further, by creating a transparent and open specification process, a municipality can foster a competitive environment, which will ultimately reduce costs and improve the quality of delivery.

Following is an outline of technology and equipment issues typically addressed in a BRT plan:

1. Fare collection and fare verification systems
- Pre-pay systems vs. on-board payment stations
- Ticket-less systems, magnetic strip technology, smart card technology.

2. Control Centre plan
- GPS systems
- Driver to control centre communications.

3. Intelligent Transport Systems (ITS)
- Real time information displays
- Security cameras
- Signal priority systems.

4. Bus technology

- Specification standards and process
- Propulsion technology / fuel choice
- Normal, articulated, bi-articulated options
- Guidance systems.

5. Interior design of bus

- Internal seating arrangements
- Space for disabled passengers and bicycles.

6. Equipment procurement process

Fare collection and fare verification systems

The method of fare collection and fare verification has a significant impact on passenger flow times and the system's overall impression to the customer. Most importantly, having fares paid before entering the bus reduces the long delays that accompany on-board payment. Once passenger flows reach a certain point, the delays and time loss associated with on-board fare collection become a significant system liability (Figure 31). In Goiania, Brazil, the local transit agency estimates that this point is reached when the system capacity reaches 2,500 passengers per hour per direction.

Pre-board fare collection also carries another benefit. By removing the handling of cash by drivers, incidence of on-board robbery is reduced. Further, by having an open and transparent fare collection system, there is less opportunity for individuals to withhold funds.

Several different technologies and mechanisms exist to facilitate pre-board fare collection, including:

- Coin or token systems
- Magnetic strip technology
- Smart card technology
- Proof of payment systems.

Again, no single solution is correct for all situations. The choice of fare collection system often involves trade-offs between costs, simplicity and management burden. In Quito, Ecuador, a simple coin-based system (Figure 32) meets the city's needs. The system thus avoids the need for any paper tickets. This system also eliminates long customer queues of people seeking to purchase fares. In Quito, an attendant window does exist, but it is only to give change to those who require it. Upon exiting a system, passengers simply file through one-way exit doors without the need for further fare verification. Often, simpler technologies also produce savings in terms of maintenance and operation, since such technologies tend to be more robust.

Magnetic strip technology also enjoys a relatively long history of application and success in the field. Such systems do require the pre-purchase of a magnetic fare card for system entry and verification. Capital costs can be significant for both the ticket vending machines and the magnetic strip readers at the fare gate. However, the advantage of magnetic strip technology is the relatively low-cost of the fare cards themselves, US$0.02-US$0.05 per card. The cards may be programd to allow multiple trips and can also permit different fares to be charged for different distances travelled. Some system providers utilising magnetic strip cards also permit discounted fares for individuals purchasing multiple trips.

Fig. 31 ▼

On-board fare collection creates delays and problems in Goiania, Brazil.

Lloyd Wright

Fig. 32 ▲

Quito uses a simple, coin-operated system.

Lloyd Wright

Smart card technology is the latest advance in the fare collection field. Smart cards contain an electronic chip that can read a variety of information regarding cash inputs, travel, and system usage. Smart cards also permit a wide range of information to be collected on customer movements, which ultimately can assist in system development and revenue distribution. BRT systems in Bogotá and Goiania have successfully employed smart card technologies (Figure 33). Smart cards permit the widest range of fare collection options such as distance-based fares, discounted fares, and multiple trip fares. Such cards also collect a complete set of system statistics that can be helpful to system managers.

The main drawbacks of smart card technology are cost and complexity. The systems require fare vending personnel and / or card vending machines. The system also typically requires verification machines at the system exits, if distance-based fares are utilised. In each instance, there is a risk of long customer queues, especially during peak periods. In addition to the costs of the vending and verification machines, each smart card is a relatively costly expense. Current prices are in the area of US$1.00 – US$2.00 per card. Unlike magnetic strip cards, though, smart cards have a long life and can be re-used. As smart cards become more common, this cost will undoubtedly continue to fall. The long-term promise of this technology extends well beyond transit fares, as some systems are seeking to utilise the same smart cards to permit purchases at shops and the payment of other bills. Such systems are already in operation in Hong Kong (where the 'Octopus' card is even accepted at some McDonald's fast food branches), and are in planning in many other cities.

Finally, systems in Europe and North America often employ "***proof of payment***" techniques, also known as "honour" systems. Such systems also entail pre-board fare collection, but customers board directly without any fare verification. Instead, fare compliance is maintained through customer goodwill and enforced through random fare verification by system personnel. Fare violators are fined. The main advantage of proof of payment fare systems is that the construction of a closed entry station is not needed. No physical separation between the station and the outside area is necessary. This design advantage can help reduce station construction costs as well as permit better station design in areas with limited physical space. The principal disadvantage of such a system is its great dependence on customer compliance that is sometimes difficult to obtain. Further, the use of fare verification staff for the random checks can be costly.

Fig. 33

Bogotá uses smart card technology for fare collection and verification.

Lloyd Wright

"Even developing cities should now consider the advantages of a central control system"

Control centre plan

As with fare collection and fare verification technologies, the cost of central control technologies has steadily decreased over the years. Thus, even developing cities hould now consider the advantages of a central control system.

