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

Version 2.0

Deutsche Gesellschaft für
Technische Zusammenarbeit (GTZ) GmbH

commissioned by:

Federal Ministry
for Economic Cooperation
and Development

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 more than 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. GTZ is elaborating training packages for selected modules, being available since October 2004.

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, color layout.
- Non-technical language (to the extent possible), with technical terms explained.
- Updates via the Internet.

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Comments or feedback?

We would welcome any of your comments or suggestions, on any aspect of the *Sourcebook*, by e-mail to transport@gtz.de, 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)

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

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3a. *Mass Transit Options* (Lloyd Wright, University College London; Karl Fjellstrom, GTZ)
3b. *Bus Rapid Transit* (Lloyd Wright, University College London)
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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 *Car Free Development*. Additional resources are being developed, and an Urban Transport Photo CD-ROM is available.

Module 3b

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Preface

Bus Rapid Transit (BRT) offers the opportunity for developing cities to develop a high-quality mass transit system at an affordable cost. This module of the Sustainable Transport Sourcebook provides an overview summary of the BRT concept and a brief description of the BRT planning process. For a more detailed explanation of the BRT planning process, please consult the GTZ "BRT Planning Guide", which is also available on the web site of the Sustainable Urban Transport Project (http://www.sutp.org).

Acknowledgements

The development of this Bus Rapid Transit module has benefited from the experiences of high-quality public transit projects from around the world. The module has particularly benefited from lessons learned to date from the TransMilenio system in Bogotá (Colombia). TransMilenio represents perhaps the most complete and inventive BRT system in the world today. The former Mayor of Bogotá, Enrique Peñalosa, has become an international champion of promoting the BRT concept.

Additionally, insights from municipal officials and consultants involved with the BRT systems in Quito (Ecuador) and Curitiba (Brazil) have added greatly to the quality and relevance of the Planning Guide. In many respects, BRT owes its existence to the creativity and determination of Jaime Lerner, the former mayor of Curitiba and the former governor of the state of Paraná. César Arias, who previously directed the BRT effort in Quito and is now a consultant on the Guayaquil (Ecuador) BRT project, has also lent considerable information for the module. Likewise, Hidalgo Nuñez and Cecilia Rodriguez of Quito's Department of Transport have provided much assistance.

A number of consultancies have worked to improve the quality of BRT initiatives. Special thanks go to the firm of Steer Davies Gleave, which is involved in BRT projects worldwide. Also, the consultancy of Akiris in Bogotá has played a central role in the development of TransMilenio, and is now leading BRT efforts in several cities. Additionally, several consultancies in Brazil helped to create many of the original BRT concepts; these firms and individuals include Paulo Custodio, Pedro Szasz, the consulting team at Logit, and the consultancy of Logitrans.

The module has benefited not only from leading developing-nation experiences but also from the growing level of interest in BRT in Australia, Western Europe, Japan, and North America. A similar compendium of experiences developed under the United States Transit Cooperative Research Program (TCRP) has been a rich source of world-wide experiences in BRT. Sam Zimmerman and the consultancy of DMJM & Harris have been leading these efforts.

The concept of BRT owes much to the persistent support of key organisations that have worked to raise overall awareness as well as provide direct assistance to interested developing-nation cities. The Institute for Transportation & Development Policy (ITDP) has consistently been at the forefront of providing direct assistance to developing cities pursuing sustainable transport options.

Finally, the module would not be possible without the strong support and effort from the team at GTZ, the German Overseas Technical Assistance Agency. Klaus Neumann played a key role in providing the layout and formatting for the final document. A great deal of thanks goes to Manfred Breithaupt, Director of GTZ's transport programme, who created the idea of the Sustainable Transport Sourcebook and who patiently oversaw the development of each module.

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Acronyms

BRT	Bus Rapid Transit
CNG	Compressed Natural Gas
GEF	Global Environmental Facility
GTZ	GTZ Deutsche Gesellschaft für Technische Zusammenarbeit (*German Overseas Technical Assistance Agency*)
ITDP	Institute for Transportation & Development Policy
ITS	Intelligent Transportation Systems
LPG	Liquid Petroleum Gas
LRT	Light Rail Transit
MRT	Mass Rapid Transit
O-D	Origin-Destination
QIC	Quality incentive contract
TDM	Transportation Demand Management
TOD	Transit-Oriented Development
TRB	Transportation Research Board
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USFTA	United States Federal Transit Administration
USTCRP	United States Transit Cooperative Research Program

1. Introduction

Effective public transit is central to development. For the vast majority of developing city residents, public transit is the only practical means to access employment, education, and public services, especially when such services are beyond the viable distance of walking or cycling. Unfortunately, the current state of public transit services in developing cities often does little to serve the actual mobility needs of the population. 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. Due to the high costs of rail infrastructure, cities can only construct such systems over a few kilometres in a few limited corridors. The result is a system that does not meet the broader transport needs of the population. Nevertheless, the municipality ends up with a long-term debt that can affect investment in more pressing areas such as health, education, water, and sanitation.

However, there is an alternative between poor public transit 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). This module provides municipal officials, non-governmental organizations, consultants, and others with an introduction to the concept of BRT as well as a step-by-step process for successfully planning a BRT system.

Of course, BRT is just one of many public transit options. The correct choice depends on an array of local conditions and factors. For an overview of different mass transit options, refer to *Module 3a (Mass Transit Options)* of the GTZ Sustainable Transport Sourcebook.

This introductory section to BRT includes the following topics:

1.1 Defining Bus Rapid Transit

Bus Rapid Transit (BRT) is a *bus-based mass transit system that delivers fast, comfortable, and cost-effective urban mobility*. Through the provision of exclusive right-of-way lanes and excellence in customer service, BRT essentially emulates the performance and amenity characteristics of a modern rail-based transit system but at a fraction of the cost.

While BRT utilises rubber-tyred vehicles, it has little else in common with conventional urban

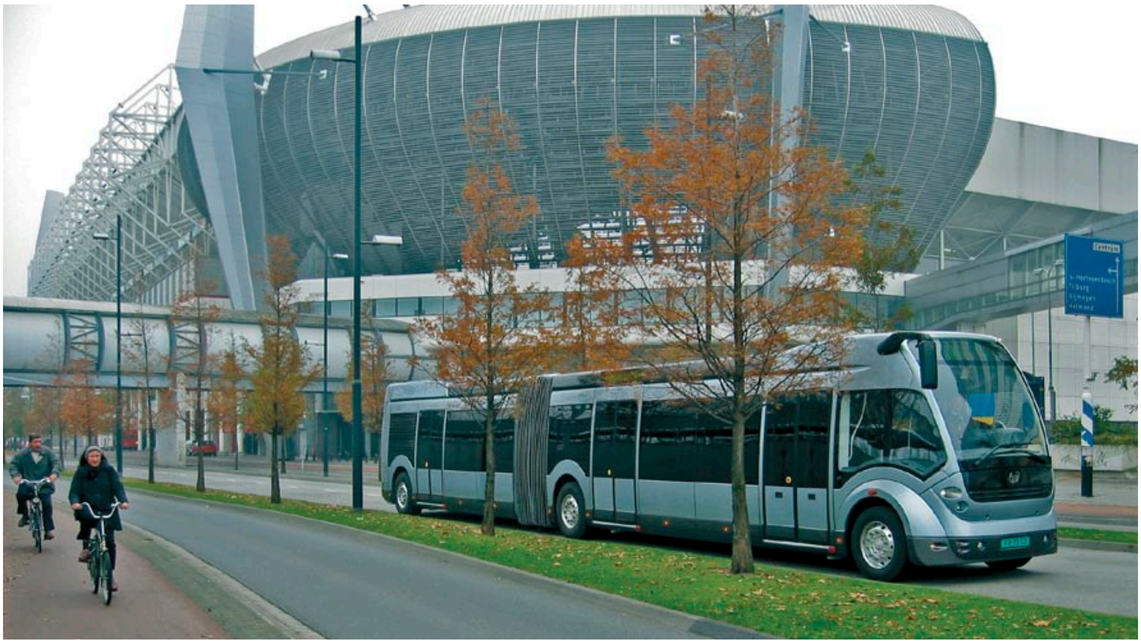


Fig. 1
Bus Rapid Transit provides a sophisticated metro-quality transit service at a cost that most cities, even developing cities, can afford.
Photo courtesy of Advanced Public Transport Systems

bus systems. The following is a list of features found on some of the most successful BRT systems implemented to date:

- Exclusive right-of-way lanes
- Rapid boarding and alighting
- Free transfers between lines
- Pre-board fare collection and fare verification
- Enclosed stations that are safe and comfortable
- Clear route maps, signage, and real-time information displays
- Automatic vehicle location technology to manage vehicle movements
- Modal integration at stations and terminals
- Competitively-bid concessions for operations
- Effective reform of the existing institutional structures for public transit
- Clean vehicle technologies
- Excellence in marketing and customer service

Local circumstances will dictate the extent to which the above characteristics are actually utilised within a system. Small- and medium-sized cities may find that not all of these features are feasible to achieve within cost and capacity constraints. Nevertheless, serving customer needs first is a premise that all cities, regardless of local circumstances, should follow in developing a successful transit service.

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 will undoubtedly continue to evolve. Nevertheless, BRT's customer focus will likely remain its defining characteristic. The developers of high-quality BRT systems in cities such as Bogotá, Curitiba, and Ottawa astutely observed that the ultimate objective was to swiftly, efficiently, and cost-effectively move *people*, rather than *cars*.

Fig. 2
Under the leadership of former-Mayor Jaime Lerner, the BRT system in Curitiba (Brazil) became a world leader in effective transit.
Photo by Lloyd Wright

1.2 History of BRT

BRT's history resides in a variety of previous efforts to improve the transit experience for the customer. The first wide-scale development of the BRT concept using occurred in Curitiba (Brazil) in 1974. However, there were several smaller-scale efforts prior to Curitiba that helped to establish the idea. High-occupancy lanes and exclusive bus lanes appeared in the United States in the 1960s. Actual construction of a dedicated busway first occurred in 1972 with a 7.5 kilometre line known as "Via Expresa" in Lima (Peru). One year later in 1973, busways were constructed in Runcorn (United Kingdom) and Los Angeles (USA).

BRT's full promise was not realised, though, until the arrival of the "surface subway" system developed in Curitiba (Brazil) in 1974 (Figure 2). Ironically, the city initially aspired to constructing a rail-based metro system. However, a lack of sufficient funding necessitated a more creative approach. Thus, under the leadership of Mayor Jaime Lerner, the city began a process of developing busway corridors emanating from the city centre. Like many Latin American cities at the time, Curitiba was experiencing rapid population growth. Beginning at a level of some 600,000 residents in the early 1970s, the city now has over 2.2 million inhabitants.

Today, Curitiba's modernistic "tubed" stations and 270-passenger bi-articulated buses represent a world example. The BRT system now has five radial corridors emanating from the city core. The system features 57 kilometres of exclusive busways and 340 kilometres of feeder services.

The mid-1970s also saw a limited number of BRT applications being developed in other cities of North and South America (Meirelles, 2000). While not as sophisticated as the

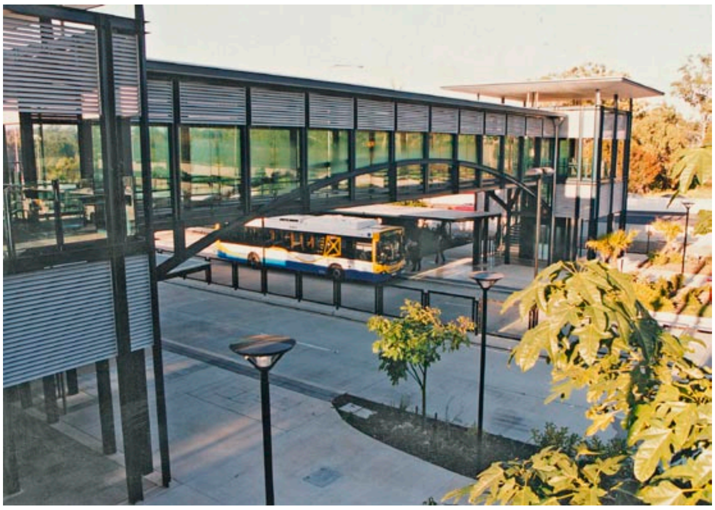


Fig. 3 and 4
Developed-nation cities such as Brisbane, Australia (left photo) and Ottawa, Canada (right photo) have also benefited from BRT.
Brisbane photo courtesy of Queensland Transport
Ottawa photo by Lloyd Wright

Curitiba system, variations on the concept were developed in Sao Paulo, Brazil (1975); Arlington, USA (1975); Goiania, Brazil (1976); Porto Alegre, Brazil (1977); and Pittsburgh, United States (1977). The Sao Paulo BRT system is currently the largest in the world with 250 kilometres of exclusive busways serving 3.2 million passenger trips each day.

Despite Curitiba's success and relative fame within the transport planning profession, the overall replication of the BRT concept was actually somewhat slow to gain momentum elsewhere. It was only in the late 1990s that BRT's profile became more widely known. Visits by technical and political teams from Bogotá (Colombia) and Los Angeles (United States) to Curitiba served to launch BRT efforts in those cities. In 1996, Quito (Ecuador) opened a BRT system using electric trolley-bus technology, and the city has since expanded the system with clean diesel technology.

However, it was the effort in Bogotá with its TransMilenio system that has particularly transformed BRT's perception around the world. As a large-sized city (7.0 million inhabitants) and a relatively dense city (240 inhabitants per hectare), Bogotá provided proof that BRT was capable of delivering high-capacity performance for the world's megacities. Today, with both Bogotá and Curitiba acting as catalytic examples, the number of cities with built BRT systems or with systems under development is quite significant.

OECD nations such as Australia, Canada, France, Germany, Japan, the United Kingdom, and the United States have seen the potential for BRT as a high-quality but low-cost mass transit option (Figures 3 and 4). The transfer of BRT technology from Latin America to OECD nations has made BRT one of the most notable examples of technology transfer from the developing south to the developed north.

There is no precise definition of what constitutes a BRT system and what represents simply an improved transit system. Depending on one's definition of BRT, there may be up to 70 systems world-wide. However, the number of cities with full BRT systems is actually more limited. The Latin American cities of Bogotá, Curitiba, Goiania, and Quito probably possess the most complete systems, in terms of all aspects of BRT. The systems in Brisbane (Australia), Ottawa (Canada), and Rouen (France) probably provide the best examples of BRT in the developed-nation context. The experiences in Africa and Asia are more limited in number and scope. The Taipei (Taiwan), Nagoya (Japan), and Jakarta (Indonesia) systems perhaps stand out as the more complete systems in the Asian region, although not quite reaching the level of full BRT systems.

In developing cities, the spectrum of public transport services can range from very basic informal services to more sophisticated options such as BRT and rail transit. Figure 5 illustrates the progression of transit services across this spectrum.

Higher-quality conventional bus services, while not BRT, can be a significant improvement for residents of most cities. The conventional bus

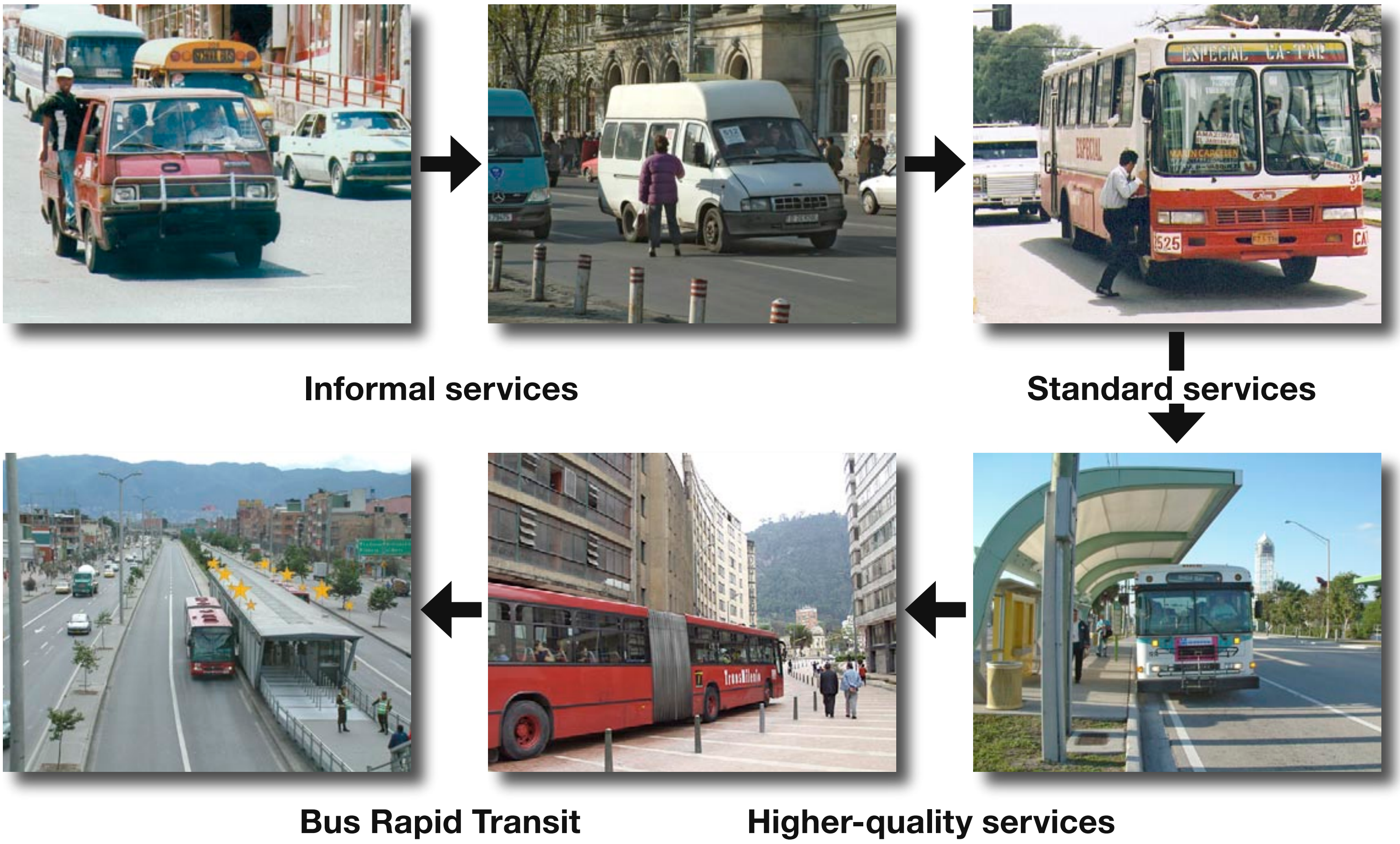


Fig. 5
Progression of transit services.
Photos by Lloyd Wright and Carlos Pardo

systems in cities such as Hong Kong, London, and Singapore have achieved considerable success without the full application of BRT attributes. London's bus network serves 5.4 million passenger trips each day, far exceeding the city's underground metro system. To achieve its level of performance, the London bus system makes extensive use of bus lanes. However, bus lanes are significantly different in nature to the busways found in most BRT systems (see Box 1).

1.3 Public transport in developing cities

For much of the world's population, public transit is a necessary evil that must be endured rather than appreciated. For many families, the ultimate goal is to one day afford individual motorised transport, either in the form of a motorcycle or automobile. The state of public transit implies discomfort, long waits, risk to personal safety, and restrictions on movement. Customer satisfaction with the myriad of informal and formal vans, mini-buses, and full-sized buses that ply developing city streets is typically extremely low.

Under such conditions, it is not surprising that such services are losing passengers at alarming rates. The private vehicle continues to make gains in virtually every city. If present trends continue, public transport may have a rather doubtful future. As incomes rise in developing nations, private vehicles are gaining usage while public transport's ridership is almost universally declining. A selection of developing cities indicates that public transit systems are typically losing in the area of between 0.3 and 1.2 percentage points of ridership each year (WBSCD, 2001).

The reasons for public transport's demise are not difficult to discern (Figure 6). 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.

However, the demise in public transport is not pre-ordained. 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

Box 1: Bus lanes or busways

Bus lanes and busways are quite different in design and effectiveness. While some well-demarcated and well-enforced bus lane systems in developed nations have succeeded (e.g., London), in general, bus lanes do little to enhance the effectiveness of public transport.

Bus lanes are street surfaces reserved primarily for public transport vehicles on a permanent basis or on specific hourly schedule. Bus lanes are not physically segregated from other lanes. While the lanes may be painted, demarcated, and sign-posted, changing lanes is still feasible. In some cases, bus lanes may be shared with high-occupancy vehicles, taxis, and/or non-motorised vehicles. Bus lanes may also be open to private vehicle usage near turning points.

Busways are physically segregated lanes that are exclusively for the use of public transport vehicles. Entrance to a busway can only be undertaken at specific points. The busway is segregated from other traffic by means of a wall, curbing, cones, or other well-defined structural feature. Non-transit vehicles are generally not permitted access to a busway although emergency vehicles often also may utilise the lane. Busways may be at surface level, elevated, or underground.

in Bogotá, Colombia, public transit ridership has actually increased in that city. Curitiba's BRT system witnessed a similar increase when initially opened, and was able to increase ridership by over 2 per cent a year for over two decades, enough to maintain the public transit mode share when every other Brazilian city was witnessing significant declines.

Fig. 6
Public transport in many developing countries means hardship and danger.
Photo by Lloyd Wright

1.4 Barriers to 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
- Existing operators
- Institutional biases
- Lack of 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. Lobby groups from rail and automobile interests can make for a powerful political argument against BRT implementation. However, for those public officials that have made the commitment to BRT, the political rewards can be great. The political leaders 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.

While automobiles may represent less than 15 per cent of a developing city's transport mode share, the owners of such vehicles represent the most influential socio-political grouping. The idea of prioritising road space to public transport may appear to be counter to the interest of private vehicle owners. However, in reality, separating public transit vehicles from other traffic may often improve conditions for private vehicles. Since public transit vehicles stop more frequently, the separation of these vehicles from mixed traffic can actually improve flows for all.

Existing transit operators may also prove to be a substantial political barrier to BRT implementation. Such operators may be quite sceptical of any change, especially when the change may have ramifications on their own profitability and even viability. In cities such as Quito (Ecuador), the existing operators took to violent street demonstrations to counter the development of the BRT system. Likewise, in other cities the private transit operators have pressured political officials through recall efforts and intense lobbying. However, it should be noted that the threat to existing operators may be more perceived than real. In most cases, an effective outreach effort with the operators can help dispel unfounded fears. In reality, existing operators can gain substantially from BRT through improved profitability and better work conditions. The existing operators can effectively compete to win operational concessions within the proposed BRT system.

The barriers noted here are mostly "perceived" barriers. In each case, a concerted effort of political officials in tandem with the private sector and the public can overcome these challenges to create a new transit system for all.

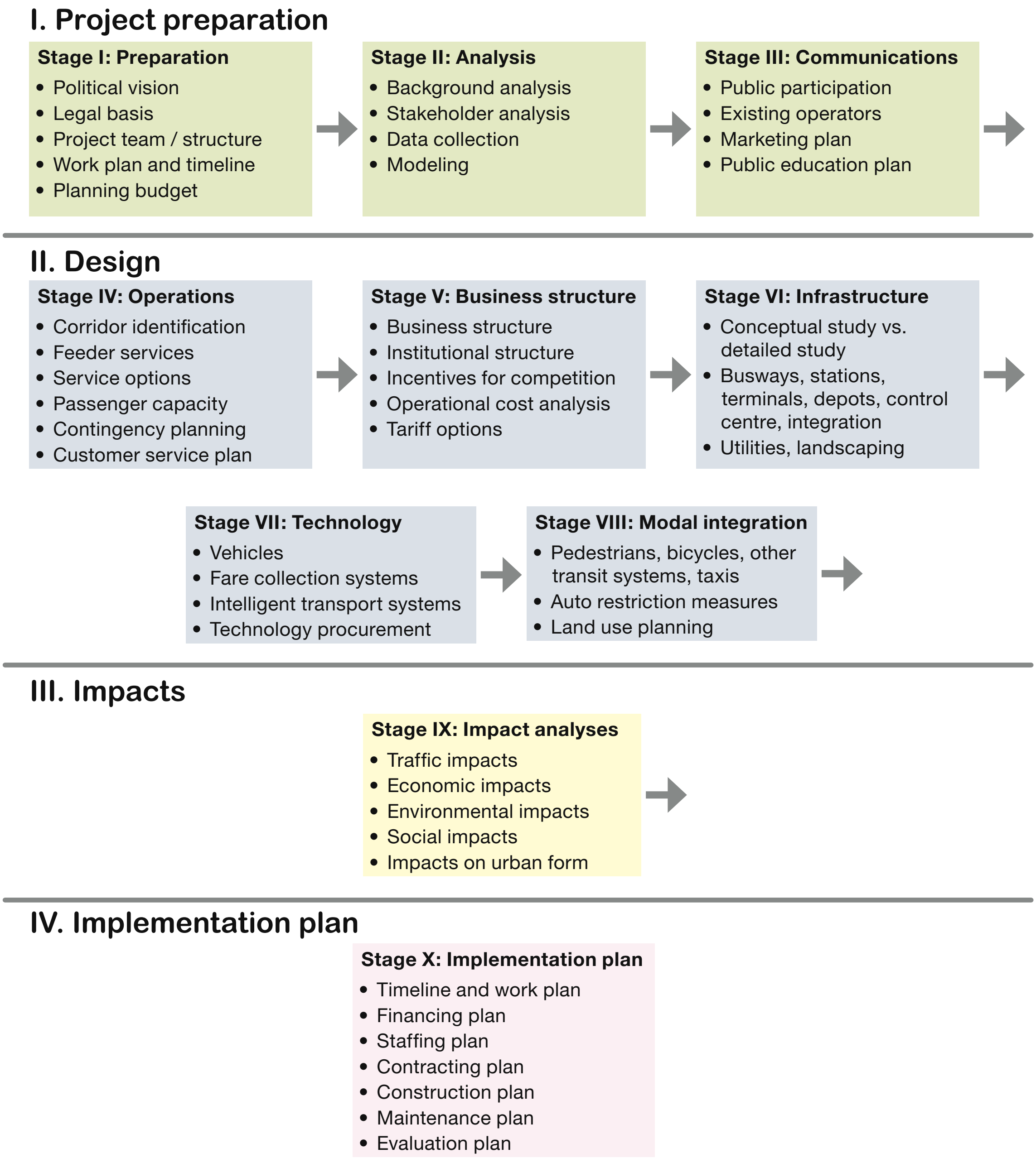
2. Planning for BRT

This overview module of BRT seeks to oultine the BRT planning process for developing city officials. It is hoped that this 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 completed in a period of 12 to 18 months. An overview of the entire BRT planning process is provided in Figure 7.

