Bus Rapid Transit
Planning Guide

June 2007

Part I – Project Preparation

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1. Project initiation

"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, anthropologist, 1901–1978

Despite the existence of a few exceptional examples in the world today, a transformation of public transport conditions is a relatively rare event. Such events do not magically arrive in a city. Catalysing public and political will towards changing existing public transport conditions is perhaps the most important activity discussed in this Planning Guide. Strong political will underscored by strong public desire for an improved public transport system is a combination for a rapid and successful project. Without either of these factors, it is unlikely a project will survive the myriad of challenges posed by special interest groups opposed to the new endeavour. With both political will and public support, it is unlikely a successful new vision can be stopped.

This chapter outlines a few mechanisms to help groups interested in catalysing a project to improve a city's urban transport system. This chapter also cites examples of how some cities have achieved political commitment for a project and how that support has been translated into a wider vision for a transformation of public transport operations. The topics discussed in this chapter are:

1.1 Project catalyst

"To accomplish great things, we must not only act but also dream. Not only plan but also believe."

—Anatole France, writer, 1844–1924

Before a customer boards a new system, before a new line is constructed, and before a plan is developed, a person or a group of persons must decide that action is required to improve a city's public transport system. The inspiration may come from a private sector operator, a civil servant, a political official, a civic organisation, or even just a concerned citizen. Nevertheless, without someone acting as a catalyst, a city's public transport potential will likely go unrealised.

The inspiration for a new public transport vision may stem from reading about alternatives, seeing a photo, visiting other cities, or a person simply asking "what if". In many cases, the catalyst may unfortunately originate from the dire conditions of public transport in much of the world today. As public transport conditions descend to depths of poor customer service, extreme levels of discomfort and insecurity, and official neglect, the issue can become a principal topic of public discourse. In too many cases, corrective actions are only undertaken once conditions become truly unbearable.

Because most top officials do not generally utilise public transport, the difficult conditions can be removed from the current political

Fig. 1.1
The Los Angeles Bus Riders Union has proven that people power can catalyse more progressive policies.
Photo courtesy of the Bus Riders Union

agenda. Instead, the impetus may fall upon public transport users and citizen groups who are closer to the day-to-day realities. In some instances, public transport users have formed their own organisations to demand improved conditions. In Los Angeles, the Bus Riders Union has successfully launched several campaigns to convince decision makers to expand

Box 1.1: BRT support organisations

A few of the organisations involved in BRT development are described below.

Institute for Transportation & Development Policy (ITDP)

ITDP is a US-based NGO that has worked on sustainable transport issues in developing nations for over 20 years. ITDP has lent direct technical assistance to several cities seeking to develop BRT systems, including the cities of Accra, Cape Town, Dakar, Dar es Salaam, Delhi, Guangzhou, Jakarta, Managua, and Quito. ITDP often enters cities at an early stage to help build the political confidence to proceed with an actual project.
http://www.itdp.org

Energy Foundation (EF)

EF is a partnership of major donors interested in solving the world's energy problems. EF has been particularly involved in promoting BRT efforts in China, and has established a BRT resource centre in Beijing. Through EF's efforts, BRT projects are completed or underway in several cities including Beijing, Chengdu, and Hangzhou.
http://www.efchina.org

World Resources Institute (EMBARQ)

The EMBARQ programme of the WRI has sought to support BRT efforts in several targeted cities including Shanghai, Mexico City, and Porto Alegre. With funding from the Shell Foundation, EMBARQ forms partnerships with local organisations and helps devise sustainable transport strategies.
http://www.embarq.wri.org

GTZ Sustainable Urban Transport Project (SUTP)

GTZ's SUTP promotes sustainable transport through information dissemination, especially by way of the "Sustainable Transport Sourcebook". GTZ has been particularly instrumental in providing a BRT training course to various cities. The course allows cities to build BRT capacity as well as initiate thought on local design options.
http://www.sutp.org and http://www.sutp.cn

Clean Air Initiative for Asian Cities (CAI-Asia)

The Clean Air Initiative for Asian Cities (CAI-Asia) works to improve the air quality of Asian cities. In December 2005, CAI-Asia launched a US$5 million programme called Sustainable Urban Mobility in Asia, which will promote sustainable transport initiatives, such as BRT. SUMA is supported through funding from the Swedish International Development Agency (Sida), the Asian Development Bank (ADB), and others.
http://www.cleanairnet.org/caiasia

bus priority lanes as well as to modernise the vehicle fleet (Figure 1.1)

In other instances, environmental organisations have led the charge due to the unsustainable nature of existing conditions, especially when private vehicle usage begins to overwhelm a city's streets and greatly harm the area's air quality. Box 1.1 notes a few of the organisations that have worked to improve urban transport conditions in the cities of developing countries.

In a similar manner, groups affected by deteriorating urban conditions, such as physicians, air quality professionals, tourism specialists, and police, may also play a contributing role in propagating the need for change. Additionally, university researchers and staff can provide the technical evidence of the costs of existing conditions as well as be the source of new ideas. In Delhi (India), staff from the Indian Institute of Technology have been leading the way with the city's new BRT system.

Likewise, the existing conditions for drivers, conductors, and transport owners may stimulate a search for a better model. In many instances, the private sector interests delivering public transport services in developing-nation cities struggle to make a living. Through awareness of successful models in cities such as Bogotá and Curitiba, private operators can see that forming an integrated network and providing a higher level of service can indeed lead to greater profit. Thus, the inspiration for change may well be initiated from the private sector.

The news media may also play a prominent role in raising awareness on existing conditions. Articles, images, and film of poor-performing public transport services can help to coalesce public opinion around the need for change. Further, articles and video on the successes in other cities may stimulate many to ask why the same could not be done in their own city.

Finally, international organisations can play a vital role in facilitating information sharing between projects as well as facilitating direct financial and technical assistance to cities. Such organisations can help to share experiences, raise awareness amongst local groups, and build the local capacity for a new project to take hold. International non-governmental organisations such as the Institute for Transportation & Development Policy (ITDP), the Embarq programme of the World Resources Institute (WRI), and the Energy Foundation have been instrumental in providing cities with both the inspiration for change and the tools to achieve it (Figure 1.2).

Fig. 1.2
The Energy Foundation helps build BRT capacity in China through seminars and outreach.
Photo by Lloyd Wright

The international private sector is also now playing an increasing role in raising awareness of mass transit options. For example, Volvo is now partnering with municipalities in nations such as India to build the capacity for options such as BRT (Hindu Business Line, 2006). While clearly private firms have their own commercial incentives for favouring one technology over another, these firms help can help to put forward ideas within the context of a competitive marketplace.

Bi-lateral agencies such as the German Technical Cooperation (GTZ), the Swedish International Development Agency (Sida), and the United States Agency for International Development (USAID) all have helped to facilitate public transport initiatives in developing-nation cities.

International funding organisations such as the Global Environment Facility (GEF) and the Hewlett Foundation likewise are key catalysts in this process. Further, international financing organisations such as the World Bank and the regional development banks not only help to financially support projects but often work to raise awareness and provide supportive guidance.

Additionally, international organisations such as the Clean Air Initiative (CAI), the United Nations Centre for Regional Development (UNCRD), the United Nations Development

Programme (UNDP), and the United Nations Environment Programme (UNEP) have also provided assistance to cities on sustainable transport issues. Municipalities thus have a plethora of international resources at their disposal to undertake a public transport improvement initiative. In many cases, it is merely a matter of contacting the right individuals to make such co-operation available.

From the concerned individual to a local civic organisation to universities and the news media and to international groups, there are a range of parties able to spark change towards improved urban transport. Any city can take advantage of these linkages to catalyse change. However, to date, most cities have not taken such a transformative step. While the gulf between problem recognition to construction of a modern mass transit system seems quite daunting, particularly to developing-nation cities, this chasm can be overcome with the array of resources now available to cities. Very often, it requires just one individual to provide the initial spark.

1.2 Political commitment

"I have never learned to tune a lute or play upon a harp, but I can take a small and obscure city and raise it to greatness."

—Themistocles, Athenian statesman, 525–460 BC

Ultimately, though, a project concept must enter the political mainstream in order to move towards official development. A leading political official must make a strong commitment to overhauling the city's public transport system. Political will and commitment are probably the most critical and fundamental components in making a new system a reality. Outside groups can certainly help to create the right conditions for project consideration, but as a public good, public transport requires political support to become a reality.

While almost all political officials will claim to hold strong political will and commitment to public transport, the reality is often quite different. Is an official willing to give priority road space to public transport over private vehicles? Will the official risk upsetting powerful lobbying groups such as existing transit operators and private motorists? Will the official seek out the best technical help they can find, and the best financial resources to make a project happen? Convincing officials to say yes to each of these questions is the basis of establishing project commitment. "Political will" are just words until backed up by tangible evidence of a serious intent to fully implement a project.

1.2.1 Political officials

"In Spanish we have this saying that it doesn't cost anything to dream. So I say let's play. Let's just imagine how you want your home to be. How you want your kids to live. Do you want to walk or drive to get bread? That's the basis of thinking about cities. We have not given

Fig. 1.3 and 1.4

Former Mayors who transformed their cities with BRT:
1. Enrique Peñalosa of Bogotá (left photo); and
2. Jaime Lerner of Curitiba (photo above).

Left photo courtesy of Por el Pais que Queremos (PPQ);
Right photo courtesy of the Jaime Lerner Foundation

enough thought to how we live. We have left too many of these decisions to others."

—Enrique Peñalosa, former Mayor of Bogotá

The creation of a political 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. Both former Mayor Enrique Peñalosa of Bogotá and former Mayor Jaime Lerner of Curitiba came to office with a strong intent to improve public space and transport (Figures 1.3 and 1.4). They also possessed a base knowledge on these topics and brought with them highly trained professionals as their core staff. 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. Naturally, the more senior the political figure leading the cause, the more likely the official's influence can lead to action. Thus, mayors and governors are the logical targets for gaining political support. In many cases, as in Jakarta and Dar es Salaam, key local politicians can quickly realize that BRT can help them politically, because it can show results within their administration. In some developing cities, support from national ministry officials may also be necessary for project approval. The role of national officials may be particularly required in capital cities.

In many instances, a mayor or governor will lack the necessary background on transport or urban planning issues. It requires confidence to grapple with a wide-spread transformation of the public transport system. In such cases, building the trust of the decision maker and giving them the necessary confidence to implement such a seemingly far-reaching proposal will be key. Political officials will be averse to risk with key constituencies, such as car owners and transit operators, unless the issue is a core part of their platform.

Further, mayors and governors are busy individuals juggling an array of issues and interests. The amount of time these officials can devote to a studied consideration of a public transport transformation is limited. For this reason, it may be more effective to target the top advisors of the mayor or governor. Such individuals may be able to give the idea greater attention, and then subsequently they would be in a position to make a trusted recommendation to the top political official.

However, even in the absence of support at the highest levels, a strategy to begin influencing officials at lower levels may still merit effort. Fortunately, there are many other starting points within the city's political and institutional environment. Deputy mayors, deputy governors, and councillors are also relevant positions from which a project can be launched. Amongst such officials it may be more likely to find a specialist with a background in transportation, environmental issues, urban planning, or other related fields. In such cases, the learning curve will likely be less.

Another useful starting point can be unelected officials holding key positions within municipal institutions. Directors and staff within departments of planning, public works, environment, health, and transportation all will likely play a role in any eventual project. Without the support of such officials and staff, institutional inertia can delay and weaken implementation. Further, these officials often have a direct relationship with top elected officials. During their daily or weekly briefings with elected officials, technical staff can prompt a discussion of public transport options. A concept being supported by both citizen's groups and departmental directors will stand a better chance of approval by a mayor than a project being pursued by just one outside group.

The best strategy is actually to approach all relevant officials, both elected and unelected, who may be influential on public transport. Even if an official is unlikely to become an overt supporter of a mass transit initiative, eliminating the threat of overt opposition is equally important. Thus, an initial pre-emptory session with the potential opposition can be vital to reducing any strongly-negative repercussions. Much care must be given to the manner in which the issue is presented to any given audience. In fact, the key points to be stressed will likely vary from one official to another given their different starting points and initial understanding of mass transit options.

One common and rather unfortunate complication is the existence of opposing political parties in key positions overseeing the project. For example, if the local government control is held by one political party while the regional or national government is held by another party, then cooperation may be lacking in making the project a reality. The lack of cooperation between national and local officials has delayed implementation of the Bangkok BRT project. While local government will typically have direct implementation responsibility, approval from the national government could be required for either budgetary or legal reasons.

The duration of the political administration's time in office is also another key factor to consider. If a mayor or governor has only a short time remaining prior to an election, then such officials may be reluctant to embark upon any bold initiative. The risk of alienating any potential voting groups can over-ride any political boost that a project announcement could entail. Further, once an incumbent takes a strongly favourable position on a mass transit option, this position may imply an equal and opposite reaction from the opposition candidates.

For these reasons, catching a political official at the earliest stages of their time in office provides the best chance for achieving commitment to implementation. Often, a major selling point for mayors and governors of an option such as BRT is that it can be built easily within a single term of office, helping to establish the politician's career. It may also be effective to introduce mass transit options even prior to officials taking office. Providing information to staff within the major political parties can be a worthwhile investment of time and effort. Identifying potential future leaders and establishing a mentoring relationship with them can be equally useful.

Fig. 1.5
International visitors gain many insights by speaking with TransMilenio technical staff in Bogotá.
Photo by Lloyd Wright

1.2.2 Awareness raising mechanisms

"Nobody made a greater mistake than he who did nothing because he could only do a little."
—Edmund Burke, philosopher, 1729–1797

There are several different mechanisms available to help alert political officials to the potential of different public transport improvement options. These mechanisms include:

- Site visits to successful public transport systems;
- Tour of own city's existing public transport services;
- Visits from successful Mayors;
- Basic information provision on options;
- Videos on public transport improvement examples;
- Simulation video of a potential system in the particular city;
- Physical models of public transport options;
- Pre-feasibility study.

These various mechanisms are not mutually exclusive, as several different information techniques can be combined to build a case on the need for change. Frequently, all it takes to generate political interest is to provide fairly basic information to mayors and other decision makers.

In most cases, however, firm political resolve only comes after the chief decision maker visits a successful system like Bogotá or Curitiba to see it and understand it for themselves. "Seeing is believing" is completely true in the case of BRT and other effective public transport options. Usually the decision makers are also accompanied by senior technical staff that will be responsible for implementing the project. Members of the city's media as well as existing public transport operators may also participate in the visit. By speaking directly with technical staff and political officials in cities with existing systems, perspective system developers can understand the possibilities in their own cities (Figure 1.5). Experiencing a high-quality system in a relatively low-income city such as Guayaquil also shows city officials that a system is possible regardless of local economic conditions. In many instances, the process to develop a new public transport system can seem quite overwhelming at the outset. Seeing systems in practice and walking through the development process can do much to dispel uncertainties and fears. At the same time, care should be exercised not to give the wrong impression that project implementation is always easy, fast, and problem free.

Surprisingly, political officials and even municipal technical staff can be relatively unfamiliar with public transport in their own city. Given the background and income levels of such persons, many will utilise their own private vehicle for transport. In the case of top elected officials, their only view of daily transport issues may be from the back of a chauffeur-driven luxury vehicle (Figure 1.6). Thus, public transport systems are frequently conceptualised and designed by individuals with relatively little actual familiarity with the daily realities of transit travel.

Organising a tour of the public transport conditions in an official's own city can be an eye-opening experience for the official. In cities such as Bogotá, Delhi, Johannesburg, and São Paulo officials have either made a point to regularly utilise public transport and/or have required staff to use public transport for certain periods of time (Figures 1.7 and 1.8).

Fig. 1.6
The only perspective many decision makers have on transport is based on a chauffer driven ride to work each day.
Photo by Lloyd Wright

Testimonials from one political official to another may sometimes be appropriate. Visits to cities by prominent former mayors such as Enrique Peñalosa and Jaime Lerner have been sponsored by international organisations to help catalyse local actions. Showing how mayors and governors who delivered high-quality systems have tended to win subsequent elections can also be quite motivating to local officials.

Advances with information and communications technologies (ICT) have put the power of sophisticated visual and software tools in the hands of most municipalities. Visual renderings of stations, vehicles, and runways can do much to excite political officials over the possibilities (Figure 1.9). Videos on high-quality public transport systems in cities such as Bogotá,

Fig. 1.7 and 1.8
Leading political officials such as former Mayor Enrique Peñalosa of Bogota (photo below) and South African Minister of Transport, Jeff Radebe, make a special effort to experience public transport for themselves.
Left photo courtesy of PPQ.
Right photo courtesy of the South African Ministry of Transport

Fig. 1.9
A rendering of the proposed BRT system in Dar es Salaam, using a combination of digital photography and graphic design software.
Image courtesy of Luc Nadal and ITDP

Brisbane, and Curitiba provide an accurate visual display of the options to decision makers. Likewise, the digital video technology is now available to simulate how a new system would actually operate in a city of interest. Being able to "virtually ride" the new system at an early stage in the planning process cannot only work to stimulate political commitment but it can also help planning staff with design considerations. In a similar manner, small models of vehicles, stations, and runways all help to give political officials a hands-on feel with the possibilities (Figure 1.10).

As noted in the Introduction to this Planning Guide, a pre-feasibility study is also an effective mechanism to build initial interest towards public transport improvement. The pre-feasibility work can include the identification of major corridors for mass transit development, early estimates of potential benefits (economic, environmental, social, etc.), and approximations of expected costs. This work will be of a fairly superficial level but will at least give decision makers a degree of confidence in a possible project direction. The faster and more compelling this early vision of the new system, the easier it will be for decision makers to build the necessary political commitment to move forward. This early vision will be needed to persuade the public and interested parties to support the project, and to guide the information gathering process.

The techniques to achieving project commitment are varied, and can depend greatly upon the local context, but the principal aim is to get the chief decision maker to make a public commitment to implement a major transformation of the public transport system, and to create a sense of expectation amongst the public.

1.3 Statement of vision

"If you want to build a ship don't drum up the men to fetch the wood, allocate the jobs and divide the work, but teach them the yearning for the wide open sea."

—Antoine de Saint-Exupéry, writer and aviator, 1900–1944

As has been stressed, political leadership is probably the single most important factor in realising a successful public transport 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 transport.

An initial vision statement from the political leadership marks an important first step in mak-

Fig. 1.10
Small-scale models, as shown here with a proposed terminal facility in Quito, helps give decision makers a three-dimensional understanding of the physical infrastructure.
Photo by Lloyd Wright

ing the case for improved public transport. 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. Thus, the statement will set the agenda for the ensuing planning activity. Examples of the type of phrases that can form part of the vision statement include:

- "Provide a high-quality, cost-effective public transit system that will ease congestion, reduce contamination, and ensure public confidence in the city's transit service."
- "Establish a fast, comfortable, economic, and car-competitive mass transit system that will serve the mobility needs of all segments of the city's population, even current owners of private vehicles."
- "By developing a modern public transport system for the twenty-first century, the city will become increasing competitive, attract more investment and tourism, and ultimately stimulate the economy and job creation."
- "Place over 80 percent of the city's population within 500 metres of a mass transit corridor."
- "Provide a one-ticket service that will allow a person to travel to any point of the city in less than 30 minutes with no delays from congestion."

While this initial vision statement will be quite broad in scope, the message can become more detailed and specific as the project progresses. Subsequent pronouncements can detail more precisely costs, travel times, and amenity features of the new service.

The announcement should be placed within an overall press and media strategy for the project. The press and media organisations should be thoroughly briefed about the vision being put forward. These organisations should also be given a basic overview of the various mass transit options and their potential for the city. In some cases, press visits to cities with existing systems can help reinforce the positive attributes of the project.

1.4 Barriers to transit improvement

"The great tragedy of science—the slaying of a beautiful hypothesis by an ugly fact."

—Thomas Huxley, biologist and writer, 1825–1895

The case for improving public transport quality would seem to quite strong. The economic, environmental and social benefits are actually quite well documented (Litman, 2005a). However, major public transport improvement initiatives are actually quite rare. The barriers to public transport improvement often overwhelm the call to action. Understanding the likely obstacles to be faced allows project developers to devise strategies for countering this opposition.

Some of the most significant barriers include:

- Lack of political will;
- Governance;
- Opposition from key stakeholders (existing public transport operators, motorists, etc.);
- Political and institutional inertia;
- Institutional biases;
- Lack of information;
- Poor institutional capacity;
- Inadequate technical capacity;
- Insufficient funding and financing;
- Geographical / physical limitations.

Political will is by far the most important ingredient in making a public transport initiative happen. Overcoming resistance from special interest groups and the general inertia against change is often an insurmountable obstacle for mayors and other officials. However, for those public officials that have made the commitment, 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. To achieve this success, a great deal of political capital was expended to convince project detractors, the mass media, and the general public.

Many political officials may be reluctant to undertake a BRT project due to the perceived risks, especially in relation to upsetting powerful special interest groups. Motorists and existing public transport operators will tend to resist such change. Thus, political officials may end up playing it safe by avoiding any type of major public transport initiative that will risk

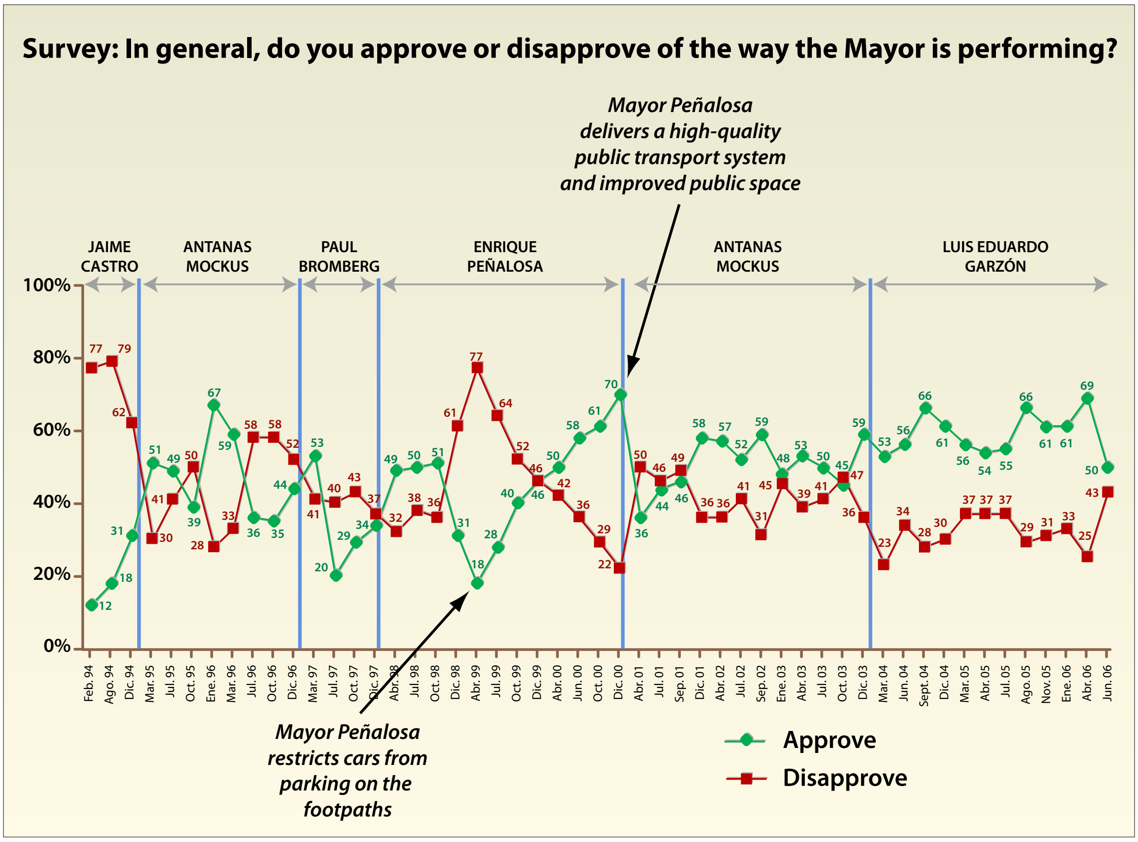


Fig. 1.11
Approval ratings of Bogotá Mayors

alienating specific stakeholders. However, when officials take the perceived low-risk path of inaction, the ensuing political rewards will certainly be diminished.

The trajectory of the popularity of former Mayor Enrique Peñalosa makes for an interesting comparison (Figure 1.11). Mayor Peñalosa implemented transport and public space changes in Bogotá that was a major shock for many persons. Under Mayor Peñalosa laws preventing persons from parking on the footpaths were enforced for the first time. Outraged motorists led a campaign to impeach Mayor Peñalosa. At this point in his term in office, Mayor Peñalosa suffered through one of the lowest popularity rankings recorded by a Bogotá mayor. However, subsequently, something rather miraculous occurred. As Mayor's vision and projects came into reality, the public responded in quite a positive manner. With the new cycle ways, the improvements in public space, and the TransMilenio BRT system, citizens could see the transformation of a city. By the time, Mayor Peñalosa finished his three-year term, he ended with the highest popularity ratings ever recorded by a Bogotá mayor.

It is quite likely that a political official with less drive and passion for public space and sustainable transport would have reversed course at the first sign of upset motorists. Instead, the risk taken by Mayor Peñalosa to transform the city and the public transport system resulted in significant political rewards and international fame.

While automobiles may represent less than 15 percent 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 public transport vehicles from other traffic may often improve conditions for private vehicles. However, motorists may only understand this benefit once the system is operating. Prior to the project, car owners may only see BRT as an intruder that is stealing road space.

Existing public transport operators will likely also view BRT as a threat to their interests and livelihood. In cities such as Quito (Ecuador), the existing operators took to violent street demonstrations to counter the development of the BRT system. The government ultimately called in the military to disperse the protests after the operators shut down public transport in the city for four days. 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. In Bogotá, the existing operators launched seven different strikes to protest the development of TransMilenio. Today, many of these same operators are shareholders of concessionaire companies in TransMilenio, and these operators have seen a significant increase in profits. Few, if any, would want to revert back to the previous system.

The professional staff within municipal agencies may also represent a barrier to public transport improvement. Such staff often do not utilise public transport as the primary means to travel. Instead, municipal officials are part of a middle class elite who have the purchasing power to acquire a private vehicle. Thus, the professionals who are responsible for planning and designing public transit systems frequently do not use public transit. This lack of familiarity with user needs and realities can result in less than optimum public transport design. Such staff may also unwittingly give funding and design preference to individual motorised travel since this mode is the one with which they are most familiar.

Despite the rise of global information networks, a lack of knowledge of options like BRT remains a very real barrier. The long period of time between the development of the system in Curitiba and the realisation of BRT by other cities is evidence of this information shortfall. Through the assistance of international agencies and non-governmental organisations, awareness of BRT has risen sharply in recent years. Visits to Bogotá by city officials from Africa and Asia have helped to catalyse new BRT projects. Nevertheless, many developing cities still do not have the basic information required to develop a transit improvement initiative.

The lack of information at the municipal level often occurs in direct correlation with the lack of human resource capacity. The transport departments of many major developing cities must cope with a wide array of issues with only a handful of staff. The lack of institutional and technical capacity at the local level inhibits the ability of agencies to consider projects even when general awareness of the opportunity is present.

Financing can also be an issue with public transport projects, although it tends to be less of an issue with lower-cost options such as BRT. Access to capital and the cost of capital can be real constraints, especially for more costly forms of public transport infrastructure. Additionally, the lack of resources to sustain any sort of operational subsidy means that systems must be largely designed to be financially self-sustainable.

Various local conditions, such as urban, geographical and topographical factors, can also present barriers to implementation. For instance, extremely narrow roadways and steep hills can pose design challenges. However, in general, there are technical solutions to each one of these issues. Local conditions require local solutions, which ultimately makes each project unique in its own way.

All of the barriers and challenges noted in this section can be overcome. Nevertheless, for many municipalities, these issues greatly dampen the ability to initiate a project. Project champions will need to provide answers to each of these barriers that represent a threat to project acceptance.

1.5 Benefits

"Nothing is ever done until everyone is convinced that it ought to be done, and has been convinced for so long that it is now time to do something else."

—F.M. Cornford, author and poet, 1874–1943

Perhaps the best answer to critics of public transport initiatives is the overall benefit that such initiatives bring to a city and the quality

Table 1.1: The benefits of public transport initiatives

Factor	Impacts / indicators
Time savings benefit to transit users	• Labour productivity • Quality of life
Time savings benefit to mixed traffic vehicles	• Labour productivity • Delivery efficiency for goods and services
Fuel savings from public transport operations	• Reduced fuel expenditures for public transport operators • Reduced fuel expenditures for vehicles in mixed traffic • Reduced dependency on imported fuel or reduced usage of domestic supply
Air quality improvements (reduced emissions of CO, NO_X, PM, and SO_X)	• Human health • Preservation of built environment • Preservation of natural environment • Labour productivity
Greenhouse gas emission reductions	• Global environment
Noise and vibration reductions	• Human health • Labour and educational productivity • Built environment
Other environmental improvements	• Reduced solid and liquid wastes • Reduced impacts on flora and fauna
Transit system employment	• Construction employment • Operational employment Commercial sector • Property values • Shop sales • Employment generation
Amenity benefits to transit passengers	• Comfort of passengers • Prestige of system Social benefits • Reductions in crime and social problems in area • Sociability of street environment • Equity for low-income groups • Increased civic pride and sense of community
City image	• City-wide pride • Tourism
Urban form	• More sustainable urban form, including densification of major corridors • Reduced cost of delivering services such as electricity, sanitation, and water
Political	• Delivery of mass transit system within one political term • Delivery of high-quality resource that will produce positive results for virtually all voting groups

of life of its inhabitants. In many cases, these benefits can be directly quantified to produce results in monetary terms. In other cases, the qualitative benefits can also be assessed within a logical framework.

Table 1.1 outlines some of the direct benefits that public transport improvements have provided to cities. Beyond these benefits, though, there exist multiplier impacts that can further increase the value to a municipality. For example, public transport projects can lead to reduced public costs associated with vehicle emissions and accidents. Such impacts include costs borne by the health care system, the police force, and the judicial system. In turn, by reducing these costs, municipal resources can be directed towards other areas such as preventative health care, education, and nutrition.

Methodologies for estimating the economic, environmental and social impacts of BRT are included in later sections of this Planning Guide.

2. Public transport technologies

"For a successful technology, reality must take precedence over public relations, for nature cannot be fooled."

—Richard P. Feynman, physicist, 1918–1988

Choosing the type of public transport technology for a city can be a highly polemical process. Given the various interest groups involved and the substantial private sector contracts at stake, the process can become quite politicised. However, making the decision within a rational framework is the only way to ensure that the customer is truly served. This chapter attempts to provide such a framework, as well as offer a discussion on each decision variable.

The choice of public transport technology will affect travel times, personal transport expenditures, and commuter comfort and safety. The choice will also dramatically affect municipal finances and a city's economic efficiency. Ultimately, the selection will shape a city's urban form and the very lifestyle of its inhabitants. Thus, an objective and effective evaluation process is an essential part of responsible and coherent decision making.

While this Planning Guide focuses upon BRT, it is only one of many different public transport options. For many cities, BRT is a highly cost-effective option for delivering a full system network that provides customers with a car-competitive public transport service. However, there are also conditions in which metro rail, light rail transit, and even conventional bus services may be the more appropriate technology choice. This chapter sets forward some of the key considerations in making a decision on the type of public transport system. Ideally, cities can establish a healthy competition between different technology options in order to ensure the most appropriate option is selected.

The topics discussed in this chapter include:

2.1 Introduction to public transport technologies

"The technologies which have had the most profound effects on human life are usually simple."

—Freeman Dyson, physicist, 1923–

2.1.1 Public transport typologies

Public transport in its broadest sense refers to collective passenger services. It can thus include the assortment of both the paratransit and formal services found in cities around the world. Public transport thus encompasses shared taxis, mini-vans, conventional bus services, BRT, water-based services, and rail-based services. *More specifically, Mass Rapid Transit (MRT) is a collective urban passenger service that operates at high levels of customer performance, especially with regard to travel times and passenger carrying capacity.* Mass rapid transit can achieve reduced travel times through the provision of widely accessible networks, higher speed vehicles, exclusive right-of-way infrastructure, special limited-stop or express services, efficient fare collection systems, and/or faster boarding and alighting techniques. Higher carrying capacities may be achieved through larger vehicles, multiple sets of vehicles (*i.e.,* a bus platoon or a train), and/or more frequent service.

Box 2.1 defines the major categories of public transport typologies. There is a wide range of permutations possible with each technology. Some LRT systems may blur the boundaries with the definition of a metro when LRT is utilised on grade-separated infrastructure. Likewise, some BRT systems have segments that go underground or on elevated structures. Nevertheless, Box 2.1 provides a general typology for public transport technologies. The continued innovation from public transport developers is likely to mean that these definitions will also continue to evolve.

Box 2.1: Types of public transport technologies

Bus Rapid Transit (BRT) – Bus-based technology typically operating on exclusive right-of-way lanes at the surface level; in some cases underpasses or tunnels are utilised to provide grade separation at intersections or in dense city centres.

Light Rail Transit (LRT) – Electric rail-based technology operating either as a single rail car or as a short train of cars, typically on exclusive right-of-way lanes at the surface level with overhead electrical connectors.

Trams – Trams can also be considered a type of LRT, but typically utilise smaller-sized carriages and may share road space with other forms of traffic.

Underground metro – A heavy rail transit system operating on grade separated tracks that are located principally underground.

Elevated rail transit – A rail transit system operating on grade separated tracks that are located principally on an aerial structure; elevated systems can also be considered a form of metro.

Suburban rail – A heavy rail transit system operating on exclusive right-of-way tracks that are located principally at the surface level but generally grade separated; typically carries passengers between suburban and urban locations; differs from other urban rail systems by the fact that carriages are heavier and the distances travelled are usually longer.

Personal Rapid Transit (PRT) – A rail- or wheel-based system carrying passengers in small Automatic Guided Vehicles (AGV); PRT typically operates on exclusive right-of-way lanes that may also be grade separated.

Bus Rapid Transit (BRT) is thus just one of the many public transport technology options. Additionally, there are a range of rail-based public transport systems that are possible, including underground metros, elevated rail systems, Light Rail Transit (LRT), and trams (Figures 2.1 through 2.6). No one of these options is inherently correct or incorrect. Local conditions and local preferences play a significant role in determining the preferred system type.

Additional types of public transport technologies are also possible. While monorail and maglev train technologies could be considered a form of elevated rail transit, these technologies are also distinctive enough to be considered as separate public transport categories. Monorail technology has been in existence for the past forty years with particular implementation experience in Japan. Some new monorail systems are still being built, such as the Las Vegas monorail, which opened in 2004.

Maglev technology is quite new and holds the potential to increase vehicle speeds considerably. The only current passenger application of maglev is found in Shanghai (China), where speeds of over 400 km per hour are reached on a 30-kilometre line between the city and its new international airport. However, at a cost of over US$300 million per kilometre, the technology is unlikely to be replicated elsewhere for the foreseeable future. Further, for many transport professionals, maglev technology is seen more as a competitor of air travel for inter-city travel rather than a practical solution within the urban public transport sector. Nevertheless, maglev represents an interesting new technology that may have future applications.

Personal Rapid Transit (PRT) is another relatively new phenomenon that is being developed as an option in lower-density developed cities. PRT utilises Automatic Guided Vehicles (AGV) that avoid the need of a driver, and thus help developed cities to reduce their relatively high labour costs in public transport operations. These vehicles may be either rubber tyre- or rail-based, and are somewhat small in size with each vehicle carrying in the range of two to six passengers. The idea behind PRT is to combine the flexibility of taxi services with the automation of fixed-track systems. A PRT system offers the






Fig. 2.1, 2.2, 2.3, 2.4, 2.5, and 2.6
Rail transit comes in a variety of forms.
Photos:
1. Hong Kong subway
(Photo courtesy of Hong Kong MTR)
2. Bangkok elevated Skytrain
(Photo by Lloyd Wright)
3. Osaka monorail
(Photo by Lloyd Wright)
4. Hankyu suburban rail system
(Photo by Lloyd Wright)
5. Strasbourg LRT system
(Photo by Manfred Breithaupt)
6. Bucharest tram
(Photo by Lloyd Wright)

potential to provide each customer with their own personal routing option, and thus leading to more point-to-point travel. The systems also combine the privacy of smaller vehicles with the advantages of a public system. The challenge for these systems is to deliver a product that is cost competitive with conventional public transport options. To date, only a few experimental systems have been developed (Figure 2.7). For these reasons, PRT is not presented in any further detail in this document.

Fig. 2.7
Personal Rapid Transit (PRT) attempts to combine aspects of both public and private transport vehicles.
Image courtesy of ULTra

2.1.2 Rail versus road

The innovation demonstrated by certain technology firms has in many ways already rendered traditional definitions obsolete. The distinctions between rail and road are increasingly being blurred by technologies that cross both realms (Figures 2.8 through 2.11). For example, the Mexico City and Paris metro systems utilise rubber-tyred vehicles, but these systems clearly give the appearance of full rail technology. The Translohr vehicle being developed for new systems in Clermont-Ferrand (France), L'Aquila (Italy), Mestre-Venice (Italy), and Padua (Italy) is a rubber-tyred tramway operating within a dedicated track. The "Transport sur Voie Reservée" (TVR) systems, developed in such cities as Caen and Nancy in France, utilise modern, rubber-tyred vehicles that operate both on and off a dedicated runway. Finally, the modernistic Civis by Irisbus is a rubber-tyred vehicle with a rounded-front and covered wheels that produces a distinctive LRT-like appearance. Such vehicles are utilised by systems in cities such as Rouen (France) and Las Vegas (US). With its enclosed stations and dedicated lanes, the Bogotá BRT system in many ways more closely resembles a metro system than a conventional bus system. As these examples demonstrate, the line between rail and road can be quite fine and perhaps somewhat irrelevant. Whether a system is called BRT or LRT or metro perhaps matters less than whether the system meets the needs of the particular customer.

Given that mass transit implies a certain level of both capacity and speed, some systems are technically better described by the more general term of "public transport" than "mass transit". Whether a system qualifies as "mass transit" is dependent both on the nature of the technology and the circumstances of the particular city. Trams and at-grade LRT systems typically carry less than 12,000 passengers per hour per direction (pphpd) and thus are perhaps more precisely defined as "public transport" technologies. Bogotá's BRT system carries as many as 45,000 pphpd and thus would likely be considered a mass transit system. However, many other BRT systems operate in cities with much lower demand and speed characteristics, and thus would likely not be considered "mass transit". Metro and elevated rail systems are capable of operating at both high speeds and high capacities,

Fig. 2.8, 2.9, 2.10, and 2.11
All these images are of rubber-tyred vehicles, making the distinction between rail and road somewhat irrelevant. Photos clockwise from upper left:
1. Mexico City subway
(Photo by Lloyd Wright)
2. Translohr vehicle in Padova (Italy)
(Photo courtesy of Groupe LOHR)
3. Civis bus in France
(Photo courtesy of NBRTI)
4. TVR vehicle in Nancy (France)
(Photo by Klaus Enslin)

and thus typically qualify for the "mass transit" term. However, there are cases of metro systems operating at relatively low capacities, such as in Delhi and Kolkata, in which the "mass transit" term may not apply (Figure 2.12). The following discussion on public transport technologies will not distinguish precisely between the semantics of "mass transit" technologies and "public transport" technologies. Instead, it is recognised that the "most appropriate" technology is the one which best meets the needs of the customers within the context of their own local conditions.

2.2 Criteria in technology selection

"Western society has accepted as unquestionable a technological imperative that is quite as arbitrary as the most primitive taboo: not merely the duty to foster invention and constantly to create technological novelties, but equally the duty to surrender to these novelties unconditionally, just because they are offered, without respect to their human consequences."

—Lewis Mumford, historian and architectural critic, 1895–1990

The decision to select a particular technology depends upon many factors. Costs, performance characteristics, local conditions, and personal preferences have historically all played a role in the decision-making process. This section will outline some of the factors that should be considered in selecting the type of mass transit system for a city.

In recent years, significant debate amongst transport professionals has occurred on whether BRT or rail-based solutions are the most appropriate. Such competition between systems can actually be healthy as it implies an environment in which all technologies must strive to improve. A rigorous evaluation process will help ensure that a city makes the most appropriate choice.

The planning and decision-making process can be defined so that the ultimate outcome reflects the goals and objectives of the city in conjunction with the current and projected trends. Figure 2.13 outlines this process. The goals and objectives will likely in part reflect the vision statement developed by the political leader. Additionally, objectives regarding quality of life and city image will likely be part of the evaluation. Demographic trends will help to indicate the transport service levels required to meet the future form of the city.

Fig. 2.12
Rush hour on the Delhi metro.
Photo courtesy of ITDP

As the decision-making process enters actual comparisons between different public transport technologies, a framework for objectively evaluating each criteria should be clearly articulated. The evaluation process will likely begin with the widest number of options under consideration. As the evaluation proceeds, increasing levels of detailed analysis will be utilised to narrow the choices. Figure 2.14 illustrates this relationship between the number of alternatives and the level of detail in the analysis.

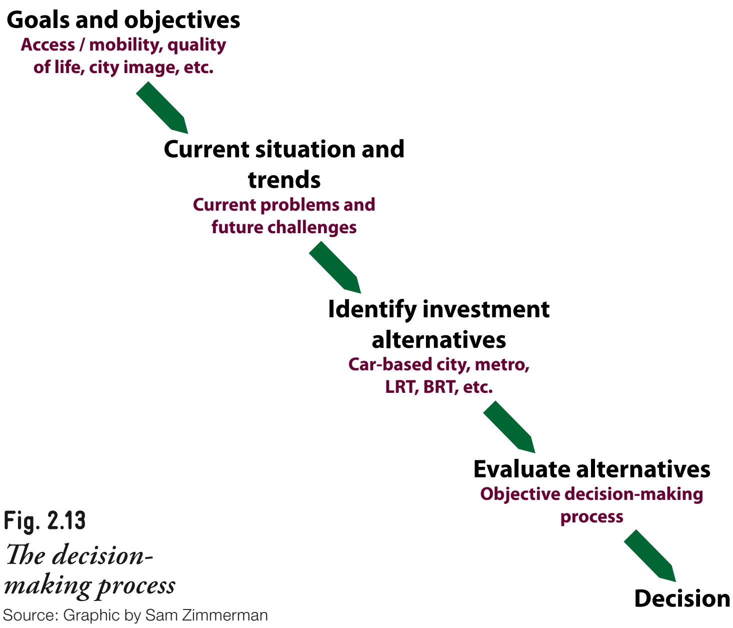


Fig. 2.13
The decision-making process
Source: Graphic by Sam Zimmerman

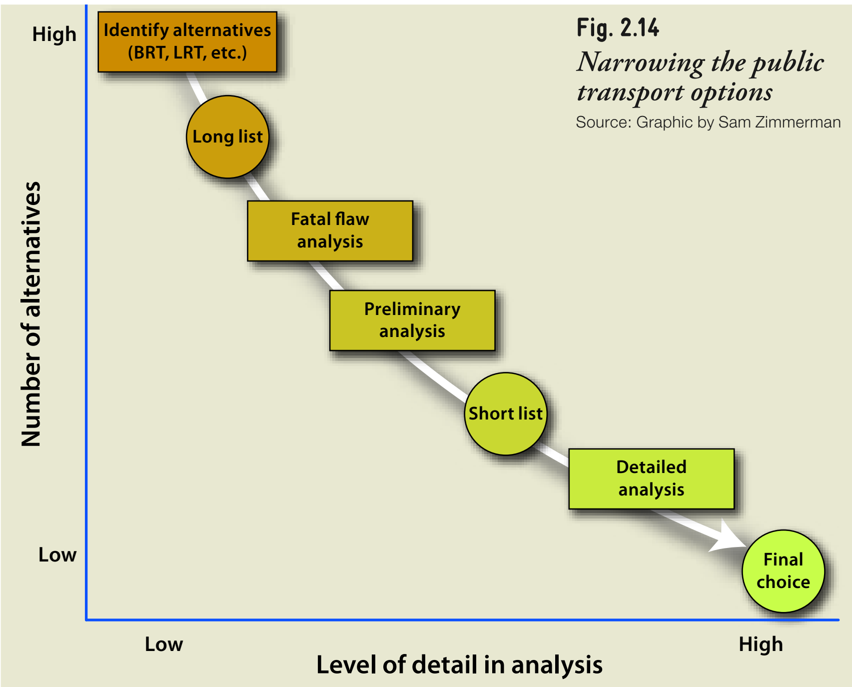


Fig. 2.14
Narrowing the public transport options
Source: Graphic by Sam Zimmerman

"Feasibility" studies and "cost-benefit" analysis may be utilised to determine in detail the financial viability of a particular option. In instances where only a single technology is considered, it is not uncommon for "feasibility" studies to almost always deliver a verdict of "feasible", irrespective of potentially better alternatives. Public transport technology decisions can thus become a self-fulfilling prophecy based upon political or personal preferences rather than customer needs.

In reality, a top-down approach that begins with a technology focus is perhaps not the ideal. It is much preferred to define desired public transport characteristics prior to selecting a particular technology. By understanding customer needs with respect to fare levels, routing and location, travel time, comfort, safety, security, frequency of service, quality of infrastructure, and ease of access, system developers can define the preferred type of service without bias toward any particular technology (Figure 2.15). Thus, much of the planning noted in this Planning Guide can actually be conducted without committing to one type of technology over another. In this scenario, the public transport technology is one of the last issues to be introduced in the decision-making process. Such a customer-orientated approach will likely have the best chance of producing a public transport service that can effectively compete with the private automobile.