Control centres permit a high degree of system management and control that affords many advantages. First, a control centre can help identify and correct bus "bunching". When this occurs, several buses are packed together in the system, while at the same time other buses are separated by great distances. Passengers are often familiar with the situation in which 3 or 4 buses of the same line arrive almost simultaneously, with no other buses for an extended period (Figure 34). Second, a control centre can also help identify and respond to problems that may arise in the system. For instance, if a bus should have a mechanical problem, a repair or tow team can be immediately mobilised. Alternatively, if a

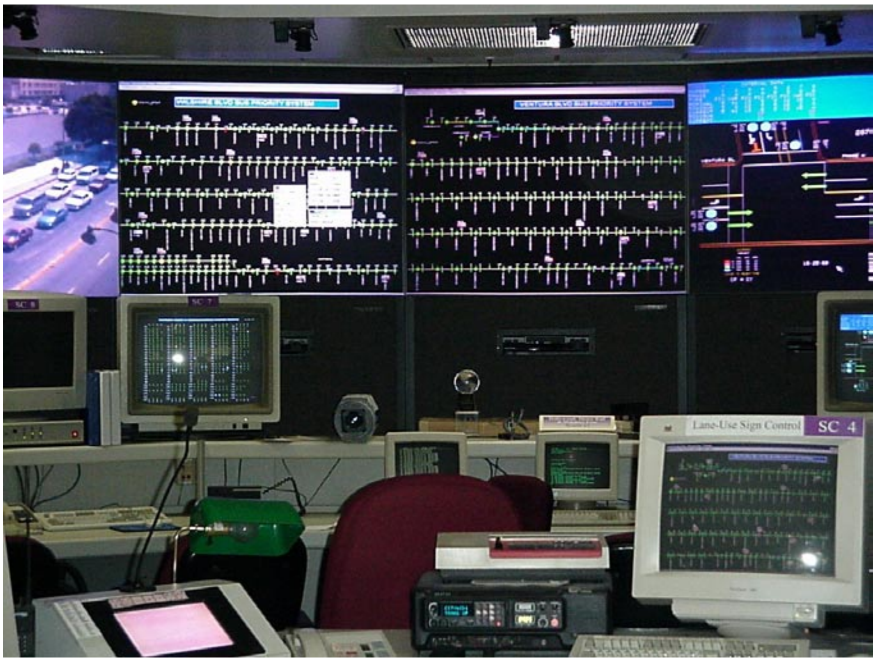


Fig. 34

BRT control centre in Los Angeles, USA, helps avoid bus 'bunching'.

Courtesy of Los Angeles Dept. of Transportation

security problem arises, the control centre can likewise provide an appropriate response, such as sending a security team to a station or bus.

> *"Control centres permit a high degree of system management and control"*

Several options exist to link buses and stations with a central control office. In some instances, a simple radio or mobile telephone system may suffice. However, increasingly Geographical Positioning Satellite (GPS) technology is providing an effective communications link (Figure 35). GPS technology permits real-time information on bus location and status. In turn, this information can be utilised for a variety of purposes including system safety and control. Additionally, such information can help determine revenue distribution to private sector operators, based upon distance travelled during the course of a day.

Intelligent transport systems

Taken together, sophisticated fare collection systems and GPS control systems are just part of a package of options under the rubric of "Intelligent Transport Systems" (ITS). An array of other options exists that can deliver considerable added value, comfort and security to the customer's transit experience. As noted, the cost of technologies are also rapidly decreasing, thus permitting application in many developing cities.

Real-time information displays can be of great value in systems in which possible separation times between buses can be over a few minutes. "Waiting anxiety" occurs to passengers who do not know when or if a bus is arriving. By knowing the expected arrival time of a bus, the customer can mentally relax as well as potentially undertake another value added activity to make best use of the waiting time. Some

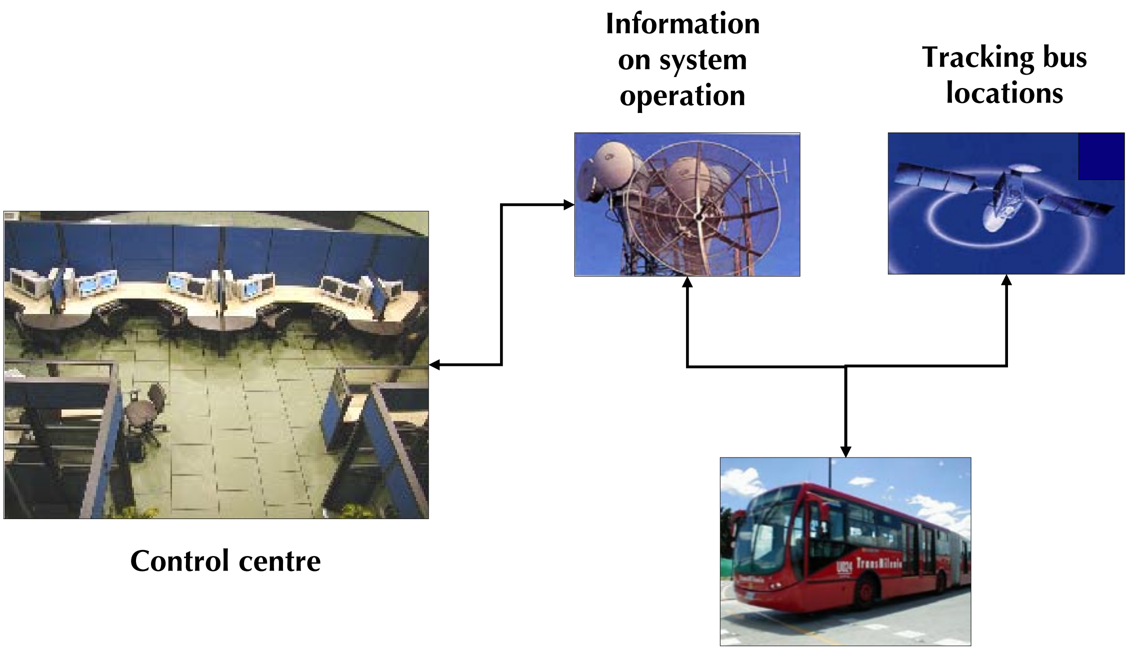


Fig. 35

GPS bus tracking system in Bogotá.

Photo courtesy of TransMilenio, SA, Municipality of Bogotá

Fig. 36
Real-time passenger information systems have recently been expanded in Singapore's MRT system.
Lloyd Wright

systems, such as the Singapore MRT, place a real-time information display outside of the station, at the entrance (Figure 36).

Security cameras are a cost-effective approach to system policing. Station managers can keep a close watch on all parts of a station area. System-wide security systems allow a central control area to observe activities in all stations and buses. The mere presence of the cameras can often deter crime. The cameras are also a visible sign to the customer of system security and can help reduce anxiety, particularly amongst vulnerable groups.