2.1 Planning Stage I: Project preparation

The first stage of the process involves galvanising the political and institutional support for the project. Additionally, this stage is also a time to organise and plan the entire BRT development process. Work plans, timelines, budgets, and the formation of a planning team are essential pre-requisites before proceeding further. Investments made early in properly structuring and organising the planning process can pay

Fig. 7: Overview of the BRT planning process



significant dividends later in terms of both the efficiency and effectiveness of the overall effort.

The topics to be presented in Planning Stage I, "Project Preparation", are:

- 2.1.1 Project creation and commitment
- 2.1.2 Legal basis
- 2.1.3 Development team
- 2.1.4 Project scope and timing
- 2.1.5 Planning budget and financing

2.1.1 Project creation and commitment

"Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed it is the only thing that ever has."
- Margaret Mead (1901-1978)

Before a smart card is used, or before a clean vehicle is purchased, or before a busway is built, a person or a group of persons must decide that action is required to improve a city's transit system. The inspiration may come from a civic group, a bus operator, a civil servant, or a political official. Nevertheless, without someone acting as a catalyst, good ideas will unlikely become reality.

Fig. 8
International visitors gain many insights by speaking with TransMilenio technical staff in Bogotá.
Photo by Lloyd Wright

The creation of an environment suitable to introducing a new mass transit system can depend upon many factors. There is no set amount of time required or set series of events. In the case of cities such as Bogotá and Curitiba, the election of dynamic mayors who entered office with a new vision was the determining factor. In such instances, the progression towards system planning happens almost immediately.

In other instances, a long period of persuasion and information gathering will precede the commitment. Site visits to cities with high-quality systems can help officials and the press visualise the possibilities. The development of videos and graphics illustrating how the system would look within a particular city can also help the visualisation process. Testimonials from one political official to another may sometimes be appropriate. Showing how mayors and governors that deliver high-quality systems tend to win elections can also be helpful. The techniques to achieving project commitment are varied, and can depend greatly upon the local context, but the principal aim is to stimulate a demand for dramatically raising a city's transit quality.

In recent years, visits to the systems in cities like Bogotá, Curitiba, and Quito have persuaded officials to other cities to proceed with projects of their own. By speaking with technical staff and political officials in cities with existing systems, perspective system developers can understand the possibilities in their own cities (Figure 8).

Political leadership is probably the single most important factor in realising a successful BRT project. Without such leadership, the project will not likely have sufficient momentum to survive the inevitable challenges from opposition groups and special interests. Further, without leadership, it is significantly more difficult to galvanise public opinion towards supporting a new outlook on public transit.

An initial vision statement from the political leadership marks an important first step in making the case for improved transit to the public. This political announcement provides a broad-based perspective on the general goals of the proposed system. This statement gives a direction and mandate for the planning teams and will 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.

2.1.2 Legal basis

In most cases, a statutory or legal mandate needs to be created prior to the project being officially recognised. This process then allows public funds to be disbursed towards the planning process as well as permits planning staff to be employed on the project. The actual authorisation process will vary depending upon local, provincial, and national laws and regulations. In some cases, city councils or provincial parliaments will need to give formal approvals before project expenditures can be realised. In other cases, the mayor or governor may have greater legal authority to approve project activities independently.

2.1.3 Development team

A new mass transit system for a city is not a small undertaking. It is unlikely to be achieved without staff dedicated full-time to the effort. Attempting to plan a BRT system while simultaneously juggling other planning duties will most likely not produce a high-quality or timely result. Thus, the organisation and selection of a dedicated BRT planning team is a fundamental step towards planning the system.

2.1.3.1 Planning staff

Depending on the intended timeline for planning and implementing the system, the initial number of full-time team members will likely vary from three to ten. As the project progresses, the size and specialties of the team will likely grow. Some of the initial posts to be filled may include:

- Project coordinator
- Administrative support
- Project accountant
- Public education and outreach
- Negotiator for discussions with existing operators
- Liaison officer for international organisations
- Finance specialist / economist
- Transport engineer
- Transport modeller
- Design specialist.

In some cases, it may be possible to outsource some of these activities to consultancies. However, it is important to retain a certain degree of in-house technical competence in order to maintain a perspective that will allow for informed decision-making.

The composition of the team may include both existing municipal employees as well as new staff with specialised skills. Since BRT is a relatively new concept, it is sometimes difficult to find staff with extensive implementation experience. For this reason, some training and even study tours may be appropriate mechanisms to develop local technical capacity (Figure 9).

Fig. 9
Study tours to cities like Bogotá, Curitiba, and Quito can greatly help build the technical capacity of staff from other cities.
Photo by Lloyd Wright

A local team working in conjunction with experienced international professionals can ideally result in a combination of world best practice and local context.

2.1.3.2 Project management structure

Initially, the team will be involved in basic fact-finding and analysis work, such as estimating both existing and projected transport demand. However, as the project begins to coalesce towards a more formalised and structured effort, then a specific organisational structure may be appropriate. Figure 10 gives an example of an organisational structure for a BRT development project. In this case, the mayor (or other leading political official) serves as the chairperson overseeing the project. This type of direct leadership involvement helps ensure that the project remains a top priority throughout the development process.

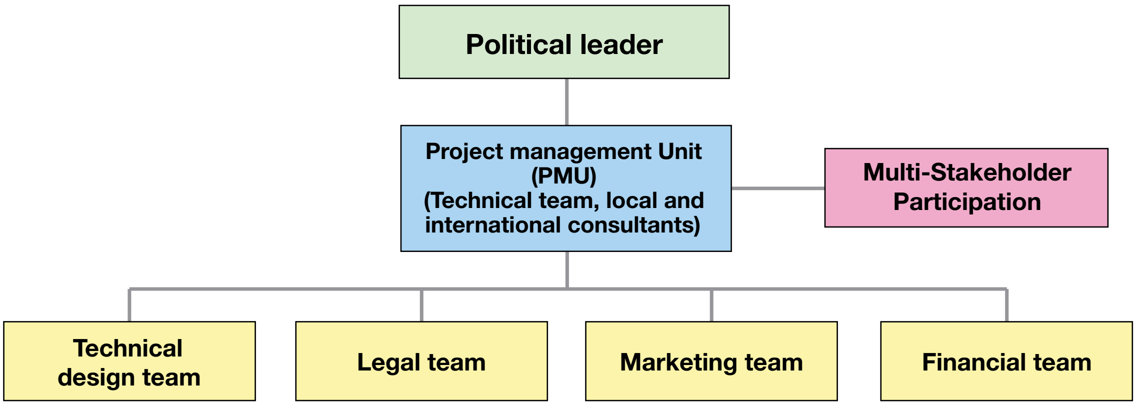


Fig. 10
The organisational structure for BRT project development should include political leadership, stakeholder involvement, and dedicated teams to key functional areas.

The organisational structure in Figure 10 also shows a steering committee consisting of key outside stakeholders such as non-governmental organisations, other government agencies, and private sector associations. Formal inclusion of all key stakeholders in the process can help ensure the necessary buy-in to make the project a reality. Giving a voice and ownership role to these groups will ideally create a spirit of shared commitment that will drive the project towards implementation.

2.1.4 Project scope and timing

2.1.4.1 Work plan and timeline

Once a vision is set for the BRT system and an initial team is formed, 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. A BRT plan can be reasonably completed in 12 to 18 months, but can take longer in cases of very large and complicated cities. The actual duration of the planning process will depend greatly upon the complexity of the project and upon other local conditions.

Completing the work plan and timeline will help ensure that important elements such as public communication and education are not in-advertently left out. 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.

2.1.4.2 Project phases

A BRT can be phased-in over several distinct periods or built in a massive single effort. Typically, cities choose to construct a system over a series of phases. The phased approach is necessitated for several reasons:

- Financing for the entire system may not be immediately available
- Results from the initial phase can help improve the design in subsequent phases
- The limited number of local construction firms may not be sufficient to construct a system across the entire city
- Phased construction reduces the disruption that the construction process brings to city traffic flows.

However, even if a system is to be built over a series of phases, it is still worthwhile to put forward a vision for the entire system. Such a vision may consist simply of a route map showing where all planned corridors are intended to be placed. Thus, even residents and stakeholders who will not immediately benefit from the initial phases of the system will see the long-term value for themselves.

A phased approach also should not be an excuse for an overly timid first phase. An extremely limited initial phase may not produce the necessary results to justify further phases. BRT along just a single corridor may not attract sufficient passenger numbers to become financially sustainable. If the financial model fails in the first phase, there may never be a second phase. A single corridor strategy depends on people working, shopping, and living on the same corridor. This highly limited set of circumstances typically means that a single corridor simply cannot achieve sufficient customer flows.

2.1.5 Planning budget and financing

2.1.5.1 Budgeting fundamentals

The realistic scope and depth of the BRT planning process is largely determined by the available funding. However, the first step should be to determine the required amount based upon the projected activities. An estimated budget for the plan can be developed from the activities outlined in the work plan. The budget will include staff salaries, consultant fees, travel and study tours, resource materials, telecommunications, and administrative support. Some of these costs may be covered by existing budgets and overheads while other line items will need newly dedicated funding. Since the planning horizon is likely to encompass 12 to 24 months of time, any cost escalations such as projected salary increases or inflationary trends should also be considered.

Budgets should be made as realistic as possible. Overly-optimistic projections will ultimately be compared unfavourably to actual results, which will be used by project opponents to undermine the project's image. Unfortunately, projecting budgets is never an exact science. Unexpected and unforeseen events will undoubtedly arise which will create the need for budgetary adjustments. Thus, it is always wise to include a contingency amount that will help cover such unexpected costs. The contingency is often represented as a percentage of the projected total (e.g., 10% of the projected budget).

BRT planning costs have historically varied considerably, depending upon the scope and complexity of the project, as well as the degree to which in-house expertise is utilised in comparison to consultants. To plan the extensive TransMilenio system of Bogotá, a total of nearly US$ 3 million was spent in the planning process. By comparison, using principally in-house professionals, the municipality of Quito spent only approximately US$ 500,000 to plan its smaller system. In general, though, planning costs will likely range from US$ 400,000 to US$ 5 million. It is hoped that the GTZ BRT planning guide will help cities plan a BRT system at a lower cost and within a shorter time frame.

2.1.5.2 Local funding sources

In comparison to other transport projects, such as road networks and rail systems, the planning costs of BRT are typically much less. For this reason, the costs are often financed within existing municipal or provincial revenues without the need for alternative financing sources such as loans or bonds. This situation can even be true of low-income, developing cities. Local, provincial, and national resources should all be quite sufficient to readily complete the BRT planning process.

2.1.5.3 International funding sources

However, at the same time, several international sources stand ready to assist cities interested in BRT. The international resources often also bring the additional advantage of allowing greater access to consultants with international BRT experience. The disadvantage of many international funding sources is the amount of effort required in the application process and the sometimes lengthy delay in receiving project acceptance.

Multi-lateral organisations such as the World Bank, regional development banks, and agencies of the United Nations may be able to provide grants to support planning activities and initial demonstrations. Unlike loans, grant-type funding mechanisms do not require repayment. One such grant mechanism is the Global Environment Facility (GEF). The GEF was created in 1991 to assist governments and international organisations in their goals of overcoming global environmental threats. The GEF has supported BRT planning efforts in cities such as Santiago (Chile), Lima (Peru), Mexico City (Mexico), and Hanoi (Vietnam). Other international organisations, such as UNDP and UNEP, may also support BRT planning activities.

Additionally, bi-lateral agencies such the German Overseas Technical Cooperation Agency (GTZ), the Swedish International Development Agency (Sida), 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 Hewlett Foundation, the Shell Foundation and the former W. Alton Jones Foundation have also been supporters of BRT activities.

2.2 Planning Stage II: Analysis

The demand for transit services will be one of the principal determining factors in designing the system. Virtually all major decisions such as the choosing the busway corridors, the size of the vehicles, the size of stations and terminals, and the type of fare collection systems will emanate from the likely passenger demand. Transport modelling tools can be useful in projecting future system demand, and thus help in determining the system's capacity needs over a longer time horizon.

A starting point for this type of analysis is to fully understand the current matrix of journeys taken in the city as well as the current supply of transport services. This section outlines both a traditional transport modelling approach as well as noting the minimum analytical requirements for determining the projected demand.

The topics to be presented in Planning Stage II, "Analysis", are:

2.2.1 Background and situational description

2.2.2 Stakeholder analysis

2.2.3 Transport data collection

2.2.4 Transportation demand modelling

2.2.1 Background and situational description

A city's public transit system is intimately woven into the existing demographic, economic, environmental, social, and political conditions. Understanding these conditions enables the BRT planner to better align the prospective public transit system with the local realities. Some of these data items will later be inputted into transportation models to project future needs. Other portions of this background information will help the planner view the proposed public transit system in its wider socio-economic context.

2.2.2 Stakeholder analysis

The pre-planning period is also the time 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 organizations will be important resources to draw upon during later public participation processes. The types of organisations to be sought during the stakeholder identification process include:

- 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.

2.2.3 Transportation data collection

A solid understanding of existing transport choices will help serve to define the present and future requirements of a BRT system. The data collected on current transport supply and demand will serve as a major input into determining the design characteristics of the system. This data may also be used within a transport software model to project various different scenarios.

The accuracy and precision of the data collected depends in part on the funding that is available for the analysis. Traffic counts and surveys encompassing large sample sizes will help provide an accurate basis but may prove to be too costly for many developing cities. Fortunately, in many cases, mode share and travel data have already been collected to a certain degree.

2.2.3.1 Minimum data collection requirements

Not all developing cities will be able to afford a full data collection process that results in identifying origin-destination pairings to any degree of great detail. However, these cities will still need to quantify existing passenger volumes on major corridors. Thus, as a minimum, cities will wish to conduct basic traffic counts on principal transit corridors. The most important focus of the traffic count will be the existing public transport passenger numbers. However, since a percentage of passengers from other modal options (e.g., private autos, motorcycles, etc.) will likely switch to the new BRT system, basic counts of these vehicles and passengers should also be undertaken.

The number of persons boarding and alighting at major points along the corridors should also be documented. The numbers will help in determining the size of stations and the resulting dwell times for transit vehicles at stations.

This basic data collection process should also include an inventory of all existing public transport vehicles (e.g., standard buses, mini-buses, vans, etc.). This inventory of transit supply can then be correlated with the corridor passenger counts. If cooperation with existing transit operators is possible, then interviews to record current routings, travel times, and passenger numbers of each operator will be quite useful.

2.2.3.2 Detailed data collection on current transport demand

Establishing the nature of existing travel patterns is fundamental to projecting the requirements for a proposed mass transit system. However, demand studies can be the most costly component of the data collection process. Finding the right balance between the need for accuracy and the level of costs is a key consideration. Funds expended on demand studies translate directly into fewer funds for other aspects of the planning process. Common elements of a demand analysis include an origin-destination survey (O-D survey), behavioural determinants for travel, and activity data (e.g., opening times of shops). The most crucial element from the perspective of developing a mass transit system is the O-D survey. Figure 11 provides a graphical representation of the data collected through an O-D analysis.

2.2.3.3 Current transport supply

The demand for transport services is only part of a city's transit equation. An inventory of the existing supply of services is also an essential part of characterising the current situation. The data collected on the supply side include:

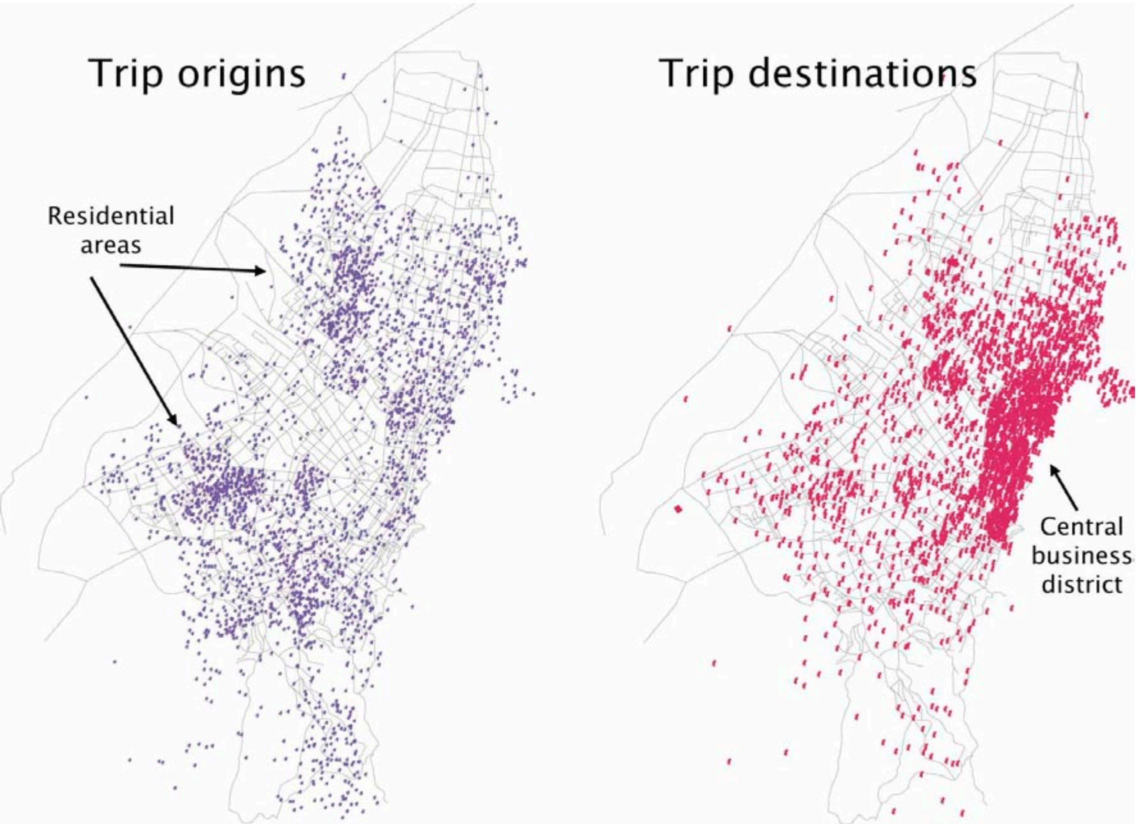


Fig. 11
Illustration of the results of an origin–destination study in Bogotá.
Illustration courtesy of TransMilenio SA

- Size and capacity of road network
- Inventory of parking facilities
- Identification of public transport networks
- Quality and coverage of pedestrian infrastructure
- Quality and length of bicycle infrastructure
- Number of public transport companies (including private operators)
- Number and age of public transport vehicles by type
- Costs of travel (both individual and mass transit modes)
- Schedules and frequency of public transport services.

Recording the number of companies with collective transit operations, including both privately- and publicly-owned entities, will provide insight into the viability of achieving competitive balances within the industry. Typically, public transit in developing cities has gravitated towards one of two structural extremes: 1.) A single, state-owned monopoly; or 2.) Hundreds (or more) of individually owned vehicles. Neither of these two predominate designs necessarily leads to an optimal result in terms of customer service or economic efficiency.

2.2.4 Transportation demand modelling

Modelling is a simplified representation of real world systems that allows projections of future conditions. Transportation modelling is quite commonly utilised to determine expected demand and supply conditions that will help shape decisions on future infrastructure needs and supporting policy measures. Modelling helps project future transport growth as well as allows planners to run projections across many different scenarios.

However, it should be noted that transportation models do not solve transport problems. Rather, the models are tools that provide decision-makers with information to better gage the impacts of different future scenarios. The type of scenarios considered and the type of city conditions desired are still very much the domain of public policy decision-making.

In some circumstances, full formal modelling may not be required at all. Instead, simplified scenario building utilising spreadsheet analysis can provide the basic information required to proceed with the BRT planning process. Of course, a full modelling process will provide a higher degree of certainty for decision-makers and planners. The decision on the degree of modelling undertaken is in part a question of the resources available (financial and temporal) and in part a question of the complexity of the city's transport sector. A highly fragmented and complex urban landscape may require more analytic effort than a city with relatively clear and consistent transport patterns.

To project future transport trends, assumptions relating transport to expected economic growth can provide basic expectations of the percentage of annual growth. The other significant set of assumptions will relate to the amount of mode shifting to take place. If current informal operators are allowed to continue in conjunction with the BRT system, what percentage of the ridership will remain with the existing operators? If the new BRT system implies an increase in fare levels, what percentage of public transport users will switch to lower-cost options such as walking or cycling? What percentage of private vehicle users (two-wheel and four-wheel private vehicles) will switch to the BRT system?

In Bogotá, an estimated 10 percent of private vehicle users switched to the BRT system during the first phase of the project (Steer Davies Gleave, 2003). Most public transport users moved to BRT since many directly competing routes by existing operators were eliminated. However, the slightly lower price of existing operators has meant that a number of customers have continued using these services in cases where they still operate.

2.3 Planning Stage III: Communications

Effective transport planning is not conducted in isolation. In many instances, insights from the public, civic organisations, existing operators, private sector firms, and other governmental entities are more relevant than merely relying upon planning staff and consultants. Systems should be designed around the needs and wants of the customer. All subsequent details with regard to technology and structure can follow from this simple focus upon the customer. As noted previously, bus systems today are often losing mode share because customer concerns about convenience, safety, and comfort are not being addressed. In developing cities, existing transport operators represent another key group that can provide insights into the design process, especially with regard to costs and the final business structure of the system.

This planning stage discusses methods for engaging these key stakeholders in the design process as well as the key attributes in providing a customer-friendly service. The topics to be presented in Planning Stage III, "Communications", are:

- **2.3.1 Public participation processes**
- **2.3.2. Communications with existing transit operators**
- **2.3.3. Marketing plan**
- **2.3.4. Public education plan**

2.3.1 Public participation processes

Typically, a significant barrier to the actual implementation of a BRT system is neither technical nor financial in nature. More often, it is a lack of political will and a lack of communication and participation from key actors that ultimately undermines a project's progress. 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 so as to retain a better understanding of the daily realities.

2.3.2 Communications with existing transport operators

"And it should be realised that 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 benefits of the intended change. 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 carry a distinct distrust of 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. At least one planning staff member should be dedicated permanently to liaison activities with the existing operators. In some instances, this

Fig. 12
The public holds the TransMilenio system in high esteem.
Photo by Jorge Ladino, from TransMilenio photo contest organised by the District Institute for Culture and Tourism

position may best be filled by a former transit operator or another person who holds personal credibility with the operators.

2.3.3 Marketing plan

Bus Rapid Transit is not just another bus service. However, communicating this effectively to the public is not an easy task. The negative stigma of existing bus systems is a formidable barrier to overcome in selling the BRT concept. In most parts of the world, the public transport is seen as an unsafe, uncomfortable, and unpleasant option.

The right marketing campaign can help put BRT in a new light for the customer. The civic pride exuded from the TransMilenio system in Bogotá has manifested itself through several unusual outcomes. Some couples have decided to hold their weddings in the system (Figure 12).

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 (Figure 13). In many instances, the use of terms such as "metro" or "rapid transit" has instilled a modern image with the customer.

2.3.4 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

Fig. 13
Examples of mass transit logos.

plan is in part designed to secure support and approval for BRT but also to better prepare the public on how the system will be used. Thus, a public education campaign is similar to the overall marketing effort, but the focus is less on selling the system and more on providing a baseline of information to the public.

The public education process starts well before the system goes into operation. Information kiosks in Brisbane (Figure 14) helped to raise public awareness. Generating excitement over the look and utility of the new public transit system can help to ensure that the project is fully implemented. A high level of public support will make it more difficult for small groups of special interests to undermine the project. Further, the degree of public support can also bolster political officials who may otherwise be swayed by detractors.

An actual small-scale demonstration of the system may in fact be one of the most effective types of public education mechanisms. Cities such as Lima (Peru) have introduced the BRT concept to residents through such a demonstration (Figures 15 and 16). In the case of Lima, a demonstration station and vehicle was placed in a central park of the city. While this demonstration did not actually provide any transport services, it did give residents a tangible example of the proposed system. Allowing residents to practice using the fare collection system reduces future uncertainty that can act as a barrier to ridership. Further, the demonstration also is one of the best means for achieving public excitement over the possibilities of a new system. Citizens can actually see and feel how the new system will change their city and their lives.

Fig. 14
Public information centre in Brisbane.
Photo by Karl Fjellstrom

Fig. 15 and 16
Lima (Perú) held a system demonstration in a central park. The demonstration featured both a station and a transit vehicle, which helped citizens understand the system prior to its construction.
Photos courtesy of the Human City Foundation.

2.4 Planning Stage IV: Operations

With the identification of travel demand characteristics (Planning Stage II) and inputs from interested groups and individuals (Planning Stage III), it is now possible to prepare a conceptual framework for the operational aspects of the new transit system. By knowing where key origins and destinations are located, the planning team can identify the most appropriate initial corridors. Further, the team can also consider the various types of routing and service options that are possible, such as feeder, express, and local services. Decisions are also possible on the level of customer service quality that will be provided within the system. Attributes such as service frequency, hours of operation, comfort levels, cleanliness, security, and safety will all eventually affect overall ridership levels.

The topics discussed in Planning Stage IV, Operations, are:

2.4.1 Corridor identification

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 demand profiles generated during the modelling process, 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.

Thus, the areas serving the highest customer demand may be selected as the initial system corridors. However, in some instances, lower demand corridors may be selected if the degree of complexity in the high-demand corridors creates implementation difficulties. System developers may first choose to address a less complex corridor in order to first gain experience. If a lower demand corridor is selected, though, it must still possess a sufficient quantity of useful origins and destinations so that the initial system will be financially viable.

Access for special groups, particularly disadvantaged communities, may also be a determining factor. Some systems prefer to develop initial lines around low-income areas so as to demonstrate that BRT has strong developmental linkages. Bogotá, for instance, focused its initial corridor in the lower-income south of the city. The initial corridors, though, will typically include key employment destinations such as central business districts. While road space in such areas may be more limited, the concentration of employment and services in central areas makes it imperative to provide direct access.

Trunk corridors are typically selected to operate upon major arterial roads. These roads often offer several advantages:

- Population densities are often higher near major arterials;
- Wider road space to accommodate both dedicated busways and mixed traffic lanes;
- Clear and logical connections with other major arterials in order to form an integrated network; and,
- A concentration of major destinations such as businesses and shopping areas.

However, major arterials are not the only option to consider as trunk corridors. In some instances, another viable alternative is the selection of a secondary street that is parallel to a major arterial.