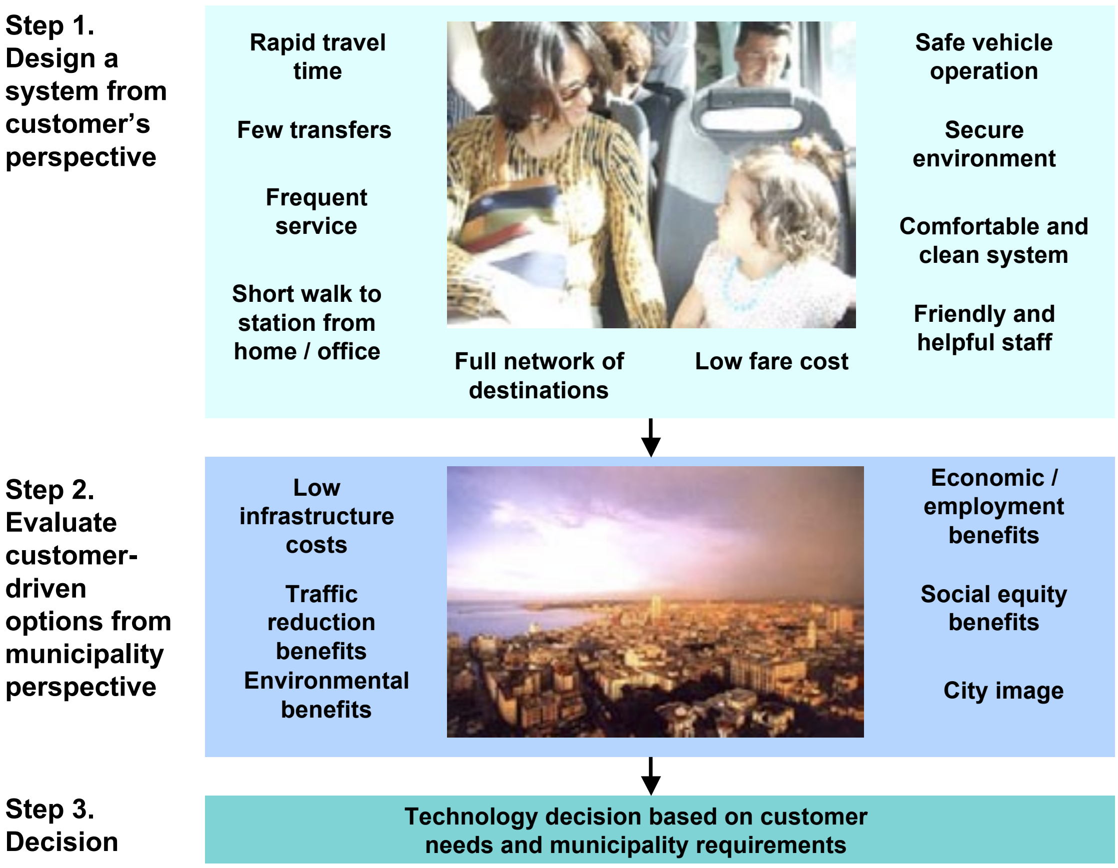


Fig. 2.15
Customer-oriented design: Shaping the technology around the customer.
Source: Graphic by Lloyd Wright

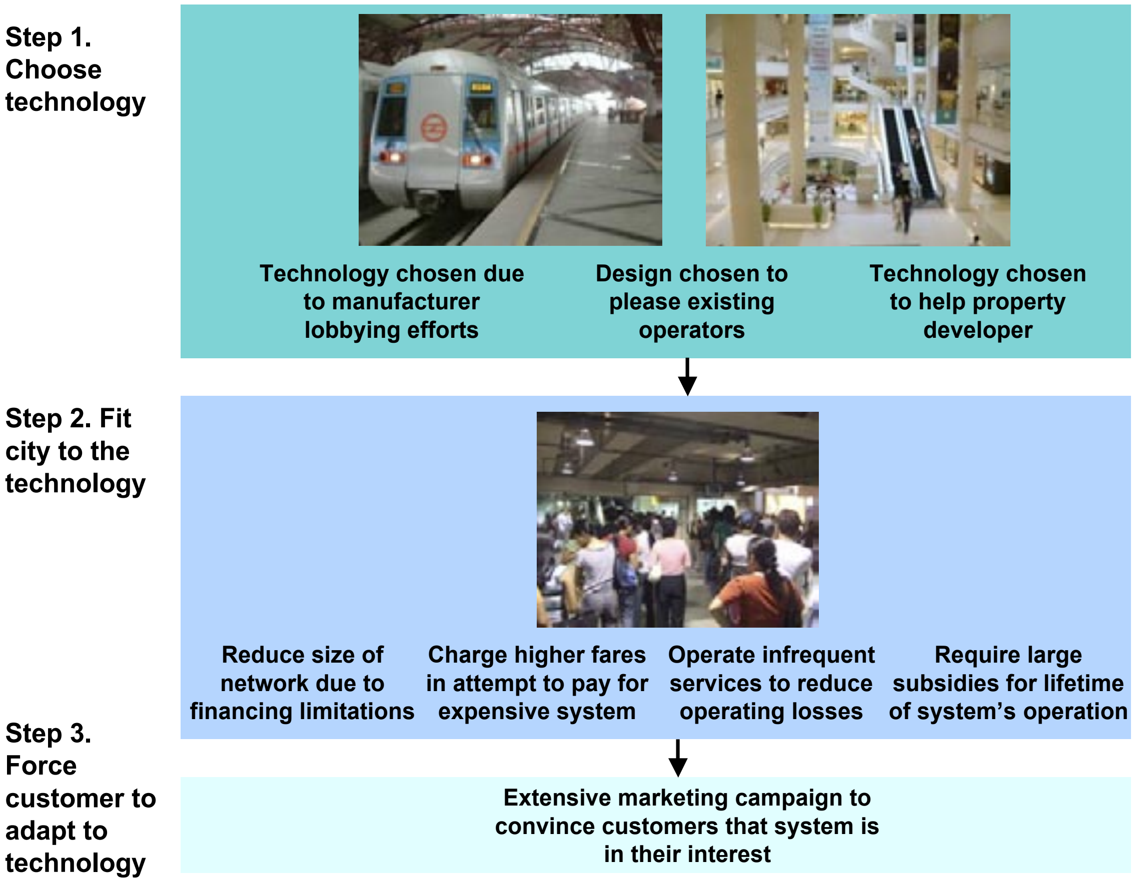


Fig. 2.16
Technology-driven design: Making the customer adapt to a technology.
Source: Graphic by Lloyd Wright

In practice, though, a political official or technical official will often state a preference for a particular technology at the outset. Such a choice may reflect an official's own personal experiences or may simply be the result of a convincing lobbying effort from interest groups or a salesperson of a particular technology (Figure 2.16). In such instances, the service is effectively being designed around a technology rather than the customer. If a technology requires a certain passenger flow to be cost-effective, then the corridors and routes will be designed around this characteristic. Clearly, though, what is good for a particular technology may not be ideal for the city residents as a whole.

In 1985, the then President of Peru made an afternoon flyover of the city by helicopter. From this vantage point, the President hastily selected a corridor for a new rail system. Unfortunately, the selected corridor did not match well with the actual demand for public transport services. The city spent an estimated $300 million from 1986 through 1991 to build and equip the first 9.8 kilometres of a planned 43-kilometre system (Menckhoff, 2002). High costs, poor location, and revised passenger estimates meant that the construction of the unused system was stopped, but the continued maintenance of the mothballed system is still a costly burden (Figure 2.17).

In other instances, a public transport system may be designed around the wishes of a property developer or a construction firm. The

Fig. 2.17
Except for the occasional llama, the "Tren Eléctrico" in Lima serves no actual customers.
Photo courtesy of Gerhard Menckoff

Table 2.1: Factors in choosing a type of public transport technology

Category	Factor
Cost	Capital costs (infrastructure and property costs) Operating costs Planning costs
Planning and management	Planning and implementation time Management and administration
Design	Scalability Flexibility Diversity versus homogeneity
Performance	Capacity Travel time / speed Service frequency Reliability Comfort Safety Customer service Image and perception
Impacts	Economic impacts Social impacts Environmental impacts Urban impacts

integration between the MRT3 and LRT2 rail systems in Manila require customers to make long walks through three shopping complexes. The intent of the interchange is not orientated towards customer convenience but rather towards maximising shop sales. In such cases, the desirability and usability of the public transport system is severely undermined. If instead the system is developed entirely around the wants and needs of the public transport customer, ultimately the greatest number of persons will benefit.

Thus, the choice of public transport technology should be based on a range of considerations with performance and cost being amongst the most important. As suggested, these requirements are ideally derived from an objective analysis of the existing and projected situation. Table 2.1 outlines categories of the characteristics that can help shape a city's decision towards the most appropriate type of public transport technology.

This chapter attempts to provide an objective review of each of these characteristics. Again, no one public transport solution is the right solution for all cities. The local circumstances and public policy objectives play a significant role in selecting the most appropriate public transport solution for any city.

2.2.1 Costs

"While real trolleys in Newark, Philadelphia, Pittsburgh, and Boston languish for lack of patronage and government support, millions of people flock to Disneyland to ride fake trains that don't go anywhere."

—Kenneth T. Jackson, historian

2.2.1.1 Capital costs (infrastructure and property costs)

For most developing-nation cities, the infrastructure costs will be a pre-eminent decision-making factor. Such cities often face a borrowing cap which acts as a ceiling to the total amount of borrowing that can be undertaken, based upon lending regulations set by institutions such as the International Monetary Fund and the World Bank. The lending capacity is often a function of the amount of loans currently outstanding as well as the level of debt relative to gross domestic product (GDP). Additionally, lending in the transport sector will have a direct impact on a city's ability to borrow for all critical functions, including such areas as water, sanitation, education, and health care. Thus, the decision on a city's public transport system will have broad ramifications affecting many facets of overall development.

Infrastructure costs

The exact capital cost of a system will depend upon many local factors, including:

- Local labour costs;
- Competitiveness of construction industry;
- Quality of management and organisational capabilities;
- Local physical conditions (topology, soil conditions, water tables, etc.);
- Design and safety requirements;
- Financing costs;
- Local content versus imported content of technology;
- Requirements to retire existing vehicle fleets;
- Levels of import duties;
- Property prices and level of expropriation required for system development;
- Level of competitiveness and openness in the bidding process.

Infrastructure cost comparisons

While it is possible to compare capital costs with other cities, the actual investment level will depend upon the nature of local conditions. Table 2.2 provides a sampling of capital costs from several different cities and several different mass transit technologies. In making such comparisons, one must take extra precaution that one is comparing the same set of cost factors. For instance, one technology bid may consider rolling stock (vehicles) to be part of capital costs while another bid may place the item in operating costs. Further, in some cases, systems may capitalise spare parts and regular maintenance activities while the more conventional treatment would be to expense such items under operating costs. For the purposes of developing a decision-making matrix between system types, one must be strict in categorising each cost type consistently. Any cost comparison should also ideally bring costs to a common base year in terms of currency values. Real rather than nominal cost values should be used when possible.

Table 2.2 indicates that BRT systems are typically in the range of US$500,000 per kilometre to US$15 million per kilometre, with most systems being delivered for under US$5 million per kilometre. By comparison, at-grade trams and light rail transit (LRT) systems appear to be in the range of US$13 million to US$40 million per kilometre. Elevated systems can range from US$40 million per kilometre to US$100 million per kilometre. Finally, underground metro systems seem to range from US$45 million per kilometre to as high as US$350 million per kilometre. The significant size of the various ranges again indicates the local nature of costing. Additionally, the range depends upon the individual features sought within each system (*e.g.,* quality of stations, separation from traffic).

The infrastructure cost per kilometre of system in conjunction with the likely financing capacity for the system will determine the overall size of the eventual public transport network. One of the most fundamental determinants of system usability to the customer is the extent of the overall network. A few kilometres of high technology will likely not coerce commuters into becoming customers. A limited system of only a few kilometres will mean that most of a person's essential destinations are not reachable by the system. When systems form a complete network across the expanse of a city, then the ability to function without using a private vehicle is considerably higher.

Figure 2.18 presents a graphical way of looking at the trade-off between infrastructure costs and network length. This figure is based on actual cost values for the Bangkok elevated rail system (Skytrain), the Bangkok subway system (MRTA), the proposed Bangkok BRT system (Smartway), and a proposed LRT system. As expected, the lower capital costs of BRT and LRT systems favour the development of a more extensive system at an equal cost.

From the customer's perspective, a full network serving most major origins and destinations

Table 2.2: Capital costs for different mass transit systems

City	Type of system	Kilometres of segregated lines (km)	Cost per kilometre (US$ million/km)
Taipei	Bus rapid transit	57.0	0.5
Quito (Ecovía Line)	Bus rapid transit	10.0	0.6
Porto Alegre	Bus rapid transit	27.0	1.0
Las Vegas (Max)	Bus rapid transit	11.2	1.7
Curitiba	Bus rapid transit	57.0	2.5
São Paulo	Bus rapid transit	114.0	3.0
Bogotá (Phase I)	Bus rapid transit	40.0	5.3
Tunis	Tram	30.0	13.3
San Diego	Rail trolley	75.0	17.2
Lyon	Light rail transit	18.0	18.9
Bordeaux	Light rail transit	23.0	20.5
Zurich tram	Tram	NA	29.2
Portland	Light rail transit	28.0	35.2
Los Angeles (Gold Line)	Light rail transit	23.0	37.8
Kuala Lumpur (PUTRA)	Elevated rail	29.0	50.0
Bangkok (BTS)	Elevated rail	23.7	72.5
Kuala Lumpur Monorail	Monorail	8.6	38.1
Las Vegas	Monorail	6.4	101.6
Mexico City (Line B)	Metro rail	24.0	40.9
Madrid (1999 extension)	Metro rail	38.0	42.8
Beijing Metro	Metro rail	113.0	62.0
Shanghai Metro	Metro rail	87.2	62.0
Caracas (Line 4)	Metro rail	12.0	90.3
Bangkok MRTA	Metro rail	20.0	142.9
Hong Kong subway	Metro rail	82.0	220.0
London (Jubilee Line ext.)	Metro rail	16.0	350.0

Fig. 2.18
Four systems at the same cost.[1)]

426 kilometres of BRT

40 kilometres of LRT

14 kilometres of elevated rail

7 kilometres of subway

Fig. 2.19
The Zurich tram system covers almost the entirety of its urban area, making it one of the world's few rail-based systems with such widespread service provision.
Image courtesy of City of Zurich

is fundamental to system usability. A system consisting merely of few kilometres or a single corridor makes the system relatively unusable to most customers. Forcing a customer to live, work, and fulfil all major daily activities in one corridor is typically an unrealistic assumption. Once a person opts for a private car to fulfil some trips, then the convenience and sunk cost of vehicle ownership will typically imply that virtually all trips by public transport are forgone.

A BRT system will likely permit a city to build a network 4 to 20 times more extensive than a tram or light rail system if the same budget is applied to both technologies. Thus, for most developing-nation applications, BRT is capable of providing more value for the given investment. However, some cities are capable of delivering

1) Assumes a total investment of US$1 billion to each system. Projected Bangkok BRT costs at US$2.34 million per kilometre. Hypothetical LRT system estimated at US$25 million per kilometre. Reported cost for Bangkok Skytrain (elevated rail) of US$72.5 million per kilometre. Reported cost of Bangkok MRTA (subway) of US$142.9 million per kilometre.

a rail-based system covering much of the urban area. The tram system in Zurich (Switzerland) is one of such examples (Figure 2.19). A Zurich resident can access virtually all points in the city through the expansive tram system, although the system is also augmented by bus services. In reality, though, few cities have the resources of Zurich to implement a rail-based system across the entire urban area. The most recent extensions to the system cost approximately US$28 million per kilometre (Husler, 2005).

There are certainly examples of very costly BRT systems as well. The section of the Boston Silver Line BRT system that goes under the Boston harbour required an investment of US$312 million per kilometre. However, anytime tunnelling is involved in a complex urban or aquatic environment the cost will be extreme. The same holds true for a rail line in the same circumstances. The main point being made in Table 2.2 is that BRT will generally cost 4 to 20 times less than a tram or LRT system and 10 to 100 times less than an elevated or underground rail system, assuming a BRT system that predominantly operates at street level. Of course, a more accurate comparison for any given situation can be gained by conducting an appropriate detailed feasibility study in which all relevant technology options are objectively compared.

Robustness of cost projections

The relative robustness of capital cost projections is also an important consideration. Higher-cost options tend to demonstrate greater disparity between projected and actual costs. As the estimated budget increases, a greater range of variables may tend to create uncertainty in the figures. This disparity translates into greater financial risk for those undertaking the project. Table 2.3 illustrates the tendency for certain public transport projects to under-estimate expected costs and to over-estimate the number of expected passengers.

There may be a variety of reasons for the under-estimation of public transport projects, including economic self-interest, technological complexity, and psychological factors. Project developers may under-estimate costs in order to win initial commitment to the project; the underestimation may particularly occur when there is no penalty or risk for doing so (Flyvbjerg

Table 2.3: Cost overruns and passenger projections of public transport projects

Project	Cost Overrun (%)	Actual traffic as a percentage of predicted traffic, opening year
Washington metro	85	NA
Mexico City metro	60	50
Tyne and Wear metro	55	50
Kolkata metro	NA	5
Miami metro	NA	50
Sao Paulo metro line 5	NA	9
Brasilia metro	NA	3

Source: Flyvbjerg, B., Bruzelius, N., and Rothengatter, W. (2003); Custodio (2005)

et al., 2003). Projects that require tunnelling, elevated structures, and advanced technology probably also incur greater cost variance due to the relative project complexity that is related to the occurrence of unforeseen events and costs. Allport (2000, p. S-23) notes that "metros are a different order of challenge, cost and risk." Additionally, overly-optimistic projections may also be due to psychological preferences for more grandiose and image-driven options.

Systems based in rail technology have suffered some of the most significant problems regarding cost escalation. The 17-kilometre Kolkata metro required 22 years to build and had its budget revised upward on 14 different occasions (Economist, 2006a). Kuala Lumpur has had a particularly difficult history with its multiple rail systems. The PUTRA rail system incurred debts of US$1.4 billion after only three years of operation. The STAR system likewise ran up over US$200 million in debts after its first five years of operation. Both these systems went bankrupt and required nationalisation. The Kuala Lumpur monorail system also has had some difficulty, requiring eight years of construction and only reaching half its originally projected ridership after its first two years of operation. The nine-kilometre number 5 Metro Line of São Paulo cost US$700 million to construct and was projected to carry 350,000 passengers per day. In reality, the system now just handles approximately 32,000 passengers per day. The Brasilia metro cost a staggering US$1.2 billion to construct and carries just 10,000 passengers per day. The feasibility study projected more than 300,000 passengers per day (Custodio, 2005).

Low infrastructure costs are perhaps the chief advantage of BRT systems. The advent of BRT is in many cases bringing a mass transit option to cities that would likely be decades away from affording a rail transit option. Dar es Salaam (Tanzania) is currently moving ahead with plans for a BRT system involving a first phase network of 21 kilometres. Per capita GDP is just US$1,200 per year in this rapidly growing city of 4 million inhabitants. And yet, the combination of World Bank support with local financial resources has placed a BRT system within the city's reach. If BRT was not an option for Dar es Salaam, the city would potentially not be able to financially support a formal public transport system within this century.

While the experience to date has indicated that the most severe infrastructure costing problems have occurred with rail systems, there is no reason the same problems could not occur with BRT or other technologies. The same incentives for project developers to underestimate costs could occur with any public transport technology. The only real difference with BRT is the degree of scale. Even if the project goes terribly wrong, the total cost exposure of the city is an order of magnitude less. When a large rail project goes terribly wrong, the very financial foundation of an entire municipality can come into question.

It should also be noted that in some instances, LRT systems may be relatively close to BRT in infrastructure costs, especially when vehicle costs are compared equally. If existing rail corridors are present and available for use, then property and construction costs for options like LRT can be dramatically reduced. Further, there are metro rail systems that have been delivered at remarkably competitive cost levels. The Madrid metro stands out as one of the most well-managed and cost-effective public transport projects to date. Through innovations such as 24-hour construction scheduling, Madrid substantially reduced construction equipment costs. Madrid also benefited from relatively soft soil conditions due to the clay base under the city. This unique set of physical conditions facilitated less costly tunnelling. Thus, the actual basis for comparison is quite dependent on local conditions. One must thus use much caution in comparing infrastructure costs between different cities.

Land and property acquisition costs

In addition to the system's physical infrastructure, land acquisition along corridors can be a major cost item in some systems. Land may be required for a variety of purposes, including:

- Rights to road space;
- Rights to underground or aerial space;
- Entry and exit points to stations;
- Terminal sites;
- Depot areas for maintenance and vehicle storage;
- Road widening to mitigate impacts on mixed traffic.

In many systems, land purchases may not be necessary. The legal designation of road space, underground areas, and aerial space may be considered public property in such instances. However, this designation varies considerably by local jurisdiction. Thus, there is no general rule favouring land and property costs for either rail or road public transport options. Either technology may involve considerable requirements for land and property acquisition or none at all.

Whether a system requires land and property acquisition will have profound impacts on the overall capital expenditures. The world's most costly public transport project to date has been the Jubilee Line extension to the London tube system. The 16-kilometre extension came to total of US$350 million per kilometre. Much of this astronomical figure was due to the procurement of private land and property in areas such as the Canary Wharf business district. However, other technology options like BRT can also involve costly land and property purchases. While the construction costs of the first phase of the Bogotá BRT system totalled approximately US$5.3 million per kilometre, the second phase has increased to as much as US$15.9 million per kilometre for the most costly segment. This increase was in large part due to land and property purchases. The city decided to widen some roadways during Phase II in order to maintain the number of mixed-traffic lanes along the BRT corridor.

There are likewise many examples of more economical systems, such as the Madrid metro or the Quito BRT Ecovía line, where little to no land acquisition was required. Given the ramifications of potential land and property purchases, planning a system that minimises acquisition requirements can be a wise strategy. Of course, much depends on local circumstances that may well be beyond the control of project developers.

2.2.1.2 Operating costs

The long-term financial sustainability of a public transport project is highly dependent upon the on-going operating costs of the system. These costs can include vehicle amortisation, labour, fuel, maintenance, and spare parts. If a system requires on-going subsidies, the financial strain can end up affecting the effectiveness of both the municipal government and the public transport service to the customer. The level of operating costs will often also be related to the expected fare levels of the service, and thus will ultimately affect affordability and issues of social equity.

Operating cost categories

The exact components of operating costs will vary somewhat depending on the technology. However, table 2.4 provides a general listing of these types of costs.

Labour costs represent perhaps the greatest difference between systems in developed nations and systems in developing nations. Whereas labour can represent between 35 percent and 75 percent of operating costs in Europe and North America, the labour component of developing-nation systems may be well less than 20 percent.

This difference has greatly shaped the direction of public transport in each context. Systems such as light rail transit (LRT) have proven quite popular in developed nations, in part due to the reduced need for operating staff. With multiple rail vehicles being operated by one driver, the labour cost per customer is greatly reduced. In contrast, the relatively low labour costs in developing city applications means that there is less penalty for modes requiring more operating staff. Further, for social reasons, maintaining or even increasing employment is often a fundamental objective of public transport projects in the developing-city context.

In developing cities, the lower impact of wages on total costs means that these costs can be overwhelmed by the other components. Porto Alegre (Brazil) offers a unique opportunity to directly compare urban rail and BRT operating costs. The city has both types of systems operating in similar circumstances. The TrensUrb rail system requires a 70 percent operating subsidy for each passenger trip. By contrast, the city's BRT system has a comparable fare structure, but operates with no subsidies and in fact returns a profit to the private sector firms operating the vehicles (Figures 2.20 and 2.21).

Table 2.4: Operating cost categories for public transport

Category	Elements
Repayment of Capital	• Vehicle depreciation • Cost of capital
Fixed Operating Costs	• Driver / conductor salaries • Fare collection salaries • Information staff salaries • Security staff salaries • Mechanic salaries • Salaries of administrative personnel and supervisors • Other administrative expenses • Insurance
Variable Operating Costs	• Fuel / electricity • Spare parts • Lubricants and other service items • Maintenance

Fig. 2.20 and 2.21

Porto Alegre operates both a BRT system and an urban rail system. While each passenger trip on the rail system requires a 70 percent subsidy, the BRT system is entirely subsidy free from an operational standpoint.

Photos by Lloyd Wright

Fig. 2.22
Low ridership and several operational mishaps have dropped the bonds on the Las Vegas Monorail to junk status.
Photo courtesy of iStockphoto

In the developed cities of North America and Western Europe, rail solutions, particularly LRT, are now being implemented with increased frequency. The divergent technology paths between developing and developed cities do not suggest one solution is better or more appropriate than another. Instead, it perhaps merely reflects different local circumstances and cost structures.

Even in developed nation conditions, though, rail systems can represent a significant financial risk. The current financial crisis with the Las Vegas monorail system is indicative of the type of risks higher-cost transit systems can face (Figure 2.22). The system loses approximately US$70,000 per day, which includes shortfalls to both existing operating costs and debt serving for the US$650 million system (6.4 kilometre line). In 2005, the system lost a total of US$20 million in part due to revenue shortfalls (Sofradzija, 2005). In early 2006, the system raised the cost of a one-way fare to US$5, which marginally raised total revenues while simultaneously reducing the number of passengers. By March 2006, the company's bond status dropped to the junk level.

Fig. 2.23
A metro rail car arrives in Bangkok from Germany.
Photo courtesy of the Bangkok MRTA Company

Thus, in many instances, BRT may compete quite strongly even on a basis of operating costs in the developed-nation context. In an extensive study of different US systems, it was found that from a sample 26 BRT systems, the operating costs were the same or less than comparable light rail systems (Levinson *et al.,* 2003a).

Vehicle costs

Vehicle or rolling stock costs may be considered either a capital cost or an operating cost, depending in part on the technology and in part on the local circumstances. For road-based systems, such as BRT, the convention has been to regard vehicles as an operating cost that will be amortised through the life of the vehicle, which is typically ten years. By contrast, rail systems tend to include the rolling stock as part of the initial capital cost. Rail vehicles will also tend to maintain a longer useful life with service periods of 20 years or longer. However, there are exceptions to the conventions on designating vehicles and rolling stock as either operating or capital costs. Some BRT systems may treat some or all of vehicle costs as a capital cost, particularly in instances where the maintenance of a low fare structure is important. Likewise, some rail systems, such as the Bangkok subway, have treated the rolling stock as an operating cost in order to move more cost items to the private sector operator.

The vehicle costs between the different technologies vary considerably, although the different useful lifetimes and carrying capacities of the vehicle types tend to balance out this difference. Today, a high-quality articulated BRT vehicle in

Latin America costs in the area of US$200,000 to US$250,000. Rail vehicle costs vary considerably depending on the technology but will typically cost in excess of US$2 million.

Bus-based systems tend to benefit from the economies of scale generated by the great number buses operating in cities today. Thus, the cost of maintenance staff and spare parts tends to be lower for such systems when compared to more specialised technologies. However, in large cities with extensive rail networks, economies of scale may be reached in purchasing spare parts and maintaining a well-trained repair team.

Buses can be manufactured in a wide range of locations, with most countries possessing some form of vehicle assembly. By contrast, there are only a few major rail manufacturers in the world today (*e.g.,* Alsthom, Bombardier, Hitachi, and Siemens). The scale required to erect local rail manufacturing is unlikely to be achieved in most developing nations. Instead, manufacturing (and the associated employment) will be based in a developed nation such as France, Canada, Japan, or Germany. When a city such as Bangkok purchases its rail metro vehicles, the carriages arrive almost fully fabricated (Figure 2.23).

Comparisons of fuel costs depend upon the technology utilised for the public transport vehicles. Rail-based systems are typically fully electrified and thus the cost structure depends on the local cost of electricity generation. BRT vehicles operate on a range of fuel types, including diesel, compressed natural gas (CNG), liquid petroleum gas (LPG), diesel hybrid-electric technology, hydrogen fuel cells, and electricity (electric trolley-buses).

Operating costs and service scalability

Cost-effective public transport services are not just designed for the highest peak demand periods. Systems must possess a certain degree of scalability and flexibility in order to be able to cost-effectively serve both peak and non-peak periods. Vehicles operating during non-peak periods with just a fraction of their potential customer demand create unprofitable conditions. Thus, the depth of the non-peak low can do much to undermine overall profitability.

Conventional bus systems, BRT, and LRT utilise smaller vehicle sizes and thus can be more adaptable to incremental changes in demand.

By contrast, longer train sets have somewhat less flexibility in matching supply and demand. Simply decreasing the frequency of the service is not an ideal solution. The sporadic offering of service during off-peak periods means that the system is less useful and less dependable to the entire customer base.

Farebox recovery

A common calculation used to compare operating cost performance for public transport is known as "farebox recovery". To what extent do fare revenues cover the system's operating cost? Systems that recover more income from fare revenues than the costs of their operations are able to operate without any public subsidy. The avoidance of a public subsidy is of particular importance in developing nations where local resources are often unable to cope with the demands of a costly public transport system. As noted, subsides to public transport operations can crowd out investment to other vital areas such as education, healthcare, water and sanitation. Gregory Ingram of the World Bank notes this concern with (Ingram, 1998, p. 7):

> "The construction costs of Metros in developing countries are so high that they crowd out many other investments… Most systems have operating deficits that severely constrain local budgets, as in Pusan and Mexico City."

This crowding out effect is particularly pronounced in the case of the Guadalajara (Mexico)

Fig. 2.24
Despite absorbing much of the city's budget, the Guadalajara Metro has achieved only a fraction of its ridership target.
Photo by Ivan Romero

Box 2.2: Operating subsidies in Manila

Manila (The Philippines) operates three elevated light rail corridors in its metropolitan region. The LRT1, LRT2, and MRT3 lines operate independently although there are interchange points where customers can change from one corridor to another (after paying a new fare). The lines are all operated by public companies.

Even putting aside the construction costs, the system has proven to be a significant drain on government budgets. The LRT2 line brings in approximately 600,000 pesos (US$12,000) in gross revenues each month (Avendaño, 2003). However, the electricity costs alone total 1.6 million pesos (US$32,000) and the other operational costs add another 1 million pesos (US$20,000).

Another line, the MRT3, has fared even worse. Despite operating at crush capacity levels, the MRT3 still loses approximately US$126 million per year. By late 2005, the MRT-3 operating company was unable to pay creditors, suppliers, and contractors (Bautista, 2005). For the same amount that Manila spends in one year for rail operational subsidies, it could build an entire BRT network.

Fig. 2.25 and 2.26
Manila's MRT-3 (left photo) and LRT-2 (right photo) have been beset by severe operational revenue shortfalls, which have strained both system and municipal finances.
Photos by Lloyd Wright

metro system. The system consumes 40 percent of the municipality's budget in order to move approximately 120,000 passengers per day (Figure 2.24). The original feasibility studies predicted an average ridership of 400,000 passengers per day (Custodio, 2005). Likewise, the three elevated rail lines in Manila all place heavy operating subsidies on the government budget (Box 2.2).

Historically, systems with high ridership levels tend to come to closer to achieving subsidy-free operations. High-capacity metro systems in cities such as Hong Kong, London, Santiago, and São Paulo largely operate without operational subsidies, especially when other income, such as property development, is included. However, for the most part, metro and other rail-based systems are not able to fully recover operating costs from fare revenues. In lower-density cities, such as cities in the US, this lack of farebox recovery is understandable due to the costly nature of public transport service across a widely dispersed customer base. The necessity of operational subsidies does not mean that these systems have failed. In many instances, the public transport system is rightly seen as a vital public service that should be supported through general tax revenues. Others have also argued that the subsidies to public transport are significantly less than the overall subsidies given to car-based infrastructure (Litman, 2005a).

The advantages of avoiding operational subsidies, though, are not insignificant. In addition to the on-going cost burden to the city and subsequent impacts on other potential investments, subsidies consume management resources and can be prone to misappropriation. Additionally, subsidies require a complex control strategy in order to avoid inciting incentives counter to the delivery of good customer service. Implementing a system that will require subsidies without end also raises issues of inter-generational equity. A commitment to subsidies into the indefinite future places a potentially heavy burden on future generations. Further, the necessity of subsidies does create an image problem for systems; many citizens and decision-makers will view a subsidised system as a burden on public resources. The perception of a system "not paying for itself" can undermine overall support to public transport.

Developing-city BRT systems often operate without subsidies. The combination of relatively high passenger demand in conjunction with scale economies and low labour costs creates a fortuitous set of conditions for profitability. Revenues cover all BRT operating costs in cities such as Bogotá, Curitiba, Guayaquil, Quito, and Porto Alegre. Further, the fare levels are often quite affordable with BRT; the customer fare is approximately US$0.50 per passenger in Bogotá and is US$0.25 in Quito and Guayaquil. The lack of subsidies also allows these cities to easily accommodate and manage private sector concessions on the corridors. Thus, not only are all operating costs recovered within the affordable fares, but a healthy profit is realised by the private operating companies.

2.2.2 Planning and management

"Plan for what is difficult while it is easy, do what is great while it is small. The difficult things in this world must be done while they are easy, the greatest things in the world must be done while they are still small. For this reason sages never do what is great, and this is why they achieve greatness."

—Sun Tzu, Military strategist, 544–496 BC

2.2.2.1 Planning and implementation time

The window of opportunity for public transport is sometimes quite limited. The terms in office of key political champions may only be three to five years. If implementation is not initiated during that period, the following administration may well decide not to continue the project. In some instances the project may be cancelled just because the new administration does not want to implement someone else's idea, regardless of the merits of the particular project. A longer development period also means that a host of other special interest groups will have more opportunity to delay or obstruct the process.

Ideally, a public transport project can be planned and implemented within a single political term. This short time span would provide an additional incentive, as the project's initiator would want to finish the project in time to reap the political rewards.

Rail-based options and BRT have significantly different planning and implementation time horizons. Examples of planning and construction times vary greatly by local circumstances, but the duration from start to completion is significantly shorter for BRT. BRT planning typically can be completed in a 12 month to 18 month time horizon. The construction of initial corridors can generally be completed in a 12 month to 24 month period (Figure 2.27). About two-thirds of phase I (40 kilometres) of Bogotá's TransMilenio system was planned and constructed within the three-year term of Mayor Enrique Peñalosa, and the remaining portion began operation within eight months of his leaving office. As the learning curve with BRT systems progresses, the actual planning time seems to be falling. Planning for the

Fig. 2.27 and 2.28
An initial BRT corridor may take 12 to 24 months to construct (left photo); by comparison a typical underground or elevated rail system will require from three to ten years (right photo).
Left photo by Lloyd Wright
Right photo by Karl Fjellstrom

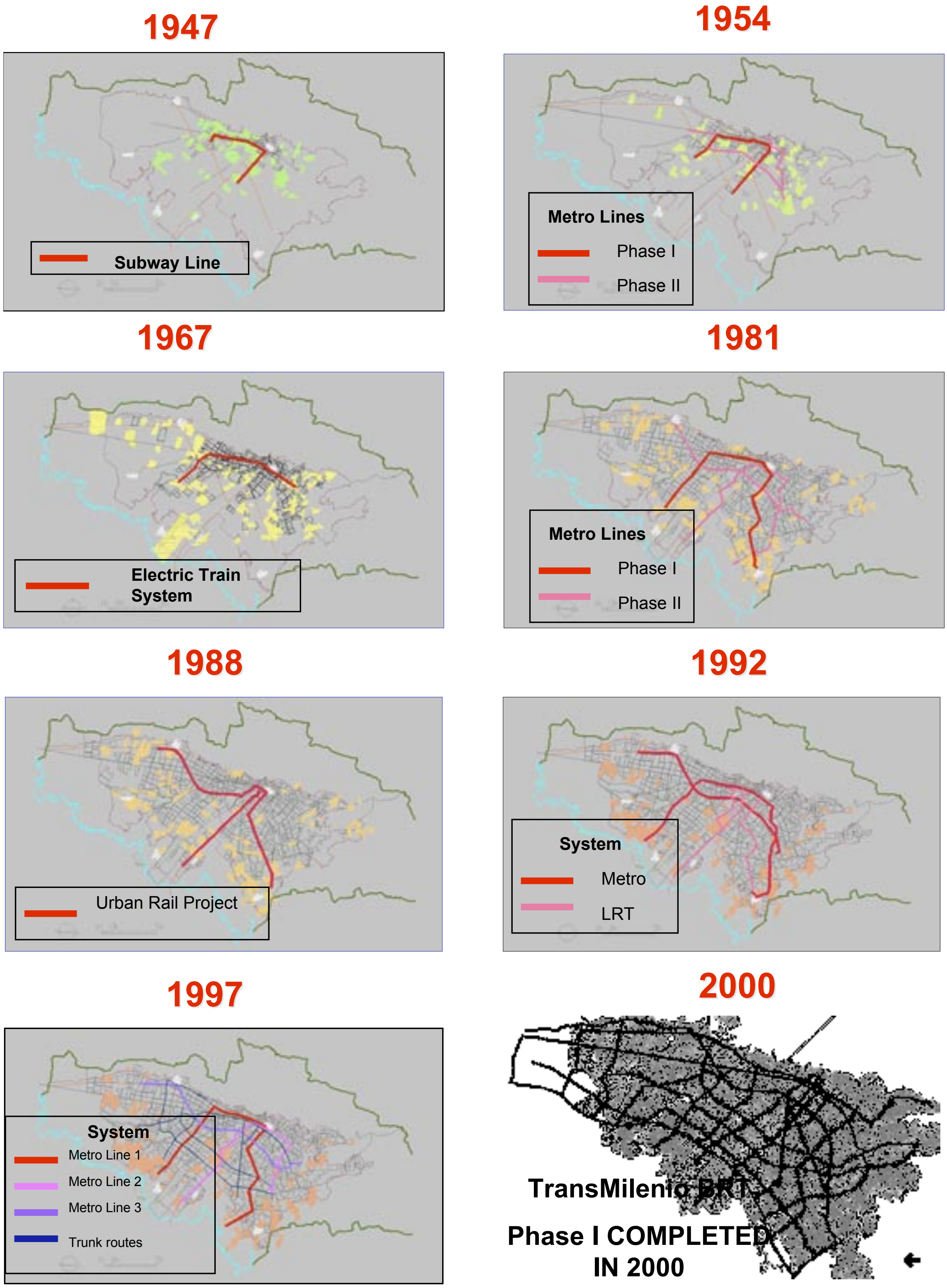


Fig. 2.29

For six decades various political administrations attempted to implement rail-based transit in Bogotá without success. The Peñalosa administration planned and implemented the TransMilenio BRT system in just three years.

Illustration courtesy of TransMilenio SA

16-kilometre phase I of the Beijing BRT system required just five months of effort.

By contrast, planning a more complex rail project will typically consume three to five years of time (Figure 2.28). Examples such as the Bangkok SkyTrain and the Delhi Metro show that construction can also require another three to five year time horizon.

Bogotá makes for an interesting case study as the city has pursued both rail-based options (metros and LRTs) and BRT. Bogotá spent over four decades developing metro and LRT plans (Figure 2.29). Not a single project advanced beyond the planning stage. In most cases, either sufficient financing was not available or the plan lost momentum with the change of political administrations. While the years of rail planning provided regular incomes to consulting firms, it did little to address the city's growing transport crisis. BRT brought the first sense of implementation reality to the city's public transport objectives. Mayor Peñalosa did in a single three-year term what could not be accomplished by fifty years of rail planning.

A longer construction phase can also mean more disruption to the functioning of the city. As portions of the city are under construction, road traffic and businesses will sometimes need to make inconvenient changes to their normal behaviour. The ensuing congestion and loss of sales caused by such disruption can do much to harm the goodwill that a public transport project can otherwise deliver. However, underground systems, such as metros, may have the advantage of less disruption at the surface level.

Obtaining the project financing can be another significant time delay. Most capital intensive technologies may require an additional amount of time in identifying financing sources and in negotiating the terms.

2.2.2.2 Management and administration

The degree of managerial and administrative oversight required by a public transport system is related to the relative complexity of the operations. Thus, cities choosing technically complicated and sophisticated technologies must be prepared for more complex managerial and administrative responsibilities. This added complexity may also imply more financial resources are required to oversee the operating supervision of the system. Allport (2000, p. S-19) points out that the level of managerial experience to oversee such complexity is sometimes difficult to find:

> "Without high standards of operations, maintenance and administration [metros] will rapidly deteriorate… The culture, managerial standards and attitudes often found in bus companies and railway corporations of developing countries are unsuitable for a Metro."

In 2004, Bangkok launched the operation of its subway system, the MRTA. In early 2005 a derailment occurred. The cause was at least partly attributable to human error and the lack of proper administrative controls.

However, partnerships with experienced vendors and management firms can help facilitate the local learning curve. Thus, if a more complex system is chosen, municipalities simply must ensure that the proper controls and expertise are in place.

Fig. 2.30
Phase I of TransMilenio (left illustration) consisted of 40 kilometres of exclusive busways. By the year 2015, the total system is expected consist of 380 kilometres of exclusive busways (right illustration).
Illustrations courtesy of TransMilenio SA

2.2.3 Strategic design considerations

2.2.3.1 Scalability

Scalability refers to the ability to match the size and scope of a system to the particular urban environment. More costly systems tend to require a relatively large scale to operate economically. The higher costs mean that relatively high passenger numbers are needed to financially sustain the system. For the same reasons, such systems may necessitate a larger network in order to operate effectively.

Further, scale is also an issue during the construction phase. Systems requiring expensive construction equipment and special expertise are more cost-effectively constructed with sufficient economies-of-scale. For example, if a city contracts tunnelling equipment and experienced construction teams, it might be relatively costly to construct just a short segment.

Systems that are scalable both in terms of its operations and construction thus give cities a bit more flexibility to match the system characteristics to the needs of the customer. With smaller-sized vehicles, BRT and LRT systems are well-attuned to meeting incremental changes in customer demand. Long sets of metro carriages are perhaps somewhat less flexible in this regard, but some systems, such as the Washington Metro, are able to reduce the number of carriages per rail set to better match off-peak requirements.

Since construction techniques for BRT are not so different than normal roadway construction, the required economies-of-scale are far less acute than those for other types of systems. BRT has been developed in cities with populations of 200,000 to mega-cities with over 10 million inhabitants. Even relatively small system additions can be economically accommodated by BRT. Thus, BRT allows cities to have a public transport system that grows and evolves in close step with the demographic and urban form changes that occur naturally in a city. Figure 2.30 illustrates the planned system expansion taking place within the Bogotá TransMilenio system.

2.2.3.2 System flexibility

"It is not the strongest of the species that survive, not the most intelligent, but the one most responsive to change."

—Charles Darwin, scientist, 1809–1882

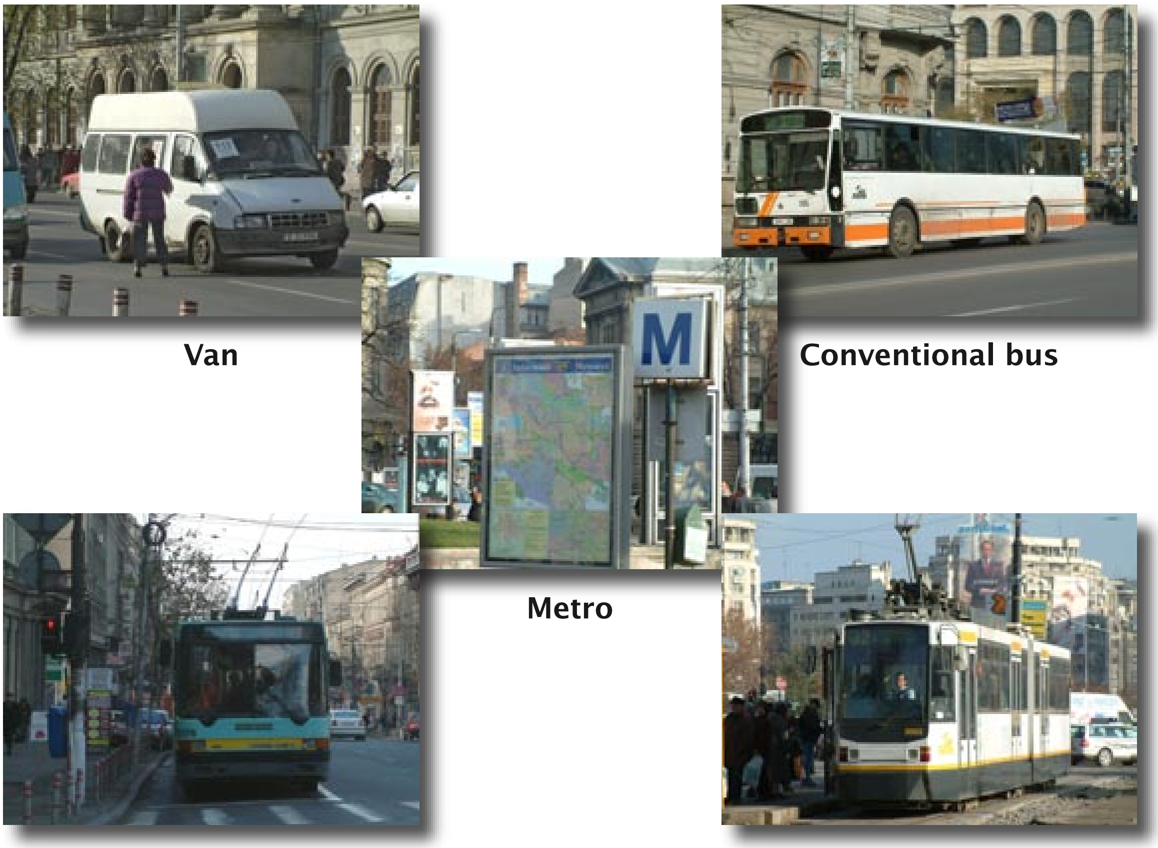
Modern modelling and planning practices have greatly aided the objective of matching public transport design to customer needs. Unfortunately, even the best crafted plans cannot account for all eventualities. Customer preferences can be difficult to know with absolute certainty. The nature of a city's urban form and demographics can change as social and economic conditions change. Thus, it is always preferable to have a public transport system that can grow and change with a city.

During the start-up phase of a new system, customer reactions and preferences are sometimes different than the original predictions indicated from modelling exercises. Demand in one area may exceed or fall short of expectations and require service adjustments. Alternatively, customer demand for express or limited stop services may be quite different from early projections. Routes may require adjustments to account for future changes in urban form.

The relative flexibility of BRT means that such changes can often be accommodated at a modest investment in terms of time and money. Changes to the Bogotá TransMilenio system were handled smoothly within the first weeks of opening the system. By contrast, routing and service changes to rail-based systems are far less adaptable. Once the expense and engineering effort of tunnelling and laying rail is made, the flexibility to make changes is rather limited. Thus, rail-based systems require a good deal more certainty in terms of the required demand and service preferences.

The combination of lower capital costs and greater scalability of BRT means that the system can preserve greater option value for future political administrations and future generations. Rather than committing a city to a prescribed path for the foreseeable future, BRT permits changes in city form, demographics, and public priorities to allow different options to be viable at a later date. Once a city has committed to an expensive technology option, both the psychological and the financial flexibility for making later changes can become limited.

BRT does not necessarily represent the endpoint in terms of a city's ultimate transit choice. The relative flexibility of BRT means that other options are not closed to a city at a later time.