"The choice of bus technology is important, but not necessarily more so than the myriad of other system choices"

Signal prioritisation techniques give preference to system buses at intersections where the system must cross mixed traffic. Los Angeles' Rapid Bus system successfully utilises signal prioritisation. As a bus approaches a signalled intersection, a transponder on the bus communicates with an induction loop located in the lane. A message is then sent to the intersection's signal controller to give a green light to the approaching bus. In the case of Los Angeles, the prioritisation is only given every other signal cycle, to reduce traffic disruption. Signal prioritisation works best when separation times between buses are over 4 – 5 minutes. In systems like Bogotá's TransMilenio, the high flow rates mean that buses are separated by as little as 30 seconds, and signal prioritisation would have relatively little useful application.

Overall, ITS can substantially improve system efficiencies. With the cost of such systems falling each day, even developing nation cities should conduct a full review of the options and potential applications.

Bus technology

Few decisions in the development of a BRT system invoke more debate than the choice of bus propulsion technology and bus manufacturer. However, it should always be remembered that BRT is far more than just a bus. The choice of bus technology is important, but not necessarily more so than the myriad of other system choices. Further, the choice of bus will in part be determined by the preceding analysis of capacity needs and busway design.

The specification of bus technology will affect operational costs and environmental performance. A decision must be made on the level of detail to be prescribed for the bus technology. Cities such as Bogotá have specified the performance characteristics of the bus, but have left it to the private sector bus operators to decide upon the technology and manufacturer. For instance, TransMilenio specifies that buses must meet a minimum Euro II emission standard. TransMilenio also specifies bus dimensions, the size and operation of doorways, interior seating arrangements, colour and many other variables. However, it is up to the bus operator, who is paying for the buses, how to best meet these requirements. Thus, in the TransMilenio system both clean diesel buses and CNG buses can be found, along with several different bus manufacturers. To the customer, however, the operation and appearance of the buses is identical.

Today, bus technology developers are seeking to provide cleaner bus options. Propulsion systems and alternative fuel options (discussed in Module 4a: *Cleaner Fuels and Vehicle Technologies*) now include:

- Clean diesel
- Compressed natural gas (CNG)
- Liquid petroleum gas (LPG)
- Hybrid-electric
- Electric
- Fuel cell.

It is generally preferable for regulators to only specify particular qualities, such as emission standards, rather than force a specific technology upon an operator. The operator will need to consider a range of factors such as fuel costs, fuel availability, maintenance, reliability, refuelling times, and performance. Likewise, each operator should be able to choose manufacturers based upon their own circumstances.

Some aspects of the bus design process, though, will be strictly mandated through the specification process. For instance, the system designers will need to specify bus dimensions and the number and size of doorways. Bus dimensions and doorway specifications should be largely determined by the flow capacities projected for the system. Standard options include:

- Vans (10 passengers)
- Mini-buses (30 passengers)
- Standard buses (70 passengers)
- Articulated buses (160 passengers)
- Bi-articulated buses (270 passengers).

The passenger capacity figures per vehicle type are only approximations, since the actual capacity will depend upon seating / standing arrangements. The vehicle size should match the passenger demand in a manner that also provides suitable frequency of service. High volume systems will likely require both large (articulate or bi-articulated) buses and high-frequency service. Lower volume systems should also strive for high-frequency service, but obviously with smaller bus types. It is also not a matter of just selecting one bus type, since feeder and trunk line vehicles will likely be quite different. Bogotá, for instance, uses articulated buses on trunk line corridors and standard buses on feeder lines.

System designers may also specify the maximum allowable age of buses operating on the system. The age specification will help to maintain long-term system quality as well as ensure all private operators are competing on an equal basis.

There has been considerable attention given to low-floor buses in recent years, particularly in Europe and North America (Figure 37). Such buses permit relatively rapid boarding and alighting without the need for ramped entry stations. However, low-floor buses also entail trade-offs. Being closer to the ground, the buses typically incur more stresses and thus have higher maintenance costs. Low-floor buses also typically cost US$50,000 – $100,000 more than standard models. Table 5 provides a comparative analysis of low-floor buses.

Fig. 37

Low-floor buses offer a rapid boarding option.

Courtesy of US Transit Cooperative Research Program and the Joikapoar Transit Authority (Jonkopings, Sweden).

Another bus design feature that has enjoyed some popularity is mechanical guidance systems (Figure 38). Systems in cities such as Essen, Germany and Adelaide, Australia have employed mechanical guidance systems to increase bus velocities and reliability. The guidance systems consist of a physical bus track that steers the bus by way of a mounted side-roller wheel. The guidance systems give some advantages in terms of speed and a potential reduction in the width of the roadway. However, the guidance tracks

Table 5: Advantages and disadvantages of low-floor buses.

Advantages	Disadvantages
No need to build ramped stations	Can cost US$50,000 to $100,000 more per bus
Can use in low-density communities where station construction is impractical	Creates difficulties in stopping fare evasion within closed fare systems
Creates more modern image with the customer	Difficult to tow when break-downs occur
More rapid boarding than systems with high steps	Lower passenger throughputs than buses with ramped entries
	Higher maintenance costs

can nearly double the construction cost of the busway. Likewise, with the shorter distances between stops (700 metres and less) in high-volume, developing country applications, the speed advantage of mechanical guidance systems becomes less attainable. Table 6 summarises some of the advantages and disadvantages of mechanical guidance systems.

Aesthetics

The aesthetic nature of the bus technology should also be an explicit component of the design and specification process. Bus styling, colour and aesthetic features figure greatly in the public's perception of the system. Some bus manufacturers are now emulating many of the design features from light rail systems (Figure 39). Simply by covering the wheels and rounding the bus body, these manufacturers have greatly increased the appeal of their product.

Interior design of bus

From a customer perspective, the interior of the bus is far more important than the mechanical components propelling the bus. The interior design will directly affect comfort, passenger capacity, security and safety. The amount of space dedicated to standing and seated areas should be based upon expected passenger flows, especially accounting for peak capacities. The width of aisle ways will also be part of this equation. Seating facing to the sides rather than to the front can open up space for standing passengers. Placement of holding devices (poles, straps, etc.) should be considered for standing passengers.