2.4.2 Feeder services

2.4.2.1 Trunk-feeder services versus direct services

Providing a transit service to all major residential and commercial sectors of a city can be challenging from a standpoint of system efficiency and cost effectiveness. The densest portions of the city necessitate high-volume vehicles to achieve the required capacity while lower-density residential areas may be most effectively served with smaller vehicles. However, at the same time, customers generally prefer not to transfer between vehicles when given the choice. The question for BRT system planners is how to balance these varying needs and preferences. Smaller residential areas do not have to be sacrificed from the system. A well-designed system can accommodate a range of population densities in order to achieve a true "city-wide" service.

In general, there are two service options for addressing the presence of both high-density and lower-density areas within a city. These options are:

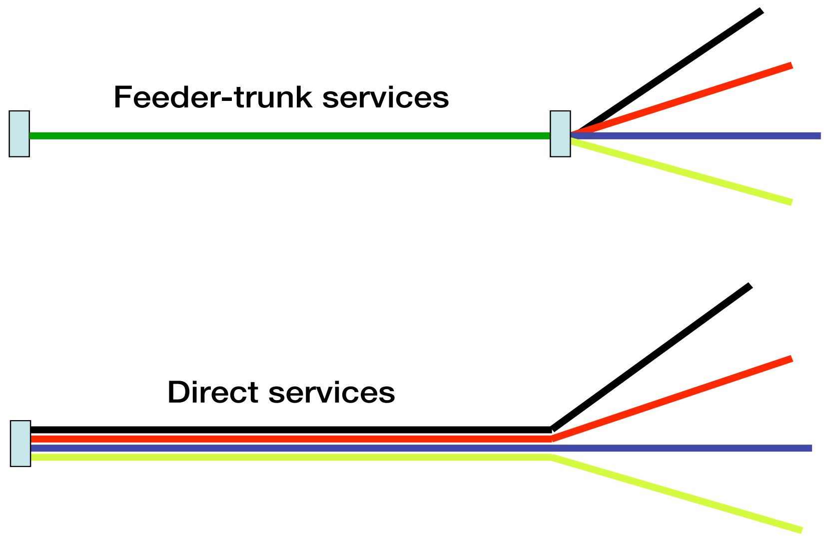
1. Trunk-feeder services; and,
2. Direct services.

Trunk-feeder services utilise smaller vehicles in lower-density areas and then necessitate passengers to transfer to higher-capacity vehicles at terminals. A trunk-feeder service thus operates relatively efficiently by closely matching vehicle operating characteristics to the actual demand. However, such services do imply that some passengers will need to transfer vehicles in order to reach their destination. The process of transferring can be seen as an undesirable burden for some passengers.

Direct services avoid the need for customers to transfer since the same vehicle serves both the feeder area and the trunk-line corridor. However, direct services incur a substantial cost penalty for operating vehicles that do not closely match the actual demand. Thus, direct services may imply that a large vehicle must enter into lower-density areas where relatively few passengers will be in the bus. Alternatively, direct services may imply that small vehicles operate efficiently in feeder areas but are undersized for the economics of trunk corridors. Direct services may still necessitate a transfer if the passenger's destination is a different corridor than the closest trunk corridor. Figure 17 provides a graphical comparison of trunk-feeder services and direct services.

In general, the most successful BRT systems (e.g., Bogotá, Curitiba, and Quito) operate with trunk-feeder services. However, there are also examples of systems, such as Porto Alegre (Brazil) and Kunming (China), which operate with direct services. The decision to choose a trunk-feeder service or a direct service can depend on many factors, including the structure of the city, the variation of population densities and service demand across different sectors of the city, distances to be travelled, and the business structure of the system.

Fig. 17: Illustrative comparison between trunk-feeder services and direct services



2.4.2.2 Lack of feeder services

Can a BRT system operate only on major corridors without any supporting feeder services? Some cities have attempted to implement a busway system without providing either feeder services or direct services into residential areas. Typically, this arrangement occurs when a city wishes to implement a limited experiment on a major corridor during a BRT project's first phase. By doing so, the municipality can avoid addressing many of the complicated issues related to existing informal operators who service residential areas. The municipality can also avoid the complications related to the integration of services. However, the results to date on such an approach have not been entirely positive.

Jakarta (Indonesia) inaugurated its TransJakarta BRT system in January 2004 with an initial Phase I corridor of 12.9 kilometres. The system in this corridor consists of a single-lane median busway (Figure 18). The corridor is largely composed of business and shopping oriented destinations with few residential origins. The

Fig. 18
TransJakarta BRT system.
Photo courtesy of the Institute for Transportation & Development Policy

municipality elected not to provide any feeder services during the opening phase. The city also elected to allow the existing bus operators to continue operating in the mixed traffic lanes. Unsurprisingly, the results have not been favourable either to the BRT system or the general traffic. The limited BRT system has carried just 60,000 passengers per day and 6,000 passengers per hour per direction at peak times. The continued operation of the existing operators in the reduced confines of the mixed traffic lanes has also exacerbated overall traffic congestion levels. Retroactively, Jakarta is attempting to arrange feeder services with existing operators but the arrangements have failed to work properly.

2.4.3 Service options

2.4.3.1 Local services and station spacing

The most basic type of transit service along a corridor is typically known as "local service". This term refers to stops being made at each of the major origins and destinations along a route. However, in comparison to conventional bus services, the distance between stops on BRT corridors is greater. A typical range of distances is between 300 metres and 700 metres.

By avoiding short stopping distances, the overall travel time is reduced due to higher average vehicle velocities. "Hail and ride" services provided by private bus operators in many developing cities implies that the bus will stop whenever a customer indicates that he or she wishes to board or alight. While this practice will reduce subsequent walking distances to destinations, the net effect of all passengers controlling stopping location greatly increases overall travel time for everyone.

2.4.3.2 Express services

Typically, a few major stations will predominate as the intended destination of customers. For many passengers, stopping at each intermediate station adds significantly to the overall travel time with relatively little commercial benefit to the system operators. Thus, both passengers and operators can benefit from the provision of services that skip intermediate stops.

BRT's relative flexibility means that "limited-stop services" or "express services" can be accommodated. The number of station stops to be skipped depends on the demand profile. Major station areas with the largest customer flows may be the most logical stops retained in a limited-stop service. However, the system can employ multiple limited-stop routes in order to ensure travel times are minimised for the largest number of customers. Thus, limited-stop routes can differ by the stations served as well as by the number of stations skipped by the service. Some routes may skip 3 or 4 stations while other routes may skip double that number.

While limited-stop services do provide much amenity value to customers, these services do introduce greater complexity to the management of the system. The coordination of vehicles on the same corridor with different travel characteristics can be a challenge. Express services are thus best implemented in conjunction with vehicle tracking technology that permits a central control team to oversee and direct vehicle movements. The provision of express services also implies particular infrastructure requirements. In order to skip stops, the limited-stop vehicles must be able to pass intermediate stations. Thus, sufficient road space must be available for either a second set of exclusive busway lanes or the provision of a passing lane at by-passed stations (Figures 19).

2.4.4 Passenger capacity

Once the initial BRT corridors are selected, the demand forecasts for these corridors can be used to determine optimum values for factors such as vehicle capacity, vehicle load factors, service frequency, and dwell times. These attributes in conjunction with the desired preferences for service types (trunk-feeder, direct, local, express, etc.) and the configuration of stopping bays will allow system developers to model different options for meeting the expected passenger capacities.

2.4.4.1 Vehicle capacity

Vehicle passenger capacity, load factors, and required service frequency are all mutually dependent. The maximum passenger capacity for a given vehicle is in part dependent on assumptions about culturally acceptable levels of customer comfort at peak times. A trade-off exists between the number of seats provided versus the amount of standing space provided. In some cases, a seated passenger consumes as much as twice the space as that required by a standing passenger. However, for long journey times passengers may have a strong preference for seating.

2.4.4.2 Load factors

The vehicle load factor refers actual capacity usage as a percentage of the maximum passenger capacity. For example, if a vehicle has a maximum capacity of 160 passengers and an average capacity of 128 passengers, then the load factor is 80 percent (128 divided by 160). Generally, it is not advisable to plan to operate at a load factor of 100 percent. At a 100 percent load factor there is no room for system delays or small inefficiencies, both of which are likely outcomes of over-crowded conditions. The desired load factor may vary between peak and non-peak periods. In the Bogotá TransMilenio system, typical load factors are 80 percent for peak periods and 70 percent for non-peak periods.

2.4.4.3 Service frequency

The service frequency refers to the wait time between arriving vehicles. The wait time is also known as the "headway" between vehicles. In general, it is desirable to provide frequent services in order to reduce customer wait times. Customers often perceive waiting times to be much longer than the actual duration. Thus, to provide a car-competitive public transit service, minimising customer waiting is fundamental. The targeted wait times are closely related to the expected load factors. Longer wait periods will tend to increase the load factor as more passengers will arrive at the station.

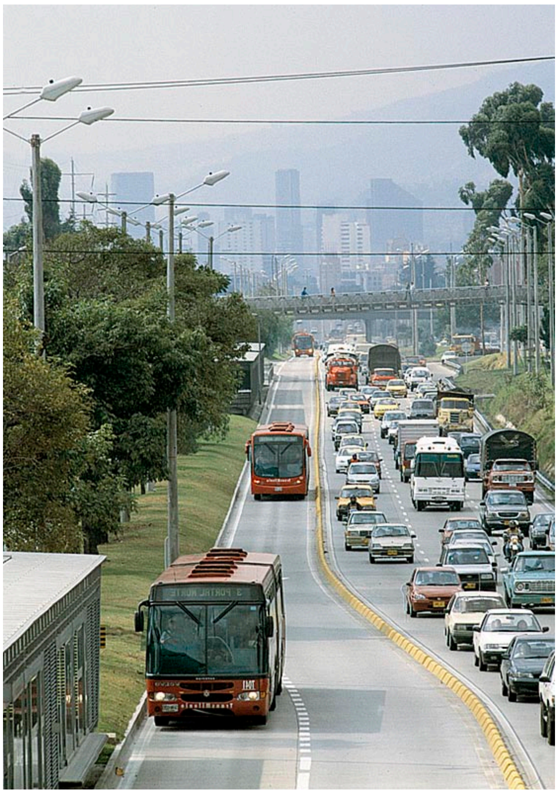


Fig. 19
The provision of passing lanes at stations in Bogotá greatly increases system capacity by allowing for express and limited-stop services.
Photo courtesy of TransMilenio SA

Service frequency varies between different cities with BRT, but in general, peak frequencies of one minute to three minutes are quite common. Non-peak frequencies are likely to be longer but usually in a range of four minutes to eight minutes. Service during weekends may also tend to follow non-peak frequencies.

2.4.4.4 Dwell time

Another factor affecting operating conditions is the vehicle "dwell time". The dwell time is the amount of time vehicles are stopped at a station to allow passenger boarding and alighting. The amount of time required depends upon many variables including:

- Passenger flow volumes
- Number of vehicle doorways
- Width of vehicle doorways
- Entry characteristics (stepped or at-level entry)
- Open space near doorways (on both vehicle and station sides).

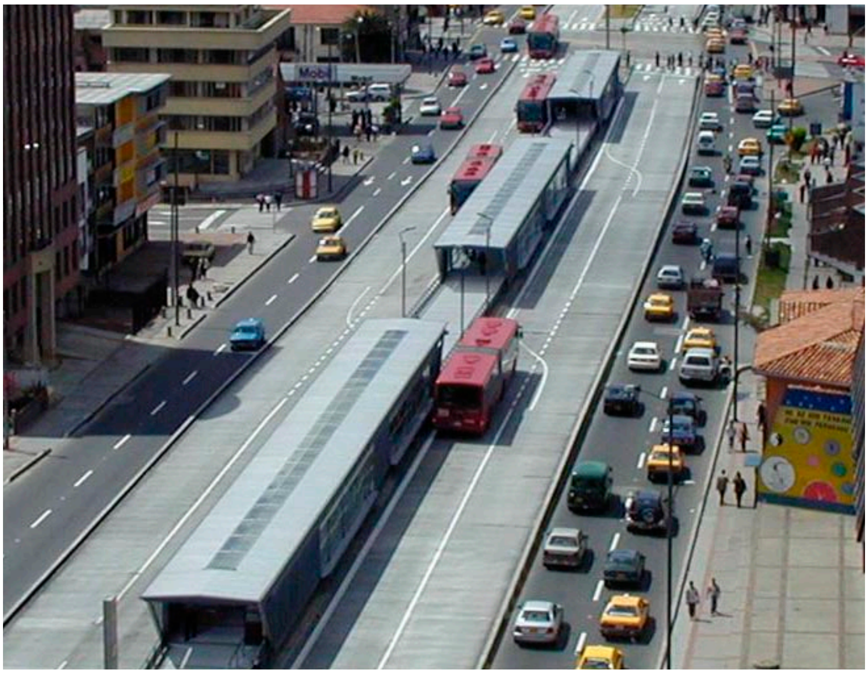


Fig. 20
Bogotá BRT stations.
Photo courtesy of Akiris

BRT systems operate with dwell times as low as 20 seconds. Conventional bus services can require over 60 seconds for boarding and alighting. In general, dwell times may be somewhat higher during peak periods than non-peak periods.

2.4.4.5 Stopping bay configurations

Passenger capacities along a corridor can be increased by providing multiple stopping bays at the station area. A stopping bay is the designated area where a vehicle will stop and align to the platform. In cities such as Curitiba, Kunming, and Taipei, only one stopping bay is provided per station. However, in other systems, allowing multiple vehicles to stop at the same time has proven to dramatically increase system capacity. Cities such as Bogotá and Porto Alegre employ multiple stopping bays within their BRT systems. Each stopping bay represents a different set of services or routes (e.g., local services versus limited-stop services or routes with a different final destination). In Bogotá, there are as many as five different stopping bays at an individual station (Figure 20).

2.4.4.6 Vehicle velocity

System capacity is actually not strictly dependent upon vehicle velocity. A system can move 20,000 passengers per hour at 20 kilometres per hour as well as at 10 kilometres per hour. Prior to the development of the Bogotá TransMilenio system, the city possessed a median busway that catered to all private bus operators. The uncontrolled system meant that there was considerable congestion on the corridor. The congestion was due to buses stopping at random locations as well as the over-supply of less efficient smaller vehicles. Nevertheless, the previous system moved approximately 30,000 passengers per hour per direction, but it did so at an average speed of less than 10 kilometres per hour. The TransMilenio system moves a similar number of passengers but at an average commercial speed of approximately 27 kilometres per hour. Figures 21 and 22 provide a visual comparison of Bogotá with the previous uncontrolled busway and with the TransMilenio BRT system along the same corridor.

Clearly, from the perspective of minimising travel time and fulfilling customer preferences, a rapid service is more desirable. While velocity and capacity may not be directly dependent, many factors that affect passenger capacity also affect average velocity:

Fig. 21 and 22
Bogotá: A corridor before and after BRT implementation.
Photo on left courtesy of Steer Davies Gleave
Photo on right by Lloyd Wright

- Number of busway lanes
- Dwell times
- Headways
- Vehicle acceleration and deceleration characteristics
- Number of controlled intersections.

As the number of vehicles on the corridor increases, the level complexity and opportunity for conflicts also increases. In turn, these conflicts between vehicles lead to reduced velocities and increased travel times.

2.4.4.7 Capacity calculations

The passenger capacity of a given corridor is calculated based upon the discussed factors of vehicle capacity, load factors, service frequency, dwell times, and stopping bay configurations. Quite often a software model will assist in calculating the expected capacity and flow rates based on these factors. In general, though, the overall corridor capacity can be calculated from the following equation:

Passenger capacity	=	Vehicle capacity	x	Load factor	x	Service frequency	x	Number of stopping bays

Table 1 provides a sample of BRT capacity figures for several different combinations of the factors from the above equation. The values in this table are merely examples; the actual potential capacities for a given city will vary depending on a variety of local circumstances.

The values presented in table 1 assume that the vehicles operate on a segregated, median-aligned busway with at-level boarding. Values will be lower for side-aligned busways where there are significantly more turning conflicts with other vehicles. Further, if the vehicles have stepped passenger entry instead of at-level entry, longer headways will be necessary to handle the additional dwell times.

2.4.5 System management and control

Centralised control of the overall transit system affords many benefits for optimising efficiencies and minimising costs. Most conventional bus services lack a centralised control and management system; many do not even possess a basic radio dispatch system. The lack of such controls means that each vehicle operates individually without the advantage of reacting collectively to service changes.

For example, a sudden change in demand, such as crowds leaving a sporting event, can be more readily addressed if additional transit supply is quickly dispatched from a central control facility to the site. A simple mechanical failure of one vehicle can stifle an entire system if a repair team or a tow truck is not immediately sent. Additionally, if a security problem arises,

Table 1: BRT passenger capacity scenarios

Vehicle capacity[1] (passengers)	Load factor	Headways (vehicle frequency in seconds)	Number of stopping bays	Capacity flow (passengers per hour per direction)
70	0.85	60	1	3,570
160	0.85	60	1	8,160
270	0.85	60	1	13,770
70	0.85	60	2	7,140
160	0.85	60	2	16,320
270	0.85	60	2	27,540
70	0.85	60	4	28,560
160	0.85	60	4	32,640
270	0.85	60	4	55,080
160	0.85	60	5	40,800
270	0.85	60	5	68,850

[1] Standard-sized bus (12 metres): 70 maximum passengers.
Articulated bus (18 metres): 160 maximum passengers.
Bi-articulated bus (24 metres): 270 maximum passengers.

Fig. 23
A public education campaign is often best conducted directly in the neighbourhoods near the new BRT corridors. Direct outreach workers are a cost-effective mechanism for informing the public.
Photo courtesy of the Human City Foundation

a control centre could provide an appropriate response, such as sending a security team to a station or bus. Without centralised control, these types of incidents will likely only be dealt with locally, which limits the effectiveness of any solution.

Further, when transporting large volumes of passengers through a corridor (over 10,000 passengers per hour per direction), a central control system becomes all the more indispensable to maintaining smooth operations. The "bunching" of vehicles within the system can easily occur without centralised monitoring and corrective actions. Further, if the bunching together of buses occurs, this situation also likely implies that there will be other points in the system where buses are too widely separated. Passengers are familiar with the situation in which two or three buses of the same route will arrive simultaneously, and then there will be no other buses for another 30 minutes. Ultimately, the price paid for failing to respond to these types of incidents will be customer dissatisfaction and lost ridership.

In a high-volume public transit system, there is very little margin for problems or errors. A vehicle breakdown, even for just a few minutes, can create havoc on the entire system. Likewise, a breakdown of a fare verification turnstile or non-functioning station door will create similar types of problems. Thus, preparing for any and all eventualities is a fundamental part of the operational plan. The development of backup and contingency plan will ensure that the system can continue to function even in difficult circumstances.

2.4.6 Customer service

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 (Figure 23).

Unfortunately, unclear maps and schedules, unclean buses, and uncomfortable rides have been all too frequently the obligatory price to be paid for utilising public transport. Public transit and paratransit operators sometimes give scant attention to customer service, assuming instead that their market is predominated by captive customers who have few other options. Such a predilection, though, can lead to a downward spiral, in which poor services push more commuters toward private vehicles. 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. The impacts of poor customer service may not be immediately evident when the majority of the users are "captive" riders who have few other transport options. However, in the medium and long term these captive riders will become discretionary riders. The discretionary riders will then likely switch to individual motorised transport the moment it becomes financially feasible to do so.

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 a hazardous and unfortunate trauma that must be endured? Individually, factors such as driver behaviour, signage, and seat comfort may appear to be insignificant measures, but their combined effect can be a significant determinant in the long-term viability of a transit service.

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. Customers probably do not care about the type of engine propulsion technology, but they do care greatly about the simple customer service features that directly affect their journey comfort, convenience and safety. Despite this rather obvious observation, too many public transport developers devote complete attention to vehicle and engineering aspects of system design and forget about the customer service aspects.

2.4.6.1 Hours of operation

The opening and closing time of the system affects both customer utility and cost effectiveness. Ridership levels during early morning and late evening operations may be somewhat limited. However, the lack of service during non-peak hours undercuts the system's overall usability which will negatively affect ridership during other times. This need for comprehensive utility does not imply systems must operate 24 hours. In fact, many transit systems with 24 service experience significant security problems (e.g., robberies, assaults, graffiti, etc.) during late night and early morning hours.

The appropriate hours of operation will likely be based on the schedules of the major employment, educational, and leisure activities of the local citizenry. Thus, the hours will depend on key local indicators, including:

- Working hours of major employers
- Start and closing hours of educational institutions (including night classes)
- Closing times for restaurants, bars, cinemas, and theatres.

The appropriate operating hours will depend upon local cultural and social practices. In Bogotá, the TransMilenio system operates from 05:00 until 23:00, reflecting the relatively early start to the work day that is practiced there.

2.4.6.2 System maps

Historically, the ad hoc and paratransit systems in much of the developing world have followed informal and uncontrolled routings that required a seasoned system insider to fully understand and utilise. Many such systems are relatively incomprehensible and have formed a formidable barrier to potential new users, such as those with occasional transport needs and temporary visitors to the city. The TransMilenio BRT system in Bogotá emulates the better underground systems of the world by providing clear and colourful system maps (Figure 24).

A good 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.

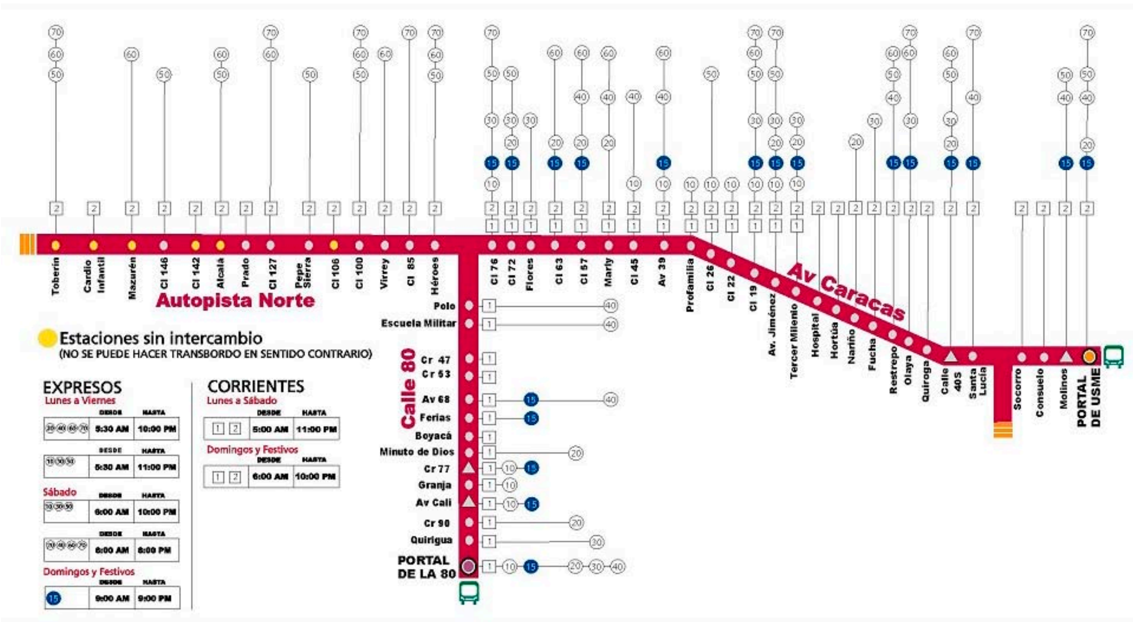


Fig. 24
System map of TransMilenio.

Fig. 25
Signage in stations in Quito provide clear guidance to customers.
Photo by Lloyd Wright

2.4.6.3 Signage

In addition to system maps, the various signage in and around stations as well as within the vehicles are key to customers readily understanding the system. Examples of the types of signage likely to be needed include:

- Instructions for using fare collection machines or vending booths
- Identification of station entry and exit points (Figure 25)
- Standing location within the station for particular routes (if multiple stopping bays)

Fig. 26
Placing real-time information displays at station entrances allows customers to make key decisions about their journey.
Photo by Lloyd Wright

- Directions for making transfers at terminals and intermediate transfer stations
- Actions required in the event of emergencies (instructions for call boxes, fire suppressing equipment, etc.)
- Identification of locations within the vehicle for persons with special needs (physically disabled, elderly, parents with child, passengers with bicycles, etc.)
- Directions to amenity facilities (e.g., bicycle parking facilities, restrooms, etc.).

The variety of signage requirements within a BRT system should not imply that an overabundance of visual cues is always desirable. Too much signage can be visually distracting and prevent customers from absorbing vital information. "Visual clutter" is particularly problematic when systems utilise extensive advertisements. While advertisements can be an effective revenue source when used discretely, essential system signage can get lost if the commercial messages are too obtrusive.

2.4.6.4 Visual and voice information systems

Traditional signage is just one means to convey information to customers. Visual displays with real-time information are increasingly being used to relay a variety of message types. Such devices can display the following types of information:

- Next station stop (display inside bus)
- Estimated arrival time of next vehicle (display on station platform)
- Special advisories such as delays, construction work, new corridors, etc.
- Customer service announcements such as information on fare discounts.

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 (Figure 26).

Voice communications can also be a useful mechanism to convey essential information. The voice announcement of the next station permits the customer to focus on other activities (such as reading, talking with friends, etc.). Otherwise, customers will tend to look up frequently either at a display or at the name of the station. Forcing the customer to know the local environment can add stress to the journey, especially for visitors and occasional transit users.

2.4.6.5 Transit staff

In public transport as in life, sometimes a simple smile or kind word can make all the difference. The role of transit staff in making customers feel respected and welcome is one of the most powerful promotional tools that exist (Figure 27). While staff behaviour is probably one of the most economical means to creating good customer service, it is also sometimes one of the most ignored.

The training of transit staff in social interaction skills should be undertaken on a regular basis. Establishing a positive environment between staff and customers is not only healthy for attracting ridership but it can also improve employee morale. For fare collection agents, conductors, and drivers who handle thousands of passengers a day, each customer may just be another face in the crowd. However, for each customer, the brief interaction with staff can significantly affect the individual's opinion of the service. Thus, it is important that transit staff view each interaction with care.

Smartly-styled uniforms for all personnel also help to raise the public's perception of system quality and professionalism. Uniforms that are both comfortable to the user as well as project a stylish image can help change how the customers view public transport.

2.4.6.6 Cleanliness and system aesthetics

The cleanliness of the system is another seemingly trivial issue that has a major impact on customer perception and satisfaction. A transit system cluttered with litter and covered with graffiti tells the customer that this service is of poor quality. Such a scene reinforces the idea that public transport customers are somehow inferior to private vehicle owners. By contrast, an attractive and clean environment sends the message that the system is of the highest quality. Such a level of aesthetic quality can help convince all income groups that the transit system is an acceptable means of travel. Ideally, the transit system will come to be viewed as an oasis of calm and tranquillity in an otherwise chaotic world. To reach this state of aesthetic quality, it merely takes good planning and design.