Van

Conventional bus

Metro

Trolley-bus

Tram

Fig. 2.31
Bucharest (Romania) has virtually every type of public transport system, but the end result of too much diversity can be customer confusion and poor integration.
Photos by Lloyd Wright

A city may elect to upgrade a BRT corridor with a rail-based option. This change may be in response to improved municipal financial conditions that allow a more capital intensive option to be implemented. The reasons for such a conversion may be related to increases in passenger demand or a desire to upgrade to a system with a higher perceived visual image. In either case, BRT provides the flexibility for such a conversion to take place. The segregated busways and high-quality stations of BRT may be directly transferable to another technology. Thus, the earlier BRT investment may not be lost entirely in the conversion process.

Of course, once a BRT system has been put in place a city may not consider a conversion to rail to be necessarily regarded as an upgrade. It is unlikely that residents of cities with high-quality BRT systems such as Bogotá, Curitiba, Guayaquil, and Pereira feel that they possess an inferior service. To date no developing city BRT system has converted to another technology option, although Curitiba has examined the possibility of a future conversion to LRT in some corridors.

The opposite of the flexibility inherent to BRT is the sense of permanence a system provides. Thus, more inflexible infrastructure, such as overhead rail and underground metro systems, encapsulate a stronger message to the population that the public transport system will be a permanent part of the city landscape. Once a city has embarked upon such a costly investment, there is frequently little psychological room to reverse course on a commitment to high-quality public transport.

2.2.3.3 Diversity versus homogeneity

In the past, the conventional wisdom for mass transit services implied that a wide diversity of public transport technologies in a city could be useful. Thus, there are cities such as Buenos Aires, Bucharest, and Paris that simultaneously possess virtually all types of transit technologies (metros, elevated rail, trams, trolleys, standard buses, mini-buses, etc.) (Figure 2.31). The idea behind this abundance of diversity is that each public transport technolgoy can be matched with the corridor characteristics that best match the technology’s optimum operating characteristics.

The costs of technology diversity

The reality, though, is often a plethora of services that are not integrated with each other and not understood by the majority of the population. Instead of serving the public in the most efficient manner, the variety of public transport technologies mostly just serve the interests of technology vendors. Physically integrating different technologies that involve separate grade levels (underground, surface level, elevated), boarding techniques, and customer flow levels can be challenging. More often, customers must make difficult and sometimes unpleasant walks between systems. Further, each technology possesses a distinctly different operating cost structure. Some systems operate without the need of public subsidy while others require a continued stream of public funding. Coordinating fare structures and distributing revenues in such an environment can be quite complex and require a high level of managerial and administrative skills. It is quite difficult to design a unified fare structure in such conditions. However, some cities, such as Seoul, have done well in providing a clear and integrated fare system across both rail and road technologies.

Operating several technology types also can imply higher maintenance costs than if a single technology is utilised. Different technologies mean different skills and personnel are needed for maintaining and operating each; there are fewer opportunities for synergies that reduce personnel costs. The various technologies will each likely require their own costly set of spare parts. Economies of scale are typically lost when purchasing multiple types of vehicles and components. Instead of one large order, smaller orders of different technologies are needed. The opportunity for reduced pricing through bulk procurement is limited.

Additionally, the complexity of managing many technology type often results in a different public agencies being created for each service. An expanding bureaucracy can increase overall administrative costs, reduce coordination, and establish “turf” that is later politically difficult to efficiently consolidate. This administrative complexity can also breed an environment where corruption is more prevalent. As the number of contracts for different technologies expands, so does the opportunity for misappropriation.

While integration of different public transport technologies is an often stated goal, rarely is such integration achieved either physically or in terms of tariffs. In Kuala Lumpur (Malaysia), the Star, PUTRA, monorail, and KLIA systems all operate with different fare structures, despite intersecting at several points in the city. Customers must negotiate difficult transfers across inhospitable roadways in order to transfer from one system to another. Once the customer arrives at the other system, a new fare must be fully paid. Likewise, despite having developed its public transport system over three decades, Manila has yet to fare integrate its LRT1, LRT2, and MRT3 systems.

The justification for a diverse set of technologies has largely been based on the assumption that each mode (LRT, BRT, elevated rail, metro, etc.) had a fairly narrow band of operational viability. However, as will be shown later, many technologies can operate cost effectively across a fairly wide range of passenger demand.

Fig. 2.32, 2.33, and 2.34
Customer conditions with road-based public transport in Bangkok.
Left and middle photo by Lloyd Wright
Right photo by Carlos Pardo

Fig. 2.35 and 2.36
How the other half lives. Conditions on rail-based systems in Bangkok.
Photos by Lloyd Wright

Public transport investments and equity

The practice of selecting many different technologies of varying quality also creates serious equity issues within a city. High-capacity corridors serving commercial centres and business districts may receive more expensive, high-technology systems. In such cases, the served customers may tend to belong more to middle and higher-income groups. Lower-income areas can end up being served by lower-quality systems such as under-funded (or non-funded) paratransit and conventional bus systems. Thus, a sort of transport apartheid can emerge in which much of the public transport investment budget actually disproportionately serves higher-income groups. While such policies may be more an outgrowth of matching a technology to demand, the consequences for the population are no less unsettling.

Table 2.5: Characteristics of highly-profitable airlines

Category	Product and operating features
Vehicle (aircraft)	Single type
Fares	Low, simple, and unrestricted
Distribution	Ticketless
Service	Single-class, high-density
Frequency	High
Punctuality	Very good
Staff	High productivity, high morale
Customer service	Friendly and responsive

Source: Adapted from Doganis (2001)

The Bangkok MRTA subway system is one potential example of this phenomenon. The system has absorbed much of the recent city's public transport budget, but serves only about one percent of daily public transport trips in the city. Further, these trips tend to be disproportionately serving middle and higher-income groups. By contrast, the city's bus system serves approximately 96 percent of the daily public transport trips, but receive little funding support or basic customer amenities (Figures 2.32, 2.33, and 2.34). The difference in travel conditions between the under-funded road based system and the heavily subsidised rail-based system in Bangkok is quite dramatic (Figures 2.35 and 2.36). Likewise, the Kolkata metro is an often cited example of a costly system serving mostly higher-income groups while other public transport forms are left to a certain degree of neglect.

An alternative model

Perhaps the best example of how technological simplification can result in a multiple of benefits can be seen in today's airline industry. The recent success of so-called "low-cost" or "no-frills" airlines can in part be tied to a fairly simplified business model. These airlines typically only maintain one type of aircraft, and thus have greatly reduced maintenance costs and spare part costs. The simplified operating environment also permits faster turn-around time between routes which leads to more revenues per passenger-vehicle kilometres. As a result such airlines (Southwest Airlines, JetBlue, GOL, EasyJet, and Ryan Air) have become leaders in terms of profitability and market capitalisation (*i.e.,* value). The business model for these companies may in fact offer a host of lessons that may provide insights into how public transport can succeed. Table 2.5 summarises these characteristics.

While urban public transport is clearly quite different from the airline industry, there are a sufficient number of parallels to consider aspects of this model. Simplicity in conjunction with excellence in customer service can be a powerful combination.

In some extreme cases of population densities and topographical constraints, a city may indeed require multiple technologies to meet its public transport needs. However, these cases are relatively rare. If a single public transport technology can adequately serve a city's mobility needs, then the ensuing cost and managerial savings can be significant.

2.2.4 Performance

A system's performance characteristics will play a large role in determining customer usage levels. It does little good to have an economical system if nobody is willing to use it. The ability of a system to attract ridership is thus a prime decision-making determinant in selecting a public transport technology.

2.2.4.1 System capacity

Characteristics affecting system capacity

The ability to move large numbers of passengers is a basic requirement for mass rapid transit systems. This characteristic is particularly important in developing-nation cities where mode shares for public transit can exceed 70 percent of all trips. Passenger capacity is affected by several factors that can differ between types of public transport systems:

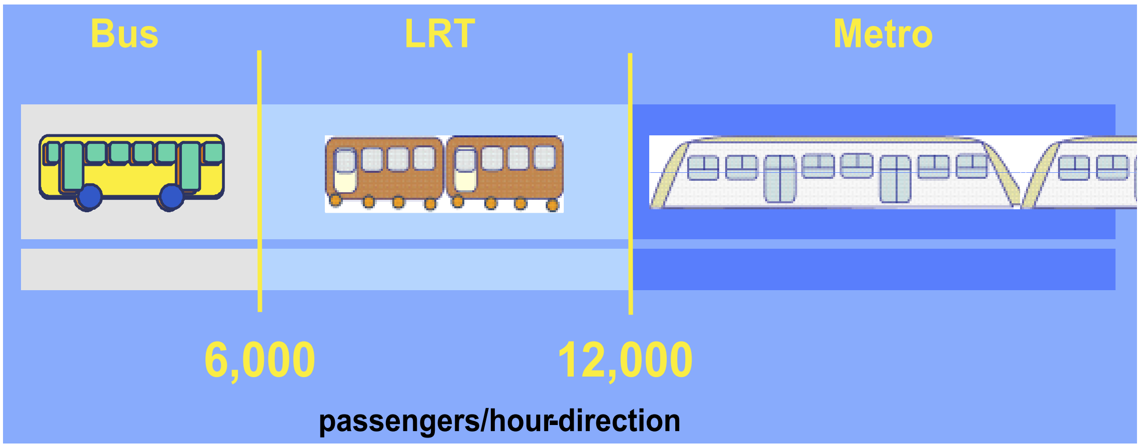


Fig. 2.37
Traditional view of public transport capacity.

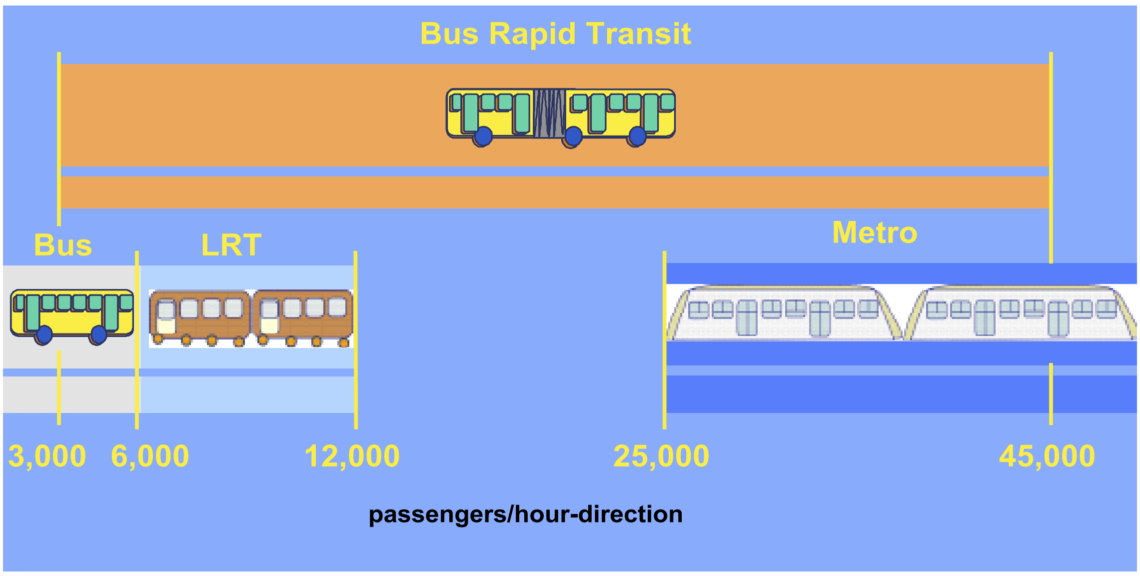


Fig. 2.38
New view of public transport capacity.

- Size of vehicle (passengers per vehicle);
- Number of vehicles that can be grouped together;
- Headway between vehicles (amount of time that elapses between vehicles in safe operation);
- Availability of limited-stop or express services;
- Boarding and alighting techniques.

In many developed-nation cities, passenger capacity is a less vital issue as the lower density of the cities along with lower market shares for public transport creates less peak demand. By contrast, developing-nation cities often have both high population densities and high market share for public transport.

System capacity comparisons

Passenger capacity and infrastructure costs have traditionally been the most significant determinants in public transpot technology decision making. Historically, a fairly strict set of technology capacity limitations has meant that buses, LRT, and metro rail operate only within rather narrowly defined circumstances (Figure 2.37). A corridor's demand characteristics would thus largely determine the possible technology. A single arterial lane of cars can typically transport from 2,000 to 4,000 passengers per hour per direction (pphpd), depending on average passenger numbers per vehicle, velocities, and separation distance between vehicles. It was previously thought that bus services could only operate in a range up to about 5,000 to 6,000 pphpd. LRT could then cover demand up to approximately 12,000 pphpd. Anything over this level would require a metro or elevated rail system.

However, busways and BRT systems have begun to change this traditional view. With the Bogotá BRT system now achieving an actual peak capacity of 45,000 pphpd, a new capacity paradigm is being created. Figure 2.38 provides a pictorial view of this new view on each technology's approximate current operating range.

Determining the appropriate technology from a passenger capacity standpoint actually requires attention to two different factors: 1. Maximum capacity; and 2. Cost-effective range of operational capacity. The first factor determines whether a technology possesses sufficient capacity to support the peak period on a given corridor. The second factor determines if the fluctuations between peak and non-peak periods fits into the range of cost-effectiveness for the technology.

Table 2.6: Actual peak capacity, selected mass transit systems

Line	Type	Ridership (passengers/ hour / direction)
Hong Kong Subway	Metro	80,000
São Paulo Line 1	Metro	60,000
Mexico City Line B	Metro	39,300
Santiago La Moneda	Metro	36,000
London Victoria Line	Metro	25,000
Buenos Aires Line D	Metro	20,000
Bogotá TransMilenio	BRT	45,000
São Paulo 9 de julho	BRT	34,910
Porto Alegre Assis Brasil	BRT	28,000
Belo Horizonte Cristiano Machado	BRT	21,100
Curitiba Eixo Sul	BRT	10,640
Manila MRT-3	Elevated rail	26,000
Bangkok SkyTrain	Elevated rail	22,000
Kuala Lumpur Monorail	Monorail	3,000
Tunis	LRT	13,400

Table 2.6 summarises capacities actually achieved on a different systems. "Actual" capacities are more typically revealing than "theoretical" capacities. It is true that some systems run at higher passenger densities, depending on cultural norms. Thus, one could differentiate between "crush capacities" and "nominal capacities". For example, the Hong Kong and São Paulo systems as well as the Bogotá BRT system operate under fairly packed customer conditions. The Tokyo subway system has employed workers with white gloves whose job is to push passengers as tightly as possible into the carriages. Obviously, such packed conditions can distort capacity values. Nevertheless, this section provides only "actual" passenger capacity values in order to avoid the arbitrariness of comparing highly theorised values that may be manipulated to make one technology more attractive than another.

Figure 2.39 compares the range of passenger capacity for each technology measured against the range of capital costs. The ranges presented in Figure 2.39 are based on actual not theoretical data.

The different sized areas of the rectangles in Figure 2.39 are also revealing with regard to the relative risk and overall flexibility of each

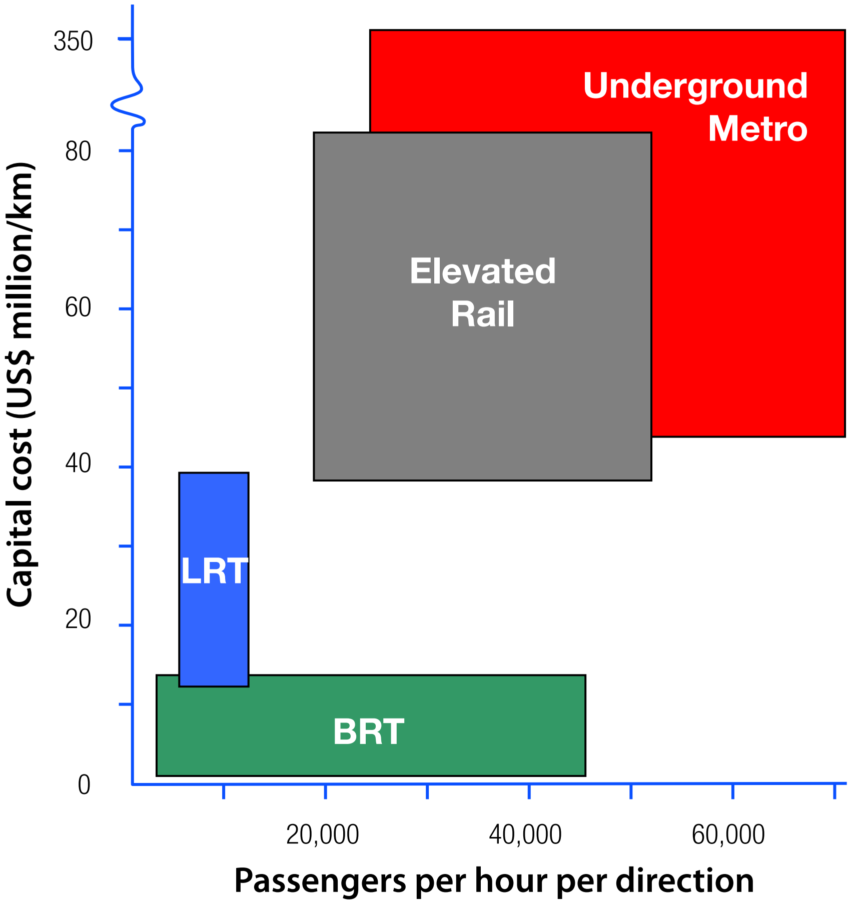


Fig. 2.39
Passenger capacity and capital cost for mass transit options.

transit technology option. Ideally, a technology will have a narrow band of possible capital cost levels (y-axis) and a wide band of profitable capacity operations (x-axis). In other words, a system that minimises costs and maximises the spectrum of profitable operating conditions provides the most cost-effective and flexible solution. The width of the range of capital costs (y-axis) can also be interpreted as an indication of the potential risk and uncertainty involved in implementing the particular project.

Metro and elevated rail capacities

Historically, passenger capacity has been the major advantage of underground metro systems and elevated rail systems. The combination of large, multiple-train sets and unencumbered fully-segregated infrastructure provides the conditions to rapidly move high volumes of customers. The metro systems in cities such as Hong Kong, New York, São Paulo, and Tokyo are capable of transporting well over 50,000 pphpd. No other public transport technology can match this level of service capacity.

Further, the efficiency of such systems when operating at high capacity levels produces highly cost-effective operations. The Hong Kong subway system has been financed entirely through passenger revenues and property development. The 88 kilometres of metro rail construction

Fig. 2.40
For cities such as Montpellier (France), LRT provides a good public image and can adeptly serve moderate peak demands (less than 12,000 pphpd).
Photo courtesy of UITP

thus required no public financing. This result is principally due to the fact that the system achieves the highest passenger demand levels of any mass transit system in the world.

As noted earlier, though, such systems are significantly less cost effective at lower demand levels. Without very high peak demand and reasonably high non-peak demand, metro rail and elevated rail systems are unlikely to be able to achieve farebox recovery. Thus, these systems require a fairly particular operating window of passenger demand. For this reason, the most successful metro rail and elevated rail systems operate in the highest demand corridors of mega-cities.

LRT capacities

LRT applications are well suited to the demand conditions of US cities and medium-sized European cities. The given population densities and urban form of such cities imply that corridor demand rarely exceeds 10,000 pphpd (Figure 2.40). In such situations, metro rail or elevated rail would likely not be a cost-effective option.

When operating at street level, LRT is limited by intersections and safe distances between train sets. Unlike some busway applications, LRT switching and signalling systems do not support vehicles over-taking one another at station stops. This limitation restricts the ability of the system to offer the type of express services that make the high capacity figures on BRT systems like Bogotá possible. Allport (2000, p. 38) reinforces this point with:

> "Typical at-grade LRT throughputs were about 4,000-6,000 passengers per hour compared to busway average of 15,000 at about the same commercial speed. There were no known LRT's operating at-grade which approach the passenger carrying capacity of the existing Curitiba, Quito or Bogotá busways.
>
> LRT achieves high speed by using a signalling system to avoid bunching, and by obtaining priority at traffic signals over other traffic; and it achieves high capacity by having large vehicles which take advantage of the signal cycles. In practice the distance between signals defines the maximum vehicle size, and the need to provide for crossing traffic limits the number of vehicles per hour. However, LRT systems are operationally vulnerable to the everyday events that happen in the centre of developing cities. Whether this is junctions being partly blocked, or road maintenance work, or a breakdown, or an accident, while bus systems are often able to get round the problem (they can overtake, leave the busways etc), LRT is not.
>
> We conclude that an LRT capacity of 10-12,000 pphpd at an operating speed of 20 kph is likely to be the limit to what is achievable."

LRT systems are capable of higher capacities if the systems are grade separated. The Manila MRT3 line could be considered an LRT system by some definitions since it draws its electricity source from an overhead cable. The system is fully grade separated through an elevated structure and currently achieves an actual peak capacity of approximately 26,000 pphpd.

In general, though, capacity is not a major constraint for LRT systems since the principal application has been in the developed nations of Europe and North America. Cities in these nations rarely have public transport demand exceeding the limitations of an at-grade system.

BRT capacities

Concerns are sometimes raised whether bus-based options such as BRT can handle the passenger flows that are often required in denser, developing-nation cities. Bogotá's TransMilenio system has done much to answer these concerns. Bogotá's system currently moves an average actual peak capacity of 45,000 pphpd (Figure 2.41). Many BRT and busway systems in Brazil are capable of peak capacities ranging from 20,000 pphpd to nearly 35,000 pphpd. In the case of Bogotá, the high capacity figures are achieved principally through the following attributes:

1. Use of articulated vehicles with a passenger capacity of 160;
2. Stations with multiple stopping bays that can handle up to five vehicles per direction simultaneously;
3. Passing lanes at stations and double lanes on some runways in order to allow express and limited-stop vehicles to pass local services
4. Multiple permutations of routing options that include local, limited stop, and express services;

Fig. 2.41
The provision of multiple stopping bays and passing lanes at stations permits the Bogotá TransMilenio system to achieve high passenger capacity.
Photo by Carlos Pardo

5. Average vehicle headways per route of three minutes, and as low as 60 seconds during peak periods; and,
6. Station dwell times of approximately 20 seconds (achieved by use of at-level boarding and alighting, pre-board fare collection and fare verification, and three sets of large double doors on each vehicle).

The fact that Bogotá's TransMilenio functions well in a city of 7 million inhabitants with a population density of 240 inhabitants per hectare says much about BRT's potential in other mega-cities. However, to accommodate Bogotá levels of capacity, a system would have to make available sufficient road space for passing lanes at stations and/or double lanes per direction along the runways. In many cities, the physical space to implement this width of infrastructure is simply not available. Moreover, dedicating any amount of road space to exclusive use by public transport is often politically difficult, especially given the relative political strength of private motorists.

Systems such as Quito and Curitiba that utilise just one lane in each direction can reach capacities of approximately just 12,000 pphpd. However, Porto Alegre (Brazil) also has only one lane available in each direction but reaches capacities of over 20,000 pphpd through the clever use of multiple stopping bays and the platooning of vehicle movements. In general, though, a BRT system or an LRT operating on a dedicated single lane will achieve the approximately the same capacity level. For most cities, these capacity levels are sufficient for the given demand. BRT is still an option of up to 45,000 pphpd, but only if Bogotá-type measures are taken.

Corridor capacity vs. network development

In reality, the debate over capacity can be a bit misleading. The capacity required on a particular corridor is principally determined by the population density along the corridor, the total catchment area for passengers, and the origin and destination profile of the residents. When a system consists of a network that covers the majority of central districts and main corridors, this catchment area typically extends to an area of between 500 metres and one kilometre around stations as well as the passenger traffic collected by feeder services. Thus, while the central areas of London and New York host dense populations, the extensive coverage of the system network distributes demand across many parallel and connecting lines. In London, the demand handled by the mass transit system does not exceed 30,000 pphpd. This lower capacity occurs not because there is little demand, but rather because the relatively large demand has been well-distributed around an overall network.

However, in cities such as Hong Kong and São Paulo, where a limited network is provided, capacities reach 60,000 pphpd and higher. In this sense, a limited network can become a self-fulfilling prophecy with respect to capacity. If a city can only afford a few metro lines, the passenger demand is drawn from a much wider area and thus creates a capacity requirement that only metros can fulfil. Hong Kong draws large numbers of passengers from Kowloon and the New Territories into a single metro line on Nathan Road. There are disadvantages to this approach. By requiring passengers to travel farther to enter the system, the system developers are making conditions less convenient to the customer, which will ultimately result in captive users seeking alternatives such as private vehicles. Also, when operating at a capacity of over 60,000 pphpd, the system is far less robust with respect to delays and technical problems. A two-minute outage in such a system can create extremely difficult conditions and backlogs.

Extending the Hong Kong subway system has been restricted due to the sole use of private capital for all infrastructure costs. Only the highest-demand corridors provide sufficient return on capital from passenger revenues to fully finance the infrastructure.

Distributing capacity across a full network of routes and corridors offers several benefits: 1. More convenient station access for customers; 2. More comfortable customer conditions; and 3. More manageable customer volumes. It is recognised that the extensive metro networks developed in London, New York, Paris, and Tokyo are not necessarily financially replicable in developing-nation cities. However, an important principle regardless of the technology chosen is to design a system with as much city-wide network coverage as possible. It is preferable from a customer standpoint to choose a less costly system that covers more origins and destinations than a costly system covering a more limited area.

2.2.4.2 Affordability

The customer tariff is related to operational costs and the level of subsidies (if any). Developing-nation public transport customers can be particularly price sensitive. A small difference tariff levels can make a substantial difference in ridership levels. Thus, technologies that involve lower operating costs are perhaps more appropriate in such a context.

As noted earlier, BRT systems have achieved a certain amount of success in providing reasonable fare levels without the intervention of operating subsidies. Fares in the range of US$0.25 to US$0.70 are typical with the subsidy-free systems in Latin America. In some cases, though, conventional bus services may be able to deliver tariffs at just below these levels. Thus, in the case of Bogotá, the small difference in conventional bus fares to the BRT system can affect ridership in certain parts of the city. In other cities, such as Quito, the BRT system and the conventional bus system offer services at the same tariff level of US$0.25.

Outside of the highest demand corridors, many metro rail systems must offer a subsidised fare level in order to achieve affordability within the local context. The Delhi Metro's fare level of 12 rupees (US$0.26) is subsidised at a level of approximately 90 percent. While this type of subsidisation can be appropriate in some circumstances, there are always questions over its long-term sustainability, especially in cities with many other investment requirements.

2.2.4.3 Travel time / speed

Travel time and operating speed are related but distinct concepts. From the customer standpoint, the actual door-to-door travel time is probably the more important variable rather than top speeds. Thus, one must also consider the time travelling to and from stations, the time spent walking from entry points to the vehicle platforms, and the time spent waiting for a vehicle. Equation 1 summarises each of the variables that contribute to calculating total travel time.

Equation 2.1: Total travel time

Total travel time	=	Travel time from origin to transit station
	+	Travel time from entering station to vehicle platform
	+	Vehicle waiting time
	+	Vehicle boarding time
	+	Vehicle travel time
	+	Vehicle alighting time
	+	Travel time from vehicle platform to station exit
	+	Travel time from station exit to final destination

The "commercial speed" of the vehicle is often more important than the "maximum speed". The commercial speed represents the average speed including the dwell time at stations. Thus, a system with short distances between stations or with long boarding and alighting times will be comparatively penalised in terms of average speed. However, a system with significant distances between stations will mean that passengers spend more time walking to and from the stations to access destinations.

As surface modes, BRT and LRT are advantaged with relatively accessible entry and exit points. In contrast, metro and elevated rail systems may require additional time to reach the platforms that are at a depth below the street or overhead. Further, the more costly systems sometimes imply that there is less coverage of the city's total area since it is not typically financially feasible to construct lines in all corridors. Thus, distances to arrive at a station may also require additional travel time or even an additional public transport trip on a feeder service.

However, once a passenger enters a vehicle, the commercial speed of metro rail systems and elevated systems can be significantly superior to either that of BRT or LRT. Underground and elevated metro systems generally reach average commercial speeds in the range of 28 to 35 kilometres per hour. LRT systems will generally achieve average commercial speeds in the range of 12 to 20 kilometres per hour. Commercial speeds for BRT systems are typically in the range of 20 to 30 kilometres per hour. These values will vary depending upon the number of intersections to be crossed, the extent to which signal prioritisation technologies are being utilised, and the separation distance between stations.

A comparison of light rail systems and BRT systems in the United States revealed higher average speeds for BRT in five of the six cities investigated (Figure 2.42). The US study noted the use of high-occupancy vehicle (HOV) lanes and the ability to augment local services with limited stop services as the reason for BRT's superior performance (US GAO, 2001). However, if special highway lanes with infrequent stops are not included in the analysis, BRT and LRT will likely have fairly comparable average commercial speeds.

The provision of "limited stop" and "express" services in addition to "local" services can be a significant factor in reducing travel times. Limited stop services imply that the public transport vehicle will skip several stations between more major travel nodes. Express services imply that even more stations are skipped allowing the service to go between major points of origins and destinations. Local services typically involve stopping at each of the stations in a particular corridor. A few metro systems, such as the New York subway, do in fact have second sets of tracks to permit limited stop services. However, these services are relatively rare for metro and LRT systems for reasons of both cost and technical complexity. The ability to safely control passing at stations is difficult with high-frequency rail services. The ability to change directions and cross paths between two rail routes requires the somewhat costly grade separation of the two tracks, at least in most urban situations (Figure 2.43). The relative flexibility of BRT permits greater ease in developing passing lanes at stations. BRT systems in cities such as São Paulo and Bogotá operate with either passing lanes and/or second sets of exclusive busway lanes in order to permit more direct services.

The relative advantage of a particular public transport technology with respect to travel time depends greatly upon local circumstances and system design. Metros may produce the highest maximum velocities, but may entail longer access and departure times. BRT's ability to provide limited stop and express services can be quite advantageous, especially for customers travelling from areas outside the central districts.

2.2.4.4 Mode share

In theory, any type of public transport technology could be designed to serve most of the trips within a city. In practice, financial limitations prevent the construction of a full network across an entire metropolitan region. Thus, more costly technologies generally can only be cost justified

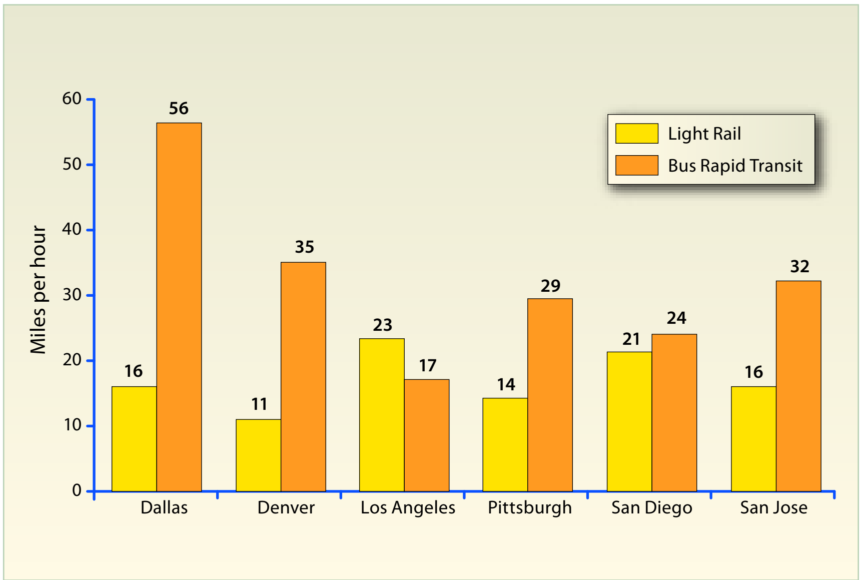


Fig. 2.42

A survey comparing US BRT systems with light rail systems showed that the BRT systems actually delivered higher average speeds.

Graph from US GAO (2001

Fig. 2.43
As this image from the Osaka monorail indicates, in order for two intersecting rail corridors to cross in high-capacity urban conditions, grade separation is likely to be necessary.
Photo by Lloyd Wright

in a few corridors, and thus actually serve fewer overall numbers of passengers.

In cities that have both a metro system and a bus network, the metro generally only carries a small portion of the cities public transport ridership. Table 2.7 compares mode shares for several cities with both a metro and a bus network. While it is true that the peak capacity of metros and elevated rail systems surpass other modes, their ability to serve large overall numbers of passengers is limited due to cost reasons. Bus systems, as both a standard service and an enhanced BRT service, continue to serve as the principal public transport backbone of most cities. In cities with metros and/or elevated rail systems, such as Mexico City and Bangkok, the numbers served by the rail systems are typically less than 15 percent of the daily trips (Table 2.7).

While metro systems often receive the largest share of public transport investment as well as political attention, the reality is that under-funded bus systems still carry the vast share of customers. This finding does not diminish the importance of high-capacity metro rail in serving key corridors. However, it may indicate that cities might also consider evaluating investment decisions based on passengers served.

Figures 2.44 through 2.47 illustrate the different treatment sometimes extended to bus services. Such examples perhaps demonstrate

Table 2.7: Mode share comparison

City	Bus	Metro	Train	Car	Motor-cycle	Taxi	Walk	Bicycle	Other
Bangkok[1], 2003	31.0	3.0	0	30.0	32.0	4.0	-	-	-
Beijing[2], 2000	15.0	2.0	0	16.0	2.0	6.0	33.0	26.0	-
Buenos Aires[3], 1999	33.0	6.0	7.0	37.0	0	9.0	7.0	0	-
Caracas[3], 1991	34.0	16.0	0	34.0	0	0	16.0	0	-
Mexico City[4], 2003	63.0	14.0	1.0	16.0	-	5	-	-	-
Rio de Janeiro[5], 1996	61.0	2.3	3.1	11.5	0.2	-	19.7	1.3	0.9
Santiago[6], 2001	28.4	4.5	-	23.5	-	1.3	36.5	1.9	4.0
São Paulo[3], 1997	26.0	5.0	2.0	31.0	1.0	0.0	35.0	0	-
Shanghai[2], 2001	18.0	2.0	0	4.0	2.0	2.0	44.0	28.0	-

Sources:
1. OTP (2003)
2. Xu, K. (2004)
3. Vasconcellos, E. (2001)
4. SETRAVI (2003)
5. IplanRio (1996)
6. Ciudad Viva (2003)

the relatively low status held by decision makers for road transport services. Despite often serving the majority of trips within a city, funding is typically quite scarce.

2.2.4.5 Service frequency

Travel time is also greatly affected by the frequency of the provided public transport service. Highly frequent service will imply lower average wait times for customers. Service frequency also affects the perception of the system's reliability and car competitiveness.

While a frequency of five to ten minutes may not seem long in relative terms, from the perspective of the passenger, wait times can have much (*i.e.*, time between different train sets or vehicles approaching a station) is safety. However, today's switching technologies permit rail train sets to arrive within 60 seconds of one another. Bus-based systems are capable of safely maintaining even closer distances. Highly frequent service, though, can result in the "bunching" of vehicles, and thus ultimately result in delays and slower average speeds.

In practice, some technologies can be disadvantaged in terms of service frequency due to the local demand profile. For example, the popularity of LRT vehicles in North America and Europe is in part due to the ability to carry as many 400 passengers utilising just a

Fig. 2.44 and 2.45

The quality of the customer's experience varies greatly in Singapore depending on whether the rail system (left photo) or the bus system (right photo) is utilised. While the Singapore rail system has received orders of magnitude more investment, it actually carries less than half as many passengers as the bus system, 1.2 million trips per day by rail and over 3 million trips per day by bus.

Left photo by Calvin Teo
Right photo by Karl Fjellstrom

Fig. 2.46 and 2.47

In Chengdu (China), despite private cars being used for only 3 percent of the trips (left photo), car-based infrastructure is being rapidly expanded, often at the expense of space for non-motorised users. At the same time, bicycles represent a 43 percent mode share and the badly maintained bus system carries 10 percent of the trips (right photo).

Photos by Karl Fjellstrom

single driver. This characteristic helps to reduce labour costs, which are relatively high in these countries. However, the other side of this equation is that larger capacity vehicles tend to result in lower frequency of service, especially in North American cities with relatively low passenger numbers. The lower frequency is due to the need to adequately fill public transport vehicles in order to operate efficiently. Table 2.8 gives peak and non-peak service frequencies for some rail-based systems in the United States.

Table 2.8: Service frequency for rail-based systems

System	Peak frequency (minutes)	Non-peak frequency (minutes)
Denver Light Rail	3-6	9-26
Miami MetroRail	6	10-60
Portland MAX	5-13	13-33
St. Louis MetroLink	10	10-30
San Diego Trolley	9-15	15-30

The proper sizing of public transport vehicles can help keep service frequency in the range of two to five minutes throughout the day. BRT systems have been successful in maintaining both high service frequencies and system profitability. The higher frequencies are particularly feasible in developing cities where customer flows are relatively large.

2.2.4.6 Reliability

Reliability is related to the level of confidence one has in the public transport system's ability to perform as expected. The concept of reliability is related to the previous discussions of travel time and service frequency, but can also refer to other system characteristics such as comfort and safety.

An unreliable service can create a high degree of personal stress if a customer does not know when or if a vehicle is going to arrive at a station. Unreliable services ultimately lead to non-captive users seeking more robust travel options, such as private vehicles.

Each type of public transport system has different characteristics with regard to reliability. The frequency of service breakdowns, the rate at which disabled vehicles can be replaced, and the operational responsiveness to changes in demand all affect overall reliability. Metros, LRT, and BRT all have excellent records of reliability, particularly when compared to more conventional public transport services. Segregated right-of-ways help to better control service frequencies and headways between vehicles. Systems with complete grade separation, such as underground metros, have a particular advantage in terms of avoiding unforeseen incidents at mixed traffic intersections.

The relative flexibility of BRT vehicles to operate inside and outside of the segregated infrastructure allows immediate adjustments to breakdowns. Service can continue while repairs or removal are taking place. The breakdown of a metro or LRT vehicle can require additional time for remedial actions. Until the disabled vehicle is cleared from the system, there can be disruption to service.

Another consideration is the impact of extreme weather considerations on the system. Systems that are completely underground are immune to such affects, although a weather-related failure of the electricity supply can obviously have an impact. Ice on rails and busways can act to slow or even halt services.

2.2.4.7 Comfort

The level of comfort within a system depends upon many design characteristics that are somewhat independent of mass transit type. Station seating and protection from the elements are dependent on system design. Underground systems have the advantage of a better natural barrier from outside weather conditions. The interior design of the vehicles is again dependent upon design specifications, and can be of equal quality for either rail or BRT services. However, some types of trams may have a more narrow width which may limit design options and in some cases create a more squeezed environment for the customer.

Ride comfort is one potential area of significant difference between BRT vehicles and rail vehicles. Rail is typically credited with a smoother ride performance both during starts and stops as well as during full operation. A smoother ride performance better permits value-added activities, such as reading, for the customer (Figure 2.48). However, not all rail systems provide the same ride quality. The Kuala Lumpur monorail technology actually delivers a somewhat "bumpy" travel experience. Additionally, older tram systems likewise may not provide an entirely smooth ride. Low-floor BRT vehicles can be susceptible to surface imperfections on the busway that will result in a "bumpier" ride. High-floor vehicles with ramped entry service can better mitigate this issue through dampening and improved suspension. With this type of BRT vehicle set-up in cities such as Bogotá, Curitiba, and Guayaquil, on-board activities such as reading are quite feasible. However, in general, the ride smoothness of rail vehicles is superior to that of BRT vehicles.

2.2.4.8 Safety

Segregated lanes for rail and BRT vehicles help to reduce the potential for accidents, and thus make such mass transit options relatively safer over more standard services. Grade separated services, such as underground metros, particularly benefit from avoiding such conflicts. Both BRT and LRT systems face potential risks when crossing intersections. The opening of the Houston (US) LRT system has been met with a higher than expected accident rate between private vehicles and LRT vehicles. Likewise, the November 2005 opening of the Orange Line BRT system in Los Angeles resulted in intersection clashes between cars and the BRT vehicles. Private vehicle owners are often unaccustomed to the presence and operation of segregated public transport vehicles and may be unprepared for the implications.

Fully grade separated systems do incur other types of risks that may affect safety. The higher maximum speeds reached on underground and elevated systems implies that in the event of a mishap, there is a greater chance for serious injury and fatalities. Just before the launch of the Kuala Lumpur Monorail a spare wheel came loose and fell to the surface, striking a journalist who happened to be walking near the system (Figure 2.49). The resulting injury required hospitalisation. Likewise, the Las Vegas monorail also had parts fall to the street level during its first year of operation. Further, underground and elevated systems have added difficulty in evacuating customers during a system emergency. Passengers may be stranded several hours prior to being evacuated in a safe manner. However, in general, modern metro systems have an exemplary record of both reliability and safety.

Fig. 2.48
The smooth ride performance of rail-based systems makes add-value activities, such as reading or studying, easier to undertake.
Photo by Lloyd Wright

2.2.4.9 Customer service

Customer service features are equally possible for both BRT and rail-based systems. Intelligent Transport Systems (ITS) that inform passengers of expected arrival times, clear maps and payment instructions, and friendly and helpful staff are not generally dependent on the type of public transport system.

However, the provision of customer service infrastructure may be related to the available capital investment. Systems with larger budgets may be better positioned to provide customer features such as comfortable seating, air conditioned vehicles and stations, and aesthetically pleasing environments. Conversely, systems requiring large track, station, and terminal investments may have little capital resources remaining to be attentive to customer comforts. The main station of the Tokyo Monorail is located on the third floor of a commercial building in central Tokyo. No lifts or escalators

Fig. 2.49
A pedestrian was seriously injured when a part fell from the Kuala Lumpur monorail during its initial trials.
Photo by Calvin Teo

are provided to access the station. Instead, prospective passengers must make a hike of three floors (Figure 2.50). Since the monorail services Haneda Airport, many passengers enter the system with large bags and suitcases, and thus have a difficult time reaching the station platform by stairs. The significant infrastructure budget of the system has restricted the developers' ability to provide customer amenities such as escalators.

2.2.4.10 Integration

The ability to transfer comfortably and easily between neighbourhood feeder services and trunk-line services is a major determinant in attractiveness of the overall system. Poorly executed transfer services often share some of the following characteristics:

- Long physical distances separate the two services involved in a transfer; for example, customers may have to cross a street to make the transfer;
- Transfer is conducted in an area unprotected from extreme weather conditions;
- Transfers are poorly timed so that long waiting periods are required; and,
- Customers must effectively pay twice for transferring between lines.

Transfers with such characteristics do little to foster customer good will. Conversely, a fare-free transfer conducted in a pleasant, safe, and controlled environment with a brief wait will minimise the undesirability of transferring.

Fig. 2.50
Despite being a premiere public transport system in the Tokyo area, the city centre station of the Tokyo monorail requires its passengers to make a three-story climb up stairways to access the station.
Photo by Lloyd Wright

In theory, easy transfers are possible with any of the public transport technologies. In practice, the cost of facilitating transfers between systems with different physical, operational, and cost characteristics can be challenging. As noted earlier, bus services tend to be the backbone of most city public transport systems, even when a rail-based system is operating on major corridors. Mass transit systems must integrate with conventional bus services in order to continue services into lower-density neighbourhoods. Surface-based systems, such as BRT and LRT, thus have an immediate physical advantage in easing simpler at-grade transfers.

Grade-separated systems, such as underground or elevated systems, imply that transfers must traverse a vertical distance. While the physical discontinuity can be overcome with the use of stairways, escalators, and elevators, in some cases these transfers are quite physically difficult, especially for the very young, the elderly, and the physically disabled (Figure 2.51). Further, directing patrons from one system to another requires clear and visible signage. The facilitation of this type of coordination between two independently managed systems sometimes fails to occur. Allport (2000, p. S-6) notes these various difficulties with:

> "Integration with the bus system is particularly necessary to metro viability, and often difficult to achieve."

Despite these challenges, some metro systems have done quite well to overcome the physical

Fig. 2.51
Whenever this is a grade difference between public transport services, there will always be challenges in facilitating easy transfers, especially for the physically disabled.
Photo courtesy of UITP

differences and have designed effective integration stations. Hong Kong, Miami, Washington, and São Paulo have achieved some success in this area (Figures 2.52).

In addition to facilitating at-grade transfers with conventional bus systems, BRT systems tend to have an advantage in terms of operational and business integration. First, there is less economic discontinuity between feeder bus services and an exclusive busway. Both systems are based on bus vehicles and operate within relatively similar cost structures. In developing-nation cities, both feeder services and busway services typically operate without subsidies. Thus, finding a business model that allows smooth integration and shared infrastructure between feeder and trunk-line services is more easily facilitated.

Fig. 2.52
The Miami busway integrates closely with the city's elevated rail system.
Photo by Lloyd Wight

By contrast, matching a system requiring operational subsidies with another devoid of subsidies can be difficult in terms of distributing revenues. In such instances, developing an integrated business model can be more complex.

Second, some BRT systems are able to cleverly eliminate the distinction between feeder and trunk-line services. In cities such as Porto Alegre (Brazil), public transport vehicles from multiple routes utilise the same trunk-line corridor, but these vehicles then leave the busway to directly serve different feeder areas. In this arrangement, virtually all customers receive a direct trip into the city centre. Likewise, the city of Guangzhou (China) is developing a system along a similar premise. Operating rail-based systems into lower-density neighbourhoods is generally not economically viable.

Accommodating other types of feeder services is equally important. Arriving at the public transport station by taxi, by bicycle, or by walking, should also be considered in the system's design. Designing for these modes is relatively independent of public transport type. However, in some cases, underground systems may be able to provide more space for bicycle parking than median LRT and BRT systems. In all cases, terminal areas should provide sufficient space to include bicycle facilities. Permitting bicycles on-board the vehicle is a significant advantage for the customer who can then use the bicycle to arrive at the final destination. In narrow public transport vehicles, such as some tram systems, the ability to enter with a bicycle may not be physically possible.

2.2.4.11 Image and status

"A man who, beyond the age of 26, finds himself on a bus can count himself as a failure."

—Margaret Thatcher, former British Prime Minister, 1925–

The perceived image and status of the public transport system is a major determinant in attracting ridership, particularly from non-captive public transport users who have other alternatives. The best designed public transport system in the world becomes meaningless if customers do not find the system sufficiently attractive to use.

Rail-based systems traditionally have maintained an edge with regard to creating a modern

Fig. 2.53 and 2.54
Rail-based systems do not always offer superior aesthetic qualities. The systems in Cairo (left photo) and Bucharest (right photo) show problems of neglect and vandalism.
Left photo by Karl Fjellstrom
Right photo by Lloyd Wright

and sophisticated image. Such an advantage becomes particularly important when attempting to attract ridership from car users. At the same time, the traditional image of the bus is relatively poor. Attracting middle-income and higher-income users to the bus can thus be difficult. Image issues, though, are not entirely restricted to bus technology. Older or poorly maintained rail-based systems may also evoke images that are not entirely favourable to attracting customers (Figures 2.53 and 2.54).