Special arrangements should also be made to cater to the needs of physically disabled and elderly passengers. The station entry ramps are an important feature, but likewise adequate interior space for wheelchairs is important. Additionally, the safe attachment of wheelchairs to a fixed interior structure may be required.

The bicycle is needlessly banned from many bus systems. With the ramped entryways of BRT vehicles, bicycles can be easily boarded, especially during non-peak periods. The space permitted for bicycles can also be an effective open space for standing passengers during peak times. Interior designs of buses in Rouen, France permit easy entry for bicycles.

Fig. 38

Adelaide's so-called O-Bahn system uses mechanical guides.

Courtesy of US Federal Transit Administration

Table 6: Advantages and disadvantages of mechanical guidance systems.

Advantages	Disadvantages
Permits higher velocities and greater safety	Significantly increases the cost of busway construction
Allows more narrow busways	Creates inflexibility regarding the type of buses that can be utilised in the system
Creates more permanent image to the BRT system	Offers no speed advantage over shorter distances

Fig. 39

"Think rail, use bus" is the appropriate motto for new bus designs that have borrowed greatly from sleek light rail designs.

Photo courtesy of Irisbus (Civis model)

Equipment procurement process

The appropriate structuring of the procurement process can create a competitive environment that will drive cost reduction and efficiency. A well-designed procurement plan will promote an open and transparent process that will help eliminate corruption and graft. System developers should seek a wide range of bidders for each piece of equipment needed. To achieve this environment of competitiveness, the procurement specifications should be sufficiently rigorous to meet system requirements while also leaving room for bidding firms to innovate. Prior to issuing tenders, an explicit set of criteria should be created that sets forth the determining parameters for selecting a bid and the relative weight given to each factor (cost, experience, quality, etc.). The determination of winning bids should be done objectively and transparently.

2.6 PLANNING STAGE VI: MODAL INTEGRATION

Like all public transport systems, BRT systems cannot be designed and implemented in isolation. Instead, such systems are just one element in a city's overall urban framework and set of mobility options. To be effective, BRT should be fully integrated with all options and modes. Other transport options such as walking, cycling, driving, taxis, and other public transport systems should not be competitors with the BRT system, but rather complementary services that in many cases will interact with BRT as a seamless set of options serving all aspects of customer demands. BRT systems are often implemented simultaneously with Travel Demand Management (TDM), which seeks to create appropriate incentives to encourage more efficient use of urban space. The following is a possible outline of the contents of this planning stage:

1. Modal integration plan

- Pedestrian access
- Bicycle integration
- Taxi stations
- Park and ride
- Train services
- Complementary services.

2. Travel demand management plans

- Green Travel Plans
- Travel Blending
- Traffic calming
- Congestion pricing / road pricing
- Parking restrictions / parking pricing
- Parking cash-out
- Fuel taxes.

3. Integration with land use planning

Please refer to Module 2a: *Land Use Planning and Urban Transport*, and Module 2b: *Mobility Management Measures*, for discussion of policy options for transit-oriented development.

Modal integration plan

Too often, system designers think of other transport modes as competing rather than complementary. By maximising the BRT system's interface with other options, system designers are helping to optimise the potential customer base. The BRT system does not end at the entry or exit door of the station, but rather encompasses the entire client capture area. People must be able to reach a station comfortably and safely if they are to become, and stay, customers.

A well-designed pedestrian access plan will provide a natural flow of walking customers from the surrounding area. Pedestrian access routes should be planned over a radius of at least 500 metres around each station. System planners should ask a few basic questions regarding the quality of the pedestrian access. Are the pedestrian walkways leading to the station well maintained? Are they sufficiently broad to comfortably handle the expected pedestrian traffic? Are they safe and well lit? Is there adequate signage to lead individuals easily to the stations? Are there logical pedestrian connections between major origins and destinations such as shops, schools and work places? Some cities now are providing low-cost, covered pedestrian walkways in order to eliminate the disincentive that the weather can bring to walking and cycling (Figure 40). In cities with extreme heat, covered walkways can reduce temperatures by 5 – 8ºC, and thus make the difference in the viability of comfortably reaching a BRT station.

The development of dedicated pedestrian zones around a BRT station can be mutually synergistic for both the pedestrian and public transport systems. The BRT system helps alleviate the

Fig. 40 ▲
Quality pedestrian pathways, such as these covered path ways in Bangkok, Thailand (left) and Panama City, Panama (right), can ease customer journeys to the BRT system.
Lloyd Wright

necessity of costly car-based infrastructure in the city core. The dedicated pedestrian zones provide a concentration of customers that can feed directly into the BRT system. Curitiba, Brazil is a leading example of integrating dedicated pedestrian zones with its BRT system (Figure 41).

Fig. 41 ▲
Curitiba, Brazil's pedestrian zone links directly to its BRT system.
Lloyd Wright

Supporting bicycle integration with BRT is another effective mechanism for dramatically increasing the potential customer base. Most customers will consider the public transport system a viable option if it is within a certain time budget of their home. For instance, individuals may consider a time travel budget of 20 minutes acceptable in reaching a BRT station. Bicycles are capable of covering a distance five to ten times greater than walking in the same time period. Thus, bicycles present an opportunity to increase the effective customer catchment area by 25 to 100 times (since area is related to the square of the distance travelled). Unfortunately, the lack of adequate cycleways and bicycle parking at stations means that many systems forego this profitable opportunity.

It is no coincidence that cities with world-class BRT systems also possess exceptional bicycle networks. Bogotá is home to Latin America's largest bicycle network, with 270 kilometres of dedicated cycleways (Figure 42). Likewise, Curitiba has done much to promote bicycle use. Merging BRT systems with bicycle networks requires integrated planning that connects stations and terminals with the cycleways. Additionally, safe and secure bicycle parking at the stations is essential (Figure 43). Secure parking facilities

Fig. 42 ◄
Bogotá, Colombia is host to both TransMilenio and a world class bicycle network.
Lloyd Wright

Fig. 43
Bicycle parking in Copenhagen, Denmark.
Courtesy of Dr. Lee Schipper

with a permanent attendant overseeing bicycle parking and the collection of bicycle claim checks can be an effective strategy. Security cameras can also give confidence to cyclists. Covered bicycle parking structures may be necessary in areas of high rainfall or during the wet season in equatorial regions.