Strict cleaning schedules are a low-cost way of maintaining a positive transit environment and customer confidence in the system. In Quito, buses are cleaned after every pass along the corridor. Once a vehicle reaches the final terminal, a cleaning team goes through the vehicle leaving it spotless in about four minutes (Figure 28). This practice reduces the time night-time cleaning teams need to spend on the vehicles. Maintaining spotless operations also sends a message to everyone that littering is not to be done and thus tends to reduce the generation of trash. Likewise, a systematic cleaning schedule for stations and terminals can also keep a system in near pristine form.

Fig. 27
TransMilenio staff.
Photo by Lloyd Wright

2.4.6.7 Security

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

Fig. 28
BRT vehicles in Quito are cleaned after each pass along the corridor.
Photo by Lloyd Wright

Fig. 29
The emergency call boxes in Ottawa BRT stations help to reassure passengers about security arrangements.
Photo by Lloyd Wright

However, crime and insecurity can be overcome with the strategic use of policing and information technology. The presence of uniformed security personnel at stations and on buses can dramatically limit criminal activity and instil customer confidence. Further, security cameras and emergency call boxes (Figure 29) both permit more rapid response to potential threats as well as deter crimes from happening in the first place. The highly visible presence of security staff and the watchfulness of passengers can reduce the possibilities of crime (Figure 30).

Fig. 30
The presence of security staff in cities such as Quito send an important message to customers about the security of the transit environment.
Photo by Lloyd Wright

2.5 Planning Stage V: Business and regulatory structure

The ultimate sustainability of the proposed BRT system is likely to depend less on the system's "hardware" (buses, stations, busways, and other infrastructure) and more on the system's "software" (the business and regulatory structure). If the BRT system can be made financially sustainable within an effective regulatory framework, then the remainder of the system design is largely a matter of technical details. The administrative and organisational structure of the system will have profound implications on the system's efficiency, operational nature, and costing.

However, effective regulatory and business structures are often quite difficult to achieve, especially when existing structures impose restraints over realising an optimum form. There is no one correct solution to structural issues, as local custom and circumstances play a determining role. Public operators may be unwilling to surrender their market and their administrative "turf". Private operators may be resistant of any changes, especially when they are unaccustomed to any governmental oversight. Ultimately, a mixed system with public and private sector roles may be the optimum approach to achieving a competitive and transparent system. Bogotá's TransMilenio provides an example of utilising the best qualities from both the public and private sectors.

The development of the system's business model will require some initial analysis of projected operating costs. This analysis will help identify the conditions in which operating companies can reach profitable (and thus sustainable) revenue levels. The calculation of operating costs will also allow initial estimates of expected customer tariff levels.

2.5.1 Business structure

2.5.1.1 Existing business structures in developing cities

The existing public transport companies within a developing city will likely fall into one of three broad categories of market structures:

1. Public systems
2. Private sector systems
3. Mixed systems (public and private roles)

Publicly-operated transit systems are quite common in developed nations. In countries like the United States and some western European nations, the public transit agency acts as both the regulator and operator. However, in recent years, these systems have made greater use of private sector contracting for specialised functions. Publicly-operated systems in the developing world are relatively rare, but there are a few examples. In some instances, the public sector has taken over routes and areas that are not sufficiently profitable for the private sector. In most cases, publicly-operated systems are not very efficient. These systems are quite often heavily subsidised, over-staffed, and offering a service that is not highly responsive to customer demands.

Historically, a lack of financial resources and institutional control has meant that developing city transit has been have left largely to private operators. In many instances, these firms and individuals operate informally with very little public oversight. With fierce competition between many struggling small firms and little governmental control, the frequent result has been poor quality services that do little to meet the broader needs of the customer. Private operators will tend not to provide service to smaller neighbourhoods and will operate at particular hours. Small operators also tend to be run in a relatively inefficient manner. Small vehicles are utilised in places where high-capacity vehicles could be operated at a more efficient level. This inefficiency can lead to higher fare levels than would otherwise be required.

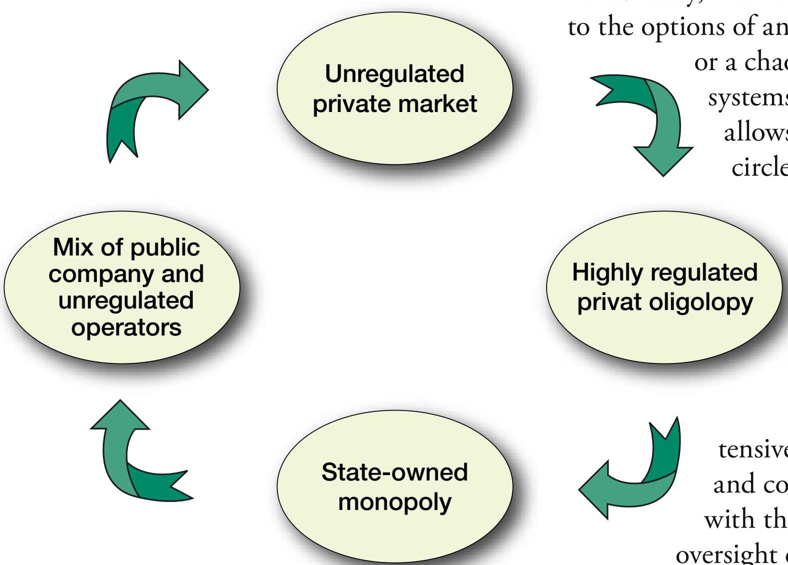
An uncontrolled transit environment can also lead to a serious over-supply of small vehicles. In Lagos (Nigeria) there are currently an estimated 70,000 mini-buses plying the streets. Until recently, over 50,000 mini-buses operated on the streets of Lima (Peru), and prior to

Fig. 31
Bus transit in Bogotá prior to TransMilenio.
Photo by Lloyd Wright

TransMilenio, approximately 35,000 buses of various shapes and sizes ran along the streets of Bogotá (Figure 31). The large number of small transit vehicles contributes significantly to congestion and poor air quality. The unwieldy number of operators also represents a regulatory challenge to municipal agencies that lack sufficient resources.

In some instances, each vehicle is owned separately, often by the person who does the driving. In other instances, the transit vehicle is operated by a driver who leases the vehicle from a separate owner. Since the driver pays a flat fee for access to the vehicle, he or she then has an incentive to drive the vehicle as much as possible during the day in order to maximise fare revenues. Drivers will thus work as much as 16-hour days. The drivers will also have an incentive to drive as rapidly as possible to make as many roundtrips as they can. Further, drivers will even cut off other bus operators in order to prevent competitors from capturing customers. In Bogotá, this behaviour was known as the "battle of the cent". Not surprisingly, the long hours, high speeds, and aggressive driving lead to extremely hazardous road safety conditions. At the same time, the captive riders have few options other than wait for the day that they can purchase their own private vehicle.

Fig. 32: The regulatory cycle



Source: Meakin (2003)

Thus, two extremes have predominated public transport regulatory structures: 1. Inefficient public monopoly; and 2. Poor quality private operators. Several cities have entered a vicious circle of moving between public and private systems along with intermediary steps of a highly-regulated private oligopoly and a mix of a publicly-operated entity competing with scores of unregulated operators (Figure 32). Cities such as Colombo (Sri Lanka) and Santiago (Chile) have moved around the entire spectrum of possibilities without ever finding a workable solution.

The regulatory cycle becomes a vicious circle in which cities attempt to find quick fixes to ingrained structural and systemic deficiencies. The cycle's characteristics along with the reasons for inevitable collapse of each stage are given in table 2.

2.5.1.2 Mixed systems

Fortunately, market structures are not limited to the options of an indebted public system or a chaotic private system. Mixed systems represent an alternative that allows cities to escape the vicious circle of the regulatory cycle. Mixed systems exploit the most appropriate role of both the public and private sectors in order to create a sustainable institutional and market structure. The use of extensive private sector contracting and concessions in conjunction with the judicious use of public oversight can produce the right set of conditions to minimise costs and ensure a high

Table 2: The regulatory cycle

Industry composition	Characteristics	"Solution"
1. Unregulated private operators	Chaotic, aggressive competition, dangerous driving, unstable services, no integration, variable fares.	Comprehensive regulation by Government.
2. Highly regulated private oligopoly	Industry consolidates into large companies producing low levels of competition followed by fare increases; political pressures from increased fares result in lower-quality services or company bankruptcies.	Government nationalisation of firms (because 'only the state can assure adequate services').
3. State-owned monopoly	Low cost-effectiveness due to confused corporate objectives (service or profit?); low, sporadic or inappropriate investment; poor services.	Government tolerates 'illegal' private operators to meet unfulfilled market demands.
4. Mix of public company and unregulated operators	Deficits from public company become politically unacceptable resulting in reduced services and increasing paratransit in the market.	Government gets out of business by privatisation or by withdrawal.

Source: Meakin (2003)

level of service quality. The challenge of achieving a well-functioning competitive structure lies in creating an appropriate set of incentives that ensures each actor is properly motivated to deliver a quality product.

Well-designed business structures for BRT systems have tended to seek considerable *competition for the market but limited competition in the market*. This strategic use of competitive motivations means that firms will have to compete aggressively within a bidding process in order to be allowed to operate. However, once the winning firms have been selected, there will not be competition on the streets to wrestle passengers away from other companies. Thus, firms will have an incentive to provide a high-level of

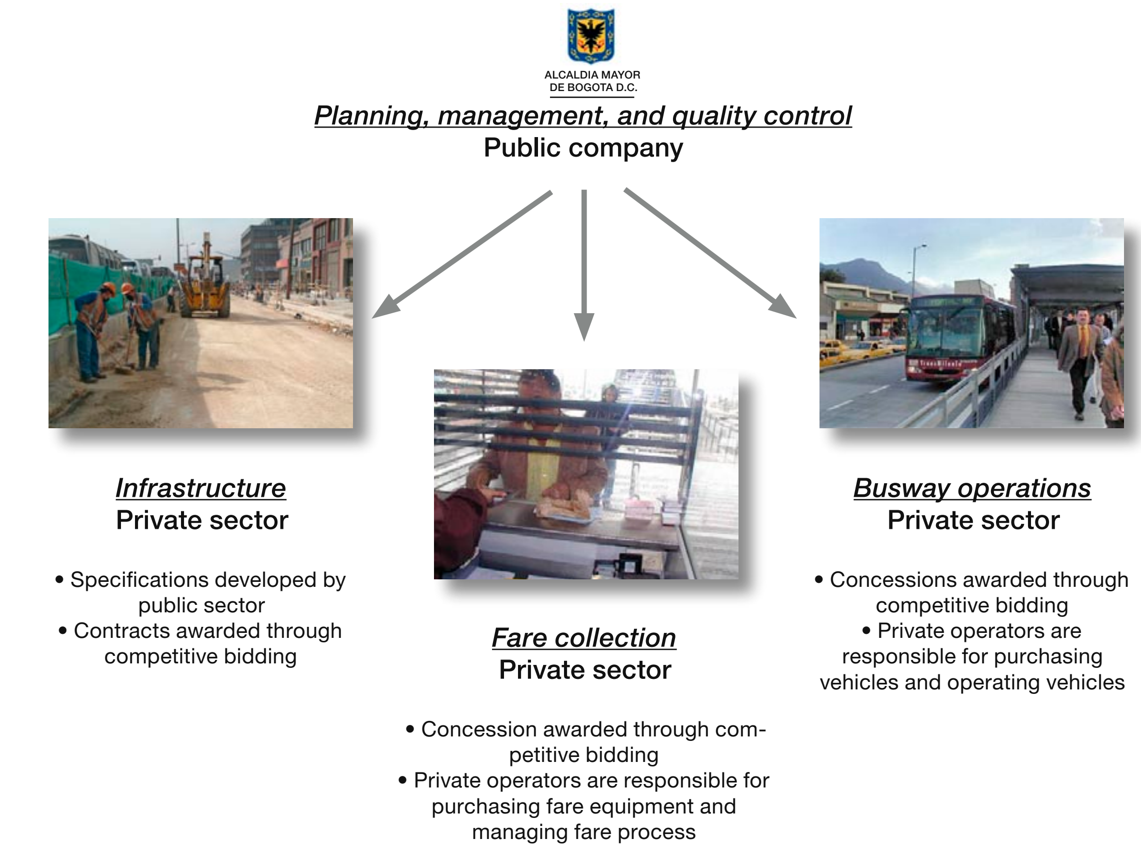


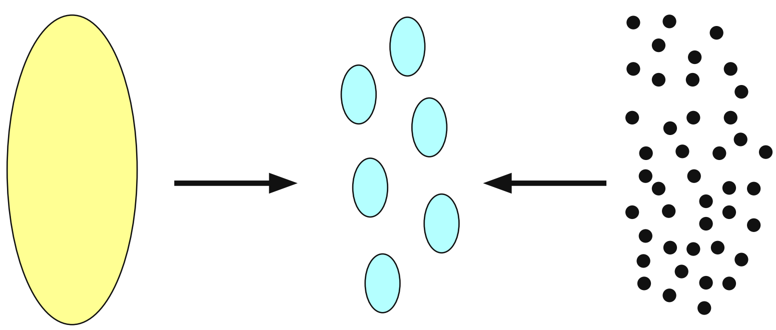
Fig. 33
Organisational structure of Bogotá's TransMilenio system.
Photos courtesy of TransMilenio SA and Lloyd Wright

service while simultaneously not generating the negative attributes of reckless driving, speeding, and cutting off other transit vehicles to gain an advantage. Some competition in the market can also be achieved by permitting multiple concession contracts along the same corridor. However, a transparent revenue distribution process along with an incentive system based on kilometres travelled rather than passenger numbers can avoid aggressive behaviour.

Bogotá's TransMilenio system has successfully developed a formula of private sector competition within a publicly-controlled system (Figure 33). The public company, TransMilenio SA, holds overall responsibility for system management and quality control. However, TransMilenio SA itself is only an organisation of approximately 70 persons, 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 buses and even fare collection equipment are purchased by the private sectors firms.

The infrastructure for TransMilenio is publicly financed, in the same manner that all other municipal road infrastructure is developed. A separate public works agency issues the tender documents to competitive bidding for the infrastructure components (busways, stations, terminals, depots, etc.). The construction work is conducted entirely by the private sector. Thus, almost all possible aspects of TransMilenio are contracted or concessioned to private sector entities with public agency oversight.

Fig. 34: The market transformation process



Source: Adapted from Meakin (2003)

2.5.1.3 Transforming existing systems to competitive, mixed systems

Of course, most cities do not begin from the point of having a well-structured system that balances the appropriate roles of the private and public sectors. Instead, most developing cities begin with one of the four conditions identified in the regulatory cycle. The challenge becomes how to transform an existing market structure into one delivering a cost-effective and high-quality service. Figure 34 shows a pictorial view of the challenge within the transformation process.

Consolidating the thousands of registered and unregistered small operators into a more manageable structure brings with it considerable challenges. Powerful interests will also likely resist any changes to the existing market structure. However, unlike the transformation of a single public entity, the thousands of private operators are both difficult to identify as well as difficult to organise. Inclusion of existing operators in the concessions process is important for political, social, and functional reasons. Ideally, the operators will have had a participatory role in designing the concessions process in the first place.

2.5.1.4 Existing operators and continuance of service

A related issue is whether existing operators should be allowed to continue to operate along the same corridors as the BRT system. In order to assure that the BRT system is financially viable, mandating the phase out of competing informal services along the same routes may be a prudent action. Politically, it also may be an important gesture to private vehicle users in order to free up the remaining road space to mixed traffic.

However, a complicating factor is that the existing operators often will not operate along exactly the same route structure. These vehicles may only use a portion of the busway corridor for their routes. At different points along the corridor, the operators will enter and exit from various other routes and neighbourhoods. Curtailing their operations will imply that some areas may be cut-off from transit services altogether. Additionally, residents who will be accustomed to a certain type of routing service may be displeased with the removal of these services.

Thus, to avoid difficulties both to the transit operators and the serviced communities, the transit agency should consider a complete review of transit routes and licensing along the BRT corridors. Such a review of the entire city's transit route structure can lead to the following types of adjustments:

- Banning existing operators from servicing certain areas;
- Re-routing the existing operators to other areas;
- Permitting the existing operators to continue along certain segments of the corridor.

2.5.1.5 Open versus closed systems

The business or market structure can also be closely related to the operational nature of the system. In some instances, a detailed bidding process will be utilised to determine which private firms will obtain concessions to operate on the busway. Firms that do not receive a concession are not permitted to operate on the busway, and many times, are also not permitted to operate on the mixed traffic lanes in the same corridor. This form of operational structure is known as a "closed system" in which the market is restricted only to firms that are successful in the bidding process.

Alternatively, the busway can be open to all existing operators without any significant restrictions based on vehicle numbers or routing. In this scenario, the operators continue in much the same business structure as before but with improved infrastructure. This option is known as an "open system" (Figure 35). However, an open system can be prone to busway congestion and slower travel times due to the lack of control over vehicle entry.

In contrast, cities such as Bogotá and Curitiba operate as closed systems by limiting entry to qualified private firms. Quito also operates closed systems on its Trolé and Ecovía corridors (Figure 36). Bogotá is perhaps the most complete example of a closed system utilising a full competitive structure.

A closed system does not imply that one cannot have multiple operators on the same corridor. Bogotá intentionally selects at least two operating firms on each corridor to ensure a degree of competitiveness within the market. In the case of strikes or operational problems with one of the operators, there is the leverage of the additional operating company to compensate.

2.5.2 Institutional and regulatory structure

The supporting institutional and regulatory structure can either create an environment of efficiency and transparency or lead to misplaced incentives and even corruption. The "public" side of an effective public-private partnership will play a pivotal role in developing and maintaining a competitive transit environment.

However, there is no one answer to an effective institutional structure since the existing agencies, historical precedents, geographical coverage of the system, and the local political dynamics will

Fig. 35 and 36
The photo at the top shows an "open system" in Porto Alegre while the photo below shows a more controlled "closed system" in Quito.
Photos by Lloyd Wright

all shape the likely outcome. The options range from relatively focused specialised agencies to large transport departments that oversee all forms of public and private transport. Further, these institutions can be either highly autonomous from the local government or closely controlled by elected officials and civil servants. The responsible level of government for a transit system is often local in nature, but the system can also be controlled in some instances by provincial governments or even national ministries. Finally, the institutional oversight of a BRT system can be implemented through an existing agency or through a newly created organisation.

In cities such as Bogotá and Curitiba, the BRT systems are overseen by smaller, fairly specialised organisations. In such instances, different aspects of BRT development and operation can reside in different organisations. In Curitiba, the planning and development of the transport master plan resides with the Institute of Urban Research and Planning of Curitiba (IPPUC). Another organisation, Urbanisation of Curitiba (URBS), is responsible for the actual implementation and management of the BRT system.

Bogotá created a new entity, TransMilenio SA, to oversee the development and operation of its BRT system. TransMilenio SA was formed as a "public company" which reports to the city's mayor through a board of directors. Other more traditional governmental departments also play a significant role in Bogotá's BRT system, but the new public company has taken a lead in terms of ensuring efficiency and an entrepreneurial approach. TransMilenio's board consists of ten directors who are derived from a cross-sectional representation of interested parties. The city's Mayor or a representative of the Mayor acts as the board's chairperson. Included in the board are non-governmental organisations and citizens groups who are able to better provide a customer perspective. The current TransMilenio board even includes an opera singer.

Bogotá's introduction of a new organisation, TransMilenio SA, provided a crucial catalyst to innovation. Trying to implement a radically different transit product through an existing entity can be difficult. Entrenched mindsets and vested interests can stifle the creativity required to develop a bold new approach such as BRT. Thus, by bringing together an entirely new team with a fresh perspective, Bogotá created something quite special.

2.5.3 Incentives for competition

2.5.3.1 Qualities of a successful incentive scheme

The right set of financial incentives can encourage contractors and concessioned firms to operate a BRT system at the highest levels of quality and performance. The wrong set of incentives will cause operators to compete against each other in a manner that risks financial sustainability and customer safety. The success of BRT systems such as Bogotá and Curitiba owe much to achieving an incentive structure that is a win for the operators, a win for the municipality, and most importantly, a win for the customer.

For a "closed" type BRT system, incentive mechanisms can be erected in at least two distinct areas. First, an incentive bidding scheme can be established to determine which operators should be allowed to gain access to the system. Second, once the operators are in place, "quality incentive contracting" can be utilised to ensure that the firms are properly motivated to achieve high levels of service.

A successful incentives process will likely evoke the following qualities:

- Transparency
- Clarity
- Simplicity
- Integrity
- Risk.

2.5.3.2 Non-competitive examples

Despite the overwhelming advantages of competitive structures, cities such as Quito, Leon, and Jakarta have elected to essentially "grandfather" the rights of existing operators into the new BRT system. The results are quite predictable. On Quito's Ecovía corridor, the existing operators formed a joint consortium (called TRANASOC) and were given exclusive rights to provide services for a ten-year period. The operators were also essentially given free financing on the new articulated vehicles since the municipality purchased the vehicles with public funds.

In Quito, the operators are to repay the municipality for the vehicles using revenues collected from the system. Unfortunately, fare collection is done directly by the operators so the municipality actually has little knowledge on actual passenger counts and revenues. Quite worryingly, the operators' repayment of the articulated vehicles is tied to profit guarantees related to the number of passengers. Clearly, the operators have a strong incentive to underestimate passenger and revenue numbers in order to minimise any repayment of the vehicles.

Leon's BRT structure is likewise skewed towards rewarding existing operators rather than overall efficiency. Like Quito, existing operators formed a monopoly consortium, in this case called the Coordinadora de Transporte. The municipality acquiesced to the consortium's demands for full monopolistic rights of operation. The consortium's operating rights to the system also does not have a termination date, implying a monopoly in perpetuity. However, on the positive side, the consortium did invest directly in new vehicles.

In Leon, the consortium operates both the trunk corridors and the feeder services. However, the distribution of revenues is handled differently for each route type. Fares are not independently collected but rather handled directly by the consortium. Even though the system has an integrated ticketing system and a single fare, fares collected by the feeder buses are kept by the feeder bus operators. The income of the feeder operators is thus based on the number of passengers. The fares collected on the trunk corridors are deposited into a fund established by the consortium. Funds are reportedly distributed to trunk operators on a basis of number of kilometres travelled. However, since the payment system is not transparent, the exact nature of the revenue distribution scheme is unclear to the municipality and the public.

Given the predictable results of manipulation and inefficiency, why do municipalities choose uncompetitive structures such as those in Quito, Leon, and Jakarta? Principally, the reason is a lack of political will. Municipal officials are not willing to entertain the possibility that some existing operators could lose their operational rights along a particular corridor. The resulting upheaval from disgruntled operators could have political consequences.

However, the choice between appeasing existing operators and creating a competitive environment is a false one. It is possible to design a system that gives an adequate opportunity to the existing operators without compromising the overall competitive structure.

2.5.3.3 Competitive bidding

The competitive bidding process ensures that firms offering the best quality and most cost-effective services are invited to participate in the new BRT system. A bidding process can also do much to shape the long-term sustainability of the system. Competition is not just reserved for trunk line operators as other aspects of a BRT system can also benefit, including feeder services, fare collection systems, control centre management, and infrastructure maintenance.

The bidding process developed by Bogotá's TransMilenio stands out as one of the best examples of providing a competitive structure directed at both quality and low cost. In reality, Bogotá used its incentive structure to achieve a variety of objectives:

- Cost-effectiveness
- Investment soundness
- Environmental quality
- Opportunities for existing operators
- Local manufacturing of vehicles
- International experience and partnerships.

Bogotá's competitive bidding process provided the incentives to completely modernise its transit system by encouraging modern vehicles, wider company ownership, and sector reforms. The principle mechanism in Bogotá was the use of a points system to quantify the strength of bidding firms. By carefully selecting the categories and weightings within the points system, TransMilenio shaped the nature of the ultimate product. Table 3 provides a summary of the bidding categories and weightings.

The points system was used in a way that rewarded inclusion of the existing operators, but the design also provided an impetus to consolidate small operators into more manageable groupings. TransMilenio established eligibility criteria that mandated a certain minimum

Table 3: Points system for bidding on TransMilenio trunk line operations

			Points	
Factor †	**Description**	**Eligibility**	**Minimum***	**Maximum****
Legal capacity	Bidding firm holds the appropriate credentials to submit a proposal	X	-	-
Economic capacity	Bidding firm holds the minimum amount of net owner's equity to submit a proposal	X	-	-
	Passenger public transport fleet in operation		30	150
Experience in operation	Specific experience providing passenger services in Colombia		50	250
	International experience on mass transit projects		0	50
Economic proposal	Offer price per kilometre to operate the service		0	350
	Right of exploitation of the concession			
Proposal to the city	Valuation of the share given to TransMilenio SA from the revenue of the concessionaire		21	50
	Valuation of the number of buses to be scrapped by the concessionaire		14	50
Composition of equity structure	Share of company's stock held by former small bus operators		32	200
Environmental performance	Level of air emissions and noise; disposal plan for liquid and solid wastes		0	200
Fleet offered	Size of fleet	X	-	-
	Manufacture origin of the fleet		0	50
	Total (1350 points possible)			

† If the proposal meets all the requirements, then the proposal will be categorised as ELIGIBLE.

* If the proposal is below any given minimal value, then the proposal will be categorised as NOT ELIGIBLE.

** If the proposal does not meet the established range, then the proposal will be categorised as NOT ELIGIBLE.

working capital and firms to be legally incorporated as formal businesses. These requirements prompted small operators to seek out partners and to professionalise their business. Bid categories such as the equity contribution of previous operators and the experience level on a particular corridor gave value to the inclusion of the existing operators. However, the participation of the existing operators was not assured, as was the case in Quito and Leon. This uncertainty provided the necessary risk to drive a more competitive offering.

2.5.3.4 Quality incentive contracts (QICs)

The competitive bidding process ensures that the most able and most cost-effective companies will participate in the BRT system. However, it is important to develop the right incentives to ensure continued high-quality service in the system's operation. A "quality incentive contract" is an effective mechanism to encourage operators to deliver excellence in service. In essence, a quality incentive contract stipulates how an operator's performance is tied to its financial compensation. If an operator fails to perform properly in certain aspects of its service, then the firm will incur penalties or deductions in its payments. Likewise, a firm that exceeds service expectations can actually be rewarded with additional payments.

Once again, Bogotá provides an excellent example of how quality incentive contracting can be used to motivate operator performance. However, many cities other cities, such as London and Hong Kong, also make use of quality incentive contracts in their bus operations. In the case of Bogotá's TransMilenio system, poor performing operators can experience revenue reductions of up to 10 per cent of the operator's monthly income. Further, in extreme cases, an operator can even lose the concession for consistently unacceptable services.