The image problem is most closely associated with bus technology. However, as has been noted, traditional bus services and BRT are two distinct types of service. BRT systems have done much to create a modern and unique identity. The modern tubed boarding stations in Curitiba helped to make a dramatic new impression for the service. Modern vehicles that cover their wheels and emulate the rounded shape of LRT vehicles also help to create a new image (Figure 2.55).

To date, the success of BRT systems in cities such as Bogotá, Brisbane, and Curitiba has dispelled much of the image concerns. It has been noted that users in Bogotá do not say that they are "going to use the bus" but rather that they are "going to use TransMilenio." The marketing of the system name and the quality of the service has been effective in creating a metro-like image.

Nevertheless, in developed cities of North America and Western Europe, the perception of BRT versus rail-based public transport is still a major decision-making consideration.

Fig. 2.55
Modern vehicles can give BRT systems a highly professional image. The vehicle in this photo is a Civis bus and not a light rail vehicle.
Photo courtesy of US TCRP media library

2.2.5 Impacts

The characteristics of different public transport technologies can result in different impacts as measured by urban, economic, environmental, and social indicators. Since public transport is often used as a policy measure to achieve a variety of social goals, an analysis of each system's impact is a legitimate part of the technology evaluation.

2.2.5.1 Economic impacts

Economic impacts can include the public transport system's ability to foment economic growth, stimulate jobs, and encourage investment. A prized objective with public transport systems is to encourage transit-oriented development (TOD), which refers to the densification of development along corridors. If a public transport project is implemented successfully, the creation of densified corridors can help to increase property values as well as shop sales levels.

While the research linking public transport projects to property values and shop sales is still limited, the results to date indicate a positive correlation. Research from the San Francisco-Bay Area indicated a US$1,578 property value premium for every 0.03 km closer a home is to a BART metro station (Lewis-Workman and Brod, 1997). Similarly, results from the Washington Metro system show a 2.4 percent to 2.6 percent premium in apartment rental prices for every 0.16 km closer to a station (Benjamin and Sirmans, 1996). Likewise, LRT systems have produced similar types of results. Evidence suggests that the Portland MAX system has produced a US$2,300 premium for homes located within 0.06 kilometres of the system (Dueker and Bianco, 1999). Additionally, Cevero and Duncan (2002a) found that homes near the San Diego LRT system increased in value by 2.1 percent to 8.1 percent depending on the distance from a station.

Fig. 2.56
The high-rise development along the Curitiba BRT system illustrates the ability of public transport to focus city development.
Photo courtesy of the City of Curitiba

While there has been relatively little analysis of property impacts from BRT, there is some evidence to suggest similar positive impacts. The rows of high-rise development along the Curitiba busways are readily-visible indications of a relationship (Figure 2.56). Likewise, many commercial centres are now being developed along the Bogotá BRT corridors. In fact, Rodriguez and Targa (2004) found that apartment rental values in Bogotá increased by 6.8 percent to 9.3 percent for every five minutes closer the location was to a TransMilenio BRT station. Additionally, during a three-month period after the construction of the Brisbane (Australia) busway, land values along the corridor increased by 20 percent (Hazel and Parry, 2003).

It should be noted that there also exists studies that do not show property value increases from public transport development. For example, Cervero and Duncan (2002b) found no appreciable effects from either the Los Angeles Red Line metro or the city's enhanced bus services. A 1998 study of the Supertram in Sheffield (UK) likewise gave no indication of impacts on property values (Dabinett, 1998). Thus, the quality and local context of the development plays a key role in determining the level of benefit. Some authors have also asserted that the local development benefit from BRT may be less than that from rail options. This assertion is based upon the idea that BRT may be perceived as less permanent than rail infrastructure. The perception of permanence is quite important to property developers who would be at risk if a public transport project was later removed. To date, there is no actual data indicating that BRT is perceived as being less permanent. As noted above, the results from Brisbane and Bogotá indicate that like rail transit, BRT can produce development gains.

Employment generation is another economic measure of a project's impact. Public transport projects generate employment through the planning and construction phase, equipment provision (*e.g.*, vehicles), and operation. In developing cities, employment creation tends to be a fairly important factor. Projects that ultimately reduce employment levels, in comparison to previous transport services, are more politically difficult to pursue. By contrast, in the developed city context, labour costs represent a much larger component of operating costs, and thus are typically a target for reduction to the extent possible.

BRT construction can provide a high level of employment per input of investment. Metro construction also provides employment but much of the project expenditures go towards the expensive machinery required for the tunnelling activities. In Bogotá, the first phase of TransMilenio produced 4,000 direct jobs during construction. The operation of the first 40 kilometres of the system also provided 2,000 persons with long-term employment.

The fabrication of mass transit vehicles offers the potential not only for local employment gains but also the transfer of new technology to a nation. Major international bus manufactures have established production facilities in BRT cities such as Curitiba, São Paulo, Pereira (Colombia), and Bogotá. The smaller economies-of-scales involved in bus manufacturing means that fabrication can be cost-effectively sourced to local sites. Rail-car production is generally not as transferable to the local level. The economies of scale with rail vehicle production imply that it is difficult to transfer fabrication from headquarter plants in countries such as Canada, France, Germany, Spain, and Japan. The importation of vehicles carries with it particular costs and risks, such as import duties and long-term currency fluctuations. Additionally, the importation of rail vehicles tends to create an awkward situation where tax funds in low-income nations are supporting employment and technology development in wealthier nations. However, at the same time, rail vehicles generally represent a higher order of technical sophistication, and this factor can be a consideration to countries interested in technology transfer opportunities.

All new public transport systems present both an opportunity and a threat in terms of operational employment. While in developed nations the reduction of employment through higher-capacity rail vehicles is a positive aspect in terms of reducing operational costs, this aspect can be a negative from the perspective of developing nations seeking to bolster employment. Likewise, BRT systems can imply a reduction of employment when many smaller vehicles are essentially being replaced by a larger articulated vehicle. In Bogotá this impact was mitigated by the fact that drivers are working shorter shifts in the new system (and making equal or better incomes). Previously a single driver would work as much as 16 hours per day. In the current system, more drivers share the same vehicle. Likewise, new employment was created through new positions related to fare collection, administration and management, and security.

All new mass transit systems, though, offer the potential to increase overall economic efficiency through reductions in congestion and subsequent gains through the supply chain. In the long term, such systems may be the backbone of improved economic growth. However, any short term negative impacts on employment levels must be handled with great sensitivity and concern.

2.2.5.2 Environmental impacts

All public transport options produce environmental impacts when displacing journeys that would be otherwise taken by individual motorised transport. Thus, the amount of expected ridership and the number of persons switching from private vehicles to public transport is a significant determinant in calculating environmental benefits. The ability of mass transit systems to encourage car users to switch to public transport depends on many factors, most notably cost and service performance. The convenience of car use makes for a challenging competitive environment. However, research in Bogotá indicates that approximately 20 percent of TransMilenio users formerly used private vehicles (TransMilenio, 2005).

The type of fuel utilised with the public transport vehicles also contributes to the overall environmental impacts. LRT and metro vehicles are almost always electrified. BRT vehicles may use a variety of fuel forms, including diesel, compressed natural gas (CNG), liquid-petroleum gas (LPG), diesel hybrid-electric, and electricity. The Beijing BRT system utilises Euro III diesel. The Bogotá system currently uses a mix of both Euro II and Euro III vehicles. The Quito Trolé line is an electric trolley-bus system. The Los Angeles Orange Line utilises vehicles CNG technology. Brazilian cities now are looking more closely at adapting diesel hybrid-electric technology to BRT systems.

Electrified public transport systems produce no ambient emissions at the local level. By contrast, BRT systems powered by fossil fuels produce local emissions. Thus, rails systems are essentially emission free at the street level. However, the overall environmental performance of such systems depends on the type of fuel utilised to generate the electricity. Renewable sources such as biomass, hydro, solar, and wind are relatively clean, but these sources typically only constitute a small percentage of total electric generation. Natural gas is also a relatively clean energy source but the combustion process does produce emissions such as nitrogen oxides and carbon dioxide. Nuclear energy is not typically utilised in developing nations, but in any case, carries with it other types of serious waste issues. Finally, coal remains a major energy source for electricity generation, particularly in developing nations such as China, India, Indonesia, and South Africa. Coal combustion produces significant quantities of nitrogen oxides and sulphur oxides, which are precursors to acid rain. Coal combustion also produces as significant emissions of greenhouse gases. If coal is a major constituent of the electricity supply, total emissions from electrified public transport can exceed the emissions of vehicles powered directly by natural gas or clean diesel technology.

While BRT vehicles can also be propelled by electricity, such vehicles more commonly utilise natural gas or clean diesel fuels. The amount of emissions from natural gas or clean diesel vehicles depends upon many factors including local geographic and topological features, fuel quality, and driving behaviour. BRT systems, even in developing nations, require fairly stringent emission levels, and typically are a dramatic improvement over the previous standard bus services. Nevertheless, natural gas vehicles and clean diesel vehicles do emit some amounts of nitrogen oxides, carbon monoxide, particulate matter, and sulphur oxides at the local level. Additionally, these vehicles also contribute to greenhouse gas emissions.

Mass transit vehicles of all types also reduce emissions through smoother operations. With fewer station stops and fewer conflicts with mixed traffic vehicles, mass transit in dedicated corridors is less prone to operational inefficiencies.

Besides air emissions, public transport is also a contributing factor to the overall level of ambient noise in a city. Since one public transport vehicle is equal to 100 or more individual vehicles, the reduction in noise, like the reduction in air emissions, can be considerable if ridership is increased. Thus, public transport in general contributes to lower decibel levels in a city. Electrified systems, such as LRT, metros, and electric trolleys, are particularly quiet while in operation. However, rail and trolley systems can also produce excessive noise, especially during braking. The noise generated from braking can be particularly amplified inside tunnels, such as with metro systems. Noise from the BART metro system in the San Francisco Bay area regularly exceeds 100 decibels. However, the noise impact from underground systems tends to only affect passengers and staff and generally has little to no impact at the surface level. The maximum permitted noise level for BRT systems such as Bogotá is generally 90 decibels. In general, electrified systems, whether rail or trolley-buses, provide a quieter operating environment.

2.2.5.3 Social impacts

Social impacts refer to the ability of a new public transport 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. Social impacts can also refer to changes in the safety and sociability of the streets.

Public transport's potential social impacts can thus include:

- Affordability of fares, especially for low-income groups;
- Creation of a social environment encouraging personal interactions;

- Attractiveness to all income segments of society and thus offering a meeting point of all income groups;
- Reduction in crime and insecurity in both the transit system and its surrounding environment.

The lower unsubsidised fare levels of BRT in developing cities can help make the public transport 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. However, this subsidy implies that public funds must be taken away from other potential public services.

Public transport 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. 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 transport improvements can have multiple social benefits. As noted, the upliftment of an area creates employment and economic growth. Additionally, evidence suggests that public transport improvements can also reduce crime. In general, the more professional the public transport environment, the less likelihood there is of crime. Further, higher levels of surveillance also can act as a deterrent. Security cameras and emergency call buttons are often utilised in both BRT and rail-based systems.

The longer train sets used in rail-based systems will tend to create greater separation between the driver and most passengers. Also, the driver of a rail system is generally separated from the passengers by an enclosed wall. By contrast, the open nature of a bus allows greater awareness by the driver of any security problems arising in the vehicle. Nevertheless, many metro systems employ regular surveillance of rail cars by way of security personnel.

2.2.5.4 Urban impacts

Public transport systems have a major impact on the shape and quality of urban life. A new public transport system will wield a considerable influence over the physical form of a city. This impact occurs both directly through the infrastructure as well as indirectly through the development that occurs along the corridor as a result. In the long term, the system will even influence where people decide to live.

The Curitiba BRT system has helped to focus considerable development along the busway corridors. A planning ordinance that restricted high-rises to the corridors also helped to achieve the transit-oriented development. The transit-development linkage is so pronounced that one can see exactly where the busways are located even when flying over the city in a jet airplane, due to the density of commercial and residential buildings. In turn, this density helps the municipality in several ways. First, more development near the public transport stations means that more people will be able to access and utilise the system. Second, the higher urban density also implies that municipal costs associated with electricity and water connections are reduced. Connecting municipal services to more suburban locations can be several times more costly.

In comparison to individual motorised transport, public transport consumes far less of the public domain. Figures 2.57 and 2.58 illustrate the difference in space requirements between 60 private vehicles and 60 public transit customers.

As surface modes, BRT and LRT require use of public road space. With its fixed guideways LRT typically requires less road width than BRT. This space savings is especially true of the smaller tram vehicles. Metros, of course, consume the least amount of surface space with only the entrance and exit points protruding into the surface area. Elevated systems still consume space due to the need for support columns. Typically, systems such as the Bangkok SkyTrain require one lane of surface space to provide this infrastructure. Additionally, footpath space is typically also taken near stations in order to provide stairways and other access means to reach the elevated platforms (Figure 2.59).

The conversion of traffic lanes to public transport lanes can become highly politicised with

Fig. 2.57 and 2.58
These images compare the amount of space required to move the same number of persons by private vehicles (left photo) and by public transport (right photo).
Photos courtesy of the City of Muenster Planning Office

Fig. 2.59
The pillars supporting elevated systems, as shown here with the Bangkok Skytrain, can also consume a considerable amount of surface space, especially in the median and sometimes along footpaths.
Photo by Lloyd Wright

arguments both in favour and against the exclusive lanes. Given the higher number of passenger-trips served in a more space efficient manner, it can be argued that public transport deserves a prioritisation. Nevertheless, automobile users will likely complain that the exclusive public transport lanes will create congestion. However, an alternative view suggests that private vehicles can also gain from the loss of a lane. In many developing cities, public transport and mixed traffic share the same road space. Conflicts arise because public transport and private vehicles have very different movement patterns. Public transport vehicles, especially informal mini-bus operations, will stop on a fairly random basis. Private vehicles, though, tend to travel directly between destinations. Thus, the random nature of the public transport vehicles will negatively impact the free flow preferences of the private vehicles. The separation of public transport from private vehicles can thus lead to greater order and flow rates for all vehicles.

The use of exclusive lanes by BRT and LRT also may result in an overall reduction in private vehicle use. The concept of "induced traffic" has been used to explain how roadway expansions seem to attract new traffic and ultimately do relatively little to deter congestion. Evidence from bridge and street closings in Great Britain and the United States indicates that a reduction in road capacity actually reduces overall traffic levels, even accounting for potential traffic transfers to other areas (Goodwin *et al.,* 1998). Thus, the empirical evidence suggests that giving exclusive road space to LRT and BRT will lead to reduced private vehicle use and little to no overall change in congestion levels. The fact that underground metro systems do not consume road space may thus result in a reduced incentive for motorists to switch to public transport. Since the existing road will continue to be available, any motorists switching will create more space, which can in turn encourage more private vehicle use.

2.3 Technology decision making

"For every complex and difficult problem, there is an answer that is simple, easy, and wrong."

—H. L. Mencken, journalist, 1880–1956

2.3.1 Comparative matrix

This chapter has attempted to provide an objective overview of the different public transport technologies. While this document outlines the planning process for the development of a BRT system, it is recognised that rail-based systems can be the appropriate technology choice in many circumstances. There is no one correct technology. As this chapter has indicated, the decision depends upon an array of local factors.

Table 2.9 summarises the findings of this chapter and notes the circumstances that are best suited to each technology.

2.3.2 Appropriate technology roles

"The proud minister of an ostentatious court may frequently take pleasure in executing a work of splendour and magnificence, such as a great highway, which is frequently seen by the principal nobility, whose applause not only flatter his vanity, but even contribute to support his interest at court. But to execute a great number of little works, in which nothing that can be done can make any great appearance, or

Table 2.9: Public transport decision matrix

Technology	Demand requirements	Advantages	Disadvantages
Metro rail / elevated rail systems	High to very high passenger demand (30,000 to 80,000 pphpd)	• Superior image for city • High commercial speeds (28–35 kph) • Attracts discretionary public transport riders • Uses relatively little public space • Low local air emissions	• Very high infrastructure costs (US$45 million to US$350 million per km) • May require operational subsidies • Poor revenue recovery during non-peak periods • Long development and construction times • Complex integration with feeder services
Light rail transit (LRT)	Moderate passenger demand (5,000 to 12,000 pphpd)	• Provides good image for city • Attracts discretionary public transport riders • Quiet ride performance • Can be fitted to narrow streets • Low local air emissions	• Moderately high infrastructure costs (US$15 million to US$45 million) • May require operational subsidies • Limitations with respect to passenger capacity
Bus rapid transit (BRT)	Low to high passenger demand (3,000 to 45,000 pphpd)	• Relatively low infrastructure costs (US$0.5 million to US$14 million) • Often does not require operational subsidies • Good average commercial speeds (20–30 kph) • Ease of integration with feeder services • Moderately good image for city	• Can carry with it the negative stigma of bus technology • Relatively unknown to many decision makers
Conventional bus services	Low passenger demand (500 to 5,000 pphpd)	• Low infrastructure costs • Relatively low operating costs • Appropriate for small cities with low demand	• Poor service image • Often lacking in basic customer amenities and comfort • Regularly loses mode share to private vehicles

excite the smallest degree of admiration in any traveller, and which, in short, have nothing to recommend them but their extreme utility, is a business which appears in every respect too mean and paultry to merit the attention of so great a magistrate. Under such an administration, therefore, such works are almost always entirely neglected". (The Wealth of Nations)

—Adam Smith, economist, 1723–1790

The previous conventional wisdom within transport planning was to employ rail-based systems wherever it was financially possible to do so. This philosophy is tantamount to spending as much as possible on a given corridor, even if the same service is achievable with a lower-cost solution. This preference can result in rail systems dominating the most lucrative corridors with virtually no possibility of covering other areas of the city. In turn, this result can imply higher fares, multiple transfers within a single journey, difficulties in effective integration between modes, and a long-term commitment to subsidies and capital repayment.

However, as the discussion in this chapter has noted, there are circumstances where metro rail and elevated rail are entirely appropriate. These circumstances can include:

- A megacity environment with actual peak corridor demand exceeding 30,000 to 45,000 pphpd;
- Extremely tight structural densities or geographical constraints (*e.g.,* a narrow strip of land bounded by water or a hillside) that do not permit use of the surface for dedicated public transport lanes; and,
- Availability of capital funding in the range of US$45 million to US$200 million per kilometre.

Likewise, there are many circumstances in which LRT systems are an appropriate technology choice. These circumstances include:

- Moderate corridor demand ranging from 5,000 pphpd up to 12,000 pphpd;
- Cities seeking an enhanced image through a visually attractive system; and,
- Availability of capital funding in the range of US$13 mn to US$40 million per kilometre.

These characteristics explain the prevalence of LRT systems in many North American and European cities.

Finally, BRT is increasingly being recognised as a sound technology option for a range of city conditions, and especially for developing-nation cities seeking both high-quality and a low-cost solution. BRT's ability to operate profitably across a broad range of operating conditions and the relatively low costs of its infrastructure has made it an option worthy of consideration. Based on the experiences to date, the conditions most favourable to BRT are:

- Passenger demand ranging from 3,000 to 45,000 pphpd along a given corridor;
- Need for average commercial speeds over 20 kph;
- Cities seeking to avoid the need for operational subsidies; and,
- Availability of capital funding in the range of US$1 million to US$7 million per kilometre.

BRT's broad set of profitable operating conditions has given the technology some versatility in terms of compatible public transport environments. BRT systems have fulfilled a range of roles in cities, including trunk services, feeder services to other transit technologies, and temporary solutions prior to rail upgrades. Table 2.10 outlines the different types of roles that BRT may assume within a city's public transport strategy.

Bogotá has demonstrated that a densely-populated mega-city can in fact be quite well-serviced by BRT alone. With actual peak capacities of 45,000 pphpd the TransMilenio BRT system is compatible to many metro systems in terms of ridership capabilities.

Table 2.10: Potential BRT roles within an integrated mass transit strategy

Service type	Explanation
Principal mass transit service	BRT can serve as the principal mass transit technology for a city, covering all trunk-line corridors and providing feeder routes
Metro extension	BRT can provide an economical means to extend metro services to outer areas
Mass transit in-fill	BRT can provide an economical means of adding mass transit lines within a city that already has some rail-based corridors
Feeder service	BRT can provide a feeder service connecting with existing metro corridors
Future conversion	BRT can serve as an economical entry into a mass transit for a city while also allowing for the future conversion to rail

Nevertheless a range of cities with existing rail systems may find BRT a compatible addition to an integrated system. As noted above, employing multiple technologies does bring with it added costs and managerial complexity. However, for cities with existing rail infrastructure and few financial resources the choice may be either BRT or waiting decades for further system expansion. Some cities with existing rail-based systems are viewing BRT as an economical means to extend or augment their systems. Medellín (Colombia) and Beijing are both developing BRT corridors that will act in concert with an existing rail-based system. São Paulo uses BRT as a means to extend the reach of the metro system to satellite cities.

A city with few financial resources may wish to consider developing a full mass transit network with BRT prior to a limited rail-based corridor. Building a single, limited corridor of high technology does little to provide a meaningful network for those persons who depend upon public transport for their daily mobility needs. In time, if the desire to convert to rail is strong, then this possibility is always there as a future conversion option. For such cities, BRT can provide a quality network over the medium term and thus do much to relieve the pressures of congestion, contamination, and inadequate access.

As stressed throughout this chapter, though, the ultimate decision on a mass transit system should not be based on a particular type of technology. Instead, the needs of the customer should be paramount above all. Placing the needs of the customer at the centre of the design process is the one mechanism to ensure the most appropriate technology is chosen.

2.3.3 The myths and realities of BRT

As a relatively new public transport option, BRT remains unknown to many decision makers. With much of the experience to date focussed in a few Latin American cities, BRT has been surrounded by several myths and misunderstandings. Table 2.11 sets forward many of these issues. BRT is clearly not the ideal public transport solution in every instance, and in many cases, works best in conjunction with other options. Nevertheless, BRT is likely to be increasingly viewed as an option for consideration.

Table 2.11: The myths and realities of BRT

Myth	Reality
BRT cannot compete with the capacity of rail systems	Bogotá's TransMilenio system moves 45,000 passengers per hour per direction while BRT corridors in São Paulo can also provide capacities over 30,000 passengers per hour per direction. Such capacity numbers are in fact larger than many rail-based systems including all LRT systems and many metro systems, such as the systems in London, Santiago, and Bangkok.
BRT is only appropriate for small cities with low population densities.	Bogotá is a mega-city of 7 million inhabitants with a population density of 240 inhabitants per hectare. In comparison, the population densities of selected Asian cities with rail-based systems are: Manila, 198 inhabitants per hectare; Bangkok, 149 inhabitants per hectare; Kuala Lumpur, 58.7 inhabitants per hectare (Newman and Kenworthy, 1999).
BRT requires a great deal of road space and cannot be built in narrow roadways	Design solutions exist for virtually every road space circumstance. Quito runs a BRT system through three-metre wide streets in its historical centre.
BRT cannot compete with rail options in terms of speed and travel time	Average commercial speeds for BRT systems generally are in the range of 20 to 30 kph. As a surface transit option, BRT reduces travel times through rapid access to stations and platforms. A US GAO study found that a comparison of BRT and LRT systems actually showed that BRT systems produced faster average speeds (US GAO, 2001).
BRT uses vehicles with rubber tyres which is an inferior technology; customers will never accept BRT	It is doubtful that anyone in Bogotá, Curitiba, Guayaquil, or Pereira feels that they have an "inferior technology". The appearance of BRT stations, terminals and vehicles can all be made to appear as sophisticated and inviting as any rail option.
BRT cannot deliver the transit-oriented development and land use advantages of rail	One only needs to see the rows and rows of high-rise development that has occurred along Curitiba's BRT corridors to realise that BRT can indeed deliver quality transit-oriented development (TOD).
BRT is fine as a feeder service, but it cannot serve main corridors	Yes, BRT can work economically as a feeder service or system extension service, and it can do so without requiring subsidies or prohibitively expensive fares. But the Latin American BRT systems have also proven that it functions perfectly well on relatively high-density mainline corridors.

3. Project set-up

"Begin with the end in mind."

—Stephen Covey, author and management consultant, 1932–

Once a leading political figure has made the decision to move ahead with the BRT project, the real planning process gets underway. It is also recognised, though, that other groups may move ahead with initial planning even when lacking a full political commitment. Thus, private sector groups or non-governmental groups may elect to develop more detailed feasibility and conceptual studies in order to gain political approval at a later junction. In reality, no two BRT planning processes are exactly alike, and gaining formal project approval can require a variety of approaches.

Even with a commitment from a leading political official, several legal steps may be necessary in order to formalise the project. Once these legal proceedings are completed, the process of forming a project team and developing a work plan can begin. The development of a planning budget and the full financing of the planning effort are also early activities. Finally, if outside consultants are to be utilised, the development of terms of references and contractual agreements is necessary to properly delineate the contracted activities.

Investments made early in properly structuring and organising the planning process can pay significant dividends later in terms of both the efficiency and effectiveness of the overall effort.

The topics to be presented in this chapter include:

3.1 Legal basis

"Before beginning, plan carefully."

—Marcus T. Cicero, Roman orator, 106–43 BC

3.1.1 Statutory approval

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.

Of greatest importance is to maintain an open and transparent process throughout. If the project is not implemented in an entirely legitimate and pluralistic manner, long-term public and political support can be undermined. If the proper authorisation mechanisms are not followed, opposition groups may later use such improprieties as a means to stop the project. The proper legal mandate will also establish the BRT project as a city-wide priority.

Beyond an initial mandate to begin the planning process other authorisations might be needed as well. Authorisations may include the creation of a specialised agency or transformation of existing ones, approval of the project budget or loans, and modification or creation of laws, regulations, and policies regarding the funding, implementation, and operation of bus systems. Many of these authorisations will require formal approvals from political bodies, such as the city council. This approval process can take considerable time and involve a substantial effort, so these requirements should be identified early in the process. Using existing legal frameworks is advised, rather than depending on changes for project implementation. Nevertheless, in some cases, preparing an adequate legal framework will be necessary.

3.1.2 Relationship to existing policies and plans

"Everyone who got where he is has had to begin where he was."

—Robert Louis Stevenson, novelist and poet, 1850–1894

The vision for the new public transport system should also be consistent with the intent and objectives set forth in existing policies and plans related to transport, land use, and economic development. The lack of consistency with existing policies and plans may create an opportunity for project detractors to legally delay or block the initiative. Thus, in some cases, policies and plans may require additions or amendments to be seen as fully compatible with the new public transport initiative.

While BRT itself may not be explicitly noted in an existing master transport plan, stated objectives to improve public transport are most likely present. Drawing a connection between the new vision and the master plan is worthwhile to ensure overall integration of the new system with the existing direction of the city's transport plan. If improved public transport is not a stated objective within the master plan or if BRT will somehow contradict existing objectives, then a review of the master plan may be in order.

Likewise, economic development and land-use plans should be examined for consistency with the proposed initiative. Typically, the reduction in congestion associated with a new public transport system will directly connect economic objectives to the BRT project. Existing land-use plans should make reference to transit-oriented development (TOD) and/or the densification of residential and commercial sites along key corridors. Such references would be consistent with the objectives of a BRT initiative.

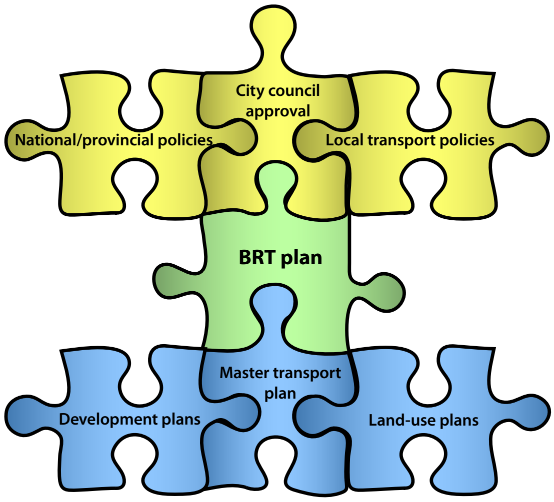


Fig. 3.1
To be approved by the required legal mechanisms, the proposed BRT project must succinctly fit with local, provincial, and national policies and plans.

Figure 3.1 outlines the importance of a BRT plan's consistency with existing policies, plans, and authorisation processes.

3.2 Development team

"Teamwork is the ability to work together toward a common vision. The ability to direct individual accomplishments toward organizational objectives. It is the fuel that allows common people to attain uncommon results."

—Andrew Carnegie, industrialist and philanthropist, 1835–1919

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.

3.2.1 Development entity

"Talent wins games, but teamwork and intelligence wins championships."

—Michael Jordan, former NBA basketball player

There are two different philosophies regarding the selection of a development entity for the new public transport initiative. On the one hand, some cities assign the project to one of the existing agencies with public transport responsibilities. Such an agency may have responsibilities regarding infrastructure (Public Works),

Fig. 3.2
Bogotá developed a new entity, TransMilenio SA, to oversee the development of the city's BRT system.
Photo by Lloyd Wright

regulation, or policy. The selected agency could also possibly have tangentially related responsibilities such as environment and air quality, health, or finance.

Other the other hand, some cities elect to create an entirely new organisational entity. The new entity may draw upon some existing agency staff, but in general would represent an entirely new team.

There are advantages to each option. Utilising an existing agency means that the development team would already possess a fairly insiders view of the current public transport situation. The existing relationship between the agency and transport operators could also be advantageous if a history of trust and co-operation is present. Further, by not creating a new entity, existing groups will not feel that their thematic "turf" has been expropriated. Also, any new organisation may have over-lapping responsibilities with the existing agencies, and thus this duplication can lead to confusion and administrative in-fighting.

An entirely new organisation offers the advantage of bringing a new perspective to the city's public transport system. It may be difficult for existing agencies to adequately think outside the box. Further, in some cases, the existing agencies may be to blame for the existing poor quality of public transport in a city. An entirely new entity will not feel as constrained by existing customs and existing biases. Additionally, the skills to deliver a successful BRT system can be quite different than the skills required to regulate conventional services. BRT development tends to be significantly more customer oriented and more entrepreneurial in nature. Some cities find that only a clean break with the past through a new organisation will result in a dramatic improvement to the public transport system.

Cities may also decide not to decide on any final choice of agency supervision for the new system. Instead, the BRT planning process can be overseen by a temporary, ad-hoc team. The decision on the eventual organisational structure can be determined through the planning process itself. At the outset, a decision can be made that the planning team will essentially be disbanded once the work is completed.

There are examples of each type of approach. São Paulo and Santiago developed their new BRT efforts through existing organisations. São Paulo's new Interligado system was co-ordinated by the Secretary of Transportation, with the participation of the bus authority (SP-Trans) and the traffic authority (Institute of Traffic Engineering). São Paulo's organisational decision was likely influenced by the fact that Interligado was a priority project of the Mayor and strong institutions already existed.

Santiago created a BRT project office within the national Ministry of Transportation. This office co-ordinated efforts of the other contributing organisations. For example, the Secretary of Transport Planning (SECTRA) had responsibility over technical aspects. Santiago also formed a project committee consisting of cabinet level officials and other key leaders, including the Ministry of Housing, Ministry of Finance, and the President of the Santiago Metro. Santiago's structure perhaps reflects the strong nature of central government institutions in overall decision making.

By contrast, Bogotá, Lima, and Dar es Salaam have all created new entities to develop their systems. From the outset, Bogotá created a project office that reported directly to the Mayor. This project office also co-ordinated efforts with other city agencies. The project office eventually became the formal oversight agency for the implementation and operational management of the TransMilenio system (Figure 3.2). Other

Colombian cities have followed the same structure, especially as a result of laws that make a specialised agency compulsory in order to receive national grants. In a similar manner, Lima has also created a special project office, which has now transformed itself into a city agency called PROTRANSPORTE.

It is perhaps worthy to note that the most ambitious BRT plans have emanated from newly created project offices or agencies. Bogotá and the other Colombian cities stand out as high-quality BRT systems. By contrast, the São Paulo and Santiago systems are possibly further from being considered "full BRT", especially when compared to Bogotá and other systems that were developed from a new institutional perspective. Thus, newly created entities may have an advantage in terms of being able to go well beyond established thinking and develop a public transport system of the highest quality.

3.2.2 Planning staff

"Creative thinking is not a talent, it is a skill that can be learnt. It empowers people by adding strength to their natural abilities which improves teamwork, productivity and, where appropriate, profit."

—Edward de Bono, psychologist and physician

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;
- Architect;
- Transport modeller;
- Design specialist.

There is a natural tendency to hire engineers first, as they are usually the people in charge of transport projects. Nevertheless, the team needs to be interdisciplinary and must have the ability to interact with public officials and corporations, transport industry, media, interest groups and so on. It is preferred that the members of the team are ambitious and not risk averse.

Special care should be exercised in the selection of the project co-ordinator. This person needs to have excellent management and communications skills, extensive experience in the creation and consolidation of new ideas, and must be as close to the political leader of the project as possible. The project co-ordinator should be fully devoted to co-ordination and management activities. Forcing this person to also juggle technical tasks will likely detract from the project's overall effectiveness.

In many instances, the team's attention may predominantly focus on infrastructure and vehicles, rather than operations, fare systems, and customer service. This tendency is natural given that infrastructure and vehicles can consume the bulk of the likely investment. However, ignoring issues like operations and customer service will ultimately undermine the entire project.

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.

Fig. 3.3
Members of the Jakarta BRT team being briefed on the Quito system.
Photo by Lloyd Wright

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 3.3).

3.2.3 Consultants

"Attachment is the great fabricator of illusions; reality can be attained only by someone who is detached."

Andrei Voznesensky, poet, 1923–

3.2.3.1 Appropriate role of consultants

Utilising consultants within a BRT project can be a cost-effective means to gain individuals with key specialties and direct BRT experience. The use of consultants allows skills to be brought on board without the cost and overhead of a full-time hire. Further, in many instances the particular skills may be only needed for one component of the project, and thus do not justify a full-time position.

Perhaps, more importantly, consultants help avoid the situation where cities are needlessly reinventing lessons already learned elsewhere. International consultants with significant BRT experience can help smooth the path from planning through to implementation. In all likelihood, such consultants have experienced many of the problems that will be faced by the local team and thus can propose effective solutions. A local team working in conjunction with experienced international professionals can ideally result in a combination of world best practice and local context.

Fig. 3.4
Dar es Salaam has successfully combined a full local team with international consultants.
Photo courtesy of Enrique Peñalosa

Of course, a city should not become over-dependent upon consultants. The local context is still best realised by local staff. The key decision-making points ultimately must be made by local officials. Consultants are one of several resources that lead to knowledge sharing.

A prudent strategy could involve building the capacity of local staff while simultaneously making selective use of consulting professionals. While Dar es Salaam officials had previous little experience with the BRT concept, the development of a core local team in conjunction with international consultants has proved to be a successful strategy (Figure 3.4).

Tracing the genealogy of recent BRT efforts reveals the influence of consulting expertise from previously successful projects. With Curitiba's early success in BRT, Brazilian consultants were particularly involved with the subsequent initiatives in Quito and Bogotá. To this day, Brazilian consultants are closely tied to several new initiatives, including BRT projects in Cali, Pereira, Cartagena, Dar es Salaam, and Johannesburg. More recently, Bogotá's highly acclaimed success has boosted the careers of those associated with TransMilenio. These consultants have been involved with a wide range of initiatives including projects in Cape Town, Lagos, Guatemala City, Lima, Mexico City, and Santiago. Consultancies from more developed nations have also made their impact with consultants from the US and Spain making substantive contributions to projects such as Bogotá and Lima. Thus, a BRT project may not only enrich a city with a new and efficient public transport system, it may also spawn a new local service industry catering to the exportation of BRT expertise.

3.2.3.2 Consultant selection and contracting

While some cities have developed well-designed systems without significant assistance from outside consultants, many cities find it advantageous to at least partially make use of persons with previous BRT experience. However, the procuring of consultant services can be difficult for municipalities with little knowledge of BRT consultant options. There can be a bewildering number of persons claiming BRT expertise. Given the myriad of BRT definitions and experiences, the perspectives and abilities of consultants can vary greatly. Thus, establishing a rational process for evaluating perspective consultants can help to ensure the municipality finds the right person(s).

Annex 2 of this Planning Guide provides a listing of some of the existing BRT consultants. Consultant selection should firstly be characterised by the process' openness and transparency. Further, structuring the process to be as competitive as possible ensures that the project developers have done their utmost to find the most qualified candidate(s). While designing an open, transparent, and competitive selection process may initially appear to be a time-consuming endeavour, the process can actually be relatively simple to implement.

Number of consulting contracts

As noted earlier, there really is not a single "BRT plan". Rather, the BRT plan consists of a series of constituent plans that each represent a distinct component of the overall project. The expertise required to develop a marketing and communications plan is quite different from the expertise required to deliver detailed engineering designs. However, there are clearly trade-offs involved in determining the optimum number of contacts to be issued.

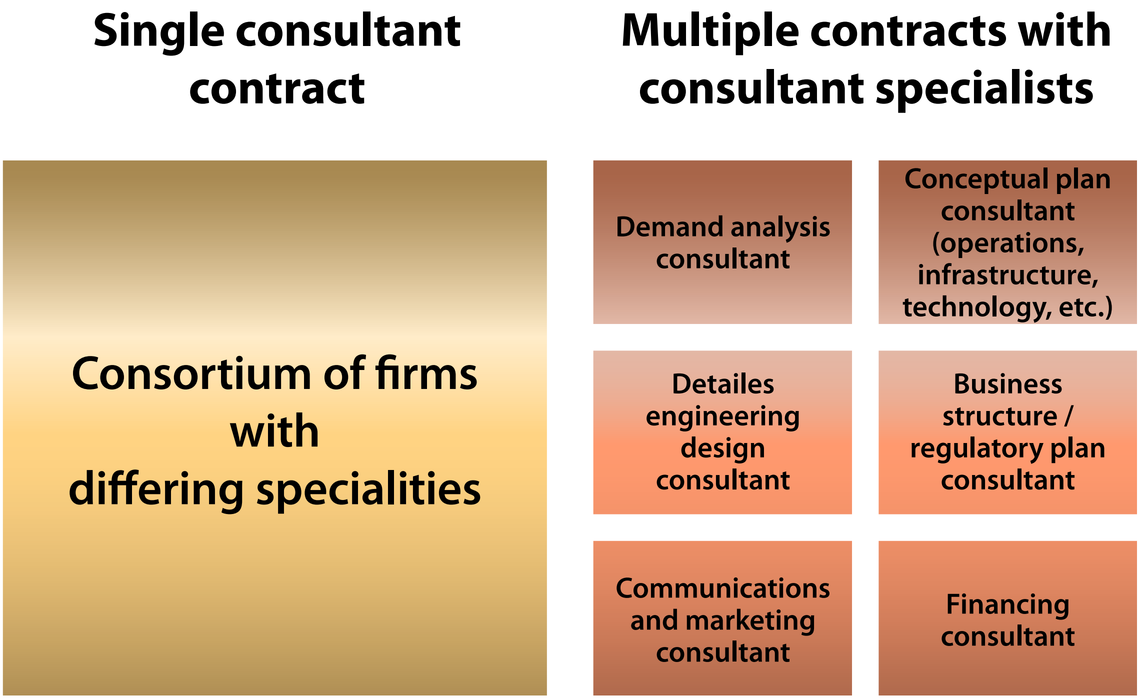


Fig. 3.5
Consulting services can either be structured through a single contract with a consortium of firms or through multiple contracts with specialist firms. Both structures have advantages and disadvantages that should be considered.

When deciding what to contract out, and into how many separate contracts, the following considerations should be weighed:

- Relative competence of private firms vis-à-vis the government in hiring the best experts;
- Possible conflicts of interest between the private contractors;
- Cost of planning;
- Project coordination.

At one extreme is the option of having the implementing government agency contract out a single consulting firm or consortium to deliver all components of the BRT plan (Figure 3.5). At the other extreme, a skilled public administrator might create a team within the government agency itself, and hire dozens of individual experts and private firms for very specific tasks. Most BRT planning processes fall somewhere between these two extremes.

Single contract

A single firm holds the advantage of ensuring that all planning components are internally consistent. For example, if separate firms are contracted for the operational and infrastructure planning, there is a much higher chance that parts of the plans will be incompatible, even with regular cross-communication. A decision that optimises system operations may be inconsistent with the funding available through the financing plan. By contrast, within a single firm, there is more likelihood that the team will develop a plan in which all parts fit closely together. Additionally, a single consulting contract is easier and less costly to manage and administer.

However, the simplicity of a single contract can compromise the overall quality of the delivered product. First, there are relatively few firms or individuals capable of delivering a quality plan for every aspect of a new public transport system. The requirement to hold expertise in every single aspect of public transport planning will limit the competitive field of possible consultants. Local firms who hold specialties in some areas (*e.g.,* engineering design and marketing), but not in other areas, may be especially disadvantaged by the single contract requirement. This lack of competition also tends to invariably increase costs.

Second, the project's quality can be compromised by firms attempting to deliver component areas where an adequate level of competence is not held. It is more productive to contract out project components to specialists who can provide greater depth to an individual topic.

Third, with ideas only coming from one source, the potential creativity and innovation being applied to the project will be limited. Different consultants tend to hold different philosophies on certain aspects of BRT design (*e.g.,* trunk-feeder designs versus direct service designs, smart cards versus lower-cost fare options). No one philosophy in inherently correct or incorrect, as local circumstances and preferences will ultimately dictate the path taken. With multiple consultants involved in the project, then this clash of ideas can spark a healthy debate in which all possibilities are more fully explored. Of course, such debates and discussions will tend to somewhat prolong the planning process, as each option put forward will require a degree of analysis.

Multiple contracts

For a skilled public administrator, having many smaller subcontracts of the very best experts only where needed to supplement government staff will yield much higher value for the money. One role that an international NGO can play is to advise the government on how to minimise planning costs by hiring individuals with the specific skills that they need. The weaker the capacity of the government to implement the project on its own, then the greater will be the incentive to lump planning activities under the management of competent corporate entities. However, this choice will come at a cost. It will be much more expensive relative to the quality of the work. Some key questions are:

- Who is more likely to make a sound choice on the selection of quality sub-contractors?
- Which structure will better ensure internal coordination within the project?
- Which structure will minimise potential conflicts of interest?

The right answers will vary on a case by case basis.

Consultant consortiums

To an extent, the problems associated with a single consultant contract can be overcome through the formation of consultant consortiums. In this case, a grouping of individuals and firms with the correct mix of skills and specialties helps to create a well-balanced team. Additionally, the consortium structure allows the combination of international and local firms with each focussing upon their respective areas of specialty.

The consortium concept works well where the organisational resources are available to help facilitate the teaming of different consultants. International consultants are unlikely to possess detailed knowledge of the possible local firms and may have difficulty in determining the most appropriate partner. Facilitating the "marriages" between the different firms and individuals may require the presence of an independent facilitator who can help make introductions between the relevant parties. Invariably, though, skilled specialists who would likely contribute to a particular planning component will find themselves without a viable partner. Further, it is likely that only a handful of successful consortiums will arise, and thus limiting the extent of the competitiveness within the bidding process. Small- and medium-sized cities may have difficulty in encouraging consulting firms to make the effort in forming successful consortiums. The perceived value of a smaller project may not be sufficient to warrant the investment in time to organise the consortium.

The emerging norm for BRT projects is to have the planning done by at least two or three contracts. It is typical that one firm, usually a planning and engineering firm with some modelling capacity, do the planning for the operations, technical specifications for the vehicle technology, and conceptual design for the infrastructure. This team might take the project all the way to the detailed engineering, but normally it takes the project as far as the detailed conceptual design. It is typical for a second firm, usually a management consultant, to manage the project, build the capacity of the government to implement and manage the operations, prepare the business plan, draft the terms of reference on the operating contracts, and prepare private sector bids. Typically there will be smaller contracts for other discrete elements, like legal support, planning bike lanes or public space in the corridor, public relations, etc.

However, on international projects, for the time being, these consortiums tend to be ad hoc, with many of the partners never having worked together, and this can frequently lead to tension and confusion within the consortium. Inter-corporate contracts are rarely able to cover every eventuality, and contract enforcement across national boundaries is expensive and difficult.

Thus, the number of consulting solicitations to be issued will depend on the particular approach being taken. If government administrative capacity is weak and a competitive number of viable consortiums can be arranged, then the single contract approach may be an option. Alternatively, the work can be strategically separated into component-based contracts. In this case, the optimum number of consulting contracts will likely be that which encourages the appropriate use of specialist skills without fragmenting the planning into unmanageable pieces. Component areas which require close coordination should probably be placed together in a single contract. Areas that require discernibly different skill types should probably be separated. Table 3.1 lists a possible division of consulting contracts for a typical BRT project.

In all cases, at least three of the activities should be contracted to firms or individuals

Table 3.1: Segmentation of consulting contracts

Type of plan/study	Types of individuals / firms
Pre-feasibility study (if needed)	Local or international consultants with public transport experience; firm should independent of the other consultants
Feasibility study (if needed)	Local or international consultants with public transport experience; firm should independent of the other consultants
Demand analysis	Local firm with modelling experience or a consortium of local and international firms in which the international firm may provide the analytic framework and modelling expertise while the local firm is responsible for the survey work
Conceptual BRT plan and detailed engineering plan (includes corridor and route selection, operational, infrastructure, integration, and technology plans)	Consortium of both local and international firms; international firms with BRT experience would help develop plan framework while local firms would provide labour-intensive activities such as detailed engineering designs
Communications and marketing plan	Generally a local public relations firm with some possible inputs from international firms/individuals
Business structure and regulatory plan	Consortium of both local and international firms; international firm provides inputs on business/regulatory schemes used to date while local firm provides the local regulatory context
Financing plan	Local or international financing expert, or municipal agency
Impact evaluation	Local or international firm; firm should be independent from the other consultants

independent of the others. Namely, pre-feasibility, feasibility, and impact evaluation should all be conducted by firms or individuals with no ties to the other consultants. This independence removes problems with conflicts of interest. A firm that has a possible interest in the full consulting work would have an incentive to return a verdict of "feasible" within the early feasibility work, regardless of the potential project's merits. Likewise, the evaluation of the plan's potential impacts (traffic, environmental, economic, and social) should be conducted by someone with no vested interest in the plan.

It is also normally a good idea to separate the contract for the conceptual design from the business plan. An engineering firm doing the conceptual design under contract is not going to want to have to redesign the entire system if the business plan determines the first iteration is not financially feasible, but this is precisely what needs to happen. They might also have relationships with specific vehicle suppliers and have an incentive to write the technical specification to favour known suppliers who will provide kickbacks. Having a separate management consulting firm evaluate the financial feasibility, for which the vehicle cost and technical specification will be a key issue, provides a certain amount of checks and balances.