Another commonly neglected opportunity for integration concerns the car taxi industry. In developing-nation cities, taxi associations can be politically powerful and often left relatively uncontrolled. In such cities, the taxis also constitute a large percentage of the vehicles creating congestion. In many cases, this congestion is largely due to taxis circulating in search of passengers. Taxis in Shanghai, for instance, are estimated to spend 80% of their travel time without passengers.

The strategic location of taxi stands in close integration with BRT stations can prove to be a 'win' for system designers, taxi drivers, city officials, and the public (Figure 44). System designers win by adding another important feeder service to their route structure. The taxi owners and drivers win by dramatically reducing their operating costs. The BRT stations provide a concentration of customers for the taxis without the need to circulate around the city expending large quantities of fuel. City officials win by helping to reduce a major factor in urban traffic congestion. And finally, the public wins by having a more flexible and convenient transit system that also reduces urban emissions and promotes greater overall efficiency.

Private vehicle owners can also be successfully integrated within the system through the development of park and ride facilities. Such facilities work best when attracting residential customers to terminals located at the end of the BRT lines. Auto users can then complete their commute more rapidly on a busway. One of BRT's best marketing strategies is the sight of a bus speeding by a long line of gridlocked vehicles. Private vehicle owners are less likely to use a park and ride facility if they are driving a substantial distance into the city and then using the public transit only for a small final portion.

Finally, BRT can also be complementary with other urban and long-distance transit options. Cities with existing metros and urban rail services can integrate these options with BRT. Sao Paulo, for instance, uses BRT to connect the ends of its metro line with other communities. Some cities with existing metro systems are unable to finance the completion or expansion of the metro. In such instances, BRT has been an economical option that will help bring a public transit connection to the entire city.

The key to successful integration is the physical connection between the two systems, the complementary marketing and promotion of the two systems, and the unification of fare structures. In Sao Paulo, the physical connection is made simple by ramps departing the metro system leading directly to the BRT system. Clear signage also helps make this integration relatively seamless. Further, the two systems can be marketed jointly under one name and logo, so that the systems are clearly unified in the eyes of the customer. Finally, an integrated fare structure permits customers to leave one mass transit mode and enter

Fig. 44
Integration between taxi stand and BRT in Quito, Ecuador.
Lloyd Wright

another without being required to purchase an additional fare.

BRT should also be integrated with long-distance public transport infrastructure such as long-distance bus stations and train stations. Again, the physical planning of the interface is the key to making this a viable option. Passengers from such modes often are carrying luggage or goods, and thus are in particular need of a convenient transfer mechanism.

Travel demand management

Part of the equation for transforming a city and its mobility structure is the provision of high-quality public transport, such as BRT. At the same time, the strategic use of incentives to discourage private vehicle use can provide multiple dividends. Use of the appropriate incentives can further bolster the ridership of the new transit system, support the sustainable restructuring of the city, lead to additional environmental and economic gains, and create a greater sense of equity through improved access and mobility.

Recent experiments with TDM or mobility management techniques have shown how the right incentives can direct people towards more sustainable transport modes. Mechanisms such as Green Travel Plans, Travel Blending, traffic calming, congestion and road pricing, parking restrictions, and parking cash-out programs have all achieved dramatic successes in moving commuters towards public transit and non-motorised options. The development of a BRT system is an ideal time to adopt TDM measures.

Integration with land use planning

The Latin American BRT systems have also demonstrated the value of integrating land-use planning with public transit strategies. BRT systems can support sustained economic development. The BRT stations in Curitiba are development nodes, which have attracted a concentration of commercial and residential development. The strategic siting of BRT stations and corridors can support both the BRT system and the city's development plans. Transit-oriented development improves customer access to shopping, employment, and services while the high-density centres ensure sufficient passenger traffic to maintain a cost-effective BRT system. Curitiba has also coordinated new residential construction around bus arteries. The end result is that the municipality can deliver basic infrastructure such as water, sewage, and electricity at a significant cost savings to the concentrated and coordinated areas of development.

2.7 PLANNING STAGE VII: PLANS FOR IMPLEMENTATION

The production of a BRT plan is not the end objective of this process. Without implementation, the planning process is a rather meaningless exercise. And yet, too often significant municipal efforts and expenses on planning end in idle plans lining office walls, with little more to show for the investment. However, the planning process can provide a confidence boost to leaders and ensure that sufficient considerations have been taken to ensure a successful implementation. Thus, this final stage of the BRT planning process is the critical point to ensure that the spirit and form of the plans can be brought to completion in an efficient and economic manner. The following is a possible outline of the contents of this planning stage:

1. Financing plan
- Local financing options
- National financing
- International financing
- Commercial financing
- Private sector financing.

2. Staffing plan
- Positions
- Hiring strategy.

3. Contracting plan for system
- Concessions
- Bidding process
- Penalties and incentives for contractors.

4. Construction and implementation plans
- Construction scheduling and timeline.

5. System maintenance plans
- Identification of maintenance items
- Maintenance schedule
- Maintenance costs and financing.

6. Monitoring and evaluation plan
- Targets and indicators
- Frequency of monitoring and evaluation
- Feedback systems for system improvement.

Financing plan

Introduction

Surprisingly, finance is not typically a major barrier to BRT implementation. One reason for this stems from BRT's relatively low capital and operational costs. Some developing-nation cities have actually found that loans and outside financing are unnecessary. Internal municipal and national funding may be sufficient to fully finance all construction costs. And since most BRT systems operate without operational subsidies, no public financing will likely be necessary as the system moves to full implementation.