2.5.4 Operational cost analysis

Once a framework for the business structure has been determined, the information from section 2.4 (operations) can be integrated to derive an initial operational cost analysis. The calculation of system operating costs will be significant 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. System designers must also be explicitly aware of the magnitude of operational cost components in order to properly set fare levels.

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 such 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. The values shown in table 4 will vary greatly, depending on local circumstances. For example, labour costs in developing cities may be in the range of 10 percent to 25 percent of total costs. By comparison, labour costs in developed cities can range from 35 percent to 75 percent of total costs.

The values presented in table 4 are used to calculate an overall operating cost per kilometre for the system operators. This value is the basis for the renumeration given to the concessioned firms providing the transit services.

Table 4: Operational cost components of BRT

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 74.0
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%

Source: TransMilenio SA, Bogotá, Colombia, June 2002.

2.5.5 Tariff options

Tariff levels will greatly determine the ultimate size of the customer base and the segments of society that can afford to use the system. The tariff levels will also determine the financial stability and sustainability of the overall system. Fortunately, the relative cost effectiveness of BRT compared to other mass transit options means that operating subsidies are typically not necessary, even with readily affordable fares. The avoidance of public subsidies can greatly simplify system management as well as reduce the continual need to justify a system's financing with public officials and the electorate.

2.5.5.1 Tariff levels

The actual tariff charged to the customer will depend upon many factors and decisions. Most importantly, the cost levels of operating the system are a principal consideration. To avoid the need for an operational subsidy, covering these basic costs is essential. Thus, a starting point for considering tariff levels is an analysis of operational costs. To the extent possible, most developing cities structure BRT systems to avoid operating subsidies. By avoiding subsidies, the city is also avoiding the complexity and added costs of managing a subsidy scheme. Further, the appearance of subsidies generally creates a negative public perception on a system that is unable to pay its own way. Few developing cities are equipped to commit to long-term transport subsidies, especially in the face of other basic needs such as education, electricity, health care, water, and sanitation. Thus, a viability test for a new public transport system is whether expected operating costs can be covered by the proposed fare level.

Of course, affordability is also a primary consideration. If the proposed fare levels consume a large percentage of the daily income of low-income citizens, then the system will fail to deliver its social development objectives. The elasticity of demand for low-income groups can be quite high. Low-income residents may not place a high premium on reduced travel times, and thus may continue to utilise lower-cost options even with the improvements presented by a BRT system. Nevertheless, some price premium can be acceptable, especially if the proposed BRT system is providing a significant improvement over existing informal services.

In the case of Bogotá, the city permitted the existing operators to increase fares one year prior to the introduction of the TransMilenio service. While the population was not entirely pleased with the increases, in general, any displeasure was directed at the private operators and not the municipality. Thus, when TransMilenio was finally introduced into operation, the cost was approximately the same as the existing services. In other cases, such as Quito, the BRT service was introduced at a slight premium to the existing services. However, the vast difference in quality between the new system and the previous older buses meant that the public was supportive of the new system.

Thus, as noted, an initial estimation of potential tariff levels can be achieved through an initial calculation of operating costs, an analysis of tariff levels with existing services, and an understanding of affordability levels for different segments of society.

2.5.5.2 Tariff types

There are two types of tariffs used in the fare calculation process. The first is the "customer tariff", which is the fare price seen by the customer. The second tariff is the "technical tariff", which reflects the actual cost per passenger of operating the system. In the case of Bogotá's TransMilenio, the customer tariff is slightly higher than the technical tariff. This difference occurs because TransMilenio also generates what is known as a "Contingency Fund":

Contingency fund	=	Revenues based on customer tariff	–	Revenues based on technical tariff

The contingency fund is designed to handle unexpected events such as unusual low levels of service demand, extended hours of operation, terrorism and vandalism, and problems associated with hyperinflation. In general, the customer tariff will be greater than the technical tariff, and thus the contingency fund will build up a positive balance. When unforeseen circumstances occur and the technical tariff exceeds the customer tariff, then proceeds from the contingency fund will be drawn upon for a temporary period. If the changed circumstances become permanent, then an increase to the customer tariff can be expected in order to ensure the financial stability of the system.

2.5.5.3 Fare adjustments

During the course of a ten-year concession, there are undoubtedly cost elements that will change with time. Fuel prices will vary based on world demand. Base labour costs will vary in step with the local economy. Accurately predicting these cost levels over a long period is a nearly impossible task due to the great number of external influences. Thus, a system is needed to adjust fares as base costs elements change.

In the case of Bogotá, all operating costs are calculated on a bi-weekly basis. If a particular trigger point is reached (such as the technical tariff exceeding the customer tariff), then a fare adjustment is authorised by the municipality. The mayor and other political officials are still involved in the authorisation through the public company's board of directors, but the stipulation of a fare adjustment is reached through the operating cost calculation.

2.5.6 Distribution of revenues

The distribution of revenues is another process which will greatly influence the behaviour of the system operators. Distributing revenues on a basis of the number of passengers or on a basis of kilometres travelled will affect behaviour in different ways.

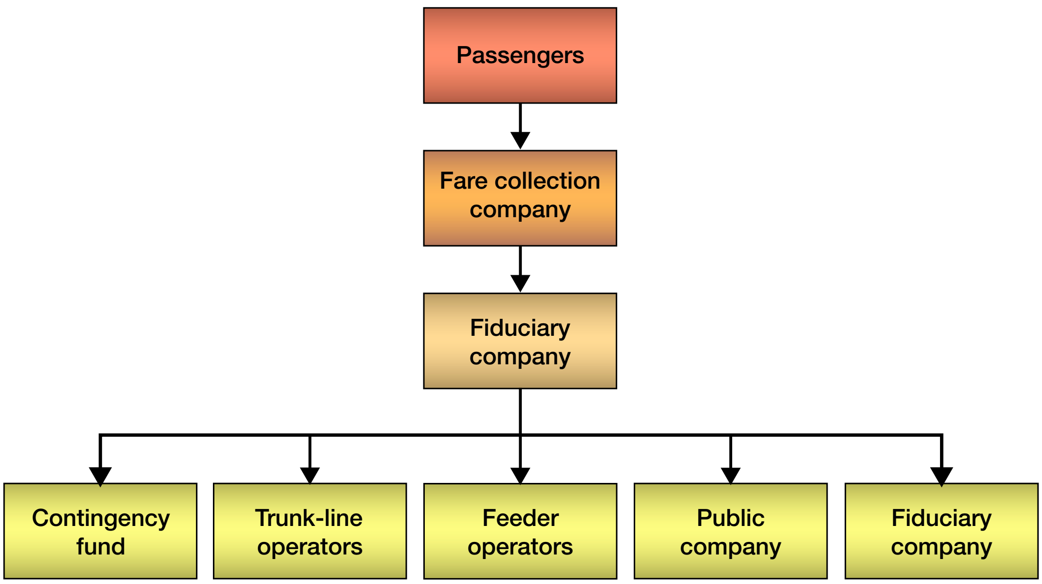
2.5.6.1 Fundamentals of revenue distribution

Traditionally, the handling of fare revenues in a developing-city transit system is a rather opaque process. Portions of the fares may be kept by conductors or drivers with understood amounts being handed over to owners. There also may be payments to police or other official entities. As such, this process does not lend itself to a transparent business model in which the public interest is carefully weighed. This process also inherently rewards drivers to maximise the number of passengers they collect during the day. With the incentive of maximising passengers, drivers then work in a manner that can conflict with public safety and rider comfort.

The transparent and fair distribution of revenues is fundamental to operating a network of integrated transit providers. If operators do not have confidence in the distribution of revenues, then their behaviour will revert to self-interested actions that undermine customer satisfaction. The most important elements in a transparent system for revenue distribution are:

1. A business and institutional structure that provides for an independent fare collection system;
2. Checks and balances in place to verify revenues at different stages of process;

Fig. 37: Flow of fare revenues through distribution process



3. Revenues distributed based upon a clear set of rules and procedures;
4. An independent auditing system.

2.5.6.2 Revenue distribution

In Bogotá, the concessioned fare collection company does not actually distribute the revenues to the bus operating companies. Since the fare collection company itself is due part of the proceeds, it would be a source of potential suspicion if the fare collection company was to fulfil this function. Instead, an independent fiduciary company (such as a bank) is the depository of the actual fares. At this stage, the public oversight company will then use the agreed upon formulas from the concession agreements to distribute revenues amongst the operating companies. Thus, the actual handling of the revenues follows the path outlined in Figure 37.

For TransMilenio, most of the revenues are distributed to the concessioned private operators who are providing either trunk line (66.5% of revenues) or feeder services (20% of revenues). These percentages were pre-determined based on negotiations and the terms of the bid process. The company with the concession for the fare collection receives 10% of the technical tariff revenues. TransMilenio SA, the public company with overall management responsibility for the system, receives 3%. Finally, the fiduciary company, called the Trust Fund Administrator, retains 0.5% of the technical tariff revenues. The fiduciary company is responsible for managing the incoming assets as well as distributing the funds to the other entities.

2.6 Planning Stage VI: Infrastructure

The physical design of the BRT system begins to give the project a physical substance that better allows all stakeholders to properly envision the final product. This process also allows the planning team to better estimate the actual capital costs expected for the project.

The design and engineering of infrastructure components is dependent upon several key factors that will dictate the eventual form of the infrastructure. Theses factors include: cost, functional attributes, and aesthetic attributes. Like so many topics in BRT, there is no one correct solution to infrastructure design. Much depends upon local circumstances such as climatic and topological conditions, cost structures, and cultural preferences. For instance, what is aesthetically pleasing in one culture will not be considered as such in another.

The physical design and engineering of the system directly follows from the operational characteristics chosen. The corridor selected, expected capacities, and service options all influence the physical design. However, the physical design may also exert influence on the operational characteristics as well. Given the varying cost ramifications of different physical designs, several iterations between operational design and physical infrastructure design may be required. Thus, physical or financial limitations that are placed upon infrastructure design can necessitate a revision of the previous work on operational characteristics.

The topics presented in Planning Stage VI, "Infrastructure", are as follows:

2.6.1 Conceptual study versus detailed engineering study

The level of detail in the infrastructure plan will evolve as the BRT project progresses. In the first stage, conceptual designs will be developed in tandem with the emerging operational plan. More detailed engineering analyses will follow once the conceptual study and the initial cost estimates warrant a commitment towards a particular design. Thus, for each infrastructure component discussed in this section (e.g., busways, stations, terminals, etc.), the planning team will first complete a conceptual study prior to moving towards more detailed engineering plans and specifications.

2.6.1.1 Conceptual study

The infrastructure conceptual study should provide a reasonable level of detail so that decision-makers may properly evaluate the cost, functionality, and aesthetics of the proposed system. Thus, the conceptual study will include overall dimensions of the infrastructure components, basic drawings, and sufficient description to develop an initial cost estimate.

Many of the initial artistic impressions and drawings of the system infrastructure will be used to help decision-makers and interested parties to begin to visualise the system. Figure 38 is an example of this type of drawing.

2.6.1.2 Detailed engineering study and design specifications

Once a conceptual design is completed and initial cost estimations are within an acceptable range, then more detailed engineering work can be undertaken. The detailed engineering design and specifications will be the basis for the actual construction work. The detailed design will also permit construction firms to make more

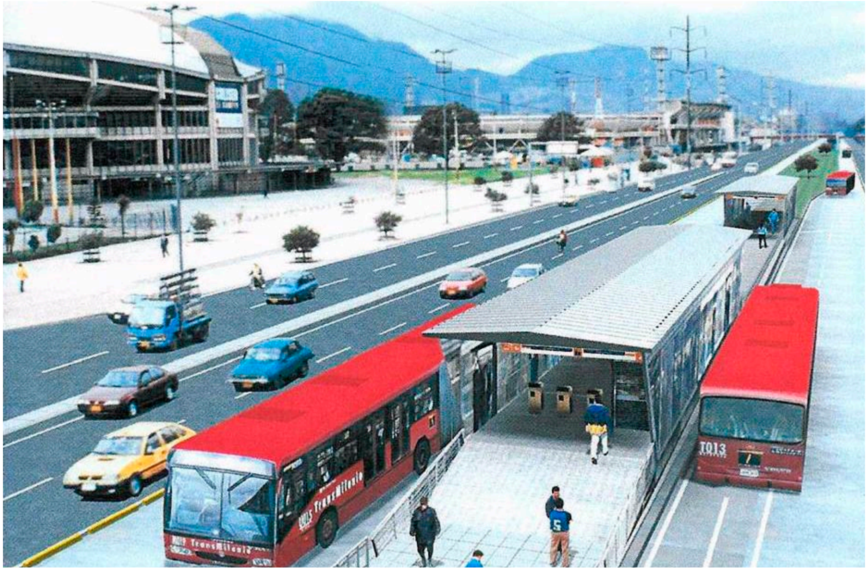


Fig. 38
Example of the types of drawings that are developed in the conceptual phase of the BRT plan.

accurate cost estimates within the construction bid process.

Given the topographical changes throughout any corridor, each section of roadway will have its own unique design. Detailed drawings generated from software such as AutoCAD will be required along each segment.

2.6.2 Busways

2.6.2.1 Lane selection

The location of the segregated busway within a specific roadway is a 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 39). This configuration reduces turning conflicts to the right (in countries that drive on the right-hand side of the street). The median location also permits a central station to serve both busway directions. A single station reduces infrastructure costs in comparison to the construction of separate stations for each direction. The median-based station also allows for more integration options with busway lines that may cross on a perpendicular street. It is far simpler to link two median stations by way of tunnels or bridges than trying to link four stations along the sides of the roadway. Two corridors may also be linked by having bus routes turn onto the perpendicular busway. Again, a median station is advantageous as customers have the option of changing routes and selecting from multiple directions within a single station.

Beyond the centre lane configuration, there exists 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 40). 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 some cases it may be possible to give over the entire roadway to the BRT system. In Pittsburgh, USA, the East and West busways operate on exclusive road networks that have virtually no interactions with mixed traffic. The East busway is in fact a former rail corridor. Likewise, segments of the Brisbane busway system operate on streets with exclusive use for BRT vehicles (Figure 41).

Fig. 39
Busway located in the centre median.
Photo courtesy of TransMilenio SA

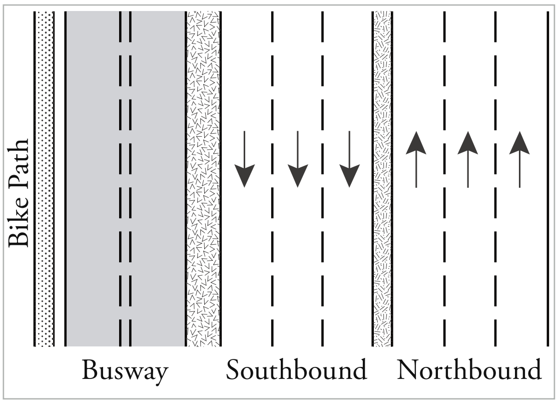


Fig. 40
In Miami (USA), BRT lanes for both busway directions are placed on one side of the roadway.
Image courtesy of the US Federal Transit Administration

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 generally do not utilise the design, primarily because of the conflicts with turning traffic. Such conflicts will greatly inhibit the system's capacity. Achieving capacities over 5,000 passengers per hour per direction is quite difficult if vehicles are frequently interfering with busway operations. Turning vehicles create the potential for the entire busway to be stopped due to an accident or congestion. Such a configuration also creates difficulty when trying to allow free-flow transfers between perpendicular lines. To do so, one would have to construct a rather elaborate set of overhead or underground pedestrian passages to keep the system closed off. In general, customers will not pay twice merely to change directions.

2.6.2.2 Busway dimensions

The availability of road space will likely be a significant design consideration in the development of the busway. Providing space for busways, pedestrian and bicycle access areas, and mixed traffic lanes can be a challenge when given the inherent limitations of existing road widths. However, typically solutions can be found to even the most space-limited streets.

Buses are generally in the area of 2.6 metres in width. To provide safe manoeuvring space for the vehicles, a standard lane of 3.5 metres is typically provided. As lanes narrow, the safe operating speed of the vehicle will likely be reduced. The width of a median station will vary depending on customer flows, but, in general, a median station will range from 2 metres to 5 metres in width. A typical roadway cross-section is presented in Figure 42.

Fig. 41
In Brisbane (Australia), BRT vehicles have exclusive use of the entire roadway.
Photo courtesy of Queensland Transport

If sufficient road space is not available to meet a preferred design option, there are still options for municipal officials to consider. Eliminating some mixed traffic lanes may seem politically difficult to achieve, but by doing so, the resulting design provides a strong incentive for shifts to the new system. Further, the promise of a new, high-quality mass transit system can help stem concerns over reduced space for private vehicles. Quito has managed to develop a busway along an extremely narrow corridor in its historical centre. In this instance, the city was able to provide an exclusive busway with as little as 3.2 metres in road width (Figure 43). Other options include the grade separation of the bus infrastructure through the use of underpasses, tunnels, and overpasses.

2.6.2.3 Passing lanes

With a single busway lane in each direction, a BRT system will reach a capacity limit at approximately 14,000 passengers per hour per direction (pphpd). This capacity level can be

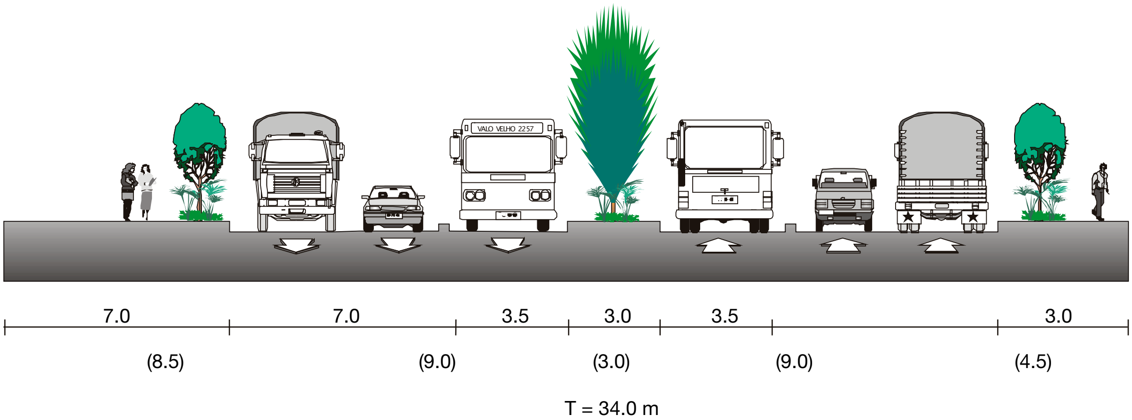


Fig. 42
A typical roadway configuration for a median busway.
Image courtesy of the Municipality of Pereira (Colombia).

Fig. 43
Quito's BRT system operates well on the narrow streets of its historical centre.
Photo by Lloyd Wright

increased with the platooning of vehicles and multiple stopping bays, but such a configuration is relatively complex to manage and control. Instead, for capacities above 14,000 pphpd the best option may be to consider a passing lane at stations or even a second lane throughout the full corridor (Figure 44). By permitting a passing lane at stations, buses can comfortably overtake other buses. Thus, multiple stopping bays and express services can be accommodated with a passing lane. A passing lane also gives a system considerable flexibility in terms of future ridership growth.

2.6.2.4 Construction techniques and materials

The construction of the busway will typically represent approximately 50 percent of the total infrastructure costs. Thus, savings through efficient design and material choice can produce significant dividends. Cost savings, though, must be viewed both from the perspective of initial construction costs and long-term maintenance costs. Lower-quality road materials may reduce capital costs but will dramatically increase maintenance costs if roadways need re-paving or reconstruction after just a few years.

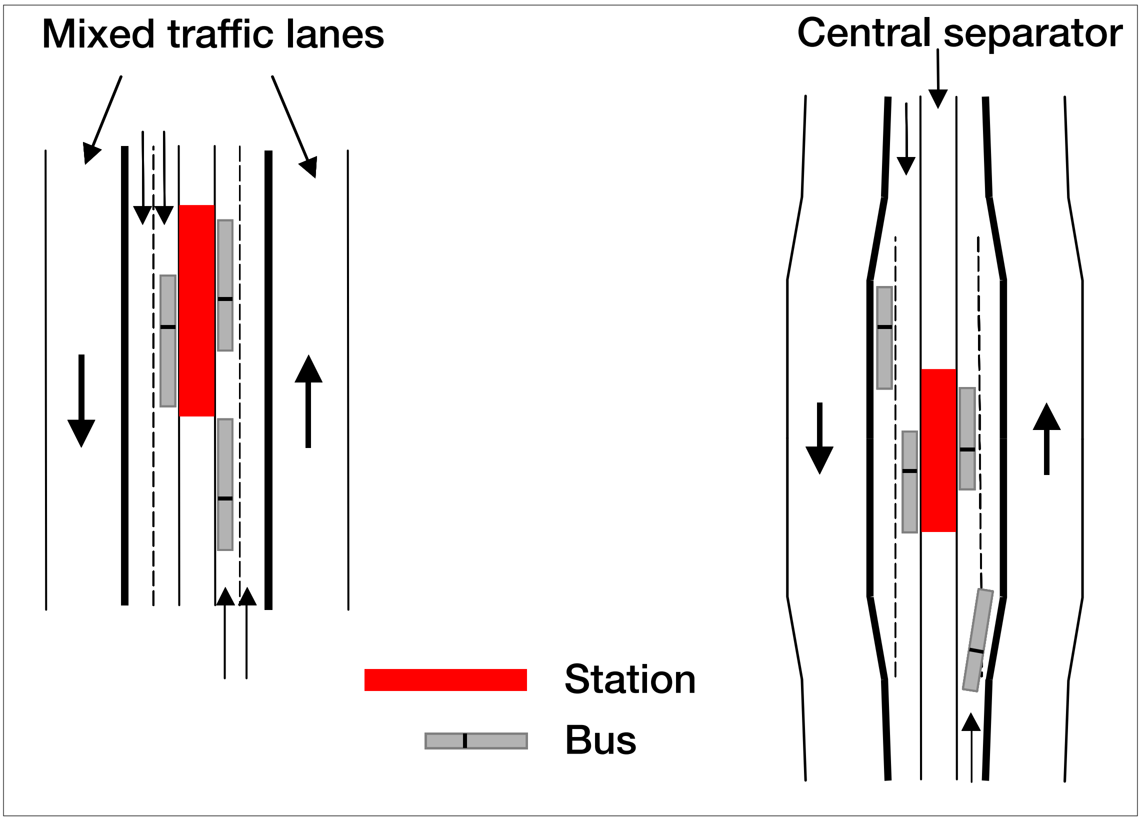


Fig. 44
The provision of passing lanes at stations can be achieved with either: 1.) A four-lane BRT system; 2.) Additional lanes provided only at stations.
Image courtesy of TransMilenio SA

In terms of longevity, concrete is typically a better choice than asphalt. Concrete is more resistant to the forces of heavy buses passing on a frequent basis. While concrete is more costly than asphalt, in general, the longer life of the surface will justify the higher initial cost. One cost-cutting option is to consider concrete only at stations. In such instances, the runways between the stations are constructed with lower-cost asphalt. The station areas are the most important in terms of retaining a stable roadway level. If station areas subside from the weight and force of the vehicles, then maintaining a level boarding height between the vehicles and the station platforms will be quite difficult. Station areas also see the most demanding surface impacts due to the forces generated by decelerating and accelerating vehicles.

2.6.2.5 Intersection design

Intersections represent several design challenges for a busway system. If not designed to give priority to the BRT system, intersections will have negative effects on travel times, system capacity, and safety. Intersections with roundabouts can create considerable uncertainty for the busway system. However, there are some solutions to the difficulties posed by intersections and roundabouts. Quito has achieved great success with its "Villa Flor" station that goes beneath the heavily-trafficked roundabout on Maldonado Avenue (Figure 45).

2.6.2.6 Grade separation

The exclusive busways, rapid boarding and alighting techniques, and the well-spaced stations all give BRT customers reduced travel times to their destinations. However, intersections and other points of interference with vehicles will negatively affect speeds and travel time. Separating the busway from these points of conflict will substantially improve travel times as well as safety.

Busways can be either "at-grade" or "grade-separated". An "at-grade" busway runs along at street level and thus must eventually cross signal-controlled intersections, which may greatly reduce the overall potential throughput 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 Quito, both the "Trolé" corridor and the new "Central North" corridor make extensive use of

Fig. 45
Quito's Villa Flor station.
Photo by Lloyd Wright

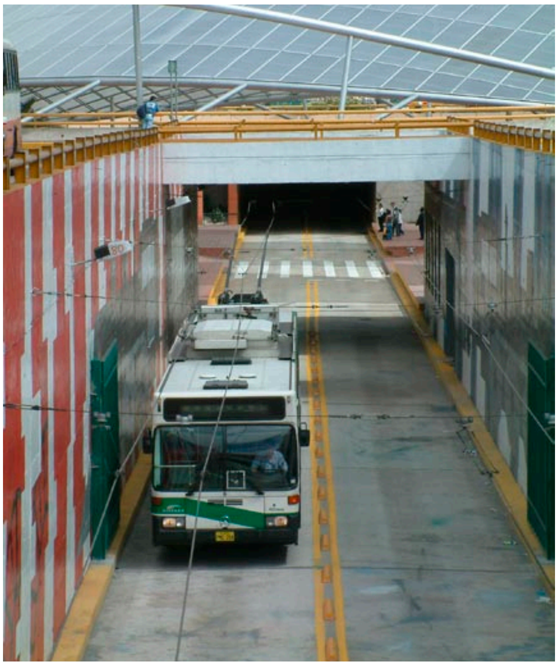


Fig. 46 and 47
Quito avoids conflicts at intersections by providing exclusive busway underpasses. The relatively modest cost of each underpass (US$ 1 million) is justified by the time savings achieved.
Photos by Lloyd Wright

underpasses. The "Villa Flor" interchange along Quito's "Trolé" corridor is a set of underpasses that help avoid several intersecting roadways and a major roundabout (Figure 46). The interchange has reduced north-south travel times from 55 minutes to 45 minutes. Quito has determined that the large travel time savings will deliver sufficient cost savings to justify the additional construction costs of the underpasses. Figure 47 notes that a typical underpass in Quito costs in the area of US$ 1 million. By factoring in the value of time for transit users and the associated impacts of traffic congestion that at-grade intersections produce, the underpasses deliver relatively short pay-back periods for Quito.