If an approach using multiple consulting contracts is utilised, then a communications framework should be established to ensure good dialogue between all parties. The municipality should make sure that all consultants are operating under a similar conceptual understanding of the project. Otherwise, problems may arise in terms of consistency and compatibility between the plan components.

Of course, cities may also elect to take upon many of these activities without the need of outside consultants. Thus, for some or all of the activities listed in table 3.1, consultants may not be required.

Expression of Interest (EOI)

Often, the first step in any competitive tendering process is to issue a call for "Expression of Interest" (EOI). The EOI document basically requests that all firms and individuals interested in bidding on the project submit a document stating their interest. The EOI should be distributed as widely as possible to all potential consultants and firms. Since many consultants may have other commitments or interests, not all targeted firms will likely respond. The very best experts tend to gravitate to the projects with the best chance for success, and will need to be convinced that the project is worthy for them to be coaxed into bidding. Simply sending out the EOI will generally not be enough, but it is an important part of the process. Further, the EOI process helps the municipality to become aware of consultants not previously identified. Responses to the EOI may help municipal officials develop a shortlist of potential consultants who will then submit more detailed proposals. The EOI process permits a wide range of consultants to extend their interest without the necessity of a lengthy and costly formal proposal.

The EOI document itself will likely be fairly simple and short. Many EOIs are only 2 to 5 pages in length. In general, the contents of an EOI may include some of the following:

- Project title;
- Project description;
- Brief description of consultant remit and expected outputs;
- Estimated timeframe for consultant selection process, project initiation, and length of consultant activities;
- List of inputs requested from applying consultants (*e.g.,* previous experience in similar projects);
- Deadline for EOI submission;
- Submission details (length, format, etc.);
- Contact details.

Annex 3 of this Planning Guide provides a contract template for a typical EOI document.

The background information and the project description are sometimes issued separately as a background memorandum. The contents of the EOI should not be unduly detailed. If the EOI and later proposal requests are overly prescriptive, then there is little room for consultants to apply their expertise and propose more effective alternatives. Thus, these documents should merely set the project goals and objectives and leave creative aspects of project design to the actual planning process.

However, since the EOI may provide relatively little information about the prospective consultant, municipalities may have difficulty in determining the short-listed firms. Experience on having worked on other BRT projects is a necessary but insufficient criterion for short list qualification. Many of the firms likely to bid will be huge planning and engineering firms which have worked on all sorts of projects all over the world, including what might be called BRT projects. The important consideration is less the firm than the resume of the project team that is concretely being proposed. Sometimes a firm with limited experience in BRT will pick up an extremely talented expert to lead their team, and this would be a stronger bid than a firm that has worked on many BRT systems but which is assigning inexperienced personnel to the specific project.

As BRT has grown in popularity, the number of self-proclaimed BRT experts has also grown, and as much additional research as possible should be done into the qualifications of the specific team being proposed. Interviewing some of the clients of the consultant's previous work, and asking around among other professionals about their reputation, may provide useful insights. The community of international BRT experts is sadly still very small, and information about fellow experts is easy to obtain. Evaluating the quality of previous plans may also be useful.

How many firms should be invited to participate in preparing more detailed bid documents? There is no single rule on the number of firms since much depends on the local capacity to evaluate detailed proposals. In some cases, a well-resourced municipality may be able to bypass the EOI stage and simply ask all interested parties to participate in submitting a full proposal. The more proposals submitted, the greater the potential for a highly-competitive contest. Generally, though, the municipality will only want to evaluate a manageable number of detailed proposals. Further, requesting proposals from individuals or firms with no experience or no chance of acceptance can be a drain on the time of both the municipality and the applicants. Thus, short-listing anywhere from three to seven firms for detailed proposals probably provides a sufficient level of competition without becoming unwieldy in administrative terms.

Terms of Reference (TOR)

The next phase of the contract solicitation process typically involves developing the Terms of Reference (TOR). The EOI merely sets forth a few generalities to solicit consultant interest. The TOR sets out the list of requirements from which the detailed proposals will be developed. While the TOR will not necessarily detail every activity to be undertaken in the planning process, it will note the specific outputs and products required. For example, the TOR could call for the delivery of specific plans, such as operational plans, infrastructure plans, architectural plans, detailed engineering plans, financing plans, and marketing plans, and the TOR will likely discuss the level of detail sought from the planning process. Nevertheless, a well-crafted TOR will leave open the possibility of creativity from the consultants in achieving these results. Some of the common topics listed in a TOR include:

- Project title;
- Detailed project description;
- Description of expected consultant outputs;
- Estimated timeframe for consultant selection process, project initiation, and length of consultant activities;
- Request for names, titles, and curriculum vitaes (CVs) of consultant team-members;
- Description of consultant's relevant experience on past projects;
- Description of other evaluation categories (*e.g.,* use of local expertise);
- Deadline for EOI submission;
- Submission details (length, format, etc.);
- Scoring process for selecting consultant;
- Contact details.

Annex 3 of this Planning Guide provides a contract template for a typical TOR document.

The number of TORs should match the number of EOIs that were issued. Thus, each different consulting contract will have its associated TOR document.

Bid price

The proposed project cost will be one of the principal decision-making factors in choosing the consultant. However, it should not be the over-riding factor if other qualities, such as experience and staff qualifications, are not adequate. In some cases, cities may be legally bound to choose the lowest bid. This practice, though, can result in unsatisfactory results.

The amount of the bid prices can be derived either through open competition or through pre-set limits. Table 3.2 describes the options for determining consultant fees.

Table 3.2: Mechanisms for consultant bid prices

Mechanisms	Description
Fixed price	A single fixed price for consultant activities is pre-set; consultants only compete on experience and quality of TOR document
Fixed maximum price	A maximum price is pre-set; consultants compete on price to the extent that it does not exceed the maximum amount
Range of acceptable prices	A range of acceptable prices is established; consultants compete on price within this range
Open bidding	No pre-set amount or range of amounts is established; consultants compete in a completely open market

The particular mechanism chosen for the bid structure may depend in part on local legal requirements. In some cases, a fixed price bidding system may be required by law. However, by introducing some degree of competitively priced bidding, the municipality gains a better measure of the difference between the competing firms. Some cities may use a fixed maximum price or a range of acceptable prices in order to keep bids within the established budget. However, in such cases, all firms may simply bid the maximum amount or the median amount of the given range. Thus, any pre-set limits will tend to reduce competition and may increase actual costs over that which could be achieved in a truly competitive market.

An open bidding process can bring with it several benefits. First, without pre-set limits firms will tend to lower bid prices in order to effectively compete with others. Open bidding will tend to encourage innovation and creativity amongst the competing firms to find the most efficient manner of delivering a high-quality plan. Second, the range of bids received provides feedback to the municipality on the actual likely costs. With a pre-set value, firms will likely adjust their effort levels and the quality applied to the final product in order to achieve the fixed amount. Third, open bidding makes it easier to distinguish between different bids. The likely spread of bid values provides a more discernible gauge to evaluate the proposals.

Of course, the risk with open bidding is that all firms will bid an amount that exceeds the maximum allotted budget. However, this over-bidding can provide valuable feedback to the municipality. It may be a sign that the municipality should consider revising the estimated budget, or it may imply that the scope of work should be reduced to more realistically reflect the available budget.

For circumstances in which over-bidding occurs and there is no room for an expansion of the budget, the TOR should include a clause invoking "no qualified response". This clause signifies that none of the proposals met the project requirements and that a possible re-bid will be required. The "no qualified response" clause may also be invoked for other reasons, such as circumstances where none of the bidding firms have adequate experience. It is also possible that the bidding documents could spell out what happens in case the bids are over an undisclosed maximum. Bids over an undisclosed maximum need not necessarily be automatically disqualified. The TOR could specify that the bid price is not final but one consideration along with technical competence and other factors in the selection of a winning bidder. An over-bid might bring about a penalty but not necessarily a full disqualification. At this point, the winning bidder can be asked to resubmit the bid within the given budget.

Submittal deadlines

The deadline for the EOI and TOR submissions must be strictly adhered. If proposals even a few minutes late are accepted, then legal challenges from other aspiring firms and individuals may cause the entire project to become delayed or blocked.

Evaluation process and applicant scoring

Prior to issuing the EOI or TOR documents, the project developers should formally establish the decision-making process. Ideally, the decision-making criteria will be created in an open and transparent manner with inputs from a variety of sources. A committee of officials should be established to oversee the bid evaluation process. Placing all evaluation responsibilities with a single person can create unintended impressions.

The decision-making process for both the EOI and TOR should be as quantitative as possible. A scoring system for ranking firms and proposals can be a useful mechanism for clear and consistent decision making. If the selection relies too heavily upon qualitative judgements, then the entire process can be open to arbitrariness and the possible appearance of impropriety. In some cases, highly qualitative decision making could be challenged by the losing applicants, and thus creating delays and additional costs. Table 3.3 provides an example of a scoring system used to evaluate consultant bid proposals.

Table 3.3: Sample scorecard for evaluating consultant proposals

Factor	Points value
Bid price	35
Project experience with BRT	20
Project experience with other transport initiatives	15
Qualifications of proposed project staff	15
Proposed methodology	10
Proposed time schedule	5
Total	**100**

Because there is no commonly accepted definition of BRT, and projects called "BRT" vary widely, it may be necessary to further qualify the type of BRT experience being sought, such as experience with "closed" BRT systems, or experience with BRT systems in developing countries. Experts that have previously only worked in the US may have no idea how to plan a system like Curitiba or Bogotá's TransMilenio. If the BRT system being planned is likely to require restructuring of existing public transport routes, for instance, this is a different skill set than for a system which does not plan to alter existing bus routes.

The points allotted each category in table 3.3 are presented for demonstration purposes only. The actual relative value of each component will depend upon local circumstances and priorities. Further, if multiple consulting contracts are to be issued, then the scoring system will likely be tailored to the specific speciality being requested (*e.g.,* marketing, demand modelling, operational planning, infrastructure design).

Phasing of contracts

Despite the best efforts to clearly articulate the project objectives in the contracts, misunderstandings can arise. In such cases, consultants may work in a project direction that differs from the intent of the project organisers. By phasing the consultant work, such misunderstandings can be corrected before a great deal of unnecessary effort is invested. The phased approach essentially requires the consultants to obtain municipal approval prior to moving to the next stage of the project. Rather than waiting until the final report is submitted to review the project, municipal officials review intermediate findings and give their approval or disapproval. Such project milestones should be explicitly stated in the contract.

Additionally, these types of problems can be avoided by maintaining a close dialogue between the consultant and municipality at all times. Weekly or even daily briefings can ensure that all parties are in agreement on the project direction. Figure 3.6 outlines the process for reviewing consultant outputs. Alternatively, municipal officials may even procure "supervisory consultants" who work principally to review and evaluate the work of the project consultants.

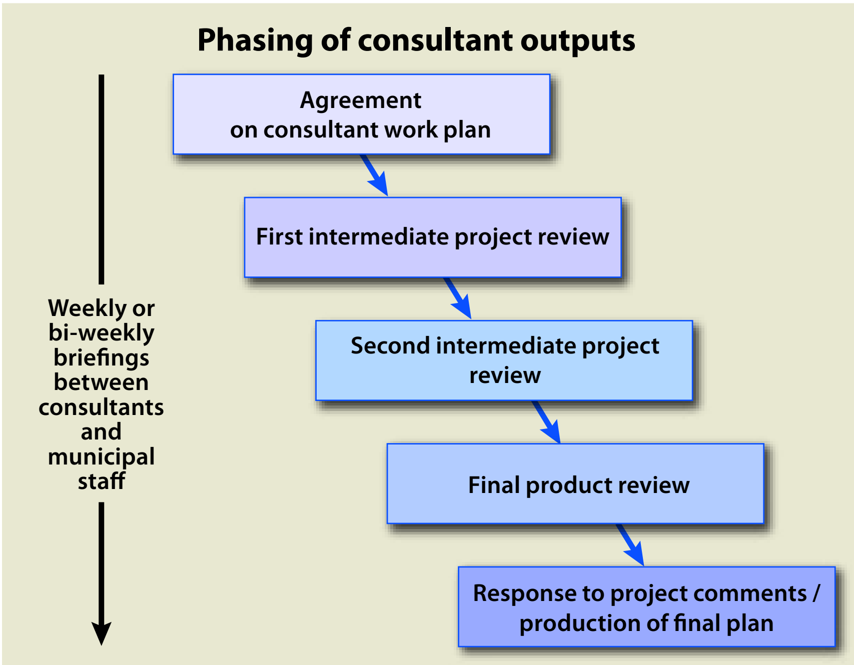


Fig. 3.6
Regular reviews and briefings by municipal staff over consultant progress helps to make sure all parties are in agreement over the project direction.

Penalties and incentives

Consultant contracts can be written to include penalty and incentive clauses to encourage good performance. Such clauses for planning work typically relate to the timely delivery of the product. However, incentives can also be applied to the quality and acceptability of the product. For example, a marketing firm can receive more compensation if the system logo or slogan is actually utilised by the BRT system.

The crafting of incentive language must be carefully considered. Ill-conceived performance clauses can produce unintended results. For example, rewarding the early completion of the work may create the incentive to rush through a poor-quality effort. In this case, it might be more advisable to just penalise a late delivery in conjunction with some form of incentive for plan quality.

Ultimately, the best defence against problems is to work with firms that already have a relationship with the government or that are interested in building a longer-term relationship that government. A government should establish longer-term relations with a few trusted firms with expertise in BRT. When problems arise, if the company believes that it has a future working with that government, it is much more likely to be responsive and flexible to government needs. Planning and engineering firms must often make large up-front investments in order to undertake complex and detailed planning work. This investment is especially true in a new city where they may not have all the information and modelling data that they need. Firms with a longer-term interest in that city are therefore likely to provide better results.

3.2.4 Project management structure

Once the project becomes officially announced to the public, a clear project management structure should be firmly in place. While pre-project fact-finding activities may be sufficiently conducted with a few staff and/or consultants, the formal project should be given a definitive personnel structure at the outset. The specific organisational structure will vary with local circumstances, but in all cases the structure should reflect the importance given to a new public transport system for the city. Figure 3.7 gives an example of an organisational structure for the Rea Vaya BRT project in Johannesburg.

Perhaps most importantly, the top political official overseeing the project should nominally be placed as the project chairperson. In most cases, this position should be held by the mayor

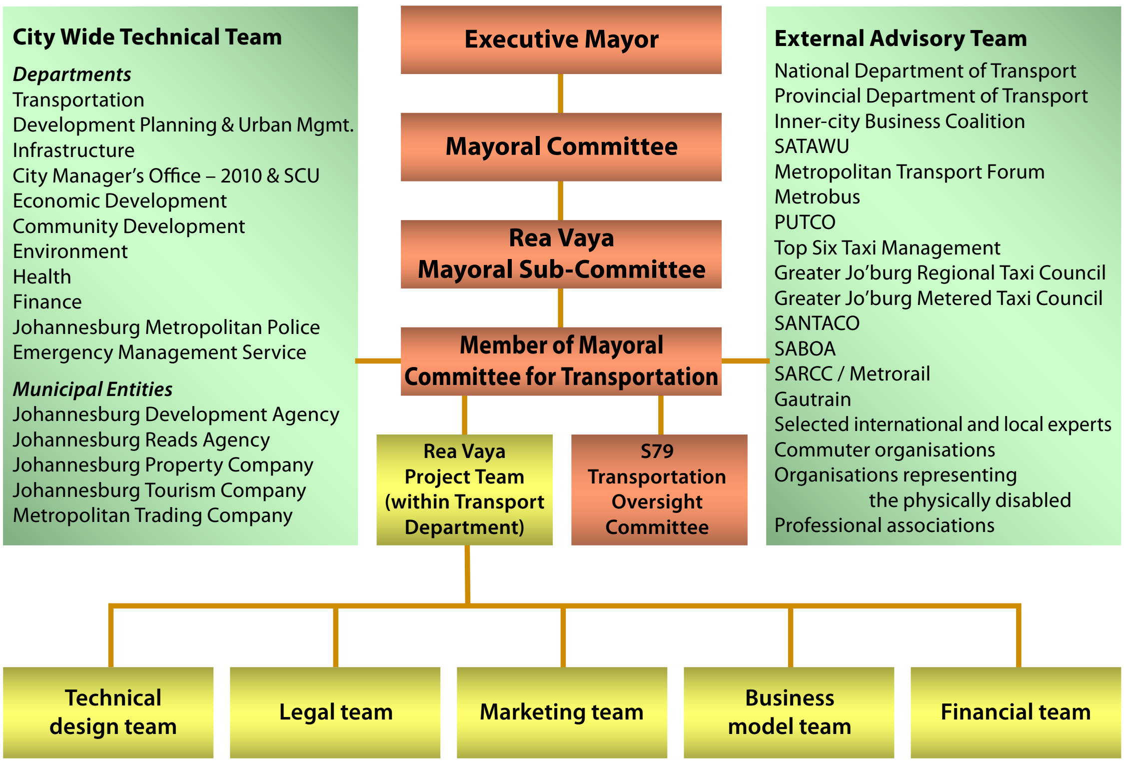


Fig. 3.7
An example of a possible project management structure for a BRT project.

or governor. In the case of Johannesburg, the Executive Mayor has the ultimate oversight and leadership on the project. The lead City Councillor for the project (*i.e.,* Member of Mayoral Committee for Transportation) has the lead role in terms of overseeing day-to-day activities.

This type of direct leadership involvement helps ensure that the project remains a top priority throughout the development process. While the project chair will not be intimately involved in all system decisions, the top political official should make an effort to become involved through regular briefings and formal committee sessions. The Mayors overseeing the highly successful BRT projects in Bogotá and Curitiba made an effort to be involved in decision-making sessions and briefings at least once a week and sometimes even more frequently. This type of high-profile involvement helps keep the project's momentum moving decidedly forward.

The organisational structure in Figure 3.7 also shows both internal and external advisory committees. The internal advisory committee consists of other city departments or entities with some interest in the project. The external advisory committee consists of key outside stakeholders, including national and provincial governmental officials, public and private transport providers, trade and labour unions, commuter organisations, and local and international experts. 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.

The inclusion of related agencies (public works, transport, urban planning, finance, environment, and health) on the steering committee helps to ensure cooperation. At some point the support and knowledge of these organisations will likely prove invaluable. Further, the inclusion of these actors will help mitigate "turf" issues and facilitate inter-agency cooperation to the extent possible.

3.3 Project scope and timing

"Time is the scarcest resource and unless it is managed nothing else can be managed."

—Peter Drucker, author and management consultant, 1909–2005

3.3.1 Work plan and timeline

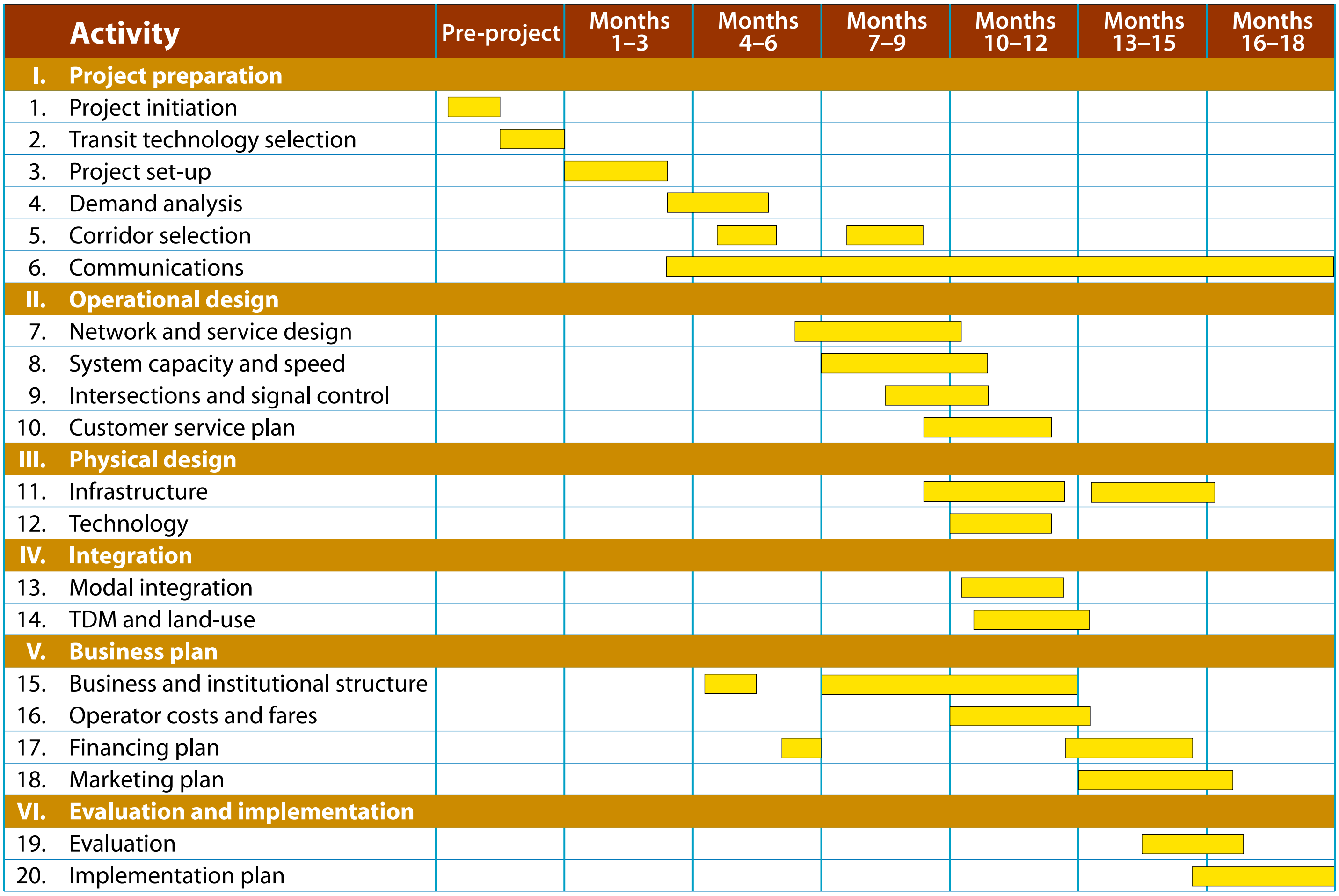
Once a vision is set for the BRT system and an initial team is formed, a detailed work plan and timeline on how to achieve the vision will be necessary. By walking through each step of the process, municipal officials and the public will have a better idea of the scope of the project and the necessary 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. However, as experience with BRT planning grows, some cities may be able to greatly reduce the required planning period, especially through cooperation with existing BRT cities and international consultants. The January 2006 launch of the Beijing BRT system was supported by just five months of planning effort. Of course, 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. Sharing the work plan and timeline with politicians, press and the public will also help ensure that all parties have realistic expectations of progress with the project.

No matter how well one plans, though, unexpected events will also act to necessitate modifications. Thus, the work plan and timeline should be revisited and revised from time to time during the planning process. Figure 3.8 provides an example of a basic BRT timeline. In an actual project, a very detailed Gantt chart should be created so that each step is carefully evaluated from a timing perspective.

Figure 3.8: *BRT Planning Process: Workplan and Timeline*



3.4 Planning budget

"A budget tells us what we can't afford, but it doesn't keep us from buying it."

—William Feather, author, 1889–1981

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 18 months of time, any temporal 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 percent 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 over US$5.2 million was spent in the planning process. By comparison, using principally in-house professionals, the municipality of Quito spent only approximately US$300,000 to plan its smaller system. The recently inaugurated Phase I of the Beijing BRT system was planned from a budget of just US$125,000. In general, though, planning costs will likely range from US$1 million to US$3 million.

Given the modest cost of BRT planning relative to other public transport options, cities should be careful not to under-invest in the planning process. As one BRT planner has noted:

> "BRT is like performing heart surgery on your city's clogged arteries. A city should not hire the cheapest surgeon it can find, it should hire the best surgeon it can find."

Skimping on the provision of resources to the planning process, and rushing the process to ensure rapid implementation deadlines determined by political imperatives, may prove costly in the long run. Proper planning helps cities to avoid the basic mistakes that can be quite costly later. It is hoped that this BRT Planning Guide will help cities plan a BRT system at a lower cost and within a shorter time frame.

3.5 Funding and financing sources

"He that wants money, means, and content is without three good friends."

—William Shakespeare, playwright, 1564–1616

Funding refers to the general provision of monetary resources to a project. Financing refers to the mechanism required to cover the difference between the available funding and the total amount required for the project. Financing may particularly refer to circumstances where there is an additional associated cost with procuring the funds (*e.g.,* interest-based loans). In the case of BRT planning, financing is usually not required at all. Even for relatively low-income countries and cities, a total planning cost of between US$1 million and US$3 million for a new public transport system may not be an insurmountable amount to be designated from local sources. Political commitment is likely to be a much greater determinant in whether to undertake the planning process rather than any fiscal limitations.

Local, provincial, and national entities are the logical starting point for identifying funding sources for BRT planning. However, the cost-effectiveness of BRT has also meant that many international sources are supportive of BRT planning efforts. Table 3.4 lists many of the possible funding sources for BRT planning.

Table 3.4: Potential funding sources for BRT planning

Funding source	Examples
Local government	New budget item Existing budget from Transport Department Existing budget from Planning Department Existing budgets from Departments of Environment, Economic Affairs, and Health
Provincial / state government	New budget item Existing budgets from Departments of Transport, Planning, Environment, Economic Affairs, and Health
National government	New budget item Existing budgets from Departments of Transport, Planning, Energy, Environment, Economic Affairs, and Health
Private sector	Private bus operators, land developers, fuel suppliers, vehicle manufacturers, etc.
Bi-lateral assistance agencies	DfID, GTZ, JICA, Sida, USAID
Bi-lateral export banks	JBIC, KfW, US TDA, US ExIm Bank, US OPIC
United Nations agencies	UNDP, UNEP, UNCRD, etc.
International environmental funds	Global Environment Facility (GEF)
Development banks	World Bank, IADB, ADB, etc.
Private foundations	Hewlett Foundation, Blue Moon Foundation, Shell Foundation, etc.

Annex 4 provides contact details for various types of bi-lateral agencies, international organisations, and private foundations.

3.5.1 Local, provincial, and national funding sources

3.5.1.1 Local government sources

In many instances, a municipality will hold sufficient to budgetary resources to plan a BRT project without any outside assistance. This situation is particularly true when the municipal leader is highly motivated towards a new public transport system.

The viability of self-funded efforts will also likely depend on the technical capacity of the government bodies charged with planning and designing the system. If the technical capacity is quite strong and if many staff members are already experienced with BRT, then much of the planning work may be conducted internally. In these cases, the planning costs may be covered through normal on-going budgets. Thus, the planning costs are effectively nominal. Quito illustrates the cost effectiveness of this approach with the Trolé corridor being planned internally for a cost of approximately US$300,000. However, the lack of outside inputs may have contributed to some of the problems currently plaguing the Quito system. Thus, short-term cost effectiveness can carry with it significant long-term liabilities.

In other cities with little in-house technical capacity, external and/or international consulting expertise may be required. In these cases, the higher planning cost may make sole reliance on municipal funding more difficult.

Even if a city envisions the need for external funding, local, provincial, or national government contributions will likely be required. International organisations typically view local contributions as an indicator of a city's true seriousness towards actual implementation. Any city would likely accept a free BRT plan, but without any local commitment of funds there is little motivation to deliver a real project. Thus, many external funding sources require a significant local (or provincial or national) contribution. A 50 percent match is frequently the standard for receiving international planning funds.

3.5.1.2 Provincial and national sources

Additional funding inputs from provincial and national agencies may be another option that avoids the requirement of non-governmental funding. In some cities, provincial and national agencies may actually hold responsibility over BRT planning and implementation. Thus, in cities such as Cape Town, Bangkok, and Jakarta, provincial funding sources have provided the some of the impetus for BRT planning. In Colombia, the national planning agency has played a central role in exporting the TransMilenio concept to other cities.

Involving provincial and national agencies also brings with it other advantages in terms of accessing additional technical experience. Of course, each additional agency involved in the project can also imply increased managerial complexity and the potential for disagreements between parties, especially if the different levels of government are represented by different political parties.

3.5.1.3 Local private sector

In some instances, the local transport situation can deteriorate to the point where the private sector may take it upon themselves to seek an alternative. Private sector involvement may stem from local officials essentially abdicating their responsibility to manage and promote public transport. Clearly, private sector involvement will also feature a bit of self-interest in which the private sector parties expect the improved public transport system to deliver corporate profits.

Private bus operators may view a move to a BRT system as the principal means to improve their profitability. Operators may also be responding to increased competition from informal vans and mini-buses that are filling a market gap left by poorly organised and managed formal services. The development of BRT in Curitiba was likely the reason that Curitiba is the only major Brazilian city where "clandestinos" (informal vans) have not infringed upon the formal market. Thus, consortiums of private operators have led BRT planning efforts in several cities including San Salvador (El Salvador) and Santiago (Chile).

Other private parties may also have an interest in BRT development. In Manila (Philippines) a local property development company has initiated BRT efforts in districts near business parks owned by the firm. A formal public transport system in this area would deliver value to the company through improved property values and better access for employees.

Private manufacturers may also have a vested interest in BRT. Vehicle manufacturers could benefit from the increased sales stemming from new BRT vehicles. For example, Volvo has launched an initiative in India to promote BRT development. Additionally, fuel suppliers may also see an advantage to BRT promotion if their product is likely to be chosen for improved environmental performance. In Dhaka (Bangladesh), a local supplier of compressed natural gas (CNG) has taken the lead to initiate BRT planning activities.

Based on these examples, municipalities may wish to form alliances with private sector associations that would be natural allies in BRT development.

3.5.2 International funding sources

The success of BRT has not been lost upon development banks and other international organisations. The lack of large capital debts and the lack of necessary operational subsidies mean that these organisations typically rank BRT as an option to promote and facilitate.

The plethora of international organisations now interested in BRT means that cities have a healthy supply of funding options. The international role is particularly relevant to the planning process. The mandate of many international organisations revolves around issues such as capacity building, information dissemination, and project facilitation. All of these issues are related to planning. Further, most international planning assistance arrives in the form of grants and not loans. Thus, planning funds typically do not carry any additional financing costs.

The international resources often also bring the additional advantage of allowing greater access to professionals with international BRT experience. An international organisation may hold a relationship with top BRT consultants, many of whom would not ordinarily be available or affordable to a particular city. A local government within a developing-nation city may have little knowledge on which international consultant to trust with the project. International organisations will often be involved in multiple cities and thus be able to identify the best-performing consultants. Likewise, some leading experts will not work directly for municipal governments for fear of never getting paid. By contracting directly with the international organisation, the consultant will be more confident in accepting the assignment.

International organisations can also ensure that local and international consulting teams work as a united team. As noted earlier, local consultants possess the critical knowledge of the local context while international consultants may possess greater BRT experience. The local and international consultants may not work in a complementary manner if each group feels the other is inadequate either for the lack of local knowledge or for the lack of BRT experience. The presence of a respected international organisation, such as a bi-lateral agency or development bank, can mediate such differences and create greater team harmony and co-operation.

The main disadvantage of involving international funding sources can be the amount of effort required in the application process. The international organisations may require an extensive analysis of the city's transport history, assurances from all relevant agencies and departments, calculations of emission benefits, and a detailed framework connecting objectives to outputs. This process may also involve seminars and workshops to build capacity and sharpen the project premise. While this application process can actually be a useful part of project preparation, the amount of time and effort involved can slow overall project development. Further, several such applications may be necessary before receiving the support and commitment of an international organisation.

3.5.2.1 Multi-lateral organisations

Multi-lateral organisations such as the World Bank, regional development banks, and agencies of the United Nations often 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. Thus, GEF funds are utilised to address such issues as the degradation of international waters, biodiversity, global climate change, ozone depletion, and persistent organic pollutants (POPS). Through the global climate change programme and the GEF's Operational Programme number 11, transport is an eligible sector for funding. BRT projects qualify under article 11.10(a) of Operational Programme 11: "Modal shifts to more efficient and less polluting forms of public and freight transport through measures such as traffic management and avoidance and increased use of cleaner fuels."

To qualify for a GEF project, a municipality will need the support of its national GEF focal point, which is typically housed at either a national ministry of the environment or a national ministry of foreign relations. Additionally, the project will need one of the GEF's implementing agencies to champion and support the project through the application process. Eligible implementing agencies include the World Bank, the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), and regional development banks (*e.g.,* African Development Bank, Asian Development Bank, Inter-American Development Bank). To date, the GEF has approved several BRT-related projects, including projects in Cartagena, Dar es Salaam, Hanoi, Lima, Mexico City, and Santiago, as well as multi-city initiatives in Colombia and China.

Fig. 3.9
Multi-lateral organisations have been quite supportive of BRT projects to date. In many cases, grant funding is available to support planning activities.

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

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

In a large city or a multi-city project, a full-sized GEF project will likely be required. For this reason, the GEF transport projects in Hanoi, Lima, Mexico City, Santiago, Colombia, and China are all full-sized projects. Medium-sized cities such as Cartagena and Dar es Salaam have received funding as medium-sized projects (MSPs).

GEF resources are unlikely to directly finance infrastructure, but are useful in assisting with the planning process. Additionally, GEF funding can also be an effective means to attract complementary financing from other sources.

Other international organisations may also support BRT planning activities. For example, the United Nations Development Programme (UNDP) has played a role in developing BRT projects in Pereira (Colombia) and Cartagena (Colombia) through technical assistance activities. The Clean Air Initiative for Asian Cities (CAI-Asia) is also playing role in BRT development through its programme known as Sustainable Urban Mobility in Asia (SUMA). The SUMA programme is a US$5 million grant-making facility made possible through resources from Sweden (Sida) and the Asian Development Bank (ADB). Likewise, the European Union (EU) posseses some of its own overseas development assistance funding. In some instances, EU funds have been applied to feasibility studies where European consortiums are positioned to capture the contracts.

While development banks are more closely associated with financing infrastructure, the project preparation grants have also been used. These grants are common when a later infrastructure loan is being considered. Cities such as Dar es Salaam (World Bank) and San José (Costa Rica) (IADB) have benefited from such grants.

Fig. 3.10
Bi-lateral agencies can also be a source of potential technical and financial support during the planning phase of the project.

3.5.2.2 Bi-lateral agencies

Additionally, bi-lateral agencies such the German Technical Cooperation (GTZ), the Japanese International Cooperation Agency (JICA), 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. GTZ has played a role supporting BRT development in such cities as Bangkok (Thailand), Buenos Aires (Argentina), Cartagena (Colombia), and Surabaya (Indonesia). Sida has assisted BRT awareness in Bangalore (India) and Dhaka (Bangladesh), and more recently, Sida has helped to fund the US$5 million Sustainable Urban Mobility in Asia (SUMA) programme. USAID has been active with BRT support in Accra (Ghana), Dar es Salaam (Tanzania), Dakar (Senegal), Cape Town (South Africa), Johannesburg (South Africa), Delhi (India), Hyderabad (India), and Jakarta (Indonesia).

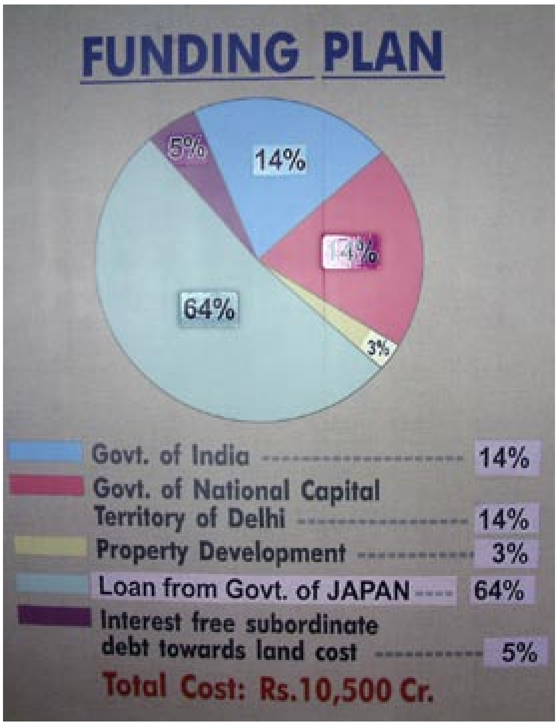


Fig. 3.11
With the assistance of JICA and JBIC, the Delhi metro benefited from concessionary loans from the Government of Japan.
Photo by Lloyd Wright

JICA has funded numerous master plans and transportation demand modelling projects in developing countries. Most often JICA, along with the Japanese Bank for International Cooperation (JBIC), encourage cities to procure Japanese rail-based technology or make use of Japanese construction firms for roadway projects (Figure 3.11). In Bogotá, JICA recommended the construction of a metro system and a large elevated roadway system (Figure 3.12). Fortunately, former Mayor Enrique Peñalosa rejected this vision and opted for the path of sustainable transport characterised by the city's TransMilenio system, cycle ways, and pedestrian zones. However, some of JICA's studies

Fig. 3.12
A JICA drawing showing a vision for Bogotá with elevated roadways. Fortunately, Mayor Enrique Peñalosa rejected this vision and opted to build TransMilenio instead of elevated roads.
Image courtesy of the Municipality of Bogotá

and master plans have made reference to the possibility of BRT.

As the example of JICA indicates, cities must be careful when governments are practicing "tied" aid, in which the technology options are limited to firms only from a particular country. Thus, a city may be limited to selecting consultants of a particular nationality or using vehicles or fare equipment manufactured in a particular developed nation. Such practices may result in sub-optimal technology solutions. Additionally, such restrictions will dampen efforts to develop skills and manufacturing capabilities locally. BRT represents a practical means to encourage appropriate technology transfer and local manufacturing. A "tied" aid package may mean that developed-nation consultants and products take precedence over local sources.

3.5.2.3 Bi-lateral import-export banks

The link to exporting products from developed nations is even more explicit with bi-lateral import-export banks. These entities have been created mostly by governments in North America, Western Europe, Oceania, and Japan for the purpose of promoting the exportation of their own manufacturing goods and services. Examples of bi-lateral import-export 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);
- US AID's Housing Guaranteed Loan program.

As with the case with some bi-lateral aid, this type of "tied" contract can come at the expense of local production. Further, the exclusive use of one nation's products will undoubtedly reduce overall competition and potentially result in a sub-optimum solution.

However, not all funding from bi-lateral import-export banks is quite so solidly tied to a particular manufacturer. Some bi-lateral import-export banks will extend funding for feasibility studies and planning work if their national firms have a chance of winning a contract, but there may not be an absolute guarantee of their firms being given an automatic contract. Thus, bi-lateral import-export banks may still be an option even when fully competitive bidding is the preference of the city.

3.5.2.4 Private foundations

Private foundations such as the Blue Moon Foundation, Hewlett Foundation, the Shell Foundation, the Volvo Foundation, and the former W. Alton Jones Foundation have also been supporters of BRT activities. The Hewlett Foundation has supported BRT activities in Beijing (China), Rio de Janeiro (Brazil), São Paulo (Brazil), and Mexico City (Mexico). The Shell Foundation, through the World Resources Institute, is assisting BRT development in Mexico City and other cities both in Latin America and Asia. In some instances, these foundations may not directly fund planning work. Instead, some foundations focus on market preparation activities, such as workshops and other capacity-building exercises, in order to help cities make the decision to proceed with a BRT project.

3.5.3 Funding and financing examples

3.5.3.1 Bogotá, Colombia

As perhaps the premiere BRT system in the world today, Bogotá's TransMilenio benefited from some of the best consulting assistance offered to date. Since few high-quality projects had been completed prior to TransMilenio, Bogotá essentially paid for the development of many ground-breaking concepts in the BRT field. With the experience of Bogotá now established and well-known, new projects have benefited from this knowledge. The planning costs of new projects have thus been substantially reduced due to Bogotá's efforts. In total, the municipality of Bogotá invested approximately US$5.2 million in the BRT planning process. While this amount seems costly, the Bogotá system is highly profitable, and requires no operating subsidies, nor subsidies for vehicle procurement.

Table 3.5 summarises the consultants utilised in the TransMilenio project and the sources of the consulting expenditures.

In Bogotá, the largest contract was for a management consultant firm (McKinsey) to provide overall project management as well as

Table 3.5: Planning costs for Phase I of Bogotá's TransMilenio

Firm contracted	Amount (US$)	Source
McKinsey & Co. (Strategic consultants)	3,569,231	United Nations Development Programme
Investment bank	192,308	Bogotá Department of Transport
Steer Davies Gleave (Technical consultants)	1,384,615	Bogotá Department of Transport
Landscape design consultants	115,385	Bogotá Department of Transport
Total	**5,261,538**	

set-up TransMilenio SA, the operating authority. McKinsey's participation was funded by the municipality through an account with the United Nations Development Programme (UNDP). For almost three years, the Municipality of Bogotá held a technical assistance agreement with UNDP through which the municipality would pay into a UNDP account. These funds would then eventually be applied to international technical assistance. Since these funds were already committed, the municipality simply allocated the money to the BRT project.

The remaining consultant contracts were also supported by municipal funding. The planning, design, and engineering work (another US$1.5 million) was paid for largely out of the ongoing budget allocations of the Municipality's Department of Transportation. This work was contracted a leading international planning firm, Steer Davies Gleave. In turn, Steer Davies Gleave subcontracted some of this work to Brazilian experts from the firm of Logit. Due to the consulting team's efforts, the TransMilenio system has proven to be fully self financing and even profitable and has represented a world best example. Thus, the large planning expenditures have helped to save the city financial resources into perpetuity.

3.5.3.2 Quito, Ecuador

Like Bogotá, Quito used ongoing budget resources to finance all of the planning. However, other than for one international UNDP expert brought in during Phase II, all of the planning and design work was done in-house by the Planning Department of the Municipality of Quito. The costs were much lower than in Bogotá, and are difficult to define precisely, as these costs were covered by the normal ongoing budget of the planning department. The total planning costs are estimated to be approximately US$300,000.

While Quito represents an admirable effort for a city with limited resources, the exclusive use of in-house staff may have contributed to some of the system's operating and financial difficulties. On the first BRT corridor, the "Trolé" line, the selection of electric trolleybus technology helped to minimise environmental impacts, but the technology has undermined overall system cost effectiveness. The use of electric trolley-buses and the accompanying required infrastructure meant that the total corridor costs came to approximately US$5.1 million per kilometre. This amount represents a cost of nearly US$4 million more than subsequent corridors that did not utilise electric trolley-bus technology. Since the Trolé line has not been entirely self financing, the corridor has remained in the hands of a public company. However, Quito is currently attempting to privatise this corridor.

The two new corridors in Quito have also suffered from operational difficulties, especially with respect to the business structure. The concession contracts given to existing operators for the "Ecovía" and "Central Norte" lines have limited municipal control of system quality and effectiveness. Further, since none of Quito's corridors are integrated with one another, the system offers little in terms of customer convenience. It is possible that many of the problems with Quito could have been avoided if the city gathered some inputs from the experiences of international experts. Quito is subsequently in the process of re-organising contractual arrangements along the "Ecovía" and "Central Norte" corridors.

3.5.3.3 Mexico City, Mexico

Planning for the Mexico City BRT system has attracted considerable international donor support. The total amount spent on system planning is estimated to be over US$1 million. The

Fig. 3.13
The Metrobus system in Mexico City has benefitted from the assistance of several international organisations, including the GEF, World Bank, WRI-Embarq, and ITDP.
Photo courtesy of Volvo Bus Corporation

detailed planning work for two BRT corridors in the Federal District and very preliminary analysis in the State of Mexico was financed by a World Bank-sponsored grant from the Global Environmental Facility (GEF). The Federal District used this money to hire local consultants to develop designs on the Insurgentes (Getinsa) and Eje 8 (Eteysa) corridors. The Shell Foundation and the Hewlett Foundation paid for international experts to review the Federal District plans. This international review process was largely managed by WRI-Embarq's Center for Sustainable Transport, along with support from ITDP to review pedestrian access issues.

The German Technical Cooperation (GTZ) funded the State of Mexico plans, which were developed by the consulting firm of "Cal y Mayor". In turn, ITDP funded international experts to review these plans, and to prepare a financing plan for the system. The State of Mexico has also contracted the Jaime Lerner Institute, the organisation headed by the former Mayor of Curitiba, to develop another pre-feasibility study on the system.

3.5.3.4 Delhi, India

In Delhi, approximately US$500,000 has been spent on planning the Delhi High Capacity Bus System. The plan's financing has emanated from three sources: the Delhi Government's general tax revenues, a grant from US AID to ITDP, and a general grant from the Volvo Foundation to the Indian Institution of Technology's Transportation Research and Injury Prevention Program (IIT TRIPP). The funds from the Delhi Government (approximately US$300,000) were used to contract out to IIT TRIPP and several private planning firms.

In Delhi's case, most of the planning work has focussed on operational and detailed engineering design. Little to no initial investment has been made for demand analysis. As a result, the planned corridors may well do much to congest mixed traffic lanes without providing substantial time savings benefits to public transport customers. The "cost" of this design flaw will be in the form of congestion imposed on the mixed traffic (fuel consumption and time lost).

3.5.3.5 Jakarta, Indonesia

Jakarta's TransJakarta system was planned with funding principally from the provincial government (DKI Jakarta). The government contracted out three local consulting firms, Pamintory Cipta, Ernst and Young, and the University of Indonesia's Center for Transportation Studies (UI CTS) for different elements of the planning. With supplemental funding from US AID, ITDP has organised a review of the plans by international consultants. Additionally, the US AID funds have supported study tours

Fig. 3.14
The TransJakarta planning process was supported by a range of local and international organisations.
Photo by Karl Otta, courtesy of the GTZ SUTP Photo CD-ROM

for key staff, work on demand modelling, public relations activities, and NGO efforts to facilitate public participation.

3.5.3.6 Dar es Salaam, Tanzania

Dar es Salaam's BRT planning efforts have been financed to date through four different sources. The largest share, approximately US$1 million, is part of a World Bank loan package known as the Central Roads Corridor improvement project. An additional US$500,000 has been awarded through a UNEP-sponsored GEF project that has been managed by ITDP. This GEF-funded component is focussing upon planning of the institutional and business model, capacity building, and non-motorized transport facilities. The Municipality itself is contributing US$600,000 to the two-year planning process. Another US$100,000 has been awarded through a US AID grant that is being managed by ITDP.