However, if financing proved to be necessary, commercial, bi-lateral and multi-lateral institutions are increasingly supportive of BRT projects. Unlike other mass transit options, BRT presents sufficiently low capital requirements and historically positive operational returns to be considered commercially bankable projects. International organisations also tend to support BRT, for similar reasons. The World Bank's recent *Urban Transport Strategy Review* (www.worldbank.org/transport) made highly favourable remarks on BRT. Bi-lateral agencies and regional development banks are also positively disposed toward cost-effective BRT projects.

Financing for BRT can be divided into three groups of activities: planning, infrastructure and equipment (such as buses). Each of these activity areas typically involves different sorts of financing organisations. Table 7 summarises potential financing sources for these activity areas.

Table 7: Potential Financing Sources for BRT.

Activity Area	Financing Source
System Planning	Local and National Sources
	Bi-Lateral Assistance Agencies (e.g. GTZ, USAID)
	United Nations Development Program (UNDP)
	Global Environment Facility (GEF)
	Private Foundations
Infrastructure	Local and National Sources
	World Bank
	Regional Development Banks (e.g., ADB, IDB)
	Commercial Banks
Equipment (e.g. buses)	Private Sector Bus Operators
	Bus Manufacturers
	Bi-Lateral Export Banks
	International Finance Corporation
	Commercial Banks

Local financing options

Before looking to international funding opportunities, though, municipalities should fully investigate local financing options. The relatively low capital cost of BRT may mean that external financing is unnecessary. Obviously, cities and national governments should try to avoid adding to existing debt levels. Potential local and national sources of BRT financing include:

- Local and national general tax revenues
- Parking controls
- Road or congestion pricing
- Dedicated tax streams (hypothecated taxes)
- Station commercial development
- Advertising
- Merchandising.

The logical starting point for any financing plan is to examine existing budgets for public transport and roadway development. Often the price of a single flyover project is equivalent to launching much of the BRT system. From equity and environmental standpoints, there is considerable justification for compensating public transport users from proceeds generated by private vehicle usage. Thus, parking controls, car user fees, and road pricing hold much potential to provide a steady revenue stream to a BRT project. Many developing cities do not currently control private vehicle parking. In cities like Cuenca, Ecuador, the implementation of parking fees through private contractors has been quite effective at raising municipal revenues (Figure 45). Road pricing schemes have been successfully deployed in Norway and Singapore, and the City of London is currently working to implement a similar type of scheme. Many Latin American cities also utilise a form of road pricing through toll roads. Such revenues can be successfully directed towards public transport infrastructure.

Bogotá made use of a dedicated tax stream from the taxation of gasoline. Twenty percent of Colombia's gasoline tax is hypothecated directly to eligible public transport projects such as TransMilenio. In a similar manner, the State of North Carolina in the United States has delivered an innovative scheme to ensure public

Fig. 45
Through the privatisation of parking enforcement, Cuenca, Ecuador has created an important new source of revenue.
Courtesy of the Municipality of Cuenca

Fig. 46
Commercialisation of station space, such as in Bangkok, Thailand, can help fund infrastructure costs.
Lloyd Wright

transit projects receive the necessary funding. One-half of a percent of the State sales tax is set aside for municipal transit projects. This revenue source generates approximately US$ 50 million each year. The State then uses these funds to provide a 50% match for municipal transit projects. The city of Charlotte is currently using this funding to develop its BRT system.

As strategic nodes for development and commercial enterprise, BRT systems also present many opportunities for commercialisation. The space inside and around stations and terminals holds particular value given the high volumes of persons passing through the system. Land values often skyrocket upon the announcement of a public transit corridor. System developers can take advantage of this situation by controlling and selling commercial space. Mass transit systems in cities such as Manila and Bangkok have used the sale of commercial space to help fund infrastructure costs (Figure 46).

Likewise, the sale of advertising space at stations and within buses can be considered. However, commercialisation of the system must be done carefully. Commercial signage should be discrete, if at all, or it will risk degrading the visual and aesthetic quality of the system. When commercial signage overwhelms stations and buses, customers are less able to distinguish signage relating to system use. The general despoiling of the aesthetic quality of the system can lower the image of the system, which can directly impact upon customer satisfaction and usage. Visual degradation can also lead to increased incidence of graffiti, vandalism and other criminal activities.

Some BRT systems have achieved such a positive status within their communities that revenue opportunities exist with system merchandising. The sale of system t-shirts, model stations and buses, and other souvenirs can in fact provide a reliable revenue stream. The marketability of the system relates back to the quality of the initial marketing impression (system name, logo, etc.) as well as the degree of social pride attained through the delivery of a high-quality product.

In some cases, international financing and funding may be an appropriate addition to a locally- and nationally-based financing plan. However, even with the interest of international agencies and foundations, local and national resources will be an important leveraging source. Further, most international organisations will wish to see a substantive financial contribution from local sources in order to be assured that there is local ownership and political will.

Global Environment Facility

International funds may be in the form of either grants or loans. Grant-type funding is usually of smaller amounts and directed at specific preparatory activities such as planning and/or initial demonstrations. One such grant mechanism is the Global Environment Facility (GEF). The GEF was created in 1991 to assist governments and international organisations in overcoming global environmental threats. Thus, GEF funds are utilised to address such issues as the degradation of international waters, biodiversity, global climate change, ozone depletion, and persistent organic pollutants. Through the global climate change program and the GEF's Operational Program 11, transport is an eligible sector for funding and BRT projects qualify in that they promote:

> Modal shifts to more efficient and less polluting forms of public and freight transport through measures such as traffic management and avoidance and increased use of cleaner fuels (Art. 11(10)(a) of OP 11).

To qualify for a GEF project, a municipality will need the support of its national GEF focal point, which is typically housed at either a national ministry of the environment or a ministry of foreign relations. Additionally, the project will need one of the GEF's implementing agencies to champion and support the project through the application process. Eligible implementing agencies include the World Bank, the United Nations Development Program (UNDP), the United Nations Environment Program (UNEP), and regional development banks. To date the GEF, with World Bank support, has approved three projects with BRT-related elements, in Santiago (Chile), Lima (Peru), and Mexico City.