2.6.2.7 Coloured lanes

The aesthetic appearance of the lanes will have an impact on the public's image of the system. The colouration of the busway is one option for creating a special and attractive BRT environment (Figures 48 and 49). A smartly coloured busway not only raises the image of the system but also creates a greater sense of permanence to the existence of the system. Coloured lanes also 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.

2.6.3 Stations

2.6.3.1 Station location

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

Fig. 48 and 49
Coloured busway lanes help to raise the public profile of the BRT system.
Photos courtesy of the US Transit Cooperative Research Program.

approximately 500 metres but can often range from 300 metres to 1000 metres, depending upon local circumstances.

2.6.3.2 Station size

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 2.5 metres to 5 metres. Passenger space in narrower stations can be partially gained by increasing the overall length.

2.6.3.3 Boarding and alighting

Station design depends greatly upon an interaction with bus technology decisions, especially with regard to the point of interface between the vehicles and the stations. 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 design of the boarding and alighting interface will affect 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. TransMilenio relies upon close alignment between the bus and the station docking area to allow quick access. Minimising the bus to station distance is a key factor in realising high customer flows as well as making boarding practicable and safe for individuals with physical disabilities (Figure 50).

Cities such as Curitiba and Quito utilise flip-down ramps (also known as boarding bridges) attached to the bus to speed up customer flows (Figures 51 and 52). When a gap exists between the vehicle and the station, passengers will tend to look down to make sure they safely cross. This small action of looking down actually delays each person's alighting time. Further, passengers have a greater tendency to depart the vehicle one-by-one when a gap exists between the vehicle and the platform. The flip-down ramps utilised in Curitiba and Quito avoid these cumulative customer hesitancies that will slow boarding and alighting. With the ramps customers will tend to move with greater confidence and speed.

Fig. 50
Level boarding makes the system accessible to the physically disabled.
Photo courtesy of TransMilenio SA

Fig. 51 and 52
The entry ramps used in Curitiba (left photo) and Quito (photo below) help to speed passenger boarding and alighting as well as improve passenger safety.
Left photo courtesy of Volvo
Photo below by Lloyd Wright

Fig. 53
Sliding doors at the station to bus interface help to protect passengers as well as deter fare evasion.
Photo by Lloyd Wright

Bogotá has made use of sliding doors at the station to vehicle interface (Figure 53). 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.

2.6.3.4 Interchange stations

As a system expands across a wider network, intersecting stations will require mechanisms to transfer from one corridor to another. An "interchange station" is a facility that permits such transfers, and thus has additional design considerations than a standard station.

There are several options for facilitating transfers between corridors. These options include:

- Multiple routings (Figure 54)
- Interchange facility

Fig. 54
The multiple platforms and stopping bays within TransMilenio stations permit easy passenger transfers between different routes.
Photo by Lloyd Wright

Fig. 55
To connect two corridors that cross one another, Bogotá utilises an underground tunnel to permit fare-free transfers between corridors.
Photo by Lloyd Wright

- Underground tunnels / overhead pedestrian bridges (Figure 55).

A system may use a combination of these interchange options, depending on the local circumstances at the interchange point.

The multiple routing technique permits corridor changes without passengers needing to transfer vehicles. Instead, different route structures call for vehicles to turn from one corridor to another.

Fig. 56
A simple and open design was selected for a station within Quito's historical centre in order to minimise intrusions on the surrounding architecture.
Photo by Lloyd Wright

2.6.3.5 Aesthetic design

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. The station designers in Brisbane have even been the recipients of architectural awards (Figure 56). The modern tube structures in Curitiba have become an international symbol of BRT as well as provide customers with an image representing speed and modernity. In Bogotá, the city also opted for a modern design but with a squared, box structure.

However, the modern look may not always be appropriate. If the system runs through or along corridors of great historical value, designers may wish to seek congruence with the adjoining architecture. Guayaquil (Ecuador) has elected to match the station design to the city's French-inspired style from the 1920s. The chosen style in Guayaquil reflects a connection between the transit stations and their surroundings. Congruence with the surroundings was the reason that Quito (Ecuador) re-designed some of its "Trolé" line stations in the city's historical centre (Figure 57). It was felt that the enclosed stations were visually too forceful within the historical centre, which is listed as a UNESCO World Heritage Site. Thus, the city opted for a more open design for the station at the Santo Domingo plaza.

Fig. 57
The modern and simple design of the Brisbane BRT stations has garnered the city architectural awards.
Photo courtesy of Queensland Transport

Station aesthetics can be negatively affected by over-use of advertisement displays. While advertising may be a needed source of revenue, 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. Thus, any decision to permit moderate amounts of advertising must be taken in conjunction with aesthetic and functional considerations.

2.6.4 Intermediate transfer stations

Feeder connections to the trunk lines do not necessarily occur only at major terminal facilities. Feeders can also intersect the trunk corridors at what are known as intermediate transfer stations. These stations are somewhat a hybrid facility between ordinary local stations and terminal facilities. Figure 58 provides an overview of the relationship between standard stations, intermediate stations, and terminal facilities.

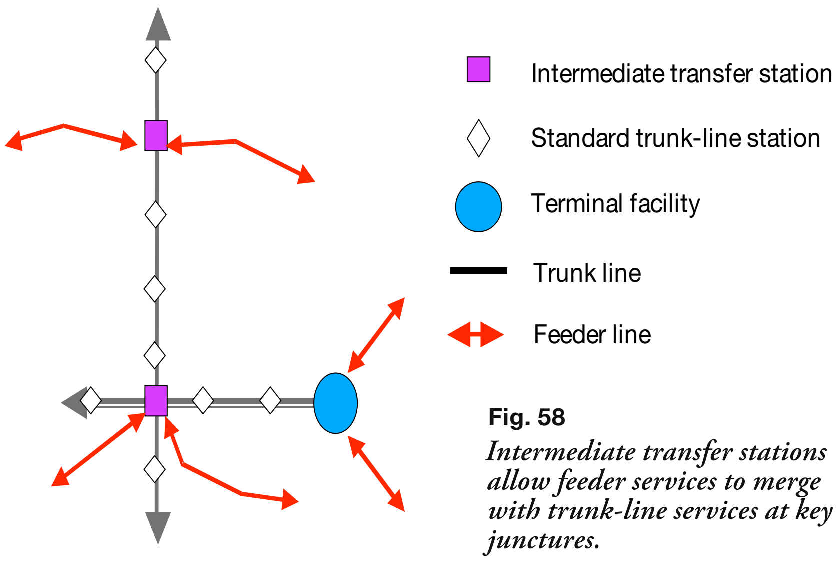


Fig. 58
Intermediate transfer stations allow feeder services to merge with trunk-line services at key junctures.
Image courtesy of TransMilenio SA

Unlike terminal sites, intermediate transfer stations may not have the luxury of space to easily accommodate both feeder platforms and trunk-line platforms. Thus, a bit of creativity is required to design and control the transfer process. Ideally, the feeder vehicles can enter a "closed" space in which a fare-free transfer can take place without concerns over fare evasion. However, this ideal is typically not the case. Instead, feeder vehicles arrive from a smaller side street, and passengers must walk from the

Fig. 59
In Bogotá, passengers departing from the feeder stations (served by green buses) walk directly via a pedestrian bridge to trunk-line stations (served by red buses).
Photo courtesy of TransMilenio SA

feeder station to the trunk-line station. A crosswalk or pedestrian bridge will often link the two stations (Figure 59).

2.6.5 Terminals

Terminals involve many of the same design issues as stations. However, given the larger number of passengers and transfer options, terminals obviously require more space. The architectural design of terminals can either mimic the style of the system's stations or take on a different look. Terminal platforms are typically not enclosed with walls since entrance to the terminal site is controlled from a distance. Terminal facilities in cities such as Bogotá and Quito have high ceiling designs with modern roof structures (Figure 60).

The number of terminals depends in part on the length of the system, the number of corridors, and the number of feeder routes converging upon a site. Typically, there are terminals at each end of a trunk-line corridor. However, if the end of the corridor does not host large

Fig. 60
The modern terminal structures in Quito provide an elegant environment for passenger transfers.
Photo by Lloyd Wright

numbers of feeder services, then a terminal may not be entirely necessary. It is also possible to site a full terminal in the middle of a corridor.

Whether or not the system is designed for fare-free transfers will have a significant impact on terminal design. Fare-free 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.

The design of the terminal space should strive to minimise both customer and vehicle movements to the extent possible. Thus, the most likely transfer points between complementary routes should be located closely together. As both feeder vehicles and trunk-line vehicles will be staging at the terminal, the movement of vehicles should be devised to avoid congestion. Most typically, feeder vehicles arrive on one side of a platform area with trunk-line vehicles awaiting on the opposite side (Figure 61).

Fig. 61
In Quito, passengers merely cross a platform to transfer from a trunk-line vehicle into a feeder vehicle.
Photo by Lloyd Wright

2.6.6 Depots

Bus depot areas serve an array of purposes including bus parking areas, re-fuelling facilities, maintenance areas, and office space for bus operators (Figure 62). 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. Further, since buses enter and leave the depot without passengers, the "dead" kilometres incurred between the depot and the passenger corridor can have a discernible effect on operating costs. However, since bus depots can consume considerable space, the location is often dependent upon the economical acquisition of sufficient property. Ideally, depots will be located near terminal facilities. The internal design of the depot area should allow for a logical movement of vehicles based on their typical requirements, such as re-fuelling, maintenance, and parking.

2.6.7 Control centre

A centralised control centre will help ensure smooth and efficient BRT operations. Controlling a high-volume BRT system spread across a major developing city is a complex and highly-involved activity. A centralised control and management system brings with it the following benefits:

- Immediate response to changes in customer demand
- Immediate response to equipment failures and security problems
- Efficient spacing between vehicles and avoidance of vehicle "bunching"
- Automated system performance evaluation
- Automated linkages between operations and revenue distribution.

While the benefits seem clear, the costs of a real-time control system would seem prohibitive for a developing city. However, the cost of central control technologies has steadily decreased during the past few years. Thus, even cities in developing nations may now wish to consider the advantages of a central control system.

Fig. 62
Bus depot and maintenance area in Bogotá.
Photo courtesy of TransMilenio SA.

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 63). GPS technology permits real-time information on bus location and status. By using the GPS technology in conjunction with vehicle tracking software and a voice communications

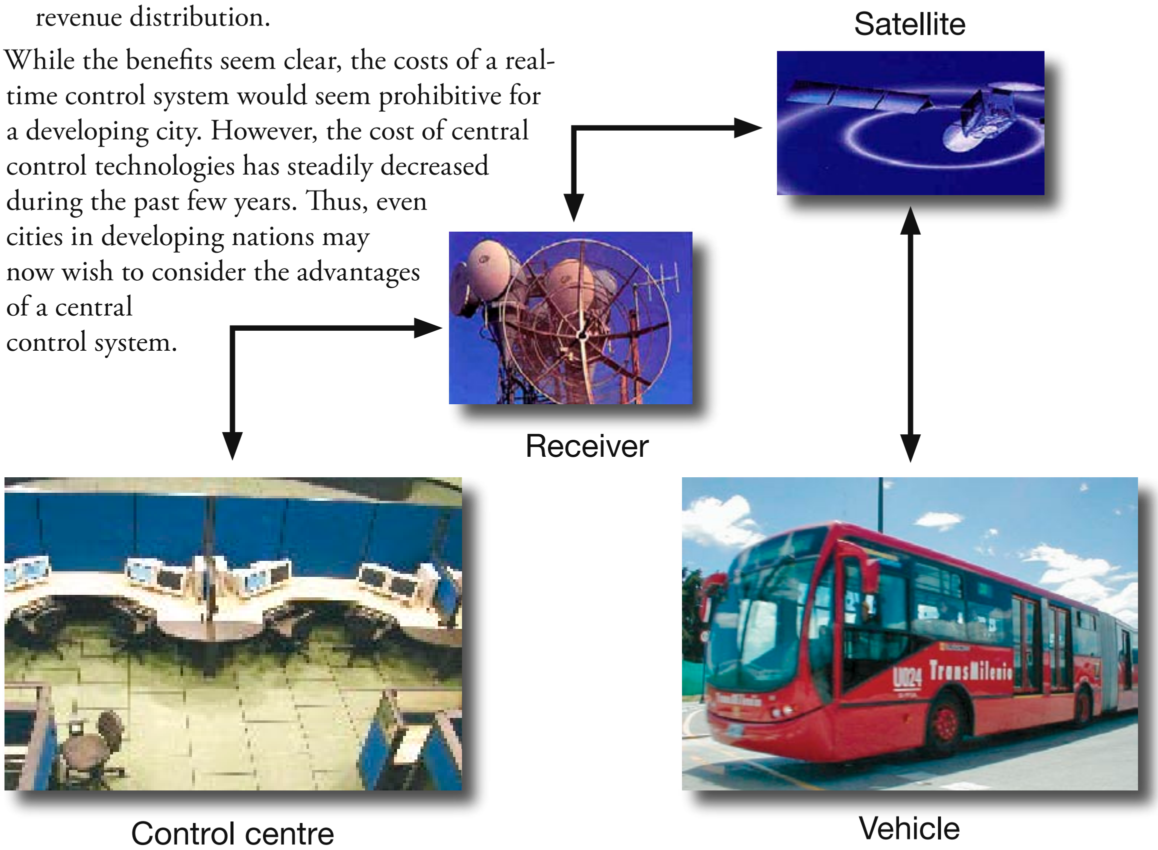


Fig. 63
GPS bus tracking system in Bogotá.
Photos courtesy of TransMilenio SA

system, Bogotá is able to closely control vehicle headways. A control centre operator will direct a driver to slow down or speed up depending on the location of other vehicles and the demand requested. Further, if a surge in demand occurs at a particular station, a new vehicle can be sent in to alleviate crowding.

2.6.8 Feeder infrastructure

Feeder services will likely provide a substantial percentage of a system's ridership since the feeder corridors are the key link into residential areas. Quality infrastructure should not just be given only to trunk lines. Feeder lines should also receive a high level of quality service; otherwise, a large part of the customer base will never give the system a chance.

Feeder services typically are not provided with dedicated busways but instead utilise mixed-traffic lanes. Since many feeder routes extend into fairly narrow residential streets, exclusive vehicle lanes is not always a practical option. However, bus lanes may also be feasible in sections of the roadway that have sufficient width. Even a relatively short bus lane can be beneficial if it permits the feeder vehicle to avoid an area prone to congestion.

2.6.9 Integration infrastructure

Ensuring that the transit system is well integrated with other modal options is critical to developing a truly usable system. The difference between a pleasant and safe walking environment and a poorly maintained pedestrian path can be the difference between customers choosing public transport over other options. Thus, the quality of the integration infrastructure is one of the determining factors in ridership and customer satisfaction.

The integration infrastructure will likely be composed of a range of components, including infrastructure components for the following types of modal options:

- Pedestrian infrastructure
- Bicycle infrastructure
- Integrated taxi stations
- Integration infrastructure for other public transport systems (e.g., water transport, rail transport, etc.)
- Park and ride facilities.

Section 2.8 discusses issues concerning each of these types of integration infrastructure.

2.6.10 Commercial space

In many developing cities, a close relationship exists between the location of transit infrastructure and the location of commercial traders. The high volume of transit customers through stations and terminals provides vendors with a concentration of potential clientele. Additionally, the proximity of vendor products to a person's daily travel route can be a task-saving convenience for some. The provision of infrastructure for commercial activities within or near transit stations can be a source of controversy. Some transit agencies may not view commercial activities as being consistent with the objective of encouraging rapid customer movements.

Transit stations may also attract the attention of large commercial retailers seeking to reap the benefits of passenger flows. Likewise, the ability to conduct grocery shopping and other tasks near the transit corridor is a benefit to customers. The presence of these commercial entities also offers some opportunities for financing the station and terminal construction costs.

2.6.11 Traffic signal control

The development of a BRT system can also present a unique opportunity to upgrade the traffic signal technology along the same corridor. A new BRT system will imply several changes that will affect traffic signal technology. These changes include:

- New priority treatment for transit vehicles;
- New exclusive lanes;
- New turning movements for transit vehicles;
- New restrictions on private vehicle turns.

With new electronic signalling technologies and software programmes now available, an upgrade of the traffic signal system should be integrated into the BRT planning process.

The appropriate synchronisation of traffic lights often does not currently exist in developing cities. A readjustment of phase lengths and synchronisation should be undertaken with a special focus on smooth transit vehicle flow. Priority signal technology is an option, but is not always feasible in high-frequency systems.

In cities such as Los Angeles, signal priority is given to transit vehicles by way of a message relayed from a vehicle transducer to the signal control box. As a transit vehicle approaches, the traffic light will extend the green phase to allow the bus to pass. However, even with relatively long peak headways of five minutes or more in Los Angeles, the signal prioritisation will only function every other phase cycle. If the phase priority is given more frequently, it will essentially give a permanent green to the direction of the transit corridor.

2.6.12 Public utilities

City streets are complicated environments. The same space that provides widespread mobility may also serve as corridors of telecommunications, electricity, water, flood control, and sewage. When implementing a busway through such a complicated area, it is not surprising that there will be competing uses of the public space. The location of public utility poles, pipes, and tubes will undoubtedly require some alteration in the BRT design work.

2.6.13 Landscape

BRT systems should add to the aesthetic quality of a city's public space rather than detract from it. 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 in tact. 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. In tropical climates, trees and vegetation can even help partially cover the station structure itself in order to reduce inside temperatures.

2.6.14 Infrastructure cost analysis

Infrastructure costs for BRT systems can vary considerably depending on the complexity and sophistication of the system as well as the local economic and topographical characteristics. Successful systems have been developed for as little as US$ 500,000 per kilometre (Taipei). However, in general, developing-city BRT systems will cost in the range of US$ 1 million to US$ 10 million per kilometre. Some of the principal factors in determining the actual infrastructure costs will include:

- Number of exclusive lanes
- Materials utilised in the construction of the lanes (asphalt or concrete)
- Expected system capacity, and thus the capacity and size of stations, terminals, and depots
- Local construction costs
- Amount of property expropriation required.

Table 5 lists the actual infrastructure costs for Phase I of TransMilenio.

Table 5: BRT construction cost breakdown, Bogotá's TransMilenio

Component	Total Cost (US$)	Cost per Kilometre (US$)
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

2.7 Planning Stage VII: Technology

BRT is not a standard bus service. BRT is a collection of best-practice measures and advanced technologies that deliver a high-quality mass transit experience. BRT's passenger vehicles, fare collection systems, and customer information systems are as sophisticated as most other types of mass transit systems, including rail systems.

However, at the same time, technology should not overshadow the main basis of BRT, which is excellence in customer service. Further, while BRT's technologies are quite advanced, the relative cost of these technologies to other mass transit technologies (e.g., light rail vehicles) is significantly less.

This section outlines the various technological options for vehicles, fare collection systems, and intelligent transportation systems (ITS). This section will also discuss how to design a competitive procurement process that will deliver the most cost-effective product.

2.7.1 Vehicle 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.

Decisions on vehicle ownership will affect the type of vehicles selected. The current common practice is for the public agency to set vehicle standards while the private sector actually purchases and operates the vehicles. Thus, while a standard set of basic requirements must be met, many decisions, such as vehicle manufacturer, are actually left to the bus operating companies. The public agency will likely develop a detailed set of vehicle specifications that each operator will be required to fulfil. However, it is up to the bus operator, who is paying for the buses, to determine how to best meet the specifications. Thus, within Bogotá's TransMilenio system, different operating companies have selected different vehicle manufacturers. However, thanks to the detailed specifications, from the perspective of the customer, all of the buses look and operate identically.

Private procurement of the vehicles also permits public investment to be focused on high-quality infrastructure. Additionally, by keeping public officials away from the bus purchasing process, there is less likelihood of corruption and misappropriation of public funds.

2.7.1.1 Decision factors

Operators purchasing BRT vehicles must weigh many factors in choosing a fuel and propulsion system technology. Beyond basic vehicle prices, there are a host of issues that must be considered. Will the vehicle technology meet required emission standards? Will the size and design of the vehicle fulfil capacity requirements? Does the technology have a history of operating consistently in developing city conditions? Does the technology require maintenance personnel with highly-specialised skills? Are spare parts for the technology expensive and difficult to obtain in a developing city? Are special re-fuelling stations required for the technology? Table 6 summarises many of the factors that an operator will consider in deciding upon a technology and a manufacturer.

2.7.1.2 Fuel and technology options

The choice of fuel and propulsion technology will affect operating costs, maintenance costs, supporting infrastructure, and emission levels. Local circumstances play a central role in fuel choice as the availability of a fuel and experience in maintaining a particular vehicle technology are key factors. Further, as attention focuses more and more on the human and environmental costs of both local pollutants and global climate change, system developers are under increasing pressure to deliver cleaner vehicles options.

The following is a list of some of the most common fuel options currently being considered for public transport vehicles (Figure 64):

- Standard diesel

- Clean diesel
- Bio-diesel (biomass fuel - diesel)
- Compressed natural gas (CNG)
- Liquid petroleum gas (LPG)
- Hybrid-electric (diesel-electric and CNG-electric)
- Electric
- Hydrogen (fuel cell technology)

A range of other possibilities also exist such as fly-wheel technology, di-methyl ether (DME), and blended fuels (e.g., water-in-oil emulsions).

Clean diesel is the most common fuel technology utilised in developing-city BRT systems today. The cost and established history of these vehicles produces a relatively known performance.

More advanced technologies such as CNG, hybrid-electric vehicles, and fuel-cell vehicles are under going testing in both developed and developing cities. However, none of these cities are actually operating full fleets with these technologies. The costs and performance of these vehicles are not entirely proven.

2.7.1.3 Vehicle size

The size and required passenger capacity of the vehicle are largely determined by the modelling analysis conducted at the outset of the project. The analysis process will have determined a projected passenger volume for a particular corridor. Vehicle capacities in conjunction with service frequency are the primary factors that will help achieve a required volume of customers.

Table 6: Decision factors for choosing a vehicle technology

Category	Factor
Cost	Purchase cost Maintenance costs Re-sale value in local market
Vehicle features	Passenger capacity Interior design options Aesthetics
Manufacturer support	Manufacturer support office in country Capabilities of manufacturing technical assistance staff Warranty coverage and conditions
Robustness	Track record of technology in a developing city Degree to which specialised skills are required for maintenance and operation Feasibility of making repairs on the road Expected percentage of up-time in operation
Re-fuelling	Re-fuelling time Type and cost of required re-fuelling station
Environment	Local emissions (NO_x, SO_x, CO, PM, toxics) Global emissions (CO_2, N_2O_4, CH_4) Noise levels Other waste products (e.g., solid waste, waste oil, etc.)

Clean diesel

Hybrid electric

Electric trolley

Fuel cell

Natural gas

Fig. 64
A range of fuel technologies are available to today's transit developers.

Manufacturers typically produce vehicles in a set range of interior dimensions. The actual number of passengers that can be accommodated in a given interior space will depend on interior layout and the number of seats provided versus the amount of space for standing customers. Table 7 summarises some typical ranges of passenger capacities for standard vehicle sizes.

Table 7: Standard vehicle types and passenger capacities

Vehicle type	Typical number of passengers	Typical vehicle length (metres)
Vans	10-16	3 metres
Mini-buses	25-35	6 metres
Standard buses	60-80	12 metres
Articulated buses	120-170	18 metres
Bi-articulated buses	240-270	24 metres

A common error is to assume that larger vehicles are somehow "better". In truth, the best vehicle size is one that permits a cost-effective operation for the given volumes and service frequency. If a large vehicle requires a ten minute headway between vehicles in order to achieve an optimum load factor, then it might be better to choose a lower capacity vehicle. Passengers prefer headways in the range of one to four minutes. Long wait times will ultimately cause passengers to choose alternative modes of transport, such as private vehicles.

2.7.1.4 Low-floor vehicles versus high-floor vehicles

There has been considerable amount of attention to low-floor buses in recent years, particularly in Europe and North America (Figure 65). By contrast, most BRT systems in developing cities utilise high-floor vehicles with ramped entry systems.

Low-floor buses permit relatively rapid boarding and alighting without the need for ramped entry stations. However, there are also trade-offs with low-floor buses. Being closer to the ground, the buses typically incur more structural stress and thus have higher maintenance costs. Road surfaces on low-floor bus routes must be maintained at a very high level in order to avoid damage to the vehicles. Small imperfections in the road surface will also tend to make the ride less smooth and comfortable for the customers. Low-floor buses also typically cost US $ 50,000 – US$ 100,000 more than standard models.

Ramped-entry vehicles with high floors are typically the most practical for BRT applications in developing cities. A level entry will permit rapid customer boarding and alighting. Only with minimal dwell times can developing city passenger capacities be achieved. High-floor vehicles permit a smooth ride experience as the additional distance permits greater absorption of road imperfections. Low-floor vehicles have a lower equivalent passenger capacity since the wheel-wells will protrude into the passenger space. Standard tow vehicles will not be able to move low-floor vehicles if there are mechanical problems. A more costly specialised tow vehicle will be required. Finally, low-floor vehicles can create difficulties with regard to preventing fare evasion. With a ramped-entry high-floor vehicle, the height of entry acts as a natural defence against individuals trying to enter from outside the station. With low-floor vehicles, fare evaders can sneak between the station and the bus, and then enter the vehicle with relatively little difficulty. Table 8 summarises the advantages and disadvantages of low-floor vehicles.

Fig. 65
Low-floor vehicles are increasingly popular in North America and Western Europe but do not always meet the needs of BRT systems in developing cities, where level boarding may be more appropriate.
Photo by Lloyd Wright

2.7.1.5 Interior design

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 areas and to 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. Standing passengers will require holding devices (poles, straps, etc.) in order to travel safely and comfortably.

Cloth and padded seating offers additional comfort to passengers (Figure 66). However, there are cost and maintenance issues to consider with these types of seats. While plastic seating is not as comfortable, such seating is less costly and is easier to clean and maintain.

Special panoramic windows allow better views of the external environment. Panoramic windows offer a larger visible area for customer views. Being able to see upcoming stations and station name plates is especially important for customers unfamiliar with a particular corridor.

Fig. 66
Cloth and padded seating can be an added expense, but the value to the customer may make such seating a good investment.
Photo courtesy of Advanced Public Transport Systems

Table 8: Advantages and disadvantages of Low-Floor Buses

Advantages	Disadvantages
Avoids the need to construct ramped stations	Can cost US$ 50,000 to US$ 100,000 more per bus
Allows the flexibility to use in low-density communities where station construction is impractical	Higher maintenance costs due to impacts from road surface and vibrations
Creates more modern image with the customer	Difficult to tow when break downs occur
More rapid boarding in comparison to systems with high steps	Lower passenger throughputs in comparison to buses with ramped entries
	More difficult for the physically disabled and elderly to enter than buses with ramped entries
	Creates difficulties in stopping fare evasion within closed fare systems
	Less comfortable ride experience since small road imperfections will affect ride smoothness
	Low-floor articulated vehicles will lose as much as 12 seats worth of floor space due to the protrusion of wheel-wells into the passenger area

Clean and highly visible windows also make the journey more enjoyable for passengers who wish to view the outside environment.