Dar es Salaam provides one of the best examples of how funding diversity can be the key to putting a project together. By approaching multiple sources, Dar es Salaam is not dependent on a single organisation. Further, since different funding sources tend to focus on different project aspects, this funding diversity also brings two other advantages:

1. Provides access to multiple sources of consulting expertise; and,
2. Ensures all aspects of the planning process are adequately addressed.

Building a synergistic package of funding sources should thus be a priority in any funding strategy.

3.5.3.7 China

In China, technical support for the first BRT system in Kunming came originally from the Swiss Government via the Zurich Sister City Project, with matching funds from general municipal government budget revenues. Technical support to Shejiazhuang came from municipal general budget revenues, with some loan funds from the World Bank. Subsequent technical support to Beijing, Chengdu, Xian, Jinan, Hangzhou, and Kunming stems from the Hewlett Foundation and the Energy Foundation, always with matching municipal funds for project staff and surveying work. Technical support to Guangzhou was originally provided by the Rockefeller Brothers Fund, but more recently the project is being supported through the funding assistance of the Hewlett Foundation.

Fig. 3.15
Several new BRT projects in China, including the new corridor in Hangzhou (photo), have benefited from the assistance of the Energy Foundation.
Photo by Karl Fjellstrom

3.6 Project phases

"Those who plan do better than those who do not plan, even thou they rarely stick to their plan."

—Winston Churchill, former British Prime Minister, 1874–1965

3.6.1 Benefits of project phasing

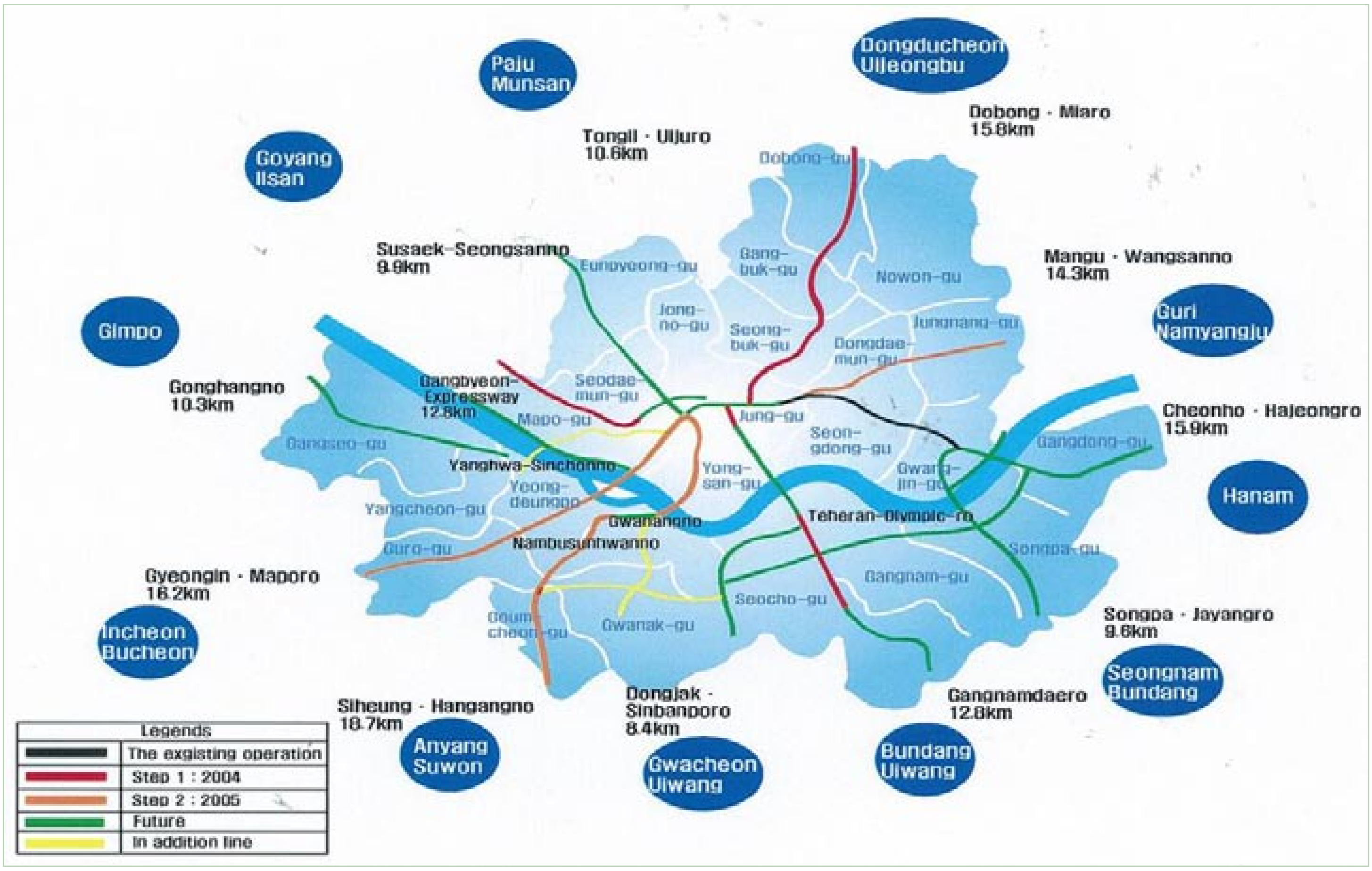
A BRT can be phased-in over several distinct periods or built in a massive single effort. Typically, cities choose to construct a system over a series of phases. The phased approach is necessitated for several reasons:

- 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.

The initial vision of the overall system will likely evolve as circumstances change. However, the evolving nature of the urban landscape means that corridors and concepts may be altered, but in general, the overall concept will still be valid.

Fig. 3.16 and 3.17

Although the systems in Jakarta (top image) and Seoul (bottom image) are being constructed in multiple phases over several years, the system developers have put forward a full vision of the future system. Images courtesy of TransJakarta and the Seoul Development Institute.



The types of factors that may change over the development horizon of the project include:

- Demographic changes in population and population density;
- New property developments that significantly alter travel frequency around major origins and destinations;
- Cost factors for both infrastructure and operations.

Additionally, the lessons learned during the first phases of the system will undoubtedly affect future designs. The BRT development process should be one of constant improvement in order to best serve customer needs.

On the other hand, phased implementation will result in distinct types of operations coexisting with different rules, actors, and conditions. A large-scale adaptation of the new system across the majority of a city can reduce the confusion and inconsistencies created by a phased approach. While a large-scale approach is typically unlikely due to physical and budgetary constraints, some small and medium-sized cities may be able to actually deliver most of their entire network within a single phase.

3.6.2 A whole-system vision

Even when a system is to be built over a series of phases, it is still worthwhile to put forward a vision for the entire system (Figures 3.16 and 3.17). 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.

Further, the establishment of an overall vision for a network will be seen as a legacy from the existing political administration to future administrations. If the concept of an entire network is firmly set, then there is less likelihood that future administrations will forgo implementation of the full system. The loss of political will is always a risk when moving from one political administration to the next. In many instances, the political instincts of the incoming administration are to jettison everything proposed by the previous administration.

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. The limited usefulness of a one-corridor system will also dampen public support for the future system.

3.6.3 Evolution versus revolution

The issue here is whether to approach BRT by a strategy of "revolution" or "evolution". A revolutionary approach implies that the city commits to a bold plan for an entirely new city-wide transport system. An evolutionary approach implies that the city begins developing its new system slowly, by implementing relatively small projects one by one. The revolutionary approach depends upon a highly motivated and charismatic political leader who can push through a wider vision. A revolutionary approach will implement all the aspects of a full BRT system at once. The evolutionary approach may only implement a limited system, and perhaps only a few BRT elements at once. It is more characteristic of municipal leaders with only a moderate amount of political interest towards public transport.

3.6.3.1 System quality and political motivation

Bogotá and Curitiba were successful with highly charismatic leaders who developed a revolutionary vision. The initial corridors of these systems were built in just a few years, and these corridors were of sufficient size to achieve financial sustainability even at the outset. Bogotá implemented virtually all elements of BRT in the first Phase of the project. Curitiba implemented most of the physical aspects of BRT in the early 1970s but many of the critical management elements of BRT emerged only gradually.

In contrast to a revolutionary approach, Jakarta initiated its BRT project with a limited single corridor of just 12.9 kilometres. The limited nature of the Jakarta system was further exacerbated by the lack of integrated feeder services. Unsurprisingly, ridership on the initial corridor has been under expectations. Based on the observed examples of BRT to date, the scope and force of the initial vision will likely set the tone for the ultimate quality of the product.

3.6.3.2 Quality versus quantity

To an extent, many of the latest BRT systems have made trade-offs between system quality and quantity. The amount of resources expended per kilometre will ultimately affect the number of kilometres constructed at any given time. While BRT is far more cost effective than many other public transport technologies, there are still limits to infrastructure financing. Thus, cities that develop very high-quality projects may be effectively reducing the number of kilometres constructed, at least over the short to medium term.

Bogotá represents perhaps the highest quality BRT system developed to date. The clean, modern vehicles, aesthetically-pleasing architecture, and use of smart cards all work to produce a metro-like appearance to the system (Figure 3.18). To date, Bogotá has completed two of its project phases, which have spanned a period of 1998 to 2006. A total of 84.33 kilometres of exclusive busways have been created in this period. In the long term, Bogotá plans to construct some 380 total kilometres of busways. However, the high quality nature of the TransMilenio system translates into somewhat higher construction costs that limit the speed at which financing for the system can be obtained. The overall length of the system directly affects ridership since a system's network of origins and destinations affect usability. Based on trip survey analysis from the year 2005, TransMilenio serves approximately 19 percent of the trips taken in the city. Non-BRT buses, minibuses, and vans still catered to approximately 51 percent of all trips. In TransMilenio's first year of full operation (2001), it served only approximately 6 percent of all trips (Como Vamos Bogotá, 2005). Thus, it is possible that the decision to build a very high quality system has somewhat reduced the speed at which a full network can be constructed.

Fig. 3.18
TransMilenio's excellence in service and design has produced a system of metro-like quality.
Photo by Shreya Gadepalli

In contrast to Bogotá's approach, cities such as Santiago, São Paulo, and Seoul are foregoing some of TransMilenio's quality for a more city-wide approach to system development. The Transantiago and Interligado systems are in some ways exchanging quality for quantity. Both Santiago and São Paulo have effectively decided to restructure and re-organise the entire city's bus system all at one time. The entire city network is being bid and concessioned all at once. These systems have tended to incorporate more of the existing bus operations into the new system, whereas, in Bogotá there is a sharp distinction between the BRT system (TransMilenio) and the non-BRT system (old, poor-quality buses and minibuses).

At the outset, only a relatively small portion of the overall network in Santiago, São Paulo, and Seoul is being converted to exclusive busways. In Santiago, only 22 kilometres of segregated busways are included in Phase I. Another 59 kilometres of roadway will receive some infrastructure improvements. However, the reach of Santiago's Phase I will extend will beyond the upgraded roadways. Once leaving the busways and the upgraded roadways, the buses will travel on standard bus routes. Existing buses will also be incorporated into the system and integrated as feeder services.

At the same time, Santiago has foregone many of the attributes that would normally constitute a high-quality BRT system. The station infrastructure is somewhat modest in design and scale (Figure 3.19). Fare verification is done on-board the vehicles, and thus greatly reducing stop efficiency and average vehicle speeds. Additionally, Santiago is utilising side-aligned stations that will cause buses to be negatively affected by turning mixed traffic.

To an extent, the systems in Santiago, São Paulo, and Seoul may be seen as hybrids between BRT and a standard bus service, akin to the definition of a "BRT lite" system given in the Introductory section of this Planning Guide.

While the approach taken by Santiago, São Paulo, and Seoul can be interpreted as a trade-off between quality and quantity, the actual motivations may be more due to the limits of sector reform in these cities. Bogotá and Curitiba benefited from highly-motivated mayors who revolutionised public transport services in their cities by wholly re-structuring the systems around the customer. In the case of Santiago, São Paulo, and Seoul, the degree of change is somewhat less so as to not affect the operations of existing fleet owners in a drastic fashion. The result of this approach, though, is a system that is far from the metro-level of quality achieved elsewhere. While Bogotá may require more time to create a full system network, the final product will clearly be car-competitive and attractive to the widest audience.

There are clearly political and technical reasons that new systems such as Santiago, São Paulo, and Seoul have embarked upon a different path than Bogotá. Neither approach is inherently correct or incorrect. Given the limits of financing resources and construction capabilities, there will always be the need to make some form of trade-off between quality and quantity. Political leaders and local officials must decide which path best fits with their political, cultural, social, and financial realities.

Fig. 3.19
The more basic station and infrastructure designs utilised in Transantiago have reduced costs and made the system more compatible with the city's standard bus operations.
Photo courtesy of Transantiago

3.7 Common planning mistakes

"If at first you do succeed, try not to look too surprised."

—Anonymous

At the project's outset, the planning team should make much effort to observe the lessons learned to date from the previous BRT efforts. Both the successes and the failures of previous project should be noted. In many ways, the problems and mistakes encountered from past efforts may be even more instructive the successes. Recognising and avoiding the most common errors can save a city considerable time and resources.

Box 3.1 summarises some of the most common errors, as identified by leading BRT consultants. The remaining chapters of this Planning Guide will provide examples of each of these common errors.

It is almost always less costly to get a system right the first time, rather than attempting to correct problems later. Once operator contracts are signed, it becomes quite difficult and costly to negotiate later changes. Attempts to integrate Quito's three independently operated busway corridors have been thwarted due to the existing contractual arrangements. Likewise, retrofitting infrastructure can be both physically and financially difficult (although the nature of BRT infrastructure makes it easier to realise adjustments than most other forms of mass transit systems). In Brisbane, a miscalculation of

Box 3.1: Most common BRT planning errors

1. System designed around a technology and not the customer
2. System designed around the existing operators and not the customer
3. Too little investment in the planning process
4. No competitive tendering of planning consultants
5. Too few full-time staff dedicated to planning the system
6. First phase is too limited in scope
7. No re-organisation of existing bus routes
8. No re-organisation of existing regulatory structures
9. Allowing all existing bus operators to use busway infrastructure, resulting in severe busway congestion
10. No competitive tendering of bus operators
11. No independent concession for fare collection
12. Public sector procurement of vehicles (instead of private sector procurement)
13. No provision for feeder services or direct services into residential areas
14. System built on low-demand corridor(s) to make construction easier
15. No provision of safe and quality access for pedestrians to stations
16. No provision for integration with other transport modes (*e.g.,* bicycle parking, taxi stands, park and ride facilities)
17. No integration of BRT plan with land-use planning or provisions for transit-oriented development (TOD)
18. Under sizing vehicles and/or infrastructure for the given demand
19. Too few doorways in vehicles/station to facilitate rapid boarding and alighting
20. No communications plan, marketing campaign, or system branding to explain or promote the new system

demand and the use of standard-sized vehicles resulted in severe busway congestion at one major station (Figure 3.20). The subsequent retrofitting of a passing lane through the station area resulted in an additional cost of US$11.4 million (Figure 3.21).

Bangkok proposed to construct its Phase I BRT system along the "Kaset Nawamin" corridor specifically because there was not traffic or congestion on the corridor (Figure 3.22). The lack of demand along the corridor was attractive because it meant that the BRT system would have no effect on mixed traffic flows. However, at the same time, there was virtually no public transport demand either along the corridor. While building a high-technology BRT system along such a corridor might prove a testing ground for the concept, it would not likely be financially viable. Building a system only where it is easy to do so is unlikely to serve the interests of public transport users.

Bangkok's long-term BRT plan also has given relatively little attention to customer convenience. The system calls for all corridors to terminate prior to arriving in the city centre (Figure 3.23). Additionally, the system routing forces most customers to make multiple transfers prior to even arriving at the final stop, which is

Fig. 3.20 and 3.21
Brisbane miscalculated demand at a major station resulting in significant busway congestion (left photo). The problem eventually had to be corrected through a somewhat costly retrofit of a passing lane at the station (right photo).
Photos courtesy of the Queensland Busway

Fig. 3.22
Bangkok proposed developing a BRT line along the Kaset Nawamin corridor expressly because there was little demand or traffic along the corridor.
Photo by Lloyd Wright

outside the principal city centre destinations. Once arriving at the periphery of the central area, customers are expected to either transfer to the rail system (which only serves a few corridors) or transfer to other options such as taxis.

The first phase of the Jakarta system and the demonstration phase of the Beijing system both suffered design problems that inhibited the performance of the systems. Jakarta's litany of initial problems included:

- Existing buses were allowed to continue operating in the mixed traffic lanes along the busway corridor, resulting in much congestion for private vehicles;
- Lack of competitive tendering for consulting services;
- Lack of competitive tendering for smart card system resulted in a non-functioning fare system;
- No feeder services were provided in conjunction with the relatively short Phase I corridor;
- A subsequent attempt to fare integrate the BRT and existing buses failed due to existing operators not accepting the transfer tickets;
- The public procurement of vehicles resulted in vehicles too small for the given demand;
- Station sizes were also too small for the given demand (Figure 3.24);
- A single vehicle doorway resulted in slow boarding and alighting times;

The problems associated with Beijing's demonstration phase included:

- Construction of busway in a corridor with little public transport demand (approximately 1,000 passengers per DAY);

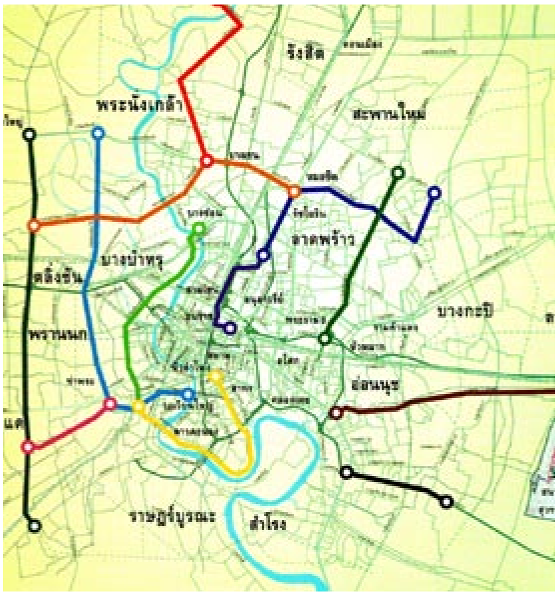


Fig. 3.23
The proposed Bangkok BRT system of the Bangkok Metropolitan Administration (BMA) features a corridor plan that forces all customers to transfer to other modes prior to arriving in the city centre.
Image courtesy of the BMA

Fig. 3.24
Small vehicles, single-door entry, and under-sized stations all contributed to crowding problems on the Phase I corridor of TransJakarta.
Photo by Shreya Gadepalli (ITDP)

- The only segment of corridor which could have benefited from an exclusive busway was the one segment without an exclusive busway;
- Interior seating design of vehicle provided space for 1.5 customers, meaning that the 18.5 metre articulated vehicle had approximately the same passenger capacity as a 12 metre standard bus (Figure 3.25);
- The five-metre wide busways were quite wide for a standard bus lane but were insufficient for two lanes (Figure 3.26).

Fortunately, for both Jakarta and Beijing efforts in subsequent phases have helped to reverse or mitigate many of these problems. Nevertheless, problems in the initial phases can do much to damage a system's image for the future. A few BRT "failures" may do harm to the concept across an entire region. Thus, cities are encouraged to closely study the lessons learned to date.

Perhaps the most serious type of implementation problem relates to political continuity. There are a handful of projects that began in a promising manner and then collapsed either due to a lack of complete political will or because there was a change in leadership. In many cases, cities expend significant resources in sending delegations on study tours and hiring consultants to develop scoping studies. In the end, many of these projects are actually quite feasible, but the drive to move to actual planning never happens for many reasons.

In the latter part of 2002, the Western Cape Province (Cape Town) began a process to develop a BRT project. A large delegation of persons was sent to Bogotá for a study tour (Figure 3.27). The government identified a corridor, Klipfontein Road, and invested resources in the initial planning. A project video was even produced. International donors (US AID through ITDP) also contributed consulting resources to the initiative. However, when the leading political advocate moved to another portfolio within the Provincial government, there was a loss of momentum. Subsequently, the Province went through two other Transport Ministers in the course of three years. In many cases, new

Fig. 3.25
The initial Beijing vehicles provided 2 seats that only had reasonable space for 1.5 persons.
Photo by Karl Fjellstrom

Fig. 3.26
The five-metre wide corridor in Beijing was quite wide for a single lane busway but insufficient for two lane operation.
Photo by Karl Fjellstrom

Fig. 3.27
In November 2002, the Province of Western Cape (Cape Town) sent a large delegation to Bogotá. Subsequent political changes meant that no project materialised in Cape Town over the following five years.
Photo courtesy of Fundación Ciudad Humana

Mayors or Ministers will reject previous projects simply because they do not wish to complete a project started by another politician.

In a similar manner, project efforts have collapsed or have been seriously stalled in such cities as Dhaka (Bangladesh), Shanghai (China), Hyderabad (India), Puebla (Mexico), and Virginia Beach (USA). In many cases, political and technical officials spent great resources in study tours and research. However, for one reason or another, the projects simply could not move beyond the basic first steps.

4. Demand analysis

"The essence of mathematics is not to make simple things complicated, but to make complicated things simple."

—S. Gudder, mathematician

The analysis of the potential passenger demand for the planned BRT system is the technical foundation for most of the subsequent planning design work. Demand estimates are critical to designing the system, planning operations, and predicting the financial viability of the system. Knowing where and when customers require transport services will help to shape a system based first on customer needs.

Often, decision-makers will want to put a new BRT system on a wide road or a ring road where there is plenty of space, but where there is little or no demand. Other times, decision-makers will choose BRT corridors for political reasons, like putting one BRT corridor in each district, regardless of the relative importance of the corridor to riders, or locating the BRT system where its benefits would accrue to politically powerful people. While such factors will inevitably be a part of the decision-making process, BRT planners need to do their best to argue for a system that serves the most passengers in the best way possible. This requires proposing not only a single corridor but eventually a network of BRT routes. If the system does not form a network, ridership will be a fraction of its potential.

First, the system needs to be designed with enough capacity to handle a reasonable estimate of projected future demand while maintaining high vehicle speeds. This projected future demand should start with an analysis of existing public transport demand, and then expanded with reasonable expectations about passenger growth. To be conservative, the system needs to be designed with plenty of extra capacity, so from a design perspective, it is better to err on the side of over-estimating future passengers. Demand estimates can be fairly approximate at first, but the sooner the demand estimate can be made accurate, the better the design. If the system is designed with more capacity than it needs, it will be needlessly expensive and consume a needless amount of scarce right of way that might otherwise be used for footpaths, bikeways, public space, parking or private vehicles. Alternatively, if capacity is too low, transit vehicles will be overcrowded, and the vehicle speeds might even be slower than current speeds even at very low levels of ridership, and thus alienating passengers. Any of these mistakes will significantly compromise the quality of service and the profitability of the system.

The demand estimate is also needed for optimising operations. Maybe a BRT system will keep the bus routes the same, but maybe the system would be much more profitable if they are significantly changed. Demand estimates will provide lots of information critical to optimising BRT service operations.

Finally, the demand estimate is critical for financial projections. For this, the demand estimates have to err on the conservative side, to be credible to banks and investors. The critical factor is that the banks and investors trust the estimates, and for this the greater the accuracy of the projection, and the more methodologically credible, the better.

When developing demand estimates, there is a trade-off between cost, accuracy, and timing. A detailed full demand modelling exercise will produce more accurate results, but developing a full traffic model can be time consuming and expensive. Planners often do not have the time or resources to build an entire model all at once. Rapid assessment techniques can produce acceptable accuracy fast and at a low cost. Partial modelling, of only the public transport system rather than the entire traffic system, will provide a better estimate of projected demand, while providing useful information for all sorts of operational issues. A full four-step traffic model will provide more accuracy, more robust estimates of traffic impacts, and better projections of possible modal shift, but cost more and take more time.

While the authority responsible for developing the BRT system should develop over time the capacity to do full multi-modal transport demand modelling, if this capacity does not already exist, it is unlikely that it can be developed at the same time that the agency is engaged in a politically time-bound BRT planning process.

In most developing countries, time and money are usually restricted at first, and local modelling capacity is limited. In such circumstances, it is better to develop the modelling capacity of the agency step by step, over time, so that the local partners learn how to collect and use the information, and so the design team will at least have at least some preliminary information about demand in a timely manner to influence critical early decisions.

Curitiba's BRT system was designed without any formal traffic modelling, so it can be done. However, Curitiba made certain design mistakes that compromised the system's efficiency, and which local leaders in Curitiba now regret. With today's modelling tools available, there is no excuse for repeating costly mistakes.

This chapter therefore outlines a step-by-step approach that provides gradually better demand analysis as the process evolves. The topics to be presented in this chapter include:

While this chapter will narrowly focus on demand analysis, it is important to emphasise that a broader understanding of how the city's public transport system is woven into its existing demographic, economic, environmental, social, and political fabric. System planners may face all sorts of questions about how the system will affect different parts of a city, and different people within a city, and not every question can be answered by even the best traffic model. Even highly technical modelling ultimately relies heavily on the judgement of the planners. As such, it is useful to assemble a lot of basic data about the city. Section 4.1 discusses the basic demographic, economic, environmental, employment, and political information often collected prior to a full demand analysis.

Section 4.2 discusses a *rapid demand assessment*. Rapid demand assessment will provide an approximate idea of likely BRT demand on major corridors using only traffic counts and occupancy surveys in key locations, accompanied by some bus speed surveys. With this information alone, a skilled BRT planner may be able to come to a demand estimate within 20 percent of the actual demand upon completion of the system.

Section 4.3 discusses a methodology for estimating demand without modelling. In cities where there is a clearly defined bus route structure, and the buses are reasonably well regulated, and routes reasonably well optimised, there is a way to *estimate demand without modelling* with reasonable accuracy. This estimation technique requires a very accurate set of route itineraries and boarding and alighting data from surveys at all the key stops.

Section 4.4 then explains how to develop a basic *public transport model*. The public transport model simulates only the public transport system, and requires in addition a passenger origin and destination survey. With a basic public transport model, most critical decisions about the BRT system and many critical operational decisions can be made, but where impacts of the system on mixed traffic and on modal shift can only be roughly estimated. Most BRT planners, including the team that designed TransMilenio, primarily used such a public transport model.

Finally, section 4.5 discusses the basics of developing a *multi-modal traffic demand model* for BRT. Such a model will provide full flexibility for testing multiple routing and pricing scenarios, a more robust estimate of plausible modal shift, emissions impacts, bus route optimisation, and a host of other useful tools.

4.1 Background and situational analysis

"You think that because you understand ONE you understand TWO, because one and one makes two. But you must understand AND."

—Sufi proverb

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.

For instance, by understanding the major employment areas of the city, one can better project the location and times of the day when public transport will be required. Further, the relative economic purchasing power of the city's inhabitants will later assist in developing a realistic tariff schedule. Demographic figures on population, population densities, and future population projections will be key inputs into the transportation modelling process. Trends in environmental conditions will help determine the sorts of air quality and noise objectives that the BRT system can help to achieve. Quantifying the social equity levels throughout the city may assist in recognising the districts that will most benefit from improved public transit services. Finally, mapping out the various political actors and the dates of upcoming elections can help establish realistic project timeframes. It is often difficult to gain political support for BRT initiatives if elections are relatively soon. However, if a political administration feels that there is sufficient time to demonstrate a tangible outcome, then the prospects for political commitment tend to be greater.

The type of background information to be collected can thus include:

- Population, population density;
- Overall economic activity (Gross Regional Product);
- Economic activity by social groupings;
- Employment levels (unemployment and underemployment);
- Environmental conditions;
- Social equity levels;
- Schedule of local, regional, and national elections.

These bigger picture issues can often shape a project in ways that a strict demand analysis cannot begin to encapsulate. Thus, a project team should also involve professionals who understand the urban and economic context of a city in addition to the local transport characteristics.

Geographical information systems (GIS) can be the ideal tool to integrate social-economic and environmental data with transport data figures. GIS software allows officials to overlay different data types upon one another. In turn, project staff can visualise transport demand figures simultaneously with other data types. Thus, the new public transport system can be prioritised in low-income areas and/or in locations with the most serious air quality problems.

4.2 Rapid demand assessment method

"Prediction is difficult, especially about the future."

—Yogi Berra, former baseball player, 1925–

If a city has no previous history in mapping its transport demand through modelling software, then the appropriate initial step is the collection of basic travel data. By cataloguing the number of vehicles and customers within the existing bus and paratransit systems, system developers can develop a basis for estimating the required characteristics of the new system. A rapid assessment of existing conditions can be a cost-effective means by which cities can begin to build an analytic database evolving into more sophisticated analysis techniques.

In this sense, the rapid assessment method is not necessarily a distinct alternative to full transportation modelling. Instead, the rapid assessment method represents the first steps in a process that can later grow into full modelling. The same steps used in the rapid assessment method will provide the basis for a modelling exercise.

Analysing the existing public transport services and the conditions in which they operate is the first step in a rapid demand assessment. The principal data that needs to be collected is:

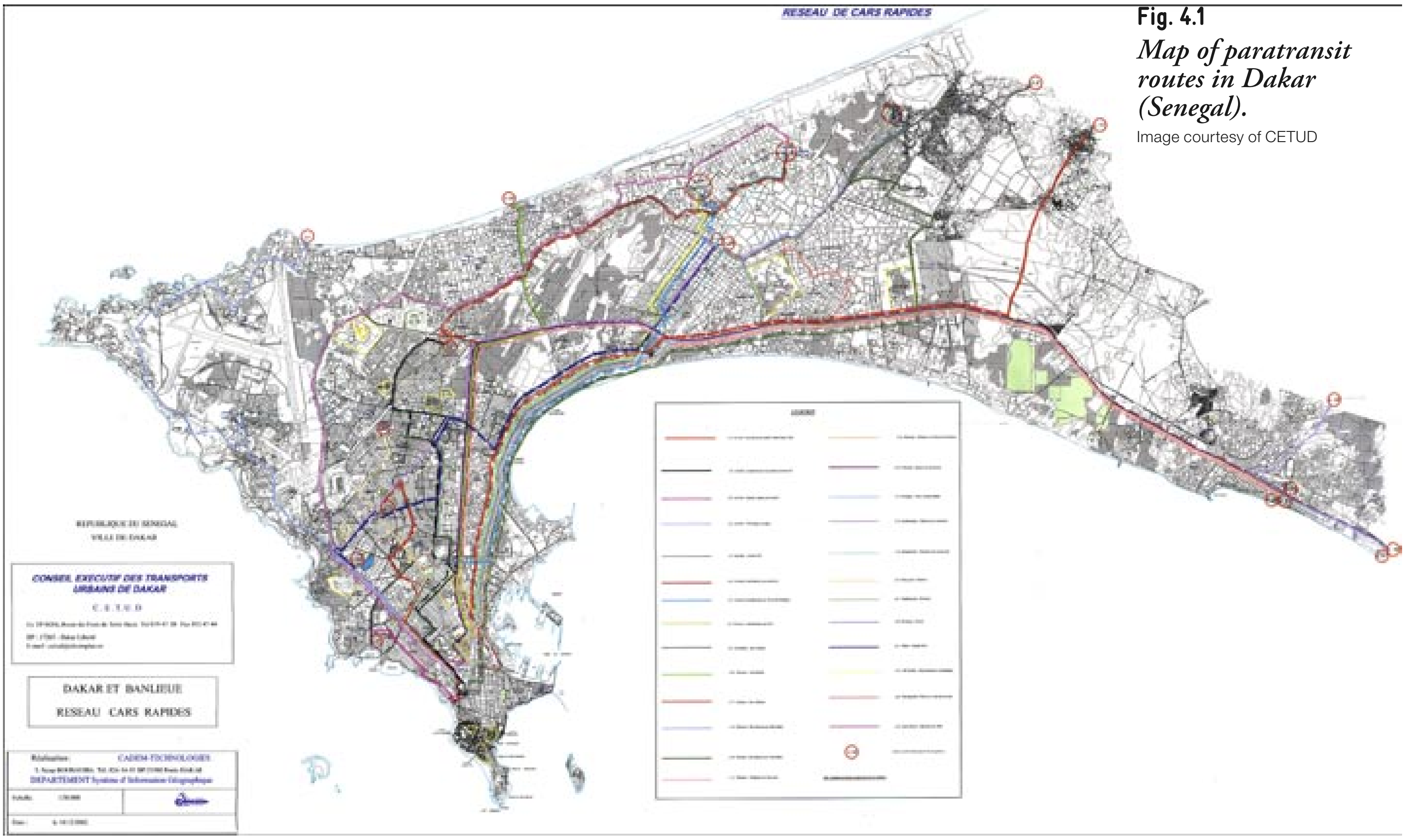


Fig. 4.1
Map of paratransit routes in Dakar (Senegal).
Image courtesy of CETUD

1. The routes of current transit services
2. The number of passengers using each route
3. The transit vehicle speeds on each route

4.2.1 Route maps

"All you need is the plan, the road map, and the courage to press on to your destination."
—Earl Nightingale, author, 1921–1989

Mapping the existing transit routes provides an initial indication of the areas with the greatest transit demand. While the roads which carry the most bus or paratransit routes do not always correspond to the highest number of public transport passengers on a given corridor, usually there is a strong correlation between large numbers of public transport routes and high passenger flows. If public transport routes are fairly well regulated, then municipal officials will likely already possess detailed route itinerary information through registration records. In some cases, a map of existing routes may also be available.

However, in many developing-nation cities, the majority of transit passengers may be served by paratransit operations that are weakly regulated. In such cases, there may be few records of specific transit routes. In other cases, registered routes may bear little resemblance to the actual situation. Thus, an initial step may involve simply mapping the existing route structure of bus and paratransit services. Interviews with existing operators, and actually riding many itineraries may be a critical first step in this mapping process.

The map in Figure 4.1 is one of the first efforts to map the existing paratransit (Car Rapide and Ndiaga Ndiaye) in Dakar (Senegal). This activitiy is often a critical first step towards bringing such services into a transparent regulatory framework.

4.2.2 Traffic counts

With the basic route structure in hand, the next step in the rapid assessment process will be *traffic counts and bus occupancy surveys*. The number of buses (or other types of transit vehicles) combined with their estimated occupancy rates will already yield a crude estimation of a corridor's existing demand. Sample surveys are listed in Annex 5.

The strategic selection of the points to conduct the traffic and occupancy survey will determine the extent to which the survey results will

Fig. 4.2
Effective traffic counts requires the right set of personnel and resources.
Photo courtesy of the Municipality of Osaka

represent the actual situation. Determining where to do traffic counts can be more of an art than a science, but some general rules can be applied.

Ideally, the survey locations will allow most trips to be easily captured with a minimum of resources and effort. If a city has a fairly clearly defined central business district (CBD), and most of the trips end in the CBD, then it is sometimes possible to do traffic counts at the entry points along a "cordon" around the CBD. For example, in Dar es Salaam, the entire CBD can only be entered through six major arterials, and few trips both originate and end within the CBD. By conducting traffic counts at just these six entry points, it was possible to obtain rough CBD demand data for each major arterial as well as the collective totals.

If travel into an area is fairly concentrated along a single direction, perhaps from north to south or from east to west, then the conditions may allow an even more selective application of counts. Dakar, for example, is a peninsula, with the CBD at the end, and a simple "screen line" count, or several screen line counts may capture most daily commuting trips. With both cordon counts and screen line counts, the overall principle is the same, but the focus of the count location is different in order to match the predominant movement of travel.

Ideally, the counts will not just involve observation of buses and paratransit vehicles. There is also great value in also counting all vehicle traffic (*e.g.,* cars, motorcycles, bicycles, trucks, pedestrians). Designers may face difficult choices regarding the allocation of scarce road right of way, and knowing the full mix of traffic, including non-motorized traffic, will be extremely helpful in making priorities.

With the data on private vehicle numbers, system developers will also be able to estimate the impact of mode switching on system demand. This data can also be later used to estimate the impact of the new system on corridor congestion levels. Additionally, if a decision is later made to utilise a full traffic demand model, then the existing data will be in a form that is readily adaptable to a more inclusive analytical package.

As the complexity of the counting process increases, though, the resources required to obtain an accurate count also increase (Figure 4.2). To identify all vehicles and produce a valid count across multiple traffic lanes, a counting strategy becomes vital. One option is to employ counting teams involving many persons at a single location in order to properly record all vehicle types in each of the lanes. Alternatively, video technology can be utilised to record traffic movement and

Fig. 4.3
The high flow rate of minibus taxi vehicles along the Soweto Highway in Johannesburg requires an organised counting strategy to get an accurate estimate of vehicles and occupancy levels.
Photo by Lloyd Wright

allow a more precise count at a later time. The video record allows quality control sampling to ensure the counting team is performing at a reasonable level of accuracy. With all counting strategies, the proper training of survey personnel should be conducted so that all participants have a common understanding of the task at hand.

4.2.3 Occupancy surveys

The number of vehicles is only one part of the demand equation. Knowing the average number of passengers in the vehicles at any given time period provides the other half of the demand input data. Given the diversity of possible vehicle sizes, the occupancy data should be categorised and collected by vehicle type. The survey should thus identify vehicles according to their seating numbers or maximum capacity numbers. For public transport and paratransit vehicles, some of the possible categorisations could include:

- 70-seat bus;
- 35-seat bus;
- 16-seat mini-bus (Figure 4.3);
- 7-seat vans.

Usually surveyors count each transit vehicle type and mark "full", "3/4 full", "1/2 full", "1/4 full" or "empty." By recording these two sets of data (vehicle type and occupancy level), the basis for a rough demand estimate is established. The average occupancy level is multiplied by the total number of vehicles for a given vehicle type over a stated time period. The smaller the time period interval, the finer the demand analysis becomes in identifying significant peak and non-peak periods. Thus, recording vehicle numbers in 15-minute intervals provides a reasonably fine level of peak identification. A one-hour interval would provide less insight into peak and non-peak conditions.

4.2.4 Recording the data

The data on the number of vehicles and the occupancy levels can be collected separately or simultaneously. The ability to collect both data sets at the same time depends on the personnel or technical resources being applied to the survey, and the volume of traffic. If all vehicle types are being counted along with all occupancy levels, then the counting will likely require either a coordinated team approach or the use of video technology. The effectiveness of video technology in identifying vehicle occupancy levels will depend on the quality of the video technology and the placement of the camera.

If a formal transportation model is not being utilised in the rapid assessment approach, then the raw data will likely next be inputted into standard spreadsheet software like Excel. This data would likely then be used to produce summary tables and graphs (Figure 4.4). The data would likely be displayed for each direction of traffic movement across both peak and off-peak periods.

If the routing of each public transport vehicle can be determined either by numerical route numbers or signage on the vehicle, then vehicle counts and occupancy surveys can be done on a route-by-route basis. This technique will not only produce a total demand figure for a given corridor but also some indication of which routes are carrying the most passengers.

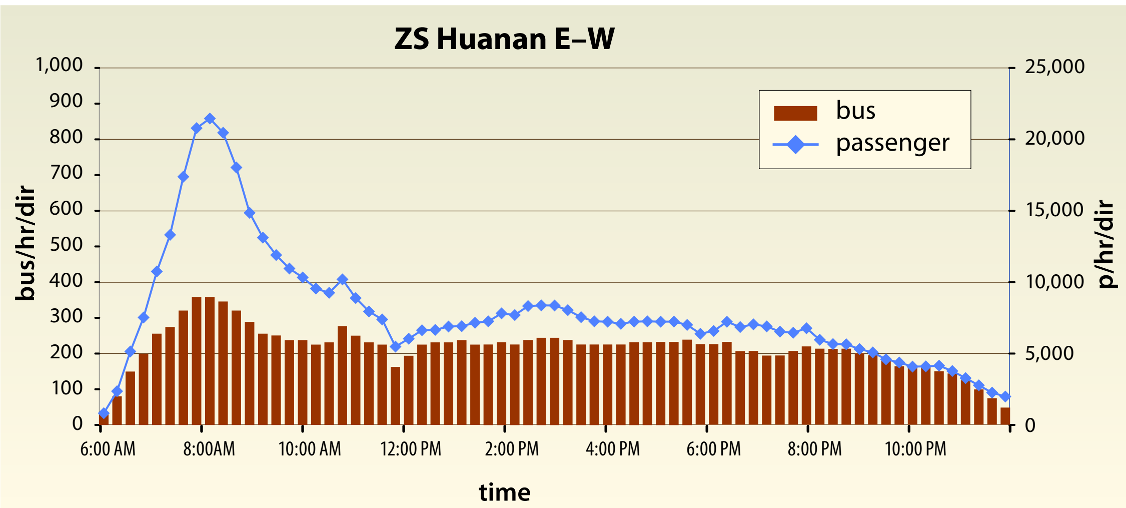


Fig. 4.4
Sample graph of vehicle and passenger movement in peak and off-peak periods

4.2.5 City-wide counts

Because in most cities, trips to the CBD are not the only important routings, and may not even be the most important trips for public transport passengers, it is usually insufficient to only do traffic counts in a cordon around the CBD. Further, some cities do not have a clearly defined CBD.

For this reason, normally one would do traffic counts at a larger selection of critical points around the city strategically chosen by local and international experts based on a rough estimate of those locations where most daily trips would pass. However, this selection process does not necessarily have to lead to a cost-prohibitive number of counting sites. For example, in the city of Dar es Salaam (population of approximately 4 million inhabitants) traffic counts in about 30 locations captured a large majority of the trips, and in Jakarta (population of approximately 9 million inhabitants) about 65 locations were sufficient. If trips are heavily peaked, then one way counts may be sufficient. Two-directional counts are best if the travel patterns do not exhibit clear-cut peak conditions.

4.2.6 Implications of demand results

By simply multiplying total transit vehicles at the peak hour with the average total passengers per transit vehicle, project developers essentially possess a reasonable estimate of the likely size of total public transport demand on most of the main corridors. At this point, the most likely BRT corridors and routes become roughly evident. By approximately correlating this demand profile with specific public transport route itineraries, a crude estimate of the corridor segments with the heaviest passenger volumes is obtained. Effectively, planners are looking for an estimate of the "maximum load on the critical link", usually measured in "passengers per peak hour per direction" (pphpd). The maximum load on the critical link is that section of the potential BRT corridor which is currently carrying the highest volume of existing public transport passengers (Figure 4.5).

A table ranking the corridors by passenger demand can greatly aid the corridor selection process. Customer demand is one of the key determinants in choosing the BRT corridor. As the corridor selection process moves forward, the most desirable corridors will likely undergo further analysis. This activity will include additional vehicle counts and occupancy surveys along that corridor. The other elements in corridor selection are discussed in Chapter 5 (*Corridor selection*).

Fig. 4.5
Demand mapping in Johannesburg helps to identify critical links.
Image courtesy of the City of Johannesburg.

With an estimate of the pphpd at the maximum load on the critical link, planners can already make some preliminary determinations about the nature of the prospective system. While these initial traffic counts will not directly imply how many passengers will use a new BRT system under different scenarios, the counts will provide some indication of how many transit passengers are currently using the corridor at the peak hour. Table 4.1 outlines a preliminary decision matrix that correlates a given passenger demand with the type of system. Further analysis and operational decision-making will ultimately determine which type of system is most appropriate.

As noted earlier, the results from the rapid assessment work can ultimately feed into a formal transportation model. The traffic counts and occupancy surveys can be used to potentially calibrate the model.

4.2.7 Counts of private vehicles

To the extent possible, private vehicles (cars, motorcycles, trucks, and others) and non-motorized trips (bicycles, pedestrians) should be included in the counting survey (Figure 4.6). The counting of private vehicles and non-motorized vehicles becomes important when difficult decisions need to be made about the allocation of scarce road right of way. First, the number and types of these vehicles can give an indication of the likely traffic impact of dedicating lanes to buses. Secondly, it will provide an early indication of how many passengers could potentially switch from private transport means to public transport.

Knowing the relative levels of private vehicles and public transport vehicles will be quite instructive in determining traffic impacts. If three quarters of the vehicles on a three lane road are buses, then a segregated busway is clearly justified. In fact, such a finding may well indicate that multiple-lane busways are justifiable; otherwise, bus passengers may experience delays due to bus congestion along a single lane. In conditions where public transport vehicles largely outnumber private vehicles, the separation of buses into a busway can actually free up space for the private vehicles. Thus, such conditions can ultimately achieve win-win results for both public transport users and private vehicle users.

Table 4.1: Typical solutions for different demand levels

Transit passengers per hour per direction	Type of BRT solution
Less than 2,000	Simple bus priority, normally without physical segregation, possible part-time bus lane
2,000 to 8,000	Segregated median busway used by direct services reducing the need to transfer
8,000 to 15,000	Segregated median busway used by trunk services requiring transfers but benefiting from fast boarding and operating speeds. Transit priority at intersections.
15,000 to 45,000	Segregated median busway, with overtaking at stops; possible use of express and stopping services. Use of grade separation at some intersections and some form of signal priority at others.
Over 45,000	This level of demand is very rare on existing bus systems. It is possible, however, to design a BRT system that would serve up to even 50,000 passengers per hour per direction. This can be achieved with full segregation, double busway, a high proportion of express services and multiple stops. This capacity could also be handled by spreading the load through two or more close corridors.

If the results show that relatively few of the road users are public transport vehicles, then the development of a busway will likely lead to an initial period of higher congestion levels for the private vehicles.

This information will also provide an important first clue as to how many passengers might switch from private cars or motorcycles as a result of the new BRT system. Such data will be important to estimating projected greenhouse

Fig. 4.6
Basic counts of private vehicles help to estimates the potential for mode shifting as well as indicate possible congestion impacts of the dedicated busways.
Photo by Lloyd Wright

gas emission impacts, which may be critical to eligibility for Global Environmental Facility (GEF) funding.

Projecting the modal shift of the project is so complex that simple techniques for making estimates may be nearly as reliable as detailed modelling. The experience of other cities lends some basis for prediction. In most reasonably well designed systems, some 5 percent to 20 percent of the motorists switch from private vehicles to BRT along a given corridor.

If the majority of the vehicles on the corridor are buses, then the traffic benefits of the project will be broadly distributed between both bus passengers and mixed traffic, but the modal shift impact will be less. If the majority of the vehicles on the corridor are private vehicles, then a busway will tend to have a stronger adverse impact on mixed traffic speeds, a stronger positive impact on bus speeds, and therefore a bigger potential modal shift impact.

Making a final determination about potential benefits of the system and potential mode shift requires additional information about current vehicle speeds and congestion points.

4.2.8 Mapping congestion points and vehicle speeds

While it is often easier to select BRT routes on wide roads, sometimes planners make the mistake of prioritising BRT on roads that have no congestion, thinking that this will also make it politically easier to implement. However, one of the major reasons BRT is more efficient than other systems is that the segregated right of way removes buses from traffic congestion. If there is no traffic congestion, then the segregated right of way is meaningless.