The size of a GEF grant depends on the type of application and the nature of the project. GEF funding mechanisms include:

- Small Grants Program (funds of less than US$ 50,000)
- Small and Medium Sized Enterprise Program
- Project Preparation and Development Facility (PDF)
  - PDF Block A (up to US$ 25,000 for project preparation)
  - PDF Block B (up to US$ 350,000 for project preparation)
  - PDF Block C (up to US$ 1 million for project preparation)
- Medium-Sized Projects (up to US$ 1 million for project)
- Full-Sized Projects (large grants of sometimes over US$ 10 million).

The GEF transport projects in Chile, Peru and Mexico are full-sized projects. GEF resources are unlikely to directly finance infrastructure, but are useful in assisting with the planning process. Additionally, GEF funding can also be an effective means to attract complementary financing from development banks.

Other international programs may also support BRT activities. The World Bank also manages the Prototype Carbon Fund, which is a public-private partnership that works to mitigate the impacts of global climate change. BRT projects that result in greenhouse gas reductions may qualify (www.prototypecarbonfund.org).

Additionally, bi-lateral agencies such the German Overseas Technical Cooperation Agency (GTZ) and the United States Agency for International Development (USAID) may be approached to assist on the provision of support and technical resources. Private foundations such as the Shell Foundation and the former W. Alton Jones Foundation have also been supporters of BRT activities.

Private sector funding can be leveraged to a significant degree, especially with regard to the purchasing of equipment such as buses. The economics of BRT are such that bus costs can be fully amortised through the fare structure. There is no reason to expend precious public funds on bus technologies; instead, public funds are best focused on providing high-quality infrastructure. Bogotá and other systems have been able to fully utilise the private sector in financing buses.

Staffing plans

The simplicity of BRT systems along with the increasing prominence of information technology have permitted large systems to be administered by relatively lean management agencies. The Bogotá TransMilenio system is managed by an organisation of only 70 people. Thus, a 70-person staff is able to oversee a transit system for a city of seven million inhabitants. To achieve such an economy of control, though, requires great planning and structuring. The types of positions to be filled and the requirements for the posts should be strategically developed.

Contracting plan for the system

Just as a competitive and open procurement process is essential to the selection of equipment and system operators, the same holds true for all contracting activities, from the use of consultants through to the selection of construction firms. A transparent bidding process supported by clear and precise specifications and well-defined selection criteria is essential. A process burdened by the lack of competition and unscrupulous dealings will ultimately undermine the project through increased costs and the loss of public trust.

Construction and implementation plans

A BRT project entails the management of a disparate group of activities to deliver a coordinated final product. The timing and order of each piece (administrative structures, costing, marketing and customer service plans, route design, busway engineering, etc.) must be carefully scheduled and delivered. A full set of construction and implementation plans with timelines can be a useful managerial tool to oversee and control the progress and direction of the overall project.

"Developing a maintenance plan and dedicated funding stream to upkeep the system is fundamental to its long-term performance"

System maintenance plans

Start-up problems aside, most systems operate well and project a highly-positive image through the initial years. As systems age, though, the question arises as to whether it will maintain its initial quality and performance. Bus systems are notoriously left with little investment and civic care over the long term. Thus, developing a maintenance plan and dedicated funding stream to upkeep the system is fundamental to its long-term performance.

The maintenance of some equipment items such as buses will be the responsibility of private sector operators. Thus, maintenance and quality standards must be explicitly stated in the original contractual agreements. Other system attributes such as the quality of stations, terminals and busways will be the responsibility of the system operators, although private sector contracts may be the most appropriate means to manage and maintain these items as well. Decisions will need to be made on the maintenance budget allocations from the operational revenue streams. The timing of such allocations may well vary over the life of the system, as specific features will degrade at different rates. Finally, decisions will need to be made as to which maintenance items should be funded through operational budgets and which should be funded through re-capitalisations.

Monitoring and evaluation plan

In many respects, the success or failure of a system will be apparent from public reactions, press commentaries, usage levels, and the system's profitability. However, to obtain an objective and quantifiable indication of a system's overall performance, a defined monitoring and evaluation plan is a fundamental requirement. The feedback from such a plan can help identify system strengths as well as weaknesses requiring corrective action.

The identification of a full set of system targets and indicators is a first basic step in the development of a monitoring and evaluation plan. Key indicators will include factors such as customer totals, customer flows, actual operational costs, kilometres travelled, velocities, customer waiting times, load factors, and crime statistics. Many of these factors will also have an important correlation to the time of day and the day of the week. However, not all targets need to be quantifiable. For instance, customer surveys should be employed to also capture qualitative impressions, particularly customer satisfaction levels. The frequency and timing of the monitoring and evaluation should also be determined at the outset.

3. BRT Resources

The groundswell of interest in BRT in the last few years has meant that new resources are now available to assist interested cities.

Background information on BRT

1. American Public Transportation Association (APTA)

APTA is a national trade association representing transit agencies and operators in the United States. The APTA website includes useful background documentation on BRT concepts.
www.apta.com/info/briefings/brief2.pdf

2. Bus Rapid Transit Central

This site is a hub for articles on BRT and links to technical information on various systems. Additionally, the site is home to a BRT discussion board that allows practioners an opportunity to get answers from their peers.
www.busrapidtransit.net

3. GTZ Sustainable Urban Transport Programme (SUTP)

The German Overseas Technical Assistance Agency (GTZ) has developed an information source on a wide range of sustainable transport topics. The SUTP web site also provides detailed discussion of the application of BRT in the city of Surabaya, Indonesia.
www.sutp.org

4. Institute for Transportation & Development Policy (ITDP)

ITDP publishes a regular newsletter, e-Sustainable Transport, that features frequent articles on BRT projects worldwide.
www.itdp.org

5. International Energy Agency (IEA)

The IEA has compared the environmental performance of different fuel and propulsion options for buses in Lew Fulton *Bus Systems for the Future: Achieving Sustainable Transport Worldwide*, 2002, which also compares emission impacts of tailpipe versus mode-shifting strategies.
www.iea.org