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 key. Additionally, the safe attachment of wheelchairs to a fixed interior structure may be required.

Bicycles can also be safely and effectively secured inside the bus. Unfortunately, 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. BRT vehicles in Rouen (France) provide this type of open area for easy bicycle entry (Figure 67).

2.7.1.6 Vehicle 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

Fig. 67
An open space within the vehicle interior serves both passengers with bicycles and standing passengers.
Photo courtesy of Graham Carey

manufacturers are now emulating many of the design features from light rail systems (Figure 68). Simply by covering the wheels and rounding the bus body, these manufacturers have greatly increased the aesthetic appeal of their product. These initial bus designs are relatively expensive, in part because other features such as optical guidance systems often accompany them. However, the idea of creating a customer pleasing form is not necessarily a costly endeavour.

Fig. 68
The vehicle in this photo is a bus and not a light rail vehicle. The advent of modern, rail-like vehicles is helping to transform the image of buses as public transport.
Photo courtesy of Irisbus (Civis model)

2.7.2 Fare collection and fare verification systems

The method of fare collection and fare verification has a significant impact on passenger flow capacities and the system's overall impression to the customer. Section 2.5 discussed the fare collection system from the perspective of the business model and the distribution of revenues to different private and public entities. This section outlines some of the technological options for collecting and verifying fares. Additionally, the advantages and disadvantages of different service options are also discussed; these options include:

- On-board versus off-board fare collection
- Distance-based fare collection versus flat fares
- Time-based fare collection
- Actual verification versus "proof of payment" systems.

Both fare collection and fare verification processes are included in this section. Fare collection refers to the fare payment process while fare verification refers to the validation of the fare. Fare collection and fare verification can actually occur simultaneously or in different steps, depending on the process and technology being utilised.

2.7.2.1 On-board versus off-board fare collection and fare verification

The decision to collect and verify fares off-board will have a significant impact on the potential passenger capacity of the system. Off-board fare collection and fare verification 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 69). 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 and fare verification also carries another benefit. By removing the handling of cash by drivers, incidents of on-board robbery are reduced. Further, by having an open and transparent fare collection system, there is less opportunity for circumstances in which individuals withhold funds.

2.7.2.2 Flat fares versus distance-based fares

The customer tariff can either be represented through a flat fare or a distance-based fare. A flat fare implies that the same fare is charged to a customer regardless of the distance travelled in the urban area. A distance-based fare implies that customers are charged based on the distance covered in their journey. The choice between the two fare options involves trade-offs between social equity issues as well as between levels of fare collection complexity.

In much of the developing world, flat fares are utilised for social equity reasons. In many developing cities the lowest income groups often reside at the urban fringe. These peri-urban areas offer property at substantially lower costs than central areas. In many cases, the poor are utilising peri-urban properties that are not owned by the individual. These informally occupied areas quite often lack public services such as water and electricity. Additionally, the long distances between the peri-urban communities and employment opportunities in the city can inhibit access to jobs, health care, and education. If a distance-based fare was implemented in such a situation, the poor at the urban fringe would end up paying the highest transport costs. In order to achieve greater social equity, a flat fare helps to give such low-income groups access to city centre services and opportunities. In such instances, a flat fare acts as a cross-subsidy from higher-income residents in the central parts of the city to lower-income residents located in peri-urban areas.

A flat fare also permits the use of simpler fare collection technologies. Ticket-less options, such as coin-based machines, are possible with a flat fare. Further, a flat fare implies that no distance verification step is required upon exiting the system. The lack of this verification step reduces queues and thus improves overall system efficiency. In general, a flat fare scheme reduces the level of complexity in fare collection by an order of magnitude.

2.7.2.3 Technology options

Several different technologies and mechanisms exist to facilitate BRT fare collection and fare verification, including:

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

No one solution is inherently correct. The choice of fare collection system often involves a trade-offs between costs, simplicity, and service features.

Fig. 69
On-board fare collection and fare verification dramatically slows customer throughputs, as evidenced here in Goiania (Brazil).
Photo by Lloyd Wright

a. Coin / token systems

Coin and token systems are amongst the simplest and lowest cost technologies available to handle fare collection and fare verification. Coin-based systems also tend to reduce queuing in comparison to other technologies. However, with this simplicity comes some limitations. Coin-based systems work best with flat-fare structures.

Queuing is reduced with coin-based systems due to the fact that the customer does not need to purchase a fare card. Instead the currency acts directly as the fare payment and verification mechanism. There is no need to issue any paper tickets to customers. In Quito, Ecuador, a simple coin-based system has worked successfully for both the city's "Trole-line" and "Ecovía" line (Figure 70).

Fig. 70
The coin-based fare collection system in Quito works quite well in terms of efficiency and cost.
Photo by Lloyd Wright

Fig. 71
Magnetic strip technology is available in two different size standards. However, this technology is slowly being replaced by smart card technology.
Photo courtesy of TransMilenio SA

b. Magnetic strip technology

Magnetic strip technology has had a relatively long history of application and success in the field. Magnetic strip technology has been used successfully in metro systems around the world (Figure 71). There are two different standards for magnetic strip cards: 1.) The standard-sized ISO 7810 card; 2.) The smaller "Edmundson" card.

The technology requires the pre-purchase of the magnetic 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. The advantage of magnetic strip technology is the relatively low-cost of the fare cards themselves, US $ 0.02 - US$ 0.05 per card. However, unlike smart cards, magnetic strip cards have a limited lifetime. In some cases, cards may be issued for only a single use. The cards are made of coated paper and can be relatively easily damaged.

c. Smart card technology

Smart card technology is the latest advent 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 72). 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.

Fig. 72
Smart card technology is increasingly a popular choice for transit systems due to its versatility, but the technology may not always be the most cost-effective option for developing cities.
Photo courtesy of TransMilenio SA

Table 9: Summary of fare collection technologies

Factors	Coin system	Paper system	Magnetic strip system	Smart card system
Set-up / equipment costs	Medium	Low-Medium	High	High
Operating costs	Low	Low	Medium	Medium
Level of complexity	Medium	Low	High	High
Number of customer queues in a single trip	1	1-2	2-3	2-3
Can provide customer tracking information	No	No	Yes	Yes
Allows automated fare verification	Yes	No	Yes	Yes
Allows distance-based fare schemes	No	With difficulty	Yes	Yes
Supports high customer flows	Yes	No	Yes	Yes
Supports high-tech image of system	Medium	Low	Medium-High	High
Space requirements for fare equipment	Medium	Low	High	High
Susceptibility to counterfeiting	Medium	High	Low to medium	Low

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.

d. Summary of fare collection technologies

This section has provided an overview of each of the major fare collection technologies. Table 9 summarises the major decision factors for each technology.

2.7.3 Intelligent Transportation Systems (ITS)

Information technology is changing all aspects of daily life. Public transport has likewise benefited from the reach of information technologies as well as the continuing reduction in technology costs. "Intelligent transportation systems" (ITS) refer to a range of information technologies that provide more choices and better quality for the customer.

Real-time information displays are one application of ITS that can alleviate concerns over the reliability of a service. Information on the transit vehicle's location can be relayed via several technologies to displays at stations informing waiting passengers of the next available vehicle (Figure 73). Real-time information helps to reduce customer "waiting stress", which affects passengers who do not know when or if a particular route is going to arrive. 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 time. Some systems, such as the Singapore MRT system, even place a real-time information display at the outside of the station. Again, this allows customers to make best use of their time as well as helps reduce stress and rushing.

2.7.4 Equipment procurement process

The appropriate structuring of the procurement process can create a competitive environment that will drive cost reduction and efficiency. Additionally, a well-designed procurement plan will promote an open and transparent process that will help to 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 permitting bidding firms the ability 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 ultimately should be decided by an objective, independent body whose members have no commercial interest with the overall project and have no relationship in any form to the bidding firms.

Fig. 73
Real-time information display in Berlin (Germany).
Photo by Lloyd Wright

2.8 Planning Stage VIII: Modal integration

BRT systems like all public transport 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. In truth, other transport options such as walking, cycling, driving, taxis, and other public transport systems should not be seen as competitors with the BRT system. Rather, such complementary services should interact with BRT as a seamless set of options serving all aspects of customer needs. Additionally, BRT systems are often implemented simultaneously with restriction measures on private vehicles. Auto restrictions, as well as Travel Demand Management (TDM) techniques, provide an appropriate set of incentives for residents to switch to more sustainable options.

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. If customers cannot reach a station comfortably and safely, then they will cease to become customers.

2.8.1 Pedestrians

If it is not convenient or easy to travel to a BRT station, then the other qualities of the system become somewhat irrelevant. Without adequate access to stations, customers will simply not utilise the system. The walking environment is a key determinant in whether the transit system is of use to the customer.

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 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 74).

Fig. 74
In Curitiba, pedestrian zones connect directly to BRT stations, and thus provides good customer access.
Photo by Lloyd Wright

Pedestrian access infrastructure can take the form of at-grade entry (e.g., crosswalks) or grade-separated entry (e.g., overpasses and tunnels). Customers typically prefer the most direct routing, and thus at-grade entry options usually deliver the most rapid approach.

However, at-grade entry by way of crosswalks can involve greater safety risks if not designed properly. Transit station areas can be prone to higher pedestrian accidents.

Curbs along the pedestrian route to the transit stations should all be ramped to provide access to customers on wheelchairs and to those carrying wheeled objects such as bicycles or trolleys (Figure 75). There is little value in making station platforms and transit vehicles friendly to the physically disabled if it is impossible for those individuals to reach the stations in the first place.

Well designed at-grade crossings can be the right choice under the appropriate conditions:

- Low to medium traffic levels
- Controlled traffic speeds
- Relatively few lanes to be crossed

- Appropriate supporting infrastructure (signals, marked crossings, etc.)

There may be instances when traffic levels, speeds, and the number of lanes to be crossed present an unacceptable danger to transit passengers. In such instances, grade-separated infrastructure (overpasses and underpasses) may be an option to consider. The challenge in designing grade-separated infrastructure is creating a walking environment that persons will actually use. If passengers ignore the overpass and instead run across uncontrolled road space, then the situation has only been made worse.

Overpasses are often avoided by pedestrians for very rational reasons. Steep stairways make overpasses a physical challenge for many, especially the young, the elderly, and the physically disabled. Overpasses may cultivate an environment inducing criminal activities such as theft and violence. Since pedestrians are contained in a relatively tight space with few options for escape or help, criminals may view such spaces as easy targets. The overpasses may also become inundated with vendors selling goods (Figure 76). Since informal vendors see such constrained spaces as a profitable density of potential customers, the overpass space can become filled with a variety of informal goods. In turn, the tight space and aggressive selling will dissuade persons from using the transit system. Overpasses may also force transit customers to walk considerably longer distances to access the station. The location of the overpass may be constrained by other overhead structures, and thus may be placed many metres away from the intended destination.

However, with a well-designed plan, both overpasses can be successfully implemented as access infrastructure for transit systems. Bogotá's modern pedestrian ramps serve as a good example of providing a functional and aesthetically pleasing overpass (Figures 77). To enter the overpass, Bogotá provides a ramped entry with a sufficiently gradual slope to ease the climb. In some instances, Bogotá also provides a stairway in conjunction with the ramps so that persons wishing to access the station more rapidly can do so. The overpasses themselves are signifi-

Fig. 76
A pedestrian overpass in Dhaka (Bangladesh) is crowded with vendors and thus acts to discourage some from using it.
Photo by Lloyd Wright

Fig. 75
Level surfaces can greatly increase the accessibility of transit stations for the physically disabled.
Photo courtesy of Queensland Transport

Fig. 77
Wide, modern pedestrian bridges in Bogotá are highly accessible and have succeeded achieving user acceptability.
Photo courtesy of TransMilenio SA.

cantly wider than the typical overpasses found in developing cities. Utilising a 2.5 metre-wide pedestrian space and an open design, Bogotá's pedestrian bridges alleviate many of the security concerns normally associated with overpasses.

2.8.2 Bicycles

The provision of bicycle infrastructure serves a purpose similar to that of pedestrian access infrastructure. Namely, bicycles are an important feeder service providing customer access to the transit system.

2.8.2.1 Bicycle parking facilities

At the station, the provision of secure bicycle parking infrastructure is essential for cyclists to feel comfortable in leaving their bicycles prior to boarding the system. Another option is to allow the cyclist to enter the BRT vehicles with the bicycle, so that the person may use the bicycle to access his or her destination on the other end of the trip (Figure 78).

The challenge with bicycle parking facilities for BRT systems usually relates to the space available. For stations located in the median of the roadway, space may be available in front of or behind the station structure. Underneath the entry ramp may also be a possibility. Alternatively, bicycle parking could be provided on the curb side of the street. In all cases, the security of the bicycle becomes an over-riding consideration.

An area being in view of security staff or transit staff is preferred since a watchful presence can be a significant deterrent to theft. Security camera coverage of the bicycle parking area is also quite helpful. At the TransMilenio Americas Terminal, bicycle parking is provided inside the terminal, at a point after a person has paid to enter the system and in clear view of the fare collection agent.

Fig. 78
The Copenhagen metro system permits cyclists to enter the system with their bicycles. The use of one's bicycle on both sides of the journey is a significant benefit to the customer.
Photo by Lloyd Wright

2.8.2.2 Cycleway infrastructure

Of course, reaching the station by bicycle can be a challenge if quality cycleways are not provided. 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 250 kilometres of dedicated cycleways (Figures 79). Likewise, Curitiba has done much to promote bicycle use as well. Merging BRT systems with bicycle networks requires integrated planning that connects stations and terminals with the cycleways. The combination of a BRT system with a cycleway network can do much to provide city-wide mobility on a sustainable basis.

Fig. 79
It is no coincidence that Bogotá possesses both a world-class BRT system and world-class bicycle infrastructure. The two systems are mutually complementary.
Photo by Lloyd Wright

The BRT system and the cycleway network should ideally be planned jointly. The planning process should aim to connect major cycleways with BRT stations at strategic locations. The idea is not to force cyclists to transfer to the BRT system but rather to offer the option of a combined public transport-bicycle commute.

2.8.3 Other public transport systems

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. Cities with water transport systems should also seek to closely integrate these systems with the bus network.

Sao Paulo, for instance, uses BRT to connect the end of its metro line with other communities. Some cities with existing metro systems are unable to finance the completion 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 a successful integration lies in 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 jointing 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 to another without the need of purchasing an additional fare.

2.8.4 Taxis

Another forgotten integration opportunity concerns the car taxi industry. In developing-nation cities, taxi associations can be politically powerful and are 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 without passengers (i.e. taxis in search of passengers). Taxis in Shanghai, for instance, are estimated to spend 80% of their travel time without passengers.

Fig. 80
In Quito, the provision of taxi stations near BRT stations helps provide customers with an additional form of feeder services. The arrangement also reduces unnecessary travel by taxi drivers looking for customers.
Photo by Lloyd Wright

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 80). 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 the city expending large quantities of petrol.

2.8.5 Park-and-ride

Private vehicle owners can also be successfully integrated with the system through the development of "park-and-ride" or "park-and-kiss" facilities. These facilities allow private vehicle users to access the transit system, and therefore complete their total commute by way of public transport. A park-and-ride facility provides a parking garage or parking lot for vehicles to be kept securely during the day. A kiss-and-ride facility does not provide parking but rather includes a passenger drop-off area for private vehicles.

Park-and-ride and kiss-and-ride facilities are effective options in suburban locations where population densities may be insufficient to cost justify feeder services. In developing cities, these areas may include more affluent households that have sufficient disposable income to own a private vehicle. Attracting this income group to the transit system can deliver several benefits. Most importantly, offsetting private vehicle use pays significant dividends in terms of emission reductions and congestion relief.

2.8.6 Auto restriction measures

Part of the equation for transforming a city and its mobility structure is providing 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. The 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 Transportation Demand Management (TDM) techniques have demonstrated the cost-effectiveness and ease with which the right incentives can direct persons towards more sustainable transport forms. The development of a BRT system is an ideal time to investigate the adoption of TDM measures.

Mechanisms that help discourage private vehicle use and thus encourage public transport use include the following:

- Reduction in available parking areas
- Increased parking fees
- Increased parking enforcement
- Parking cash-out programmes
- Day restrictions by license plate number
- Congestion charging and road pricing
- Travel Blending or TravelSmartTM
- Green travel plans
- Traffic calming measures.

2.8.7 Integration with land use planning

Public transport planning and land-use planning should be undertaken in an integrated fashion to capture mutually-beneficial synergies. Land-use patterns that promote commercial and residential densification around transit stations will both promote public transport and add to customer convenience. This type of development strategy, known as transit-oriented development (TOD), is increasingly being undertaken in conjunction with new transit systems.

Development around BRT stations in Curitiba represents one of the best-known examples of TOD. The station areas in Curitiba have acted as development nodes for commercial shops, housing, and public service centres. The five exclusive busways in Curitiba are lined with high-rise development, reflecting the higher land values near the BRT system. Zoning regulations in Curitiba supported this type of development by restricting high-rise construction to areas near the busways.

The end result in Curitiba has been a land-use planning scheme and a BRT system that have worked to be mutually supportive. The municipality has also benefited in another way, as the cost of public service delivery has been reduced along the corridors.

2.9 Planning Stage IX: Impacts

The true impact of BRT is not simply the physical system but rather the improvements that it creates in people's lives. Evaluating the expected impacts on traffic levels, economic development, environmental quality, social interactions, and urban form all help determine whether the BRT system will add real value. The projection of system impacts is thus a crucial step in cost justifying the final development and the cost of construction. Further, by examining the system's expected impacts, it is possible to determine what types of improvements or modifications are required from the design.

2.9.1 Traffic impacts

At the outset of the project, the initial modelling work helped to select the appropriate corridors and the likely ridership numbers. Once the initial design and planning work has been completed, it is appropriate to re-examine how the new system will function in the city's transport matrix. Motorists, taxi operators, and others currently using the road network will likely want to be reassured that the development of the BRT system will not lead to gridlock. A traffic impact analysis can help provide the political reassurance that the system will deliver its promise.

Thus, at this stage, a traffic modelling exercise should be conducted to project how the designed system will affect traffic levels as well as improve conditions for current transit passengers. The design information from the operations and infrastructure plans (sections 2.4 and 2.6) can provide the input into the model. A similar modelling process as outlined at the outset (section 2.2) can be followed. However, at this stage, the planning team will have more precise and focussed data to input.

2.9.2 Economic impacts

An efficient public transport system can be an effective catalyst for stimulating local economic development. The provision of access and mobility is closely tied to development objectives. This relationship is especially the case in developing cities where private vehicle ownership is relatively low. A BRT system can affect the local economy through the following impacts:

- Employment generation;
- Economic efficiency in moving people and goods;
- Property values; and,
- Technology transfer.

2.9.2.1 Employment generation

a. System construction

The new BRT system will likely represent a dramatic transformation of the proposed corridors. As with any project of this magnitude, the system will generate a considerable amount of employment through the construction process. Based upon similar projects from the past, it is possible to project the amount of employment and the duration of the employment from the construction phase (Figure 81). An additional measure of interest, particularly in the developing city context, can be the number of persons being supported by each construction job. Further, construction jobs can sometimes be an important area of employment for unskilled labour groups. Employment generated for these individuals can be especially important since there may otherwise be limited opportunities.

b. Operations

The consolidation of informal transport services into a coherent BRT system brings with it concerns over the loss of employment. The small mini-buses that normally precede the introduction of the BRT system typically employ a

Fig. 81
Documenting the amount of employment generated from system construction can help make the economic case for the system.
Photo by Lloyd Wright

driver and a conductor. By contrast, a single articulated BRT vehicle may replace four to five small buses. Thus, it would appear that a single driver is replacing as many as ten persons employed by the mini-buses.

However, the reality is actually quite different. The standard mini-bus will generally operate with its single set of employees for as much as 16 hours in a day. The BRT vehicle will actually involve three to four different shifts of employees operating the same vehicle. Thus, the number of drivers will not appreciably change. When the feeder service drivers are included, BRT may actually increase the number of drivers. However, the big employment boost from operations stems from the myriad of positions created from fare collection, security, information services, and management and operations (Figure 82). Most of these functions did not exist in the previous informal sector.

The development of an employment matrix comparing jobs in the before and after scenarios will likely produce a beneficial comparison for the new BRT system. Additionally, since the existing operators will have the opportunity to bid on serving the new system, the spectre of maintaining existing employment while also expanding new opportunities can be quite strong.

Additional employment is also likely to be generated due to indirect impacts from the BRT system. The boost in shop turnovers near transit stations can lead to additional employment. Likewise, the construction of new commercial centres next to stations and terminals will have significant employment benefits. Also, if the new system encourages local manufacturing of buses, then more employment can be expected.

2.9.2.2 Property values

BRT busways and the associated stations and terminals will tend to provide a new economies-of-scale along a particular corridor. A concentration of passengers and development will tend to increase the value of being located near the transit corridor. Property values, shop turnovers, and property vacancy rates will all be positively affected by the introduction of the system. The increase in property values mirrors the expected increases in customer numbers at stations and terminals.

2.9.3 Environmental impacts

Public transport projects typically bring positive environmental impacts through the reduction of private vehicle use and subsequent associated emissions. Quantifying the expected environmental benefits of the BRT project can help to justify the project as well as strengthen the image of the initiative with the public. As a major project, an Environmental Impact Assessment (EIA) is likely to be required.

The expected reduction in vehicle emissions will likely be the principal benefit. However, the system will also likely reduce overall noise levels as well as the release of both liquid and solid waste products. The construction process itself can be disruptive and lead temporarily to some increases in emissions. However, by calculating emission reduction benefits across the life of the BRT project, the overwhelming evidence to date suggests that BRT can markedly improve the state of the urban environment.

As a system-based approach to public transport, the TransMilenio system is able to address virtually all the possible components

Fig. 82
Despite one articulated vehicle replacing many smaller buses, the overall amount of employment in public transport operation will likely increase with BRT.
Photo by Lloyd Wright

in an emissions reduction effort. Specifically, TransMilenio is achieving emission reductions through the following mechanisms:

- Increasing the share of public transport ridership by dramatically improving the quality of service (in terms of travel time, comfort, security, cleanliness, etc.);
- Replacing 4 to 5 smaller buses with a larger articulated vehicle;
- Requiring the destruction of 4 to 8 older buses for every new articulated vehicle introduced into the system;
- GPS controlled management of the fleet allowing the optimisation of demand and supply during peak and non-peak periods;
- Encouraging transit-oriented development around stations and along corridors; and,
- Emission standards currently requiring a minimum of Euro II emission levels with a future schedule requiring eventual Euro III and Euro IV compliance.

Prior to TransMilenio, as many as 35,000 public transport vehicles of various shapes and sizes plied the streets of Bogotá. In order to rationalise the system, companies bidding to participate in TransMilenio were required to scrap older transit vehicles. During the first phase of TransMilenio, the winning bids agreed to scrap approximately four older vehicles for each articulated vehicle introduced. In the second phase, the successful bids committed to scrapping between 7.0 and 8.9 older buses for each new articulated vehicle (Figure 83). The destruction of older vehicles prevents the "leakage" of these vehicles to other cities.

2.9.4 Social impacts

Social impacts are also generally positive as BRT systems give lower-income groups more access to public services and economic opportunities. Social impacts refer to the ability of a new transit system to help create more social equity within a city. Thus, this factor is related to previous discussions on affordability and employment creation, as well as social changes due to the new urban environment.

The lower unsubsidised fare levels of BRT in developing cities can help make the transit system accessible to a wider social audience. Of course, with subsidisation, fares on LRT and metro systems can likewise be made affordable to the majority of the population. The metro systems in Mexico City and Delhi, for example, employ significant fare subsidies in order to ensure accessibility.

Fig. 83
Bidding operating companies in Bogotá received additional points for agreeing to scrap older, more polluting vehicles.
Photo courtesy of TransMilenio SA.

Transit systems can also provide one of the few places in a city where all social groups are able to meet and interact. An affordable and high-quality system can attract customers from low-income, middle-income, and high-income sectors (Figure 84). This role as a common public good can be quite healthy in creating understanding and easing tensions between social groups.

The regeneration of an urban area due to public transit improvements can have multiple social benefits. As noted, the upliftment of an area creates employment and economic growth. Additionally, evidence suggests that public transit improvements can also reduce crime.

Fig. 84
A high-quality transit system serves an important social function by bringing together persons from all parts of society.
Photo by Lloyd Wright

2.10 Planning Stage X: Implementation plan

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 expenditures on plans end in idle reports 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.

2.10.1 Timeline and workplan

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 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.

Just as a strict timeline and workplan was developed for the BRT planning process, similar management tools will be required for the implementation plan. Construction of an initial set of corridors can be reasonably completed within 12 months to 18 months after the BRT plan is developed, provided financing is available and contractual agreements with construction firms and suppliers are readily achievable. However, the actual construction time depends upon many local factors, including the size and complexity of the initial corridors, the availability of financing, and the legal clearance to proceed.

In the implementation phase, events can be more difficult to control than during the planning process. Accidents, strikes, legal challenges, and technical problems are just a few occurrences that can delay the construction process. Thus, additional contingency time for unforeseen events should be factored into any timeline. A conservative timeline should be particularly considered when announcing expected start dates to the press and public. A missed launch date can create a negative image of the system even before the public has had an opportunity to experience the system for themselves. By contrast, an earlier than expected start will be heralded as a sign of a highly-efficient development process.

Some of the elements in the implementation timeline and workplan include:

- Finalisation of financing
- Finalisation of construction contracts
- Ground-breaking ceremony
- Finalisation of operating company bidding and awarding of concessions
- Hiring of all public company staff
- Continued expansion of pre-launch marketing programme and public education programme
- Periodic reviews of construction progress and completion of contract milestones
- Construction completion
- Testing phase
- System launch

Each of these elements should be included in the implementation timeline and workplan.

2.10.2 Financing plan

Financing does not need to represent an insurmountable barrier to BRT implementation. In comparison to other mass transit options, BRT's relatively low capital and operational costs puts the systems within the reach of most cities, even relatively low-income developing cities. 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. Further, since most BRT systems operate without operational subsidies, no public financing will likely be necessary beyond the provision of infrastructure.

However, developing a complete financing package will require much effort and persistence. Ideally, an effort on financing should begin at the earliest stages of the planning process. The financing plan should also be developed on an iterative basis with the operational and infrastructure design process since the available financing will be a determinant factor in the design possibilities. The expected financing that will be available to private operators should also be a consideration as the technology plan is developed. If the cost of the specified transit vehicle exceeds the likely financing reach of the private operators, then the implementation of the envisioned plan will be compromised.