BRT systems should therefore be located not on the least congested routes, but on the most congested routes if benefit to public transport passengers is to be maximised. Choosing congested roadways will also tend to encourage modal shifts from private vehicles to public transport.

Therefore, an important element of a rapid assessment is to look at existing bus speeds along the possible BRT corridors (Figure 4.7). This information will be critical to the calculation of benefits of the new system. If average bus speeds in a corridor are high (*e.g.,* over 20 kph), shifting to a BRT system is not likely to bring a significant improvement in bus speeds. In such conditions, little mode shift from travel time improvements can be expected, although mode shifts may occur for other reasons, such as improved system image and comfort. If, on the other hand, speeds are very low (*e.g.,* under 12 kph), then a BRT system can bring significant travel time improvements for passengers, and a higher level of modal shift from private vehicles and ordinary buses can be expected.

This point may appear obvious, but a surprising number of new BRT systems are being built on roads with little or no congestion in order to avoid political problems. The demonstration phase of the Beijing BRT system, for example, was built on a new road with no bus routes, no bus demand, and no congestion. On the part of the route where congestion was the most severe, the buses currently re-enter mixed traffic, removing any possible benefit of the BRT system. In Delhi, the new high capacity bus system (HCBS) being planned was initially only approved for that part of phase I corridor which is not congested, while the second part of Corridor I which passes through the old city faces greater political resistance for fear of worsening traffic congestion. Even in São Paulo, while many routes have exclusive lanes into the CBD, once the vehicles enter the city centre

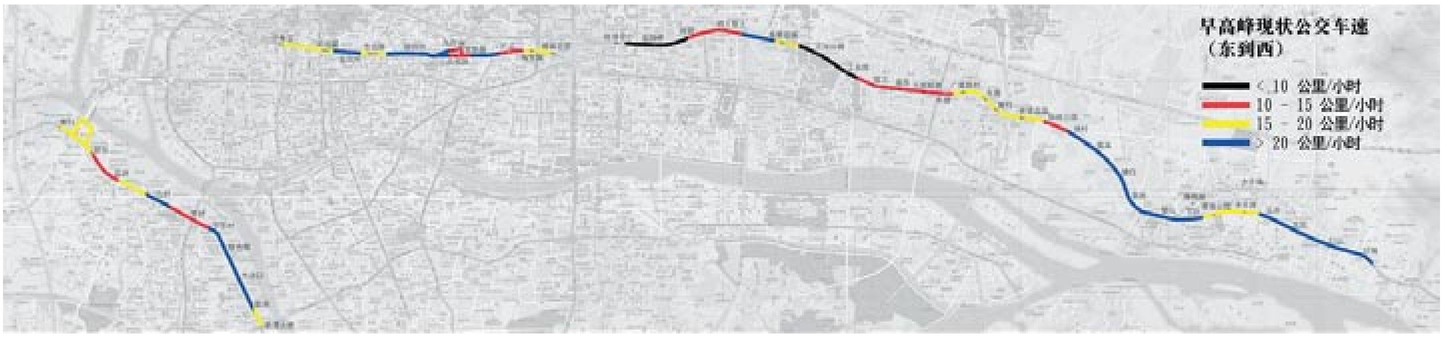


Fig. 4.7
Existing bus speeds on three different potential BRT corridors in Guangzhou. A black line indicates links with average bus speeds below 10 kph, a red line indicates bus speeds from 10 kph to 15 kph, a yellow line indicates speeds from 15 kph to 20kph, and a blue line represents speeds greater than 20 kph. Physical separation of the busway in the short term will only yield benefits in the black, red, and yellow sections.
Image courtesy of ITDP

Fig. 4.8
São Paulo's busways provide dedicated right-of-way to public transport outside the city centre, but once in the CBD most public transport vehicles no longer serve the area with priority treatment.
Photo by Lloyd Wright

most routes are forced to re-enter mixed traffic, undermining the benefits of the physical segregation at the most critical point (Figure 4.8). Normally, the CBD is the most congested part of a city. It is therefore of crucial importance that a new BRT system both serve and penetrate the congested CBD.

Table 4.2: Projected modal shift impact based on type of BRT corridor

Type of BRT Corridor	Projected Modal Shift Impact from private vehicles
Little congestion, buses > 30% of the vehicle fleet	5%
Some congestion, buses around 25% of vehicle fleet	10%
Many links congested, buses around 15% of vehicle fleet	15%
Very congested, few buses on the corridor	20%

Collecting information on existing bus speeds and mapping it is generally not very difficult. Many bus operators already collect this information or have it readily available. If not, if the bus route itinerary is known and the distances between stops are known, it is simply a matter of riding the key bus routes during the peak hour, taking the time at each stop, and by relating this time with the distance calculating the speed for each link.

Often, for GEF funding, a decision has to be made about projected modal shift impacts of a BRT system before the system is clearly defined. For such circumstances, the Table 4.2 is offered as a possible approach, based on observed impacts in BRT systems around the world. It combines the information about the vehicle mix on each corridor and the level of congestion on those corridors.

4.3 Detailed demand estimate without modelling

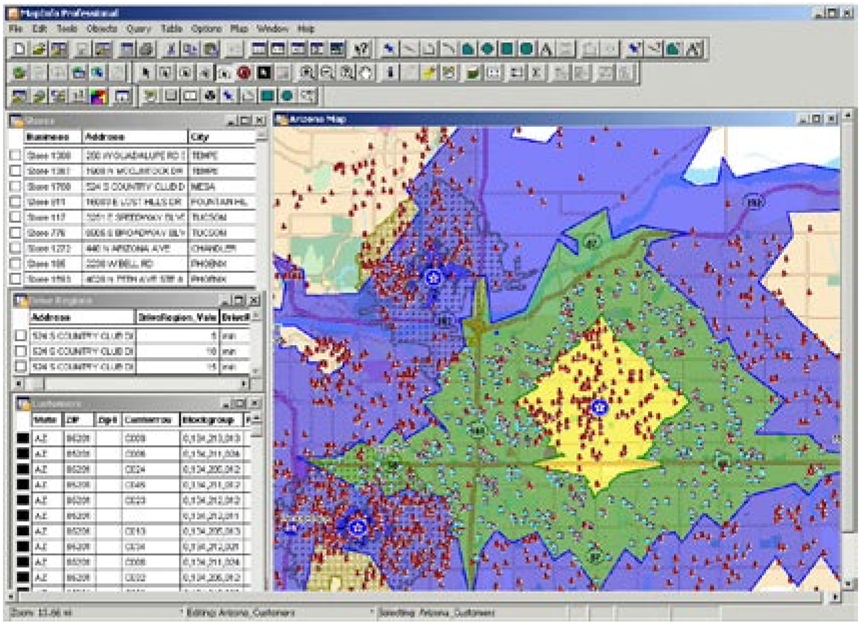
"Computers are useless. They can only give you answers."

—Pablo Picasso, artist, 1881–1973

The first step in moving beyond the demand analysis already done in the rapid assessment method is to map a very detailed and accurate itinerary of all existing transit routes. Software employing geographical information systems (GIS) can be quite useful to this end. Perhaps this was already done in the pre-feasibility phase, but it is a good idea at this point to put these itineraries into a GIS program like MapInfo, AutoCAD or TransCAD. This mapping could be done on a paper map but it will save a lot of time doing the computations using a GIS system, and if the data is already geo-coded it will be easy to put the routes into a traffic model like TransCAD, EMME II, or Visum later on.

In some cities, where a significant share of transit demand is handled by paratransit vehicles, shared taxis, and other forms of collective transport that do not have fixed itineraries, this methodology will not work. In other cities, paratransit vehicles usually follow some reasonably predictable route between a well known origin and destination, and the basic itineraries can be estimated. In cities where the existing bus routes are all public buses that closely follow routes assigned by a transport department or transit authority, mapping these bus routes may have already been done, and if it has not been done, it should be quite easy.

During the rapid assessment, the technical team should have already done a significant number of transit vehicle counts and bus occupancy surveys in strategic locations which will capture most of the transit demand in the city. Once the critical corridors have been selected, traffic counts and transit vehicle occupancy surveys should also have been completed in order to get a sense of the demand along the corridor. If this was not done before, it should be done now.



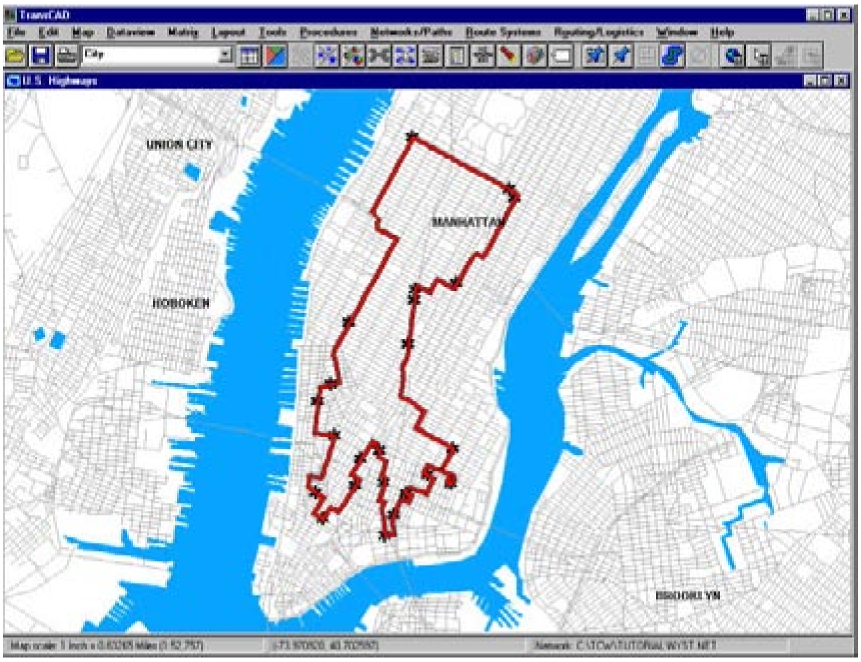


Fig. 4.9 and 4.10
Software packages such as MapInfo (above) and TransCAD (below) give the modelling process a user-friendly visual interface.
Images courtesy of MapInfo and TransCAD

Fig. 4.11
A count of boardings and alightings at each station will be invaluable information in terms of prioritising corridors, sizing vehicles, and sizing stations.
Photo by Lloyd Wright

At this point, an additional survey should be conducted: a boarding and alighting survey on each public transport line (Figure 4.12). For this type of survey, surveyors should ride the entire length of each major transit line during the rush hour recording how many people are getting on and off the vehicle at each stop. At the same time, the speed of the vehicle can also be recorded. If GIS is used, and accurate distances are recorded in the itinerary, the surveyor simply needs to record the time of each stop, and then the speed can be calculated based on the distance.

The boarding and alighting survey will give a picture of how many passengers are on each bus line at different parts of their journey, some of which may be included in the proposed BRT corridor.

The projected boardings and alightings at each new BRT station will be useful data to allow designers to avoid station congestion. By aggregating the boarding and alighting data as in Figure 4.13, the station can be designed to

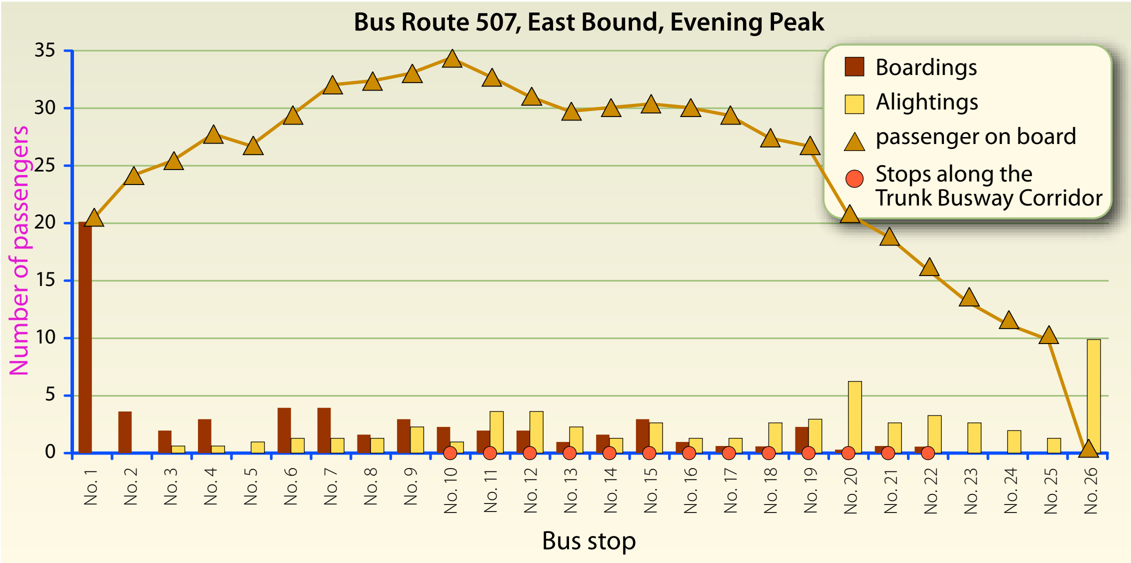


Fig. 4.12
Boarding and alighting survey results on bus route 507 in Guangzhou (China). The stops with yellow dots connected with a red line are stops along the new planned Zhongshan Road BRT system.
Image courtesy of ITDP

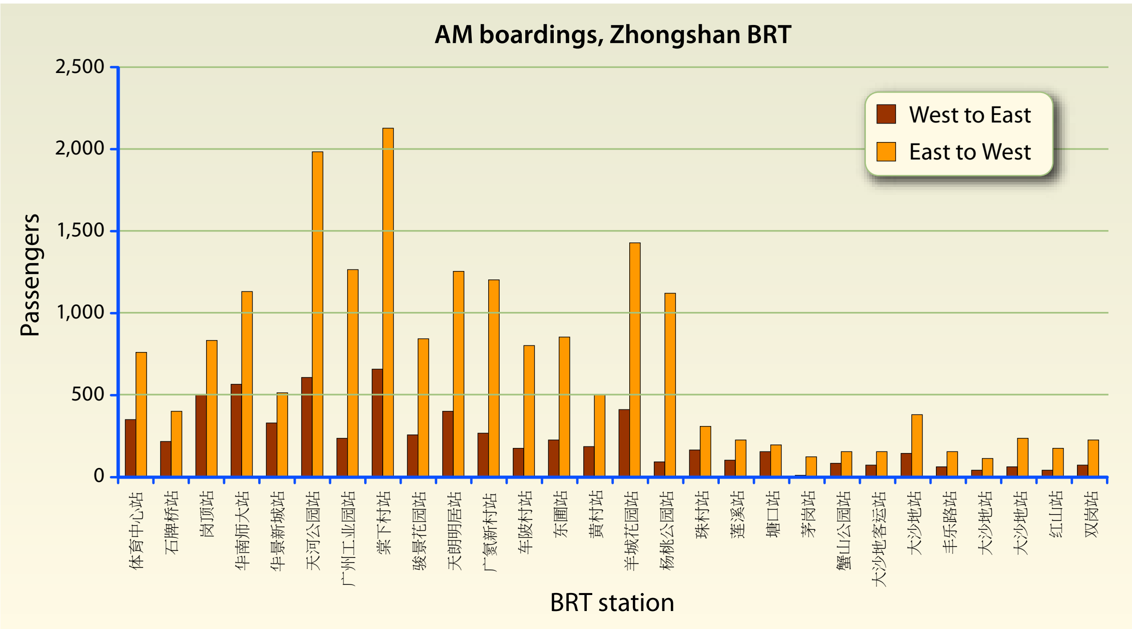


Fig. 4.13
Aggregate data for boardings and alightings

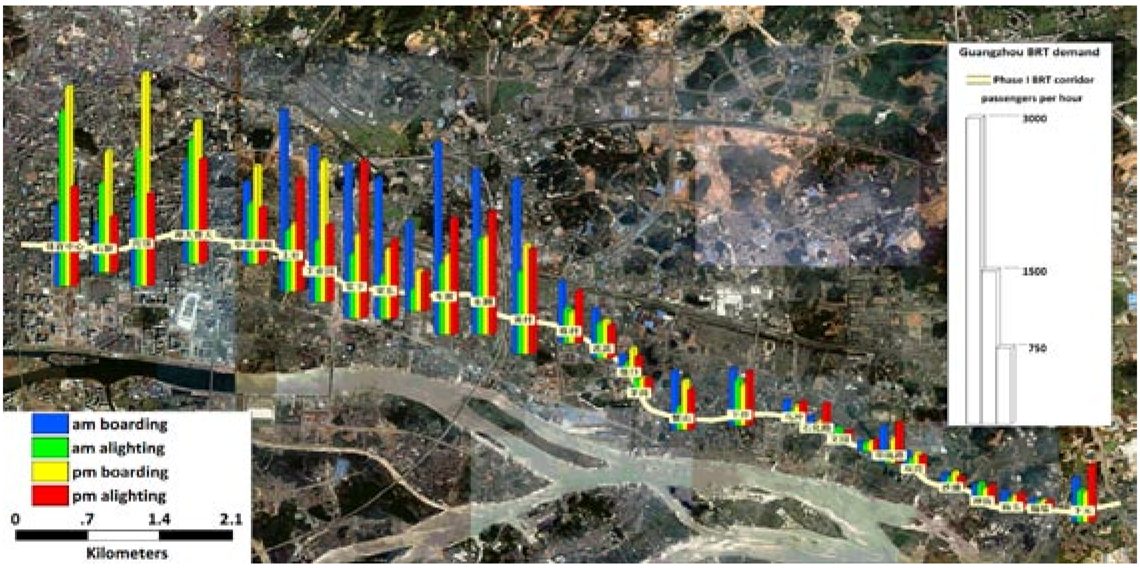


Fig. 4.14
Ridership by bus line by stop

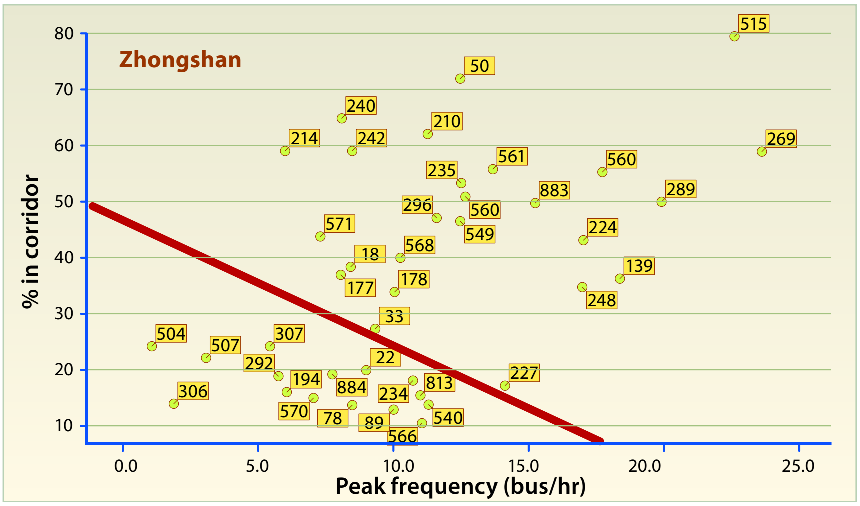


Fig. 4.15
Peak frequency and percentage of route traversing the corridor.
Image courtesy of ITDP

handle the specific number of passengers likely to use the station.

By adding up the ridership at each stop along all existing routes, the total passengers likely to use the system at any given point can be determined. The resulting map will show the *maximum load at the critical link* (Figure 4.14).

With a sense of the maximum load on the critical link, derived from aggregating the ridership data of each route, many preliminary judgements can already be made about the basic system design, and about which routes should be incorporated into the new BRT system. This information will also indicate which routes will not be a priority for inclusion in the initial project phases. This process is more of an art than a science, but two factors are typically used:

- Percentage of the existing route that traverses the corridor; and
- Frequency of the vehicles by route in each direction.

To analyze which routes should be included in the system, and which routes should be left to operate outside the system (if at all), might be analysed through a graphical analysis as shown in Figure 4.15.

Figure 4.15 indicates the frequency and percentage of the routing utilising the proposed corridor on Zhongshan Road in Guangzhou. All the routes with a high frequency that are heavily concentrated on the corridor should be incorporated into the system, or else the BRT system will not capture the bulk of the transit demand in the corridor. The more routes that heavily overlap with the full length of the corridor, the easier the corridor will be to design.

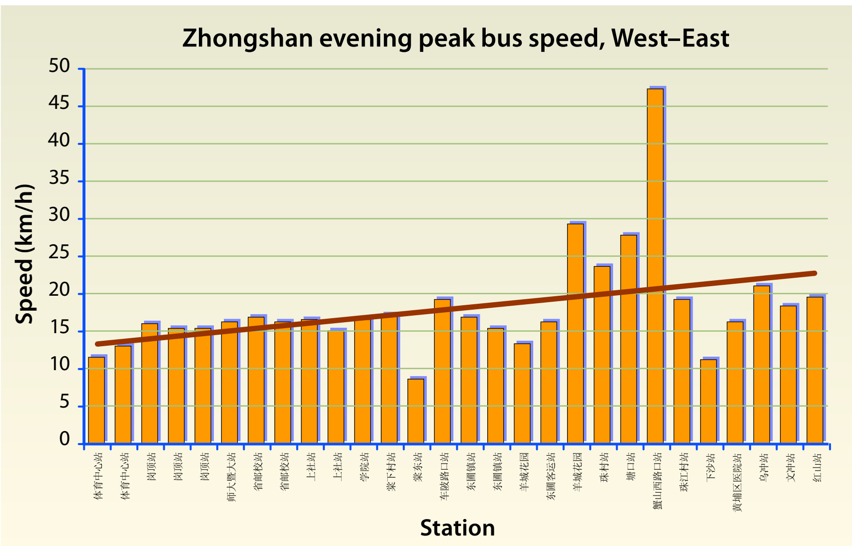
By collating the public transport demand for only those routes that will be brought into the new BRT system, planners have arrived at a first estimate of the maximum load on the critical link of the actual proposed BRT system's projected demand. This amount will be some fraction of the total maximum load on the critical link in the corridor. With this level of demand analysis, many of the serious design mistakes typically observed can be avoided.

Using the same boarding and alighting survey, average vehicle speeds in the corridor can be calculated and arranged in a graph as shown in Figure 4.16. The new BRT system, if designed correctly, should be able to achieve speeds of up to 29 kph throughout the corridor. Multiplying the number of current passengers by the difference between existing aggregate speeds and the projected BRT operating speed will yield the projected time savings benefit of the corridor.

This level of analysis will already give a good idea of how many of the existing transit system's passengers the new BRT system will capture, assuming that the price of service is the same. This is a very good baseline for a minimum demand assumption.

However, planners still need to make some assumptions about how many new passengers

Fig. 4.16
Average bus speeds in the corridor



are likely to be attracted from other modes. To get a robust estimate requires a traffic model, but an important clue will be the existing bus speed data. If existing public transport speeds are already at or above 26 kph, it can safely be assumed that the new system will not provide a significant time savings benefit. This lack of time savings will limit the number of new passengers attracted to the system, although customers may be attracted for other reasons (safety, security, comfort, fare price, etc.). The lower the existing public transport speeds, the higher the projected modal shift (Figure 4.17).

It is highly unlikely that short term modal shift will be more than 25 percent of the baseline demand from existing public transport trips, though to be conservative the system should be designed to accommodate an increase of 50 percent above existing public transport demand. However, there may be exceptions. If a city's bus system has all but collapsed, and there are a large number of difficult to count shared taxi trips, it may be that modal shift will be higher. In cases of such uncertainty, full demand modelling is recommended.

4.4 Estimating demand with a public transport model

"The best way to predict the future is to invent it."

—Immanuel Kant, philosopher, 1724–1804

This section will describe how to build a basic traffic model that only models the public transport system. With this basic public transport model it will be possible to develop a much more robust estimate of the demand on the existing system. It will also enable the planning team to much more easily test the demand for different alternative scenarios for fares, small changes in the routes, as well as to optimise operational characteristics.

In many cities, some sort of traffic model will already exist, but in the developing world it is relatively rare to have the transit system already coded into a traffic model. Often if there is a traffic model, it is only usable for motor vehicles and has very limited capacity to model public transport systems. If a good traffic model already exists, it should be possible to simply put the public transport system and the proposed

Fig. 4.17
If existing public transport services are slow or inefficient, the upgrading to BRT will produce a significant shift in passengers to the new service.
Photo by Lloyd Wright

BRT scenario into the existing model. If not, the BRT team should start by modelling the public transport system first, which will be the most important information for BRT planning.

4.4.1 Choosing a modelling software

The first step in setting up a public transport model is to obtain traffic modelling software. The development of transportation modelling software has greatly aided the process of transport supply and demand projections. Software models today can greatly ease the modelling process and increase accuracy and precision. However, with an array of software products on the market, the transport planner can be left with an overwhelming set of options. Of course, there is no one software solution that is inherently correct. A range of variables will guide the software selection process. These variables include cost, familiarity of municipal staff and local consultants with a particular product, degree of user friendliness sought, degree of precision sought, and the overall objectives of the modelling task. The table below lists a few of the commonly used software packages that are on the market today.

The strongest packages for general purpose planning and design of BRT systems are Emme/2, Cube/Trips and Visum with TransCad offering close capabilities. All of these are rather expensive packages but again, the most significant costs will be those of training

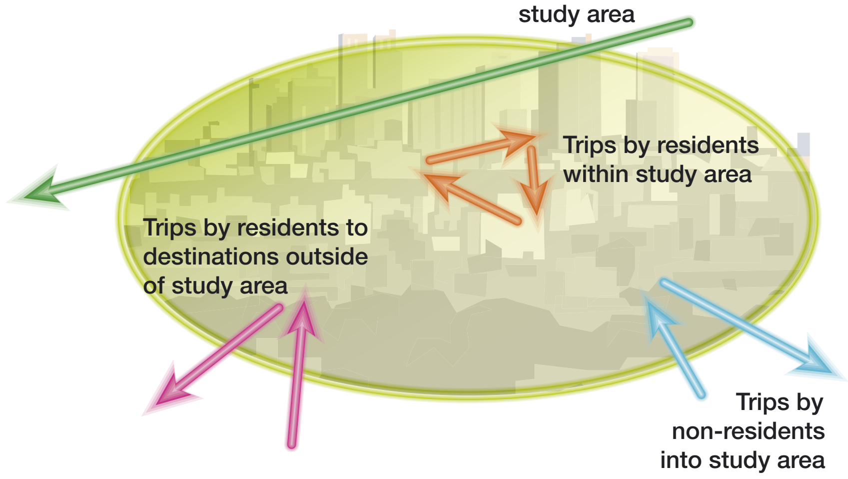
Table 4.3: Options for transport modelling software

Software name	Vendor	Comments
EMME / 2	INRO Consultants Inc.	Good general purpose
CUBE/ Trips	Citilabs	Good general purpose
TransCAD	Caliper Corporation	Good integration with GIS, easy to use
VISUM	Ptv/ITC	Good general purpose
AMSUN2		Microsimulation model useful for animations for intersection design
Paramics	SIAS	Microsimulation package, very useful animations for traffic design
VISSIM	Ptv	Microsimulation package, good animations, good integration with VISUM
QRS II	AJH Associates	Low cost but weaker on PT assignment
TMODEL	TModel Corporation	Low cost but weaker on PT assignment
SATURN	Atkins-ITS	Good for congested vehicle assignment, but no PT assignment

leading to effective use and familiarity with the package. Older and more sophisticated modellers like the flexibility of Emme/2, which allows them to easily write sub programs, called 'macros', but Emme/2 does not yet have a windows interface (it is under development), and its graphics capability is fairly weak. More and more consultants are now using Emme/2 in combination with other programs with better GIS capability, such as TransCAD. Saturn, TMODEL, QRS II, all either have no public transport assignment component or else are fairly weak at modelling public transport demand, and are not recommended for BRT.

Amsun2, Paramics, and Vissim simulate trip making at a high level of detail, in particular vehicle-by-vehicle. These are very powerful packages to study priority at junctions and interactions and delays at stops. They should only be used for these purposes and in combination with the macro demand models listed above, as they are not appropriate for BRT route analysis.

Fig. 4.18
Representation of study area for analysis.



Source: Adapted from Ortúzar and Willumsen, 2002

4.4.2 Defining the study area and the zoning system

Normally, the study area for a BRT system will be the areas currently served by bus and paratransit services. If the decision maker has already pre-selected a particular corridor as the first BRT corridor, then the catchment area for this corridor will be the study area.

To analyse travel in the study area, the entire area, as well as some areas outside the study area, need to be divided into a number of zones (Figure 4.18). As all origin-destination data will be collected and coded to this zoning system, establishing these zones is an important first step. Usually the zones are based on census tracts or political subdivisions that have been used as the basis of any existing census information or previous origin and destination studies. Using census and other administrative zones that already exist in the city will increase the chance of compatibility with the overlaying of different data types.

The information needed for modelling, however, is not exactly the same as information needed by the census bureau, so some census zones are usually consolidated into bigger zones, and others are broken up into smaller zones. Traffic modellers are generally less concerned about information outside the study area. As a result, they tend to consolidate zones outside the study area into fewer, larger zones. This consolidation is a simple matter of adding up the data associated with each zone.

Typically, modellers need more detailed information in the city center and/or along the proposed BRT corridor. So typically, the modellers will break up census zones into smaller zones, using more detailed census data if available, or just dividing the zones using their judgement based on aerial photographs (Figure 4.18). Sometimes, households and employment will be concentrated into some parts of a large zone and not others, and it is important to break up the zone to capture this geographical concentration.

Selecting the size of the zones and the number of zones is a trade-off between accuracy, time, and cost. The size and number of zones will also depend in part on how the data was collected and how it will be used. For BRT systems, for a large city like Jakarta, roughly 500 zones were used to analyse the main relevant BRT corridors. In a smaller city like Dar es Salaam, only 300 zones were necessary for the main BRT corridor analysis, though for detailed traffic impact analysis the city centre was later broken into an additional 20 zones.

Table 4.4 lists the number of zones that have been developed for various cities. Note that cities such as London have multiple levels of zones that permit both coarse- and fine-level analyses.

These zones, and the road network, must be coded into the traffic model if it has not already been done. This process will not be described here in any detail, as it is a standard function of all traffic modelling, and is thoroughly described in the documentation of any commercially available traffic demand model. However, the basic points of this process are summarised below.

Data is usually entered into a traffic model either as a point, usually called a "node" which has a specific "x" and "y" coordinate, or as a "link", which is a line connecting two nodes. Normally, each intersection and each major bend in a road is assigned a separate node. Nodes are usually numbered. Ideally, the x and y coordinates of each node should correspond to actual latitude and longitude. Making sure these nodes correspond to actual latitude and longitude is called "geocoding". Geocoding will ensure that data from different sources are consistent.

Normally roads are broken up into different links. Links are usually named from their origin node and their destination node.

For example, in Dar es Salaam, there was already an existing GIS map. If no GIS map exists, then staff will have to utilise a Geographic Positioning System (GPS) devise to record the coordinates of each of these points (Figure 4.20). In Dar es Salaam, the team initially defined 102 nodes, and later increased it to 2,500 important nodes. By the end, the nodes represented most of the important intersections in the city. Each node will be recorded in a simple spreadsheet (Table 4.5).

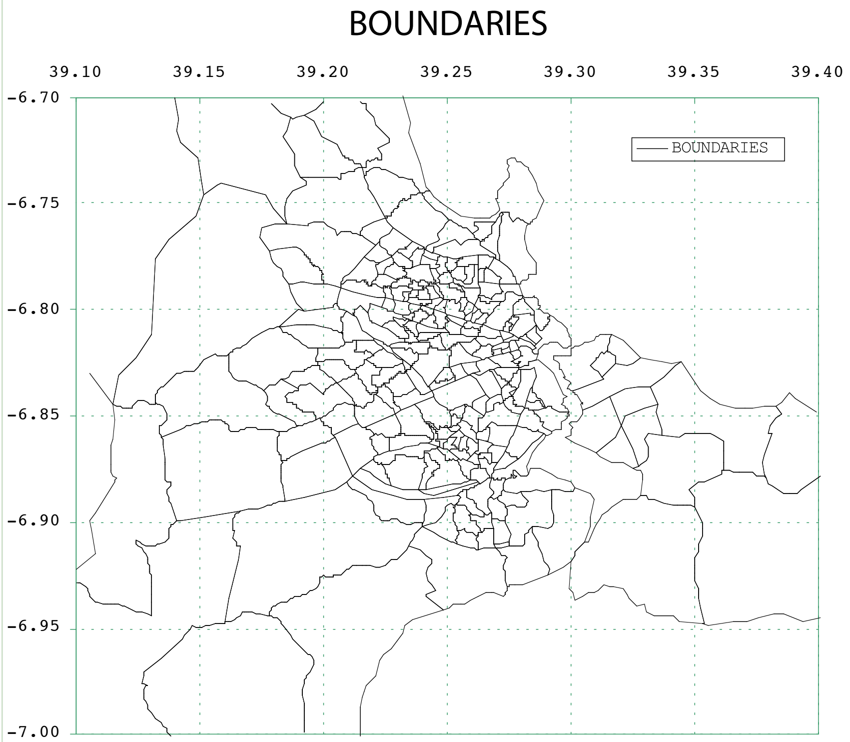


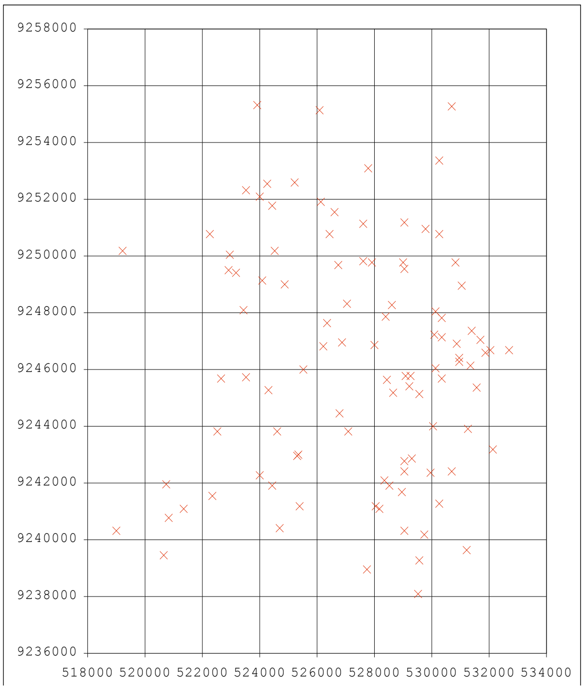
Fig. 4.19
Geographic area divided into zones for modelling purposes. Zoning system for Dar Es Salaam BRT feasibility study.

By connecting these nodes, a series of links are defined that represent different roads. For example, in Dar es Salaam, Morogoro Road between Sokoine Drive and Samora Avenue, is

Table 4.4: Typical zone numbers for modelling studies

Location	Population (million)	Number of zones	Comments
Bogotá (2000)	6.1	800	BRT project
Jakarta (2002)	9.0	500	Normal zones
Dar es Salaam	2.5	300	BRT project
Cali	2.0	203	Normal zones
London (1972)	7.2	2,252 ~1,000 ~230 52	Fine level subzones Normal zones at GLTS GLTS distri cts Traffic boroughs
Marseille (2001)	1.5	562	Normal zones
Montreal Island (1980)	2.0	1,260	Fine zones
Ottawa (1978)	0.5	~120	Normal zones
Santiago (1986)	4.5	~260	Zones, strategic study
Washington (1973)	2.5	1,075 134	Normal zones District level

Source: Ortúzar and Willumsen (2002) and ITDP



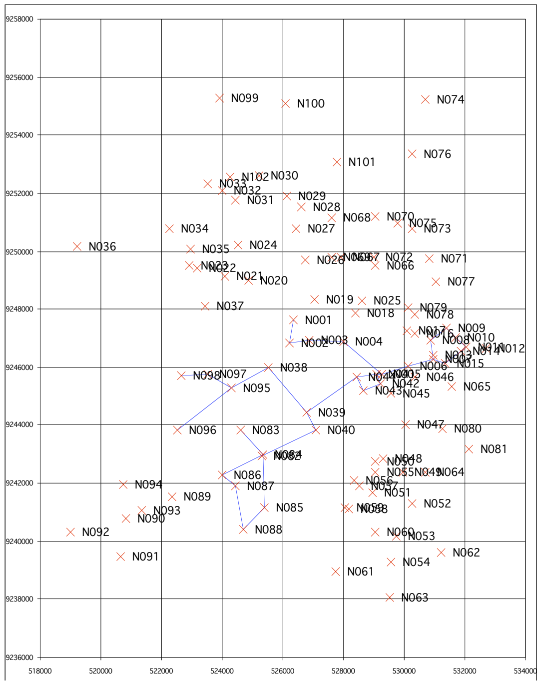


Fig. 4.20
Nodes and links from the Dar es Salaam transit model used to design the DART system.
Images courtesy of the City of Dar es Salaam

a link (the link between the nodes Morogoro Road X Sokoine Drive and Morogoro Road X Samora Avenue). Link data can also be entered into the traffic model from an Excel spreadsheet (Table 4.6).

These links are generally further defined, based on the number of lanes and other characteristics, but for public transport planning it is not really necessary to further define at this point.

Zones are generally entered into a traffic model based on the nodes of all points that are needed to define the boundary. In an Excel spread sheet, each zone will just look like a series of nodes defined by their x and y coordinates.

Once the data is entered into a model, the zone is actually represented by a special type of node called a "zone centroid". This zone centroid is a node that is used to signify the average characteristics of the particular zone. In Dar es Salaam, for example, in addition to 2,500 nodes along roads, there were another 300 zone

Table 4.5: Node coordinates in Dar es Salaam

Node identification number	X coordinate	Y coordinate
13	16340	26375
14	16835	26370
17	17212	26440
23	16433	26090
24	16835	26090
27	17339	26185
28	17580	26300
33	16435	25810
34	16835	26805
127	17110	26060
128	17540	25930
134	17285	25675

Table 4.6: Link data for the traffic model (Dar es Salaam example)

Link	Node A	Node B	Two directional
1	13	14	Yes
2	14	17	Yes
3	13	23	Yes
4	14	24	Yes
5	17	27	Yes
6	23	24	Yes
7	24	127	No
8	127	27	No
9	27	28	No
10	23	33	Yes
11	24	34	Yes
12	33	34	Yes
13	28	128	No
14	128	134	No
15	134	34	No

centroid nodes. Trips are generated and attracted to these centroids. It is therefore important to know how these centroids are connected to the real network, in particular to stations in a new BRT design. Normally these zone centroids are in the middle of the zone, but if all the population is concentrated in one smaller part of a zone, it is better to move the zone centroid closer to the population concentration.

Fig. 4.21
Collecting data on origins and destinations and fares paid from passengers using the Dar es Salaam "Daladalas" helped to define the operational characteristics of the proposed BRT system.
Photo by Lloyd Wright

4.4.3 Origin-destination survey and matrix

"If you have to forecast, forecast often."
—Edgar R. Fiedler, economist

The next survey required for constructing the public transport model is sometimes called an "on-board origin destination survey". This survey is one of a family of surveys called "intercept surveys", where individuals are interviewed about their origin and destination (where they began their trip and where they will end the trip).

4.4.3.1 Data collection

All the origin and destination information collected will be coded as between the zone centroids of two of these zones, and aggregated based on these zones. A trip between two zones is called an 'origin-destination pair', or OD pair. The table of all the trips between each OD pair by any given mode, in this case public transport, is called the OD matrix.

To conduct an on-board OD survey, public transport users are interviewed either on-board a bus or paratransit vehicle, (and in that case it is not an interception point but a section of a road between two intersections) or at stops and interchanges. Sometimes, with the cooperation of the police, paratransit passengers can be interviewed very efficiently by having the van driver pull over and allow the passengers to be interviewed. In Dar es Salaam, with the cooperation of the police, the planning team, wearing DART (Dar es Salaam Rapid Transit) shirts, stopped Daladalas (paratransit vehicles) and interviewed all of the passengers inside (Figure 4.21). Other data besides OD information can also be collected, if appropriate. Other useful information can include the fares paid and the services used, but the questions should be kept as simple as possible. Although it is tempting to ask about waiting times, these are seldom accurately reported by individuals and are best estimated by another method.

On-board OD surveys of bus passengers are typically attempting to focus upon the passenger flows during the morning peak period. However, it can be difficult to avoid capturing non-peak trips as well, so normally data is collected for approximately four hours around the morning peak, and averages are taken or weighted.

The survey locations should correspond to the locations where the traffic counts were conducted earlier, if these points were chosen wisely. In the case of Dar es Salaam, the points where the origin destination surveys were conducted were the same 34 points of the original traffic counts. This precision was possible due to the assistance of the police to pull over the vehicles at particular locations. In Jakarta, the surveys were conducted on board the buses, so surveys were conducted along key links that corresponded as closely as possible to the points where previous traffic counts had been conducted.

4.4.3.2 Sample size

The sample size for intercept surveys depends on the accuracy required and the population of interest. The error for an intercept OD survey is a function of the number of possible zones that a passenger might travel to when passing through a particular point. As a simple rule, Ortúzar and Willumsen (2001) suggest the following table for a 95 percent confidence in an error of 10 percent for given passenger flows:

Table 4.7: Sample size for origin-destination surveys

Expected Passenger flow (passengers/period)	Sample size (%)
900 +	10.0 %
700-899	12.5 %
500-699	16.6 %
300-499	25.0 %
200-299	33.0 %
1-199	50.0 %

Usually, on BRT corridors, the flows are much greater than 900, so 10 percent of the total passenger flow at any given survey point is a reasonable general rule. In the case of Dar es Salaam, the average passenger flow at the peak hour was around 10,000, so 1,000 passengers were surveyed at each point, or some 34,000 surveys. In Jakarta, 120,000 surveys were conducted, of which 20,000 were useless. Other survey data was not taken during the morning peak, so ultimately about 65,000 of the surveys were usable. This quantity was all that was possible with the budget available, and constituted roughly 3 percent of the peak hour flows. In Jakarta, the survey numbers were weighted based on the flows on the corridor.

Origins and destinations should be recorded as accurately as possible, for example as the nearest intersection or other key identifier. These locations then have to be attributed to the zone in which they are located, so the origin and destination can be coded to the zone centroids.

Table 4.8: General form for a two-dimensional trip matrix

Origins	Destinations					
	1	2	3	...j	...z	$\sum_j T_{ij}$
1	T_{11}	T_{12}	T_{13}	$\ldots T_{1j}$	$\ldots T_{1z}$	O_1
2	T_{21}	T_{22}	T_{23}	T_{2j}	T_{2z}	O_2
3	T_{ij}	T_{ij}	T_{ij}	T_{ij}	T_{ij}	O_3
I	T_{i1}	T_{i2}	T_{i3}	T_{ij}	T_{iz}	O_i
Z	T_{z1}	T_{z2}	T_{z3}	T_{zj}	T_{zz}	O_z
$\sum_i T_{ij}$	D_1	D_2	D_3	$\ldots D_j$	$\ldots D_z$	$\sum_{ij} T_{ij} = T$

Source: Ortúzar and Willumsen, 2001

4.4.3.3 Error types

The data collection process is thus prone to two types of errors: measurement errors and sampling errors. Measurement errors arise from misunderstandings and misperceptions between the questions asked and the responses of the sampled subjects. Misinterpretation by the interviewer can result in the incorrect listing of a response. Frequently, during an OD survey, for instance, a person will identify the origin and destination of their trip, but neither the interviewee nor the surveyor are able to locate this location within any of the zones on a map. Sometimes surveyors will also not do the work responsibly and will make up answers. There may also be a degree of bias in which respondents answer questions in a manner that represents a desired state rather than reality.

Avoiding measurement errors is a complex process that requires a lot of local knowledge, and should start at the survey stage. One method is to ask the interviewee the best local landmark, and have the local staff identify as precisely as possible its location on a map. Another method is to have the interviewees pick their origin and destination from a pre-selected list of areas and sub-areas, and specific popular destinations. The latter method will probably avoid a lot of trouble and confusion, but will lose some subtlety regarding walking distances. In countries where street names and neighbourhoods are far from standardised, the latter method may be more effective.

Sampling errors occur due to the cost and feasibility of surveying very large sample sizes. Sampling errors are approximately inversely proportional to the square root of the number of observations (*i.e.,* to halve them it is necessary to quadruple the sample size) (Ortúzar and Willumsen, 2001).

4.4.3.4 OD matrices

Once each OD pair is coded to specific zone centroids, a separate OD matrix is created for each survey point. For each survey point and each direction, it is simply a matter of adding up the trips surveyed between each OD pair for the peak hour. This raw survey data will give you a preliminary OD matrix for each direction at each survey point. Table 4.8 outlines the general form of a two-dimensional trip matrix.

Table 4.9: O-D matrices expanded by expansion factor

Point	Factor inicial	Sample	Passengers per peak hour	Daladala small	Daladala large
P 01 W1	12.9295302	298	3853.0		
P 01 W2	1.53046595	558	854.0		
P 02 W1	6.545655774	493	3227.008297	320.5	63.0
P 03 W1	5.833990702	515	3004.505212	68.0	68.0
P 03 W2	2.928214064	522	1528.527741	60.0	54.0
P 04 W1	14.87864833	619	9209.883319	409.5	95.5
P 06 W1	9.375530401	511	4790.896035	65.5	107.0
P 06 W2	4.431338691	358	1586.419251	83.0	62.5
P 07 W1	2.597194766	502	1303.791773	164.0	8.0
P 07 W2	9.968302596	449	4475.767865	210.0	16.0
P 09 W1	12.92116263	470	6072.946436	180.5	65.5
P 09 W2	6.609650125	485	3205.680311	181.0	47.5
P 10 W1	25.42999509	515	13096.44747	628.5	65.5

From Table 4.8, "T_{11}" indicates how many trips were made within zone 1. "T_{ij}" indicates the total surveyed trips between zone i and zone j. "O_1" is the total origins in Zone 1, and "D_1" is the total destinations in Zone 1.

This simple matrix is still not a full OD matrix for the whole city's public transport trips during the peak hour. To get to that, the number of people surveyed needs to be related to the total number of transit passengers per direction per hour at each survey point. This process is called expanding the matrix. The total number of public transport passengers at the peak hour is taken from the data that was collected earlier at each of the same points using the transit vehicle occupancy surveys. For example, in Dar es Salaam, on some corridors 1,000 out of 10,000 hourly transit passengers per direction were collected on some corridors, which yields an expansion factor of 10. On this matrix, the observed OD trips need to be multiplied by 10 to get the total public transport trips at the peak hour. On other corridors, where 1,000 interviews were taken for only 6,000 passenger flows, the expansion factor is 6, so the surveyed OD trips need to be multiplied by six. Each separate matrix needs to be expanded by its appropriate expansion factor, as indicated in Table 4.9.

Because the point of each OD survey was chosen to pick up a discrete set of OD pairs, each individual OD matrix will largely cover a different part of the city. So the individual matrices will have some OD pairs with actual values, and some OD pairs with zero trips (Table 4.10 and Table 4.11).

Table 4.10: OD Matrix #1 East Bound Morogoro Road and United Nations Intersection

Origins	Destinations					
	1	2	3	4	5	$\sum_j T_{ij}$
1	4	10	6	0	0	O_1
2	12	4	2	0	0	O_2
3	16	5	12	0	0	O_3
4	3	2	0	0	0	O_i
5	0	0	0	0	0	O_z
	D_1	D_2	D_3	D_4	D_5	Total

Table 4.11: OD Matrix #2 South Bound Old Bagamoyo Road and United Nations Intersection

Origins	Destinations					
	1	2	3	4	5	$\sum_j T_{ij}$
1	0	0	0	12	15	O_1
2	0	0	3	15	20	O_2
3	5	2	15	8	10	O_3
4	0	0	0	6	11	O_i
5	0	0	5	12	10	O_z
	D_1	D_2	D_3	D_4	D_5	Total

Table 4.12: OD Matrix Dar es Salaam

Origins	Destinations					
	1	2	3	4	5	$\sum_j T_{ij}$
1	4	10	6	12	15	O_1
2	12	4	3	15	20	O_2
3	16	5	15	8	10	O_3
4	3	2	0	6	11	O_i
5	0	0	5	12	10	O_z
	D_1	D_2	D_3	D_4	D_5	Total

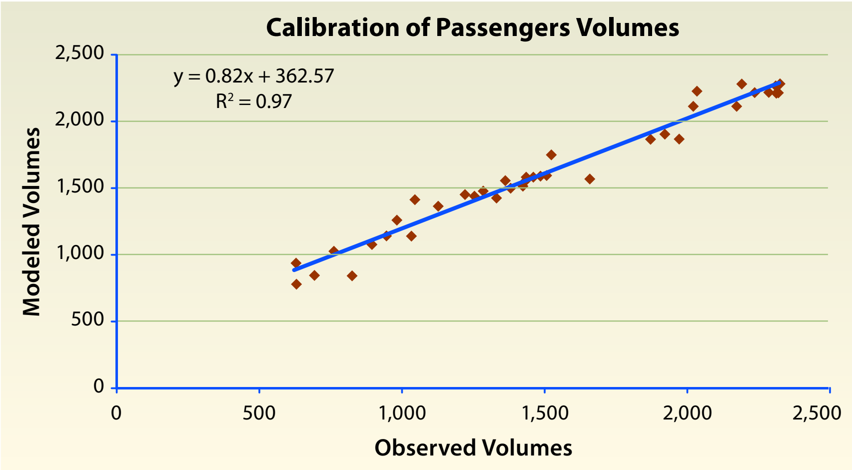


Fig. 4.22
Modelled versus observed passenger volumes in Jakarta.
Grahpic courtesy of Remi Jeanneret

To develop the full OD matrix for transit trips in Dar es Salaam, a simple estimate would be to take the maximum value for any OD Pair in any observed survey. Others believe taking the average of the observed trips. For illustration purposes in Table 4.12, the values from the previous two tables have been combined to form a complete OD matrix (assuming that only two points are surveyed).

This methodology is used to avoid double (or triple) counting of some trips. This double counting may happen because some journeys may have been intercepted by more than one survey station, either potentially or in the sample. In this case, steps must be taken to avoid exaggerating their importance in the matrix by weighting those cells appropriately, for example taking the average value of duplicated cell entries. For more details, consult Ortúzar and Willumsen (2001). On the other hand, sometimes people may go in very different directions to reach the same endpoint, so using this method will undercount the total demand.

4.4.3.5 Validation

Due to these distortions, along with measurement and sampling errors, it is usually necessary to undertake corrective actions. A validation process is typically done at the conclusion of the data collection process in order to provide a degree of quality control.

Validation is usually accomplished by looking at OD pairs route by route, and doing an informal trip assignment, assigning the OD trips to specific public transport routes, and comparing the aggregate total trips to the aggregate trip counts developed from the occupancy surveys and transit vehicle counts (Figure 4.22).

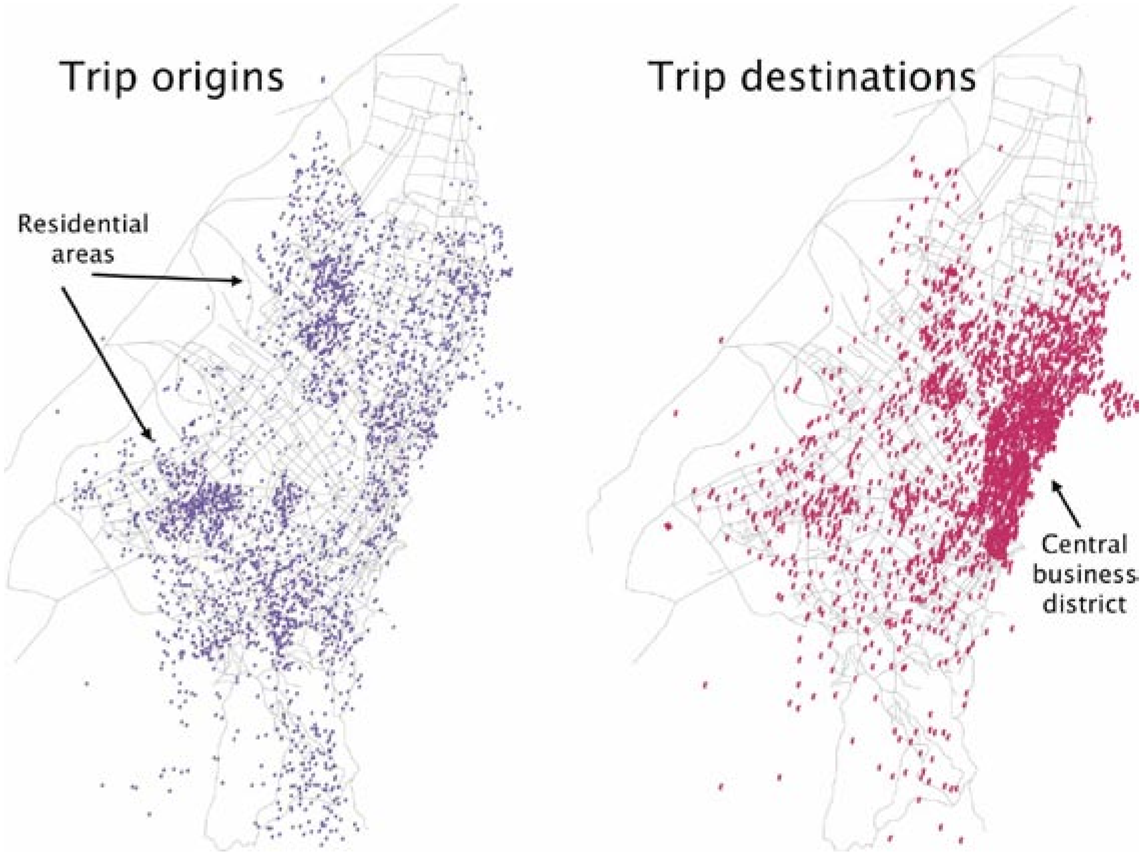


Fig. 4.23
Origin-destination map for Bogotá.
Image courtesy of TransMilenio SA

Once the OD matrix has been cleaned and calibrated, the OD matrix can be input into the traffic model, and the testing of different scenarios can begin. The OD matrix can also be used to generate an origin-destination map that gives decision-makers an overall view of the density of origins and destinations in the city. The OD map will frequently illustrate the extent to which trips are distributed or are centralised within the city. The OD map of Bogotá shows that there is a heavy concentration of trip destinations to the centre of the city (Figure 4.23)

4.4.4 Outputs of the public transport model

"I have not failed. I've just found 10,000 ways that won't work."

—Thomas Edison, inventor, 1847–1931

Once the road system and the OD matrix are input into the traffic model, different scenarios for the BRT system can be tested. While the output from the public transport model will be used at various points throughout this guide, for the time being it will be used to generate demand estimates for specific BRT system scenarios.

The first step is generally to take a look at the existing public transport demand on all major corridors throughout the city at the peak hour. These results should now show a much more accurate estimate of total existing public transport demand on all the major corridors in the city. This result is a valuable tool for prioritising which corridors should be included in the BRT system. Figure 4.24 is a picture of the total existing transit demand on all of the major corridors in Jakarta.

These total demand estimates, or "desire lines", tell how many public transport passengers are currently on each major corridor. It still does not say anything about how many public transport passengers will be on a specific BRT system.

When first coding the existing public transport system into the model, the following additional information was required:

- Vehicle capacity (total standing capacity is all that is used);
- Public transport (this will be a series of links; each direction needs to be coded separately because sometimes bus routes do not go and return on the same roads);
- Specific location of the bus stops (for most of the network, just assume the bus stops are at the intersections, but the BRT corridor nodes should be added specifically at the bus stop, and the links between the bus stops should be broken into separate links);

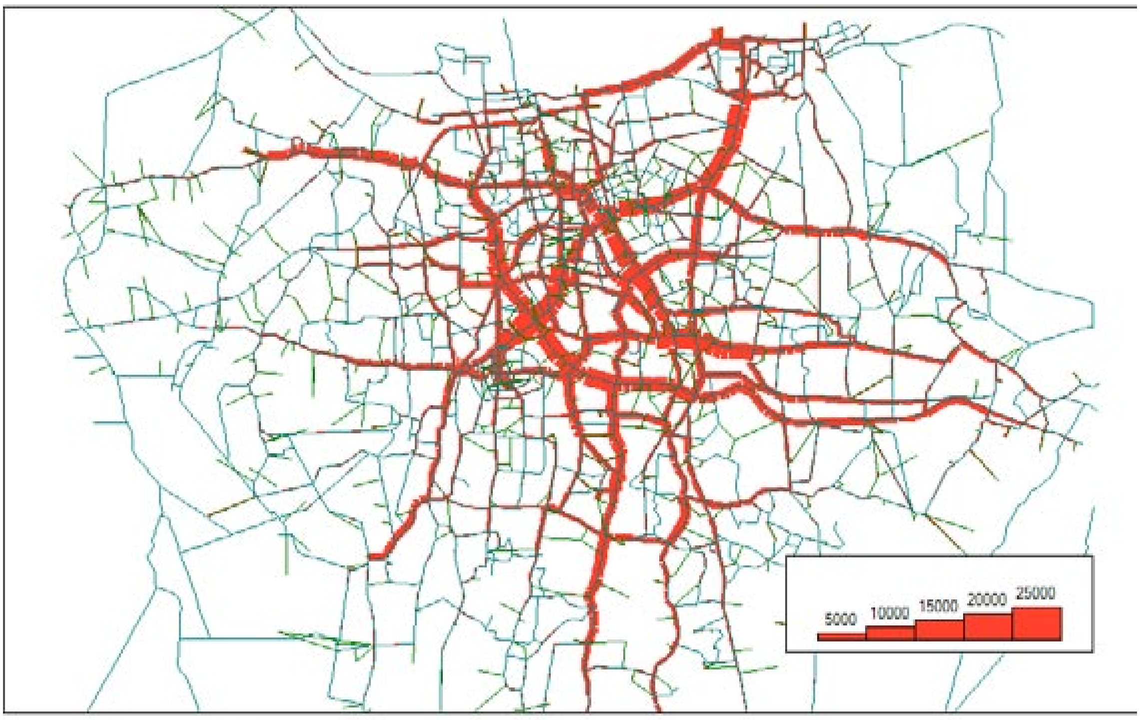


Fig. 4.24

A graphical illustration of demand volumes (also known as "desire lines") from Jakarta.

Image courtesy of ITDP

- Speed on each link (this will be taken from the bus speed and boarding and alighting survey);
- Bus fare (usually the models allow fare * distance and if there is a flat fare leave the distance blank);
- Bus frequency;
- Value of time (there are various ways of calculating this value, but in practice this value is based either on interviews with bus passengers or 50 percent of the hourly wage rate for the typical bus passenger).

At this point, the scenario to be tested should be carefully defined. In the case of TransJakarta, the scenario was essentially defined trough a decision taken by the Governor. The Governor's design decision was as follows:

- TransJakarta would go from Blok M to Kota station with 24 stops at specific locations;
- TransJakarta would have fully segregated lanes and of certain design;
- TransJakarta would charge a flat fare of Rp. 2,500 (US$0.30);
- There would be no feeder buses and no (functional) discount transfers from any existing routes;
- Ten existing bus lines travelling between Blok M and Kota would be cut; all other bus routes would be allowed to continue to operate in the mixed traffic lanes at curbside bus stops;
- 54 buses were procured to operate in the system.

When coding this BRT scenario into the public transport model, there is a small difference between coding a new BRT link and coding just any other bus route. The main difference is that normally, in order to test some unique elements of the BRT system, the BRT link will be coded as an entirely new road link with special BRT characteristics, rather than assuming that it is a bus line operating on an existing road link that is open to transit vehicles and other vehicles. This new BRT link in the model will only be coded for use by a specific BRT vehicle that may be a new vehicle category that does not already exist. In the case of Jakarta, these vehicles are only used on the BRT system. This special coding of the BRT link is also required to give this route special fare characteristics, such as the possibility of free transfers between routes when the system expands to more than one route. Thus, coding a new BRT route is no different than coding any public transport route, except:

- The bus speed will be higher than for routes on the mixed traffic links. The BRT bus speed must be calculated specifically based on the system's design, and how to do this is laid out elsewhere in this guide, but it is generally between 20 and 29 kph;
- Some new bus stop locations will be created, which will affect walking times;
- Bus frequencies will be specific to the number of buses and the bus speed;
- If a lane of mixed traffic is being removed from the existing link, the definition of the characteristics of that link will need to be changed to reflect the loss of a lane. This change will only be necessary for running the full traffic model in the future;
- It may be necessary to adjust downward the bus speeds for all the bus routes that are running in the mixed traffic lanes. If there is only a public transport model, this will only be an estimated impact. If there is a full transportation demand model, the model will help calculate this impact.

After defining the new BRT links and assigning it a new BRT route with the characteristics reflecting the political decision, the projected demand for this specific scenario can be calculated (Figure 4.25).

In the case of Jakarta, the projected demand on Corridor I for the scenario determined by the Governor was tested. Based on the lack of a feeder system and the unwillingness to cut

Fig. 4.25
Demand estimate for TransJakarta Corridor I, Scenario I.
Image courtesy of ITDP

bus routes that ran parallel to the new BRT system, it was known that the demand on the new system would not be very high. It was also known that because one mixed traffic lane had been removed, while few of the buses in the mixed traffic lanes had been removed, mixed traffic lanes would be more congested. However, due to the lack of a full traffic model, the precise scale of this impact was not known. The planning team therefore encouraged the Governor to add more feeder buses with free transfers onto the trunk system, and to cut more existing bus routes.

Note that this demand estimate assumed that the new BRT system will only get the trips from existing public transport trips. It did not assume that any trips would be attracted from other modes, as the public transport model alone did not have the capacity to provide much of an answer to this question. Nevertheless, this analysis produced a very good conservative first estimate of the likely demand.

To include some possible modal shift from private vehicles, it is usually sufficient to simply add 25 percent to the demand, but this modal shift impact will vary based on the difference between the bus speeds on the new BRT system and the mixed traffic speeds that can reasonably be expected after the BRT system opens. The greater the shift in relative speeds, the greater the projected modal shift. In Jakarta, for example, the political decision to allow many buses to continue in the mixed traffic lanes was certain to add to congestion in the mixed traffic lanes. This situation created a lot of controversy initially, but it did lead to a significant modal shift impact. According to surveys of passengers, roughly 20 percent had shifted from private cars, motorcycles, and taxis.

In Bogotá, where a well designed system actually decongested the mixed traffic lanes, the modal shift impact in the first phase was a modest 10 percent of private vehicle users to the BRT system (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. As the system has expanded, approximately 20 percent of current BRT customers are former private vehicle users.

With this demand estimate, planners are better able to assess whether the physical designs proposed will have sufficient capacity to handle the projected demand, whether stations will congest, and whether or not the system is likely to be profitable or operate at a loss.

4.5 Estimating demand using a full traffic model

"Those who have knowledge, don't predict. Those who predict, don't have knowledge."

—Lao Tzu, philosopher, 6th century BC

Most BRT systems in the developing world have been planned using only a public transport model, without having the full transportation system modelled. The lack of full modelling occurs because such modelling is only in its infancy in most developing countries, and it takes time to build up the data and the skills and resources to develop a full traffic system demand model. Nonetheless, the tools provided by the full transport demand model are very useful to BRT planning, and if time and resources allow, developing a full traffic demand model is worthwhile.

4.5.1 Overview

With a full traffic model, you will have a much better sense of "potential" passengers on the BRT system that currently may be taking motorcycles, private cars, bicycles, or walking. Planners will also get a much more complete understanding of congestion on different points of the network, and a much better capacity to assess the projected traffic impacts of the new BRT system.

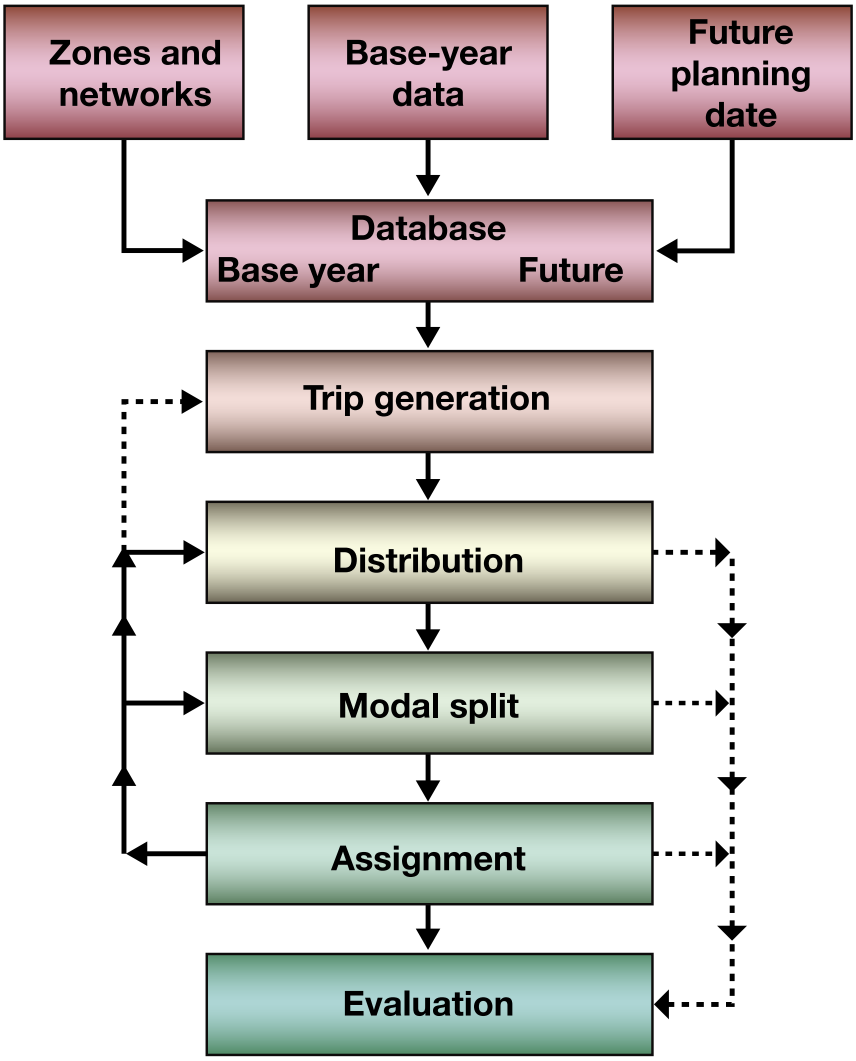
Guidelines for how to build and operate a full traffic demand model is beyond the scope of this guide. However, some basic information on traffic modelling is included here to give BRT planners a general overview of how these models work, and some specific examples of where they are relevant to BRT planning.

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.

While complex mathematical relationships underpin transportation models, the basic premise behind the modelling analysis can be presented in an understandable form to a wide audience. Figure 4.26 outlines the classic four-stage transport model. This model still serves as the basis for the various software products that today enable effective transport modelling.

Fig. 4.26
Representation of standard transport model.



The ***Trip Generation*** stage deals essentially with demand growth issues. Thus far, this chapter has only considered how much demand the BRT system will probably have when it opens, but does not provide much guidance regarding longer term demand trends. Normally, long-term public transport usage will be influenced by growth of population, income and vehicle ownership. These changes are captured by the best trip generation models. If these elements of growth are expected to be different in different parts of the city, then it is worth developing at least a simple set of trip generation models. If, on the other hand, there is urgency in BRT design and growth is expected more or less uniformly throughout the urban area, then perhaps a very simple trend extrapolation model could be used.

The ***Trip Distribution*** stage consider situations where the new BRT mode will change the origin or destination of trips, for example by making some schools or shopping areas more accessible than others. In the case of work trips, any re-distributional effect may take some time but shopping and social trips may react more quickly. As BRT schemes can be implemented more rapidly than rail schemes, there may be a case for postponing any consideration of trip redistribution until the system is actually operational.

The ***Mode Split or Choice*** stage considers the potential for attracting to BRT current users of other modes, in particular private vehicle users. Again, the likelihood of this depends on how much better the new system will be compared to existing services. If car ownership is low (say below 8 percent) and the change in ride quality is not that different, it may be possible to design a BRT system without considering explicitly a mode choice model. A rough estimation by an experienced planner of how many people would transfer from car would be sufficient. On the other hand, in some cases it is necessary to have a good grasp on this mode transfer figure to size the system and estimate de-congestion benefits.

The Assignment stage is in most large cities essential and requires a good public transport model and also a model of the interaction with the rest of the traffic.

4.5.2 Additional data needs

Much of the data required for the full traffic demand model will have already been collected during the initial analysis period. It is fairly common for transport departments to do traffic counts, and if recent traffic counts exist in reasonable locations, this data should be usable. If counts for all vehicles were not done earlier, they need to be done now to calibrate the traffic model.

Secondly, when the road network is coded into the traffic model, it is no longer enough to simply identify existing road links, but the definitions of these links (how many lanes, etc.) becomes important. Furthermore, all existing alternative modes such as commuter rail lines, subway lines, etc. must be coded into the model.

Also, at this point, demographic data for each zone defined earlier becomes important, such as population by zone, employment by zone, average income by zone, vehicle ownership by zone, etc. This information is usually obtained from census data. Historical growth rates in population and employment by zone are the best first indicator of the likely growth rate of future trips in specific locations. Knowing household incomes and motor vehicle ownership levels will help indicate whether most people will take the bus regardless of the price, or whether they will switch to a car or motorcycle. Mapping the income levels throughout the city will also help to define price elasticities and target lower income beneficiaries, both important to developing the fare structure. Thus, traffic models are usually built up from demographic data on population, employment, and vehicle ownership.

Finally, for full traffic demand modelling, the planning team will need to conduct a full household origin destination survey. This survey is necessary since the team will only initially have estimates of origins and destinations for public transport trips. By contrast, the full transportation model will require OD matrices for all modes, including walking trips and private vehicle trips.

Surveying all members of a household regarding individual travel practices (destinations, mode choice, reasons for mode choice, travel expenditures, etc.) provides a very complete picture of where people are going, when, and sometimes why. This process is called ***trip generation***. Likewise, work place surveys can also be an effective mechanism. Unfortunately, household and work place surveys are probably the most costly of the O-D techniques. As a result, sometimes shortcuts are taken. Home interviews are the best way to obtain information on trips made per household, vehicle ownership data, linked journeys and overall levels of expenditure in transport.

The number of observations is constrained by financial and human resources. While the statistically desirable sample size for household surveys may be that represented in Table 4.13 (Bruton, 1985), the reality of what is possible is often quite different.

Table 4.13: Sample sizes recommended in traditional home interview surveys

Population of area	Sample size (dwelling units)	
	Recommended	Minimum
Under 50,000	1 in 5	1 in 10
50,000 – 150,000	1 in 8	1 in 20
150,000 – 300,000	1 in 10	1 in 35
300,000 – 500,000	1 in 15	1 in 50
500,000 – 1,000,000	1 in 20	1 in 70
Over 1,000,000	1 in 25	1 in 100

Source: Bruton (1985) in Ortúzar and Willumsen (2001)

In some locations, it may be very difficult (and expensive) to gain access to certain types of households or even define them unambiguously.

In general terms, if no household survey data has already been conducted, one would like to collect at least some 1,000 home interview surveys and preferably 3,000 in order to obtain a broader picture of household demand. The trip data from these interviews will then be combined with that from intercept surveys to obtain a more accurate trip pattern in the study area.

4.5.3 Detailed modelling for BRT

"The analysis of the thing is not the thing itself."

—Aaron Allston, novelist

Market segmentation can be a key issue in deriving good modelling results. Different people react in different ways to changes in the transport system. Even the same person may behave in different ways when travelling to work, on business or during leisure time. These differences affect design when considering the service during peak (mostly journey to work and education) and off-peak periods (mostly shopping, social and recreational trips). The proper segmentation of data can be costly since it requires more carefully collected data and greater detail in the modelling process. However, the benefits of segmentation can be a system well-tailored to the needs of the customer.

4.5.3.1 Trip generation

The data collected in the previous section will serve as the key inputs into the modelling process. The first stage of the process consists of utilising demand models to define trip generation characteristics. Specifically, the model attempts to match the total number of origins for a given area to specific destinations. Quite often trips are categorised by classifications such as trip purpose, time of day, and person type. Trip purpose may include the following:

- Work;
- Education;
- Shopping;
- Social and recreational;
- Personal business;
- Accompanying others;
- Other.

Of these, the first two are never omitted but sometimes all the others are grouped under the catch-all category of "other purposes".

Classification by time of day may differentiate between morning peak, evening peak, and off-peak periods. Classification by person type typically focuses upon personal characteristics such as income level, car ownership levels, household size, and household structure. These personal characteristics along with other factors such as residential density play a role in determining the number of trips produced per household. The selected transport model will utilise these factors to calculate an estimated number of trips.

4.5.3.2 Trip distribution

The next stage of the modelling process involves obtaining the base year demand matrix for all the categories (or segments) of users. As with the public transport OD survey data presented previously, the OD data from the household survey should be coded to each zone, collated, and formed into a full OD matrix for each separate mode. By using the household survey data to obtain the OD matrix, some of the risks of double counting or undercounting that arise with an on–board transit OD survey can be avoided, so the OD matrix should generally be more reliable, so long as the survey size is large enough and sufficiently free of errors.

Because of sampling limitations it is very likely that the resulting matrix will be very sparse; in other words, most cells will have no trips in them. Some of these zeros will be there because the intercept surveys could never interview trip makers making that journey (there was no survey point that intercepted that particular O-D pair). Others may simply be zero because that journey was not observed in the sample.

In these cases, it may be desirable to in-fill some of these empty cell values with a synthetic estimate of the number of trips. The most often used synthetic method for matrix estimation is the Gravity Model (see Ortúzar and Willumsen, 2001). This can be calibrated from the observed data, ideally home interviews as they capture trips of all possible lengths.

Since models are used to project the impacts of future scenarios, one also must consider how to represent expected changes in the number of trips. The gravity model is also useful in this context as it takes into account the changes in travel costs. Ultimately, the trip distribution model should be calibrated and validated for accuracy. For example, the model should be able to reasonably replicate the base year distributions in order to show that it is relevant to the area being studied.

4.5.3.3 Modal split

From a policy point of view, perhaps the most important stage in the transport modelling process is the selection of mode choice for the different trips. Determining the number of trips to be made by public transport, non-motorised options, and private motorised options will have a profound impact on future municipal investments. The factors that affect mode choice can be summarised into three groupings (Ortúzar and Willumsen, 2001):

1. Characteristics of the trip maker

- Car availability and car ownership
- Possession of driving license
- Household structure (young couple, couple with children, retired, singles, etc.)
- Income
- Residential density

2. Characteristics of the journey
   - Trip purpose (work, school, shopping, etc.)
   - Time of day when the journey is taken
3. Characteristics of the transport facility

   Quantitative:
   - Relative travel time (in-vehicle, waiting and walking times by each mode)
   - Relative monetary costs (fares, fuel and direct costs)
   - Availability and cost of parking

   Qualitative:
   - Comfort and convenience
   - Reliability and regularity
   - Protection, security

The mode choice model will typically include these factors in estimating levels of usage between different modes. Segmentation will be, of course, very important. One should only include choices that are really available to each type of user. For instance, driving a car is only optional to those in households that have a car available. In some cases, travellers with a car provided by their company are in effect captive to that mode, as they have no choice.

If it has been decided that the BRT design must consider customers attracted from other modes, mode choice modelling will be essential. However, this is a specialised undertaking usually requiring good modelling techniques and trained specialists. If it is not possible to conduct a full modelling process, then it may be appropriate to make a simplified assumption about potential demand increases due to mode shift. This shift is unlikely to represent more than 5 to 20 percent of the demand in the new system.

4.5.3.4 Assignment

The previous stages in the modelling process focussed primarily on the demand side of public transport services. The "assignment" stage is where the supply of public transport services are matched with these demand conditions. Within a BRT system, the assignment stage also helps to identify usage levels amongst different routing and service options. For instance, it is quite useful in planning terms to know the number of passengers who will be utilising express routes versus local routes.

In order to accurately model public transport route choice, it is necessary to represent the network with a good degree of realism. Centroids and centroid connectors should be used to represent access times to stations. Moreover, there is always an additional time to reach the right platform in a BRT or metro system. Transfer times and waiting times for the next available service should also be represented in the generalised cost of travelling along a particular route. People dislike transferring services because of the uncertainty involved, so there is usually a transfer penalty to consider in addition to the time spent changing services.

Fares should also be accurately represented and this may prove very tricky in some cases. If there is no fare integration, each change of service will involve paying a new fare. This additional cost may be represented as a "boarding charge". If the fare has an element proportional to distance, this amount must be added to the journey. For integrated and zonal fares the issues may be more complex to handle but most modern software can cope if skilfully used.

It is important to adopt a realistic assignment model for public transport. This is particularly important when dealing with corridors where many bus routes converge. If all bus services have similar operating speeds (a common occurrence on a corridor) earlier models will tend to allocate all trips to the service with the highest frequency. In reality, people will probably choose the first bus that comes along, and thus allocating trips to services perhaps in proportion to frequency rather than "all-or-nothing" to the highest frequency service. Contemporary software packages, especially those developed and tested for high public transport usage like Emme/2, Cube/Trips and VISUM, perform better in this respect.

Equilibrium conditions within assignment are achieved when each passenger has been assigned the most efficient routing based upon inputs factors such as monetary costs and time of travel. Equilibrium is very important in dealing with private vehicle assignment but has an equivalent representation in public transport route choice.

Congestion effects may take place because buses are very crowded and users will experience loses in comfort (increases in generalised costs) similar to driving under congested conditions. An additional problem arises when passengers cannot board a bus (or metro, LRT vehicle) because it is full and must then wait for the next service. The first of these problems (crowding) is easier to model accurately than the second one but both may be important in replicating current conditions.

For the purpose of designing a new BRT system, one should try to avoid excessive crowding and delays to passengers because they cannot board a bus. Therefore, congested public transport assignment should be less of an issue for design purposes. In any case, congested public transport assignment is tricky and requires good use of a suitable software platform; it should not be attempted without at least a minimum of experience.

4.5.3.5 Evaluation

The previous modelling stages have combined supply and demand factors to develop an overall simulation of a city's transit services. The final stage of the process is to evaluate the robustness of the particular solution being proposed by the model. Hopefully, the model will produce equilibrium conditions that lead to a single identifiable solution for the given input factors. In evaluating the model, several iterations are run in order to determine if the model results converge to an equilibrium point. If several iterations produce such a convergence, then the proposed solution is considered to be sufficiently robust. The lack of a convergence implies that changes in the model structure may be necessary before proceeding.

4.5.4 Assessment of the feasibility of the system

Once some sort of transit or traffic model has been developed, and a clear scenario for the BRT system has been defined, it should be possible to make a preliminary assessment of the general feasibility of the system.

A good litmus test of whether a new BRT system makes sense is to compare the existing generalized cost of some popular trips (origin-destination pairs) as it exists before the BRT system, and what they might be with the new BRT system serving those trips. As a proxy for cost savings, the value of time savings can be utilised. However, it should be recognised that time savings is just one of the many reasons for encouraging public transport usage. Other factors include environmental benefits, fuel cost savings, urban design benefits, and social benefits. Further, time savings may be realised not just by public transport passengers but by private vehicle users as well.

Equation 4.1 Generalised time cost

The generalised time cost GC of travelling between two points using one or more bus services can be described as follows:

$$GC = a * IVT + b * WTM + c * WAT + d * TTM + e * NTR + f * FAR$$

Where

- **IVT** is the time in minutes spent in the bus(es)
- **WTM** is the total waiting time to board the bus
- **WAT** is the total walking time to and from bus stops
- **TTM** is the time spent transferring from one service to another, if any
- **NTR** is the total number of transfers required for the journey, if any
- **FAR** is the total fare paid for the whole journey

The factors *a, b, c, d, e* and *f* are parameters representing the weight attached to each of these elements in the journey. This generalised cost can be represented in time or money units. For example, by dividing the whole formulation by f the generalised cost would be measured in money units. It is more advantageous to divide the formulation by a and then measure generalised costs in (in-vehicle) time units.

A good staring point to investigate how much better the new system will be is to assume that *b, c* and *d* to be twice as big as *a* and that *e/a* is about 3 minutes [1)].

This provisional formulation could then be written as:

$$GC = IVT + 2\ WTM + 2\ WAT + 2\ TTM + 3\ NTR + \alpha * FAR$$

In this case, α is equal to *f/a* and is often interpreted as the inverse of the Value of Time (savings)[2] . The generalised costs in this case would be measures in generalised in-bus minutes.

It would be desirable to consider this relationship and sketch how a new BRT system would reduce the generalised cost of travel for a set of relevant origin-destination pairs. This calculation could be accomplished using information already available on existing services, fares, frequencies and travel times compared with a new system that may have faster travel times on a trunk corridor but require transfers and perhaps longer walking times. This would give an idea of how much faster the buses should operate on the trunk corridor to compensate most travellers for the need to add one or more transfers.

For example, if one is considering the introduction of a trunk and feeder system that will replace a number of direct services, one can make the following estimation to check whether this scenario is going to improve travel to users. One can assume that the feeder services will have similar performance to the current services but perhaps a higher frequency for the relevant OD pair. For example, one can assume that waiting time will be reduced by 2 minutes each way and that walking time will remain the same. The trunk and feeder service may require an average of, say, 1.5 transfers per trip where beforehand there was none. Each transfer will require additional waiting time for the new service (say 2 minutes each), so the original savings in waiting time will be lost. The trunk road will have to provide an overall time saving of 3 times 1.5 minutes (4.5 minutes) to be better than the old system, provided the fares remain the same. Therefore, unless one can provide an average time savings on the trunk route of 5 minutes it will not be worthwhile to introduce a trunk and feeder service. These calculations would have to be repeated for a number of representative journeys to support a decision one way or another.

The existing public transport system may be used to identify some key corridors where significant elements of demand will concentrate. Direct observations of the number of buses with a reasonable estimation of their passengers at peak periods would enable an initial sizing of the new system. This determination can be achieved in a short period of time and without detailed information on Origin-Destination patterns.

[1] Research results agree that walking, waiting and transfer times are between 1.5 and 3 times as onerous as in-bus times, the precise values depending on cultural and local conditions like the weather. Similarly, the need to transfer is perceived by users as adding a notional 3 to 6 minutes to their journey.

[2] An initial estimate for α could well be the length of working time required to earn one unit of currency, for example how many minutes it takes to the average earner to earn US$1. The average earner in question is the type of user the new BRT is trying to benefit most. For example, if the average wage rate per hour for the population of interest is US$2, then α is 30 minutes per dollar.

5. Corridor selection

"Look at every path closely and deliberately, then ask ourselves this crucial question: Does this path have a heart? If it does, then the path is good. If it doesn't, it is of no use."

—Carlos Castaneda, author, 1925–1998

The choice of BRT corridors, and the specific roads on which to build the BRT system, 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 principal determining factor in corridor selection is the level of public transport demand, which was considered in Chapter 4 (*Demand analysis*). This chapter first discusses the different roadway and design options that indicate the suitability of BRT for a particular corridor. Second, this section will discuss options for BRT through narrow right-of-way corridors. Third, a cost-benefit model will be presented to quantitatively evaluate the merits of a particular corridor.

Though a corridor's importance will vary with circumstances, the choice of a particular roadway as part of a BRT network should be prioritised through the following considerations:

1. Maximise the number of beneficiaries of the new BRT system
2. Minimise the negative impacts on general traffic
3. Minimise operational costs
4. Minimise implementation costs
5. Minimise environmental impacts
6. Minimise political obstacles to implementation
7. Maximise social benefits, especially to lower-income groups.

Even though a new mass transit system will have profound impacts on the commuting patterns and quality of life of a city's inhabitants, officials sometimes make key decisions based on purely political criteria with relatively little forethought to the consequences. Thus, this section seeks to provide a rationale framework for corridor and routing decision making. While political concerns are legitimate, they can often lead to poor results if technical issues are not also considered. A detailed comparative analysis of each of the factors discussed in this chapter gives project developers the best chance at producing a cost-effective and useful public transport service.

The contents of this chapter are:

5.1 Corridor identification

"Many roads lead to the path, but basically there are only two: reason and practice."

—Bodhidharma, Buddhist monk, 6th century

The starting point for corridor decisions is the demand profiles generated during the analytical process outlined in Chapter 4 (*Demand analysis*). This process helped to identify the daily commuting patterns in both spatial and temporal terms.

5.1.1 High-demand areas

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. The demand profiles and origin-destination (O-D) results from the earlier traffic counting and modelling will ideally guide corridor decision making.

In addition to reviewing the results of the demand analytic work, other key indicators assisting corridor decisions include the location of:

- Existing services;
- Central business district (CBD) (Figure 5.1);
- Educational centres;
- Large commercial centres;
- Business parks and industrial areas;
- Areas of rapid urbanisation.

In this early phase of corridor selection, all options should be fully explored. Rather than immediately discarding certain corridors for political reasons or for lack of sufficient road width, system developers should try to think outside the existing conventional wisdom. Closing down possibilities too early can result in unforeseen network connections being lost. The proposed BRT system should both complement existing land use patterns as well as reflect the future aspirations of city leaders, planners, and citizens.

Further, system developers should not just focus only on likely Phase I corridors. Certainly a city-wide BRT system will likely be implemented over a series of phases, encompassing several years of distinct efforts. However, developing a full city map of all potential future corridors can be useful for several reasons. First, it is difficult to evaluate the usefulness of a particular corridor without visualising its future connectivity with other parts of the city. Secondly, decision makers and donor agencies are often willing to tolerate a Phase I system that is not entirely viable financially if a Phase II has already clearly been articulated that will bring the project into full financial feasibility. Third, developing a full BRT map can be quite useful from political and marketing standpoints to ensure public support over the long term.

5.1.2 Major arterials

While BRT systems sometimes utilise all types of roads, BRT trunk corridors are usually located on primary arterial roads serving central business districts and other popular locations, while feeder bus routes (if any) will tend to serve secondary arterials and some local streets. Primary arterials are usually those roads which serve long distance trips within the city, and secondary arterials usually serve a mix of longer distance and shorter trips. BRT is rarely put on limited access highways which are primarily designed for intercity travel and usually difficult to access. BRT trunk routes are frequently located usually on primary arterials because:

- Population densities are generally highest near major arterials;
- Major arterials tend to serve medium and longer distance intra-municipal trips, which are ideal for BRT;
- In developing countries, only major arterials form clear and logical connections with other major arterials to form an integrated network;
- Major arterials tend to have a concentration of existing bus or paratransit routes; and,
- Arterials also tend to host a concentration of major destinations such as businesses and shopping areas.

The choice of primary arterial roads may also provoke less concern about noise and traffic impacts since these roadways already have a significant presence of motorised vehicles. It is generally the aim of BRT systems to achieve high-speed services, and high speeds on residential streets or dense commercial streets are generally incompatible with pedestrian safety. Choosing roads with existing concentrations of public transport vehicles also means that locating these vehicles in an exclusive lane will help to decongest the remaining mixed traffic lanes.

Fig. 5.1
As this image of central Bogotá indicates, central business districts are a logical part of any complete BRT network.
Photo courtesy of Oscar Diaz and Por el País que Queremos (PPQ)

5.1.3 Secondary roads

"Do not go where the path may lead, go instead where there is no path and leave a trail."

—Ralph Waldo Emerson, author and poet, 1803–1882

Secondary roads often hold the advantage that they are more "traffic calmed" for effective busway conversion. In some cases, a secondary road may be entirely converted to BRT use, with access being prohibited to private vehicles. The feasibility of such an approach depends upon existing use patterns in the area. If the area is largely commercial, then the busway may co-exist quite well, especially since it will provide a concentration of customers for the businesses. Historical centres may also require this approach since the narrow roadways may not permit both exclusive transit lanes and mixed traffic use. Cities such as Bogotá, Curitiba, and Quito have decided that certain portions of their BRT corridors will only cater to public transport customers and non-motorised traffic (Figures 5.2 and 5.3). Many key destinations, such as historical centres, do not possess an arterial infrastructure, but such areas nevertheless should be a priority of public transport service.

However, if there are no parallel roads, individuals and businesses may require private vehicle access to their properties along a public transport corridor. Truck deliveries are critical to the survival of small shops, for example. Such conflicts can generally be resolved with the establishment of access hours during non-peak periods, but this approach is not always possible. A remaining solution is to legally expropriate such properties for public purchase, but such purchases can be quite costly as well as sometimes politically disruptive.

In general, though, secondary roads are considered more commonly as feeder routes. Feeder routes generally operate in mixed traffic like normal bus services. Since extensive residential sites are located along secondary roads, providing services to these areas becomes essential to operating a viable system.

5.2 Analysing corridor options

"Success is a journey, not a destination.

—Ben Sweetland, author

5.2.1 Measuring road width and available right of way

A logical starting point for analysing corridor options is to record the road and right-of-way width throughout each potential corridor. While road and right-of-way widths may be constant for long stretches of a corridor, fluctuations can occur. For example, as corridors enter denser central districts and historical centres, less road width may be available. Likewise, at certain intersections and interchanges, there may more or less road space available.

The roadway width and the right-of-way width can be graphically noted in a plot of width against corridor location. Figure 5.4 shows such

Fig. 5.2 and 5.3
Major arterials are not the only options for BRT corridors. Cities such as Bogotá and Quito have made use of narrow roadways in the city centre to give exclusive access for public transport and pedestrians.
Left photo by Shreya Gadepalli
Right photo by Lloyd Wright

a plot for a proposed BRT corridor in Hyderabad (India). The band in yellow shows the central district of the city, where roadway and right-of-way widths are quite narrow.

In addition to noting physical dimensions along a roadway, an initial survey should also note other features, such as the present condition of the median area and pedestrian areas. Is the median a relatively open area or does it possess significant infrastructure (such as sculptures or utility poles) or greenery (such as large trees)? Are the pedestrian paths adequate for providing access to a public transport system or do they likely require widening? Are there difficult intersections along the corridor, such as roundabouts with fountains or artwork? In many cases, there are practical solutions to these challenges, but an initial survey can do much to categorise the major issues that will require further consideration.

5.2.2 BRT runway widths

There are no hard rules regarding the necessary road width. Successful BRT systems have been built in areas where the entire road width is only 3 metres (*e.g.,* portions of the Quito historical centre). In an ideal situation, the roadway width will support a median station, one or two BRT runways, two mixed traffic lanes, and adequate space for pedestrians and cyclists (Figure 5.5). As noted earlier, many major arterials will fit this description. Much of Quito's Ecovía (Figure 5.6), Trolé, and Central Norte corridors are based on this configuration.

A standard vehicle lane is typically 3.5 metres in width. However, lanes can be as narrow as 3.0 metres; and a narrower lane will tend to reduce speeds and the risks of serious accidents. A BRT vehicle and many trucks are typically 2.6 metres in width while a standard car is approximately 2.2 metres in width.

The two mixed traffic lanes provide several advantages. If a car breaks down or if a taxi stops for a passenger or if there is a very slow moving vehicle, other vehicles can go around such obstacles by using the second lane. In this sense, a second lane more than doubles the amount of road capacity provided by a single lane.

However, in the right circumstances, traffic systems can also function quite well with only a single BRT lane and a single mixed traffic lane. Rouen (France) operates its BRT system on a 14 metre-wide street in this fashion (Figure 5.7). The problem with vehicle breakdowns is solved by a semi-permeable barrier between the BRT lane and the mixed traffic lane. Typically the divider is such that vehicles can not infringe upon the BRT lane. In Rouen, road bumps

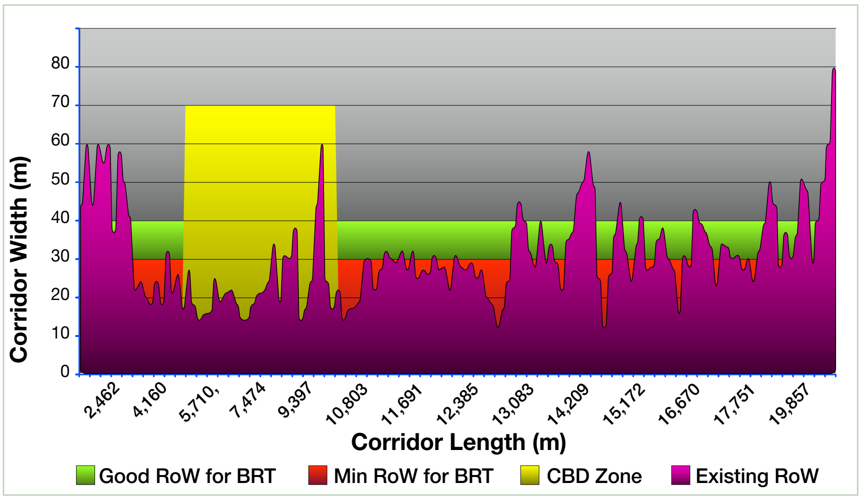


Fig. 5.4

Mapping roadway and right-of-way widths is a basic first step in analysing a corridor for BRT potential. This example shows issues with narrow widths in the central district of Hyderabad (India).

Image courtesy of ITDP