6. National Bus Rapid Transit Institute

The National BRT Institute is an information clearinghouse on BRT.
www.nbrti.org

7. Transport Roundtable Australia

This site provides useful information and articles both on general BRT issues as well as specific links to Australian systems in cities such as Brisbane and Adelaide. In October 2000, the Transport Roundtable sponsored a conference related to BRT in Brisbane.
www.transportroundtable.com.au

8. US Federal Transit Administration

This site provides an overview of the USFTA's national BRT programme as well as information on the activities underway in each of the participating cities. The site also provides a number of useful links to technical documents.
www.fta.dot.gov/brt

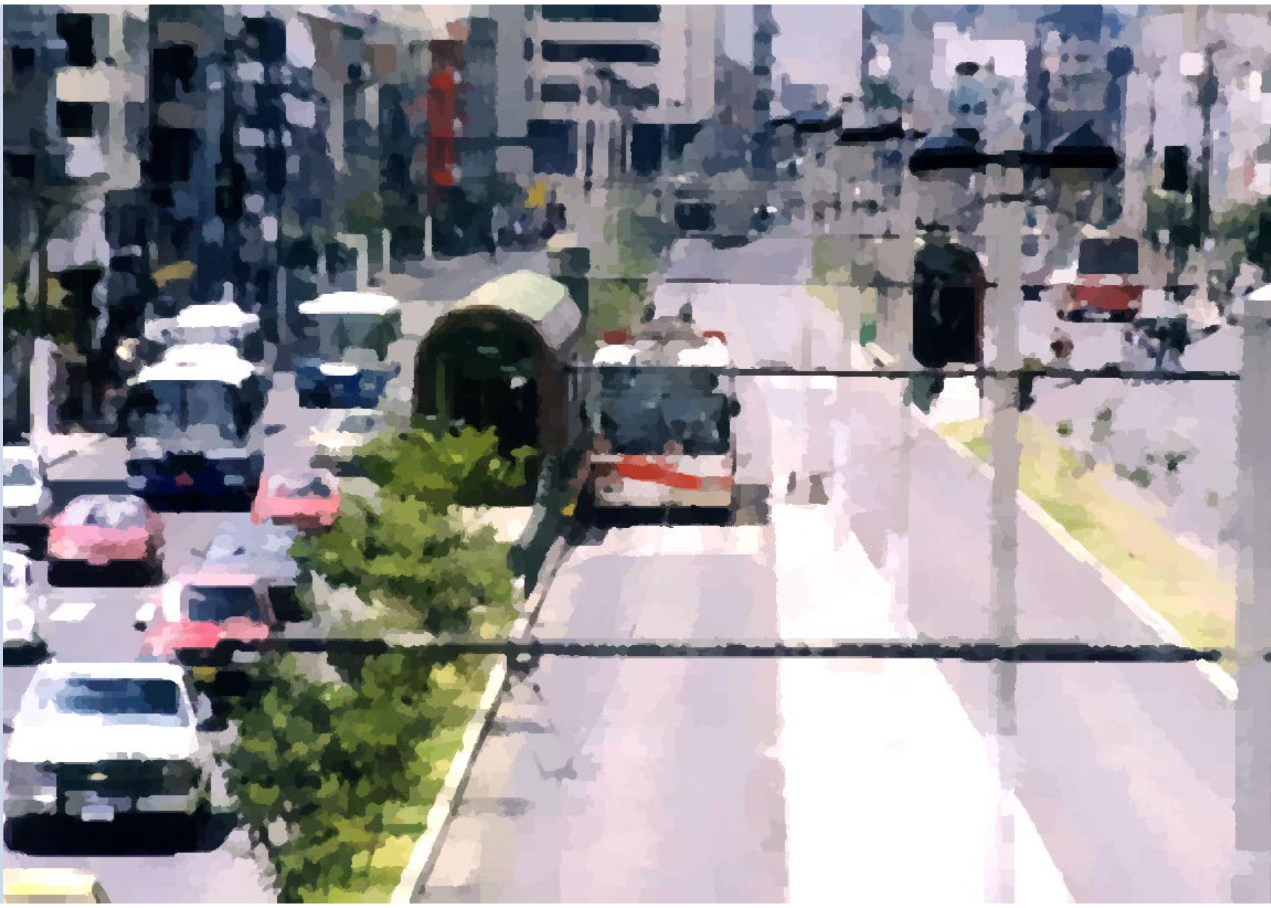
9. World Bank

The World Bank completed its *Urban Transport Strategy Review* in 2001. This document, *Cities on the Move*, presents the World Bank's new strategy for supporting sustainable urban transport options, and also provides a wealth of information on public transit systems, including BRT.
www.worldbank.com/transport

City projects

- Adelaide, Australia
  www.adelaidemetro.com.au/guides/obahn.htm
- Auckland, New Zealand
  www.nscc.govt.nz/brt
- Bogotá, Colombia
  www.transmilenio.gov.co
- Boston, USA
  www.allaboutsilverline.com
- Brisbane, Australia
  www.transport.qld.gov.au/busways
- Cleveland, USA
  www.euclidtransit.org
- Curitiba, Brazil
  www.curitiba.pr.gov.br/pmc/ingles/solucoes/transporte/index.html
- Eugene, USA
  www.ltd.org/brt1.html
- Hartford, USA
  www.ctbusway.com/nbh
- Leeds, UK
  www.firstleeds.co.uk/superbus/html/
- Los Angeles, USA
  www.mta.net/metro_transit/rapid_bus/metro_rapid.htm

- Miami, USA
  www.co.miami-dade.fl.us/transit/future/info.htm
- Orlando, USA
  www.golynx.com/services/lymmo/index.htm
- Phoenix, USA
  www.ci.phoenix.az.us/brt
- Pittsburgh, USA
  www.portauthority.com
- Quito, Ecuador
  www.quito.gov.ec/trole/trole_1.htm
- San Francisco, USA
  www.projectexpress.org
- San Pablo, USA
  www.actransit.org/onthehorizon/sanpablo.wu
- Santa Clara, USA
  www.vta.org/projects/line22brt.html
- Sydney, Australia
  www.rta.nsw.gov.au/initiatives/e6_c.htm



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