The long-term vision of the financing strategy will likely vary from the financing applied to the system's initial corridors. Bogotá relied upon local funding sources in its first phase, but is now able to tap a greater amount of international financing sources for its subsequent phases. Table 10 outlines the funding sources for TransMilenio's Phase I.

Table 10: Financing for Phase I of TransMilenio

Source	Percent of contribution to infrastructure costs
Municipality*	48%
Revenue from petrol tax	23%
National government	19%
World Bank loan	10%

* Revenues from the sale of the municipal electricity company

Source: Sustainable Transport, 2003

If an initial project phase is successful, as was the case with TransMilenio, then the number of financing sources for subsequent phases will tend to increase. This tendency is largely due to financial organisations gaining confidence in a project once the city successfully delivers initial phases.

2.10.2.1 Financing options

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 11 summarises the potential financing sources for these activity areas. Section 2.1.5 has already discussed financing options for planning activities.

For the most part, the financing plan will concentrate on financing infrastructure. The business model developed in section 2.5 should have ensured that the equipment costs (e.g., buses) will be financed by the private sector. The private operators themselves will need to develop their own financing plans so that the focus of the public financing will likely remain on infrastructure.

Table 11: 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 Programme (UNDP) Global Environment Facility (GEF) Private foundations
Infrastructure	Local and national general tax revenues Petrol taxes Road pricing / congestion charging Parking fees Improved enforcement of traffic regulations Land value taxation Sales or leasing of commercial space near stations Advertising Merchandising Commercial banks Municipal bonds World Bank Regional Development Banks (e.g., ADB, IDB) Emissions trading
Equipment (e.g. buses)	Private sector bus operators Bus manufacturers Bi-Lateral export banks International Finance Corporation Commercial banks

2.10.2.2 Local and national sources

The most stable and low-cost financing options are likely to found quite close to home. Local revenue sources are generally the base financing source for realising BRT initiatives, especially during the initial project phases. As was the case for Bogotá, local and national sources may well be sufficient to finance much of the system's initial infrastructure. Cities and national governments also exert more control over their own resources, and thus in many instances, can

Fig. 85
The congestion charging scheme in London provides significant funding for the city's bus system.
Photo by Lloyd Wright

ascertain the long-term reliability of the revenue flow. Further, many potential local sources for BRT also carry the benefit of discouraging private vehicle use, which will only further strengthen the soundness of the BRT system.

a. Existing transport budgets

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. Re-directing local and national roadway projects to transit priority projects can be justified on both cost and equity grounds. In many instances, the BRT investments will serve the dual purpose of improving both public transport and private vehicle infrastructure. The construction of the TransMilenio corridors in Bogotá also included upgrades to the nearby mixed traffic lanes.

b. Fees and taxes

Dedicated revenue streams from special fees and taxes can help establish a long-term sustainable basis for financing BRT development and expansion. Such fees and taxes include:

- Local and national general tax revenues
- Petrol taxes
- Road or congestion pricing
- Parking fees
- Enforcement of traffic regulations
- Land-valuation taxation

Most of these fees and taxes will also act as disincentives to private vehicle use. Petrol taxes, parking fees, and congestion pricing will all help to encourage public transport use.

Bogotá made use of a dedicated tax stream from the taxation of petrol. Twenty eight percent of Colombia's petrol 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 transit projects receive the necessary funding. One-half of one 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 percent match for municipal transit projects.

As noted previously, congestion charging and electronic road pricing has served as a highly effective revenue stream for public transport projects in London and Singapore (Figure 85). These measures have also been credited with substantially reducing vehicle congestion levels. However, road pricing schemes can be complex to implement. Further, given the technology involved and significant start-up costs, a separate initial financing plan may be necessary just to implement a road pricing scheme. The municipality may have to wait several years before the initial investment delivers a net return.

Parking fees can be equally as effective in discouraging vehicle use as road pricing, but the relative ease of implementation of parking restrictions makes parking control a more viable short- and medium-term option. However, changes in parking fees and regulations will likely require local council approval. In the case of applying fees to parking at commercial sites, special legislation is also a likely requirement. Many developing cities may currently have few parking restrictions and poor parking enforcement. While a parking fee regime will produce a dramatic increase in city revenues in such cases, the political challenge of introducing an entirely new charging scheme can be difficult.

Land-value taxation is a new financing opportunity that holds much promise to revolutionise the manner in which mass transit projects are financed. The arrival of a high-quality transit system along a corridor can dramatically increase the value of properties in the area. The proximity to the transit network means greater convenience for residents and greater customer flows for commercial enterprises. The idea is being pursued in the United Kingdom where land values around several high-profile transit projects have increased significantly. Property values within one kilometre of stations on the Jubilee Line extension (London Underground system) increased by approximately £ 13 billion (US$ 23.4 billion) as the project developed (Riley, 2001). The cost of the entire extension was only £ 3.5 billion (US$ 6.3 billion). Unfortunately, none of the windfall increases in property values were captured by the government. A tax on the property value increases could have paid for the Jubilee Line extension. Thus, many

Fig. 86
Land-value taxation is a mechanism to capture the windfall property value gains from properties near new transit systems.
Photo by Carlos Pardo.

groups are devising property valuation mechanisms to help capture revenues to pay for the transit infrastructure (Figure 86).

c. Commercial revenue opportunities

The inherent attractiveness of the new transit system can open up new commercial opportunities that will produce positive revenue streams. Commercial development of stations, advertising, and merchandising are just a few the creative mechanisms that the city can take advantage of to generate additional revenues.

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 leasing of commercial space to help fund infrastructure costs (Figure 87).

Likewise, the selling on advertising space at stations and within buses can be an option to consider (Figure 88). However, the commercialisation of the system must be done with a great deal of caution. Commercial signage should be discretely done, if at all, or it will risk degrading the visual and aesthetic quality of the

Fig. 87 and 88
Commercial property development and advertising within the system, if done in an appropriate and subtle manner, can be a lucrative revenue source.
Photos by Lloyd Wright

system. When commercial signage overwhelms stations and buses, then 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 is directly related to customer satisfaction and usage. Visual degradation can also lead to increased incidences 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.

2.10.2.3 International sources

a. Combining local and international sources

In some cases, international financing and funding may be an appropriate addition to a locally- and nationally-based financing plan. If outside financing proves to be necessary, commercial, bi-lateral and multi-lateral institutions are increasingly supportive of assisting BRT projects. Unlike other costly mass transit options, BRT presents sufficiently low capital requirements and historically positive operational returns to be considered commercially bankable projects. Likewise, international organisations also tend to support BRT for similar reasons.

If international financing is pursued as an option, such financing should only be considered an augmentation to existing locally- and nationally-based financing. International resources will most likely never fully finance the system. A lack of local and national financing support sends the message that the governmental entities are not really supportive of the project.

b. Bi-lateral support

Section 2.1.5 outlined the various international organisations that would potentially provide some support to a developing city's BRT planning process. The list of international organisations that would potentially help finance infrastructure development is more limited. Most overseas development agencies will not directly fund infrastructure. Likewise, private foundations more typically lend support to technical capacity and not directly to financing infrastructure.

Developed-nations do offer export-promotion financing that can be utilised within a developing-city mass transit initiative. Some examples of these types of banks include:

- German Kreditanstalt für Wiederaufbau (KfW)
- Japanese Bank for International Cooperation (JBIC)
- United States Export-Import Bank (EX-IM Bank)
- United States Overseas Private Investment Corporation (OPIC)
- United States Trade & Development Administration (TDA)

c. International development banks

The principal international financing sources will likely be the World Bank and regional development banks. The World Bank Group actually consists of five different organisations, each with a different mandate in supporting development. Most loans for BRT will be managed through the International Bank for Reconstruction and Development (IBRD). However, for the lowest-income countries, the International Development Association (IDA) may be the appropriate lending organisation. Additionally, the International Finance Corporation (IFC) focuses on supporting private sector initiatives in developing countries, and thus the IFC could be an appropriate source of finance for concessioned operators.

Regional development banks operate in a similar manner as the World Bank but with a more focused geographical mandate. The list of regional development banks include:

- African Development Bank (AfDB)
- Andean Development Corporation (CAF)
- Asia Development Bank (ADB)
- Central American Bank for Economic Integration (CABEI)
- Council of Europe Development Bank (CEDB)
- Development Bank of Southern Africa (DBSA)

- Eastern and Southern African Trade and Development Bank (PTA)
- European Bank for Reconstruction and Development (EBRD)
- Inter-American Development Bank (IDB)
- Islamic Development Bank (ISDB)

2.10.3 Staffing and management plan

As the project moves closer to implementation, the full establishment and staffing of the BRT management agency will be required. Section 2.1.3 outlined some of the positions required to develop the BRT plan. While a staff of three to ten persons may be sufficient at the planning stage, to develop the full management organisation a wider range of positions and skills will be needed. The build-up of staff will likely occur in a phased manner with certain key positions being filled initially.

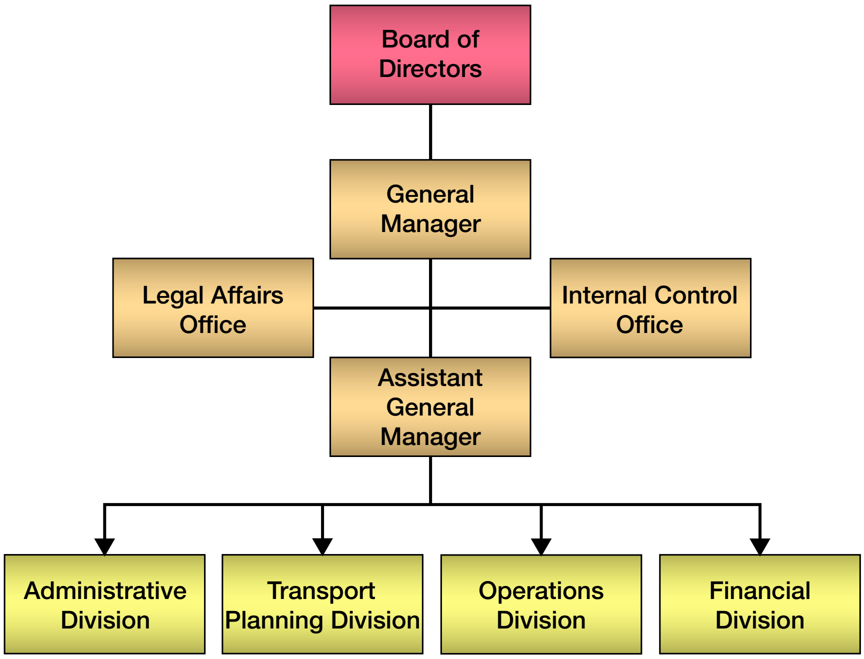
The formal establishment of the public management company for the BRT system should follow from the structures detailed in section 2.5 (Business and Regulatory Structure). This structure has the BRT management entity reporting to the mayor's office either directly or through a representative board of directors. The legal process to form the management entity should be completed well before the system is launched. TransMilenio SA was legally formed in October 1999, over a year prior to the system launch in December 2000.

The organisational structure of the management entity should promote clear lines of responsibility and should provide logical sub-units pertaining to the major functions of the organisation. Such units may include administration, financial control, legal affairs, operations, and planning. Figure 89 outlines the internal organisational structure utilised by TransMilenio SA.

TransMilenio manages to fulfil its mandate with a staff of approximately 80 persons. The simplicity of BRT systems along with the increasing prominence of information technology have permitted large transit systems to be administered by relatively lean management agencies. Table 12 lists the number of employees at TransMilenio SA by functional area.

Each position should be competitively advertised and processed through a formal interview process. The long-term success of the system will very much depend on the skills and creativity of the management agency's staff.

Fig. 89: Organisational structure of TransMilenio SA



2.10.4 Contracting plan

Leveraging the competitiveness and efficiency of the private sector allows cities to deliver more cost-effective transit systems. However, to ensure that the private sector performs in the manner intended, clear and precise contractual arrangements must be established. These contracts will specify the activities to be undertaken, the expected final products, the duration of the activity, and the means for receiving

Table 12: Employees by functional area in TransMilenio SA

Functional area	Number of employees
General Manager's Office	5
Assistant Manager's Office	5
Legal Affairs Office	5
Internal Control Office	3
Administrative Division	17
Planning Division	11
Operations Division	27
Financial Division	7
Total	80

Source: TransMilenio SA

compensation. As noted earlier, "quality incentive contracts" are an effective mechanism for linking contractual performance to the amount of the eventual payment. A set of fines and penalties may also be appropriate in order to discourage underperformance and errors.

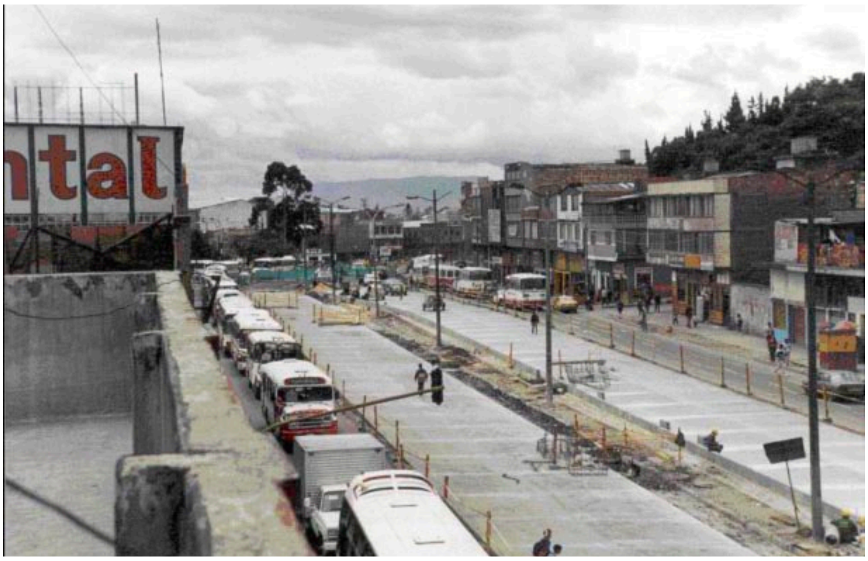
2.10.4.1 Types and characteristics of contracts

This planning guide has already outlined many of the types of contracts that will be required to plan and implement the BRT system. These contracts include:

- Consultant contracts
- Trunk-line operator concession
- Feeder concession
- Fare collection concession
- Fiduciary contract
- Construction contracts

While the terms and nature of each contract will vary by the intent and circumstances, each will share some general characteristics. The awarding of contracts should all be based upon a competitive framework in which firms bid to pre-determined criteria. A well-defined scoring system is then utilised to select the bidding firm offering the greatest potential to deliver a high-quality and cost-effective product. The entire process will need to be open and transparent so that the public's confidence in system development remains strong. Financial incentives should be built into contracts in order to encourage superior performance. The timely delivery of each product should be well-specified with defined penalties for failure to perform.

Fig. 90
The construction process can cause many problems including congestion, noise, and dust. A construction plan should seek to minimise these types of inconveniences.
Photo courtesy of TransMilenio SA



2.10.5 Construction plan

The construction process represents a great risk to the image and future of the new transit system. The closing of roadways, the construction noise, and the blowing dust can all give the new system a negative first impression to the population (Figure 90). Thus, organising the construction work in a city-friendly manner should be a top consideration.

A construction plan should be delivered in conjunction with the contracted firms. Each step of the process should be mapped out to minimise the negative impacts. In some cases, construction at nights, weekends, and holidays may be the best options for avoiding the prolonged closure of key connecting roads. A public education plan can also help to warn residents of the work and to offer suggestions on commuting alternatives. It may also be best to work on a segment by segment basis rather than closing the entire length of a particular corridor. However, the particular strategy will depend much upon local circumstances. The management of traffic re-routing and traffic control during the construction should be coordinated between the construction firm, the police, and the public transit agency.

The manner of the construction process should also be noted in the construction contract. It is also possible to include financial incentives to construction firms that successfully minimise negative impacts of road closings and construction dust and noise.

2.10.6 Maintenance plan

Start-up problems aside, most systems operate well and project a highly-positive image through its 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. The maintenance of system infrastructure components (busways, stations, terminals, depots, and control centre) will depend on the nature of the original construction contracts. Linking the original construction contracts to maintenance responsibilities can produce the right incentives for quality construction. However, there are trade-offs between this approach and the cost of the construction contract. Thus, responsibility for maintenance may be held by either private firms or the municipality.

At a certain point, each infrastructure component will likely require a major overhaul. The expected lifetimes of roadways, stations and other infrastructure will depend upon such factors as use patterns, topography, and climate. Roadways may require reconstruction every five to ten years, depending on the materials utilised in the original construction. Stations, terminals, and depots should last for several decades before major reconstruction is required. Estimating the lifespan of the infrastructure components will also allow financial planners to determine later re-capitalisation needs of the system.

2.10.7 Monitoring and evaluation plan

In many respects, the success or failure of a system can be apparent from public reactions to the system. The customer's opinion is perhaps the single most important measure. However, to obtain an objective and quantifiable indication of a system's overall performance, a defined monitoring and evaluation plan is fundamental. 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. A baseline value should be created for the relevant indicators. Thus, the evaluation work will begin prior to the development of the system. By noting such factors as average vehicle speeds, travel times, and public transport usage prior to the system's development, it will be possible to quantify the benefits gained by the new system. Most indicators will be quantitative in nature, but qualitative assessments can also be accommodated through survey work.

A strict monitoring and evaluation schedule should be established. Many of the system performance indicators, such as passenger numbers, will be collected automatically through the management control system and the fare collection data system. Other indicators will require direct periodic measurement. The initial period of system operation will likely be a period of more frequent measurement since there will be great interest to evaluate the original design and operational assumptions. Feedback from the initial monitoring may shape the design and operational adjustments that frequently occur in the first year of operation. After the initial months of operation, though, a regular pattern of data collection should be established.

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. Governmental and non-governmental organisations have dedicated substantial resources to share knowledge on BRT. This section notes some of these key organisations and technical resources:

3.1 BRT support organisations

1. **American Public Transportation Association (APTA)**
   http://www.apta.com/info/briefings/brief2.pdf
2. **Breakthrough Technologies Institute**
   http://www.gobrt.org
3. **Bus Rapid Transit Central**
   http://www.busrapidtransit.net
4. **GTZ Sustainable Urban Transport Programme (SUTP)**
   http://www.sutp.org
5. **Institute for Transportation & Development Policy (ITDP)**
   http://www.itdp.org
6. **International Energy Agency (IEA)**
   http://www.iea.org
7. **National Bus Rapid Transit Institute**
   http://www.nbrti.org
8. **Transit Cooperative Research Program (TCRP)**
   http://www4.trb.org/trb/crp.nsf
9. **Transportation Research Board (TRB)**
   http://gulliver.trb.org
10. **Transport Roundtable Australia**
    http://www.transportroundtable.com.au
11. **US Federal Transit Administration (USFTA)**
    http://www.fta.dot.gov/brt
12. **World Bank**
    http://www.worldbank.com/transport

3.2 Technical resources

This document has sought to provide an overview of the BRT concept as well as provide insights into the BRT planning process. However, there are several other publications that also provide additional perspectives and information on the topic of BRT. This section lists some of these documents.

Allsop, R. (2000), *Mass rapid transit in developing countries*, London: Halcrow Fox.

Friberg, L. (2000), Innovative solutions for public transport: Curitiba, *Sustainable Development International*, 3: 153-157.

Hardy, M., Stevens, W., and Roberts, D. (2001), *Bus rapid transit vehicle characteristics,* USFTA report number FTA-DC-26-7075-2001.1. Washington: Federal Transit Administration.

Litman, T. (2004), *Evaluating public transit benefits and costs*, Victoria: Victoria Transport Policy Institute (http://www.vtpi.org).

Meakin, R. (2002a), *Bus regulation and planning.* Eschborn: GTZ.

Meakin, R. (2002b), *Urban transport institutions*. Eschborn: GTZ.

Meirelles, A. (2000), *A review of bus priority systems in Brazil: From bus lanes to busway transit*. Presented at the Smart Urban Transport Conference, 17-20 October, 2000, Brisbane, Australia.

Robelo, J. (2003), *Basic busway data in Latin America*, Washington: World Bank.

(Web document: (http://www.worldbank.org/transport/urbtrans/pubtrans.htm).

TAS Partnership Ltd. (2000), *Quality bus infrastructure: A manual and guide*. London: Landor Publishing.

TCRP (2002), *A toolkit for self-service, barrier-free fare collection*, TCRP Report 80. Washington: National Academy Press.

TCRP (2002), *Estimating the benefits and costs of public transit projects: A guidebook for* *practitioners*, TCRP Report 78. Washington: National Academy Press.

TransMilenio (2003), *Plan marco sistema: TransMilenio*. Bogotá: TransMilenio SA.

Transportation Research Laboratory (TRL) (2004), *The Demand for Public Transit: A Practical Guide*. Report TRL 593, Wokingham, UK: TRL.

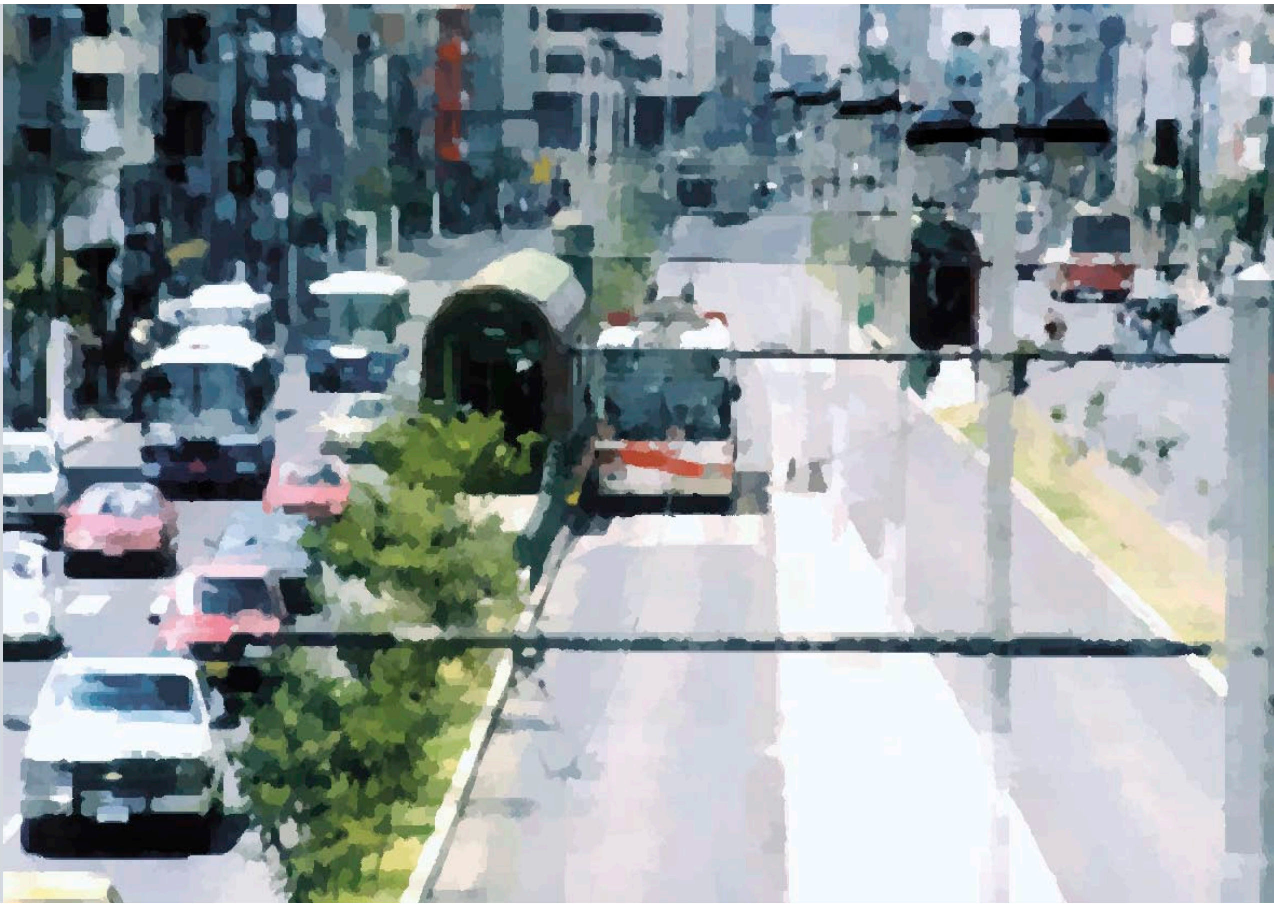
US FTA (2001), *Proceedings of the FTA / PRHTA bus rapid transit fare collection workshop*. Washington: Federal Transit Administration.

US GAO (United States General Accounting Office) (2001), *Bus rapid transit shows promise*. Washington: US GAO.

Wright, L. and Fjellstrom, K. (2003), *Mass transit options*. Eschborn, Germany: GTZ.

3.3 Links to BRT cities

- Adelaide, Australia
  http://www.adelaidemetro.com.au/guides/obahn.htm
- Auckland, New Zealand
  http://www.nscc.govt.nz/brt
  http://www.busway.co.nz/brt.html
- Bogotá, Colombia
  http://www.transmilenio.gov.co
- Boston, USA
  http://www.allaboutsilverline.com
- Brisbane, Australia
  http://www.transport.qld.gov.au/busways
- Cleveland, USA
  http://www.euclidtransit.org
- Curitiba, Brazil
  http://www.curitiba.pr.gov.br/pmc/ingles/solucoes/transporte/index.html
- Eugene, USA
  http://www.ltd.org/brt1.html
- Hartford, USA
  http://www.ctbusway.com/nbh
- Leeds, UK
  http://www.firstleeds.co.uk/superbus/html/
- Los Angeles, USA
  http://www.mta.net/metro_transit/rapid_bus/metro_rapid.htm
- Miami, USA
  http://www.co.miami-dade.fl.us/transit/future/info.htm
- Orlando, USA
  http://www.golynx.com/services/lymmo/index.htm
- Phoenix, USA
  http://www.ci.phoenix.az.us/brt
- Pittsburgh, USA
  http://www.portauthority.com
- Quito, Ecuador
  http://www.quito.gov.ec/trole/trole_1.htm
- San Francisco, USA
  http://www.projectexpress.org
- San Pablo, USA
  http://www.actransit.org/onthehorizon/sanpablo.wu
- Santa Clara, USA
  http://www.vta.org/projects/line22brt.html
- Sydney, Australia
  http://www.rta.nsw.gov.au/initiatives/e6_c.htm



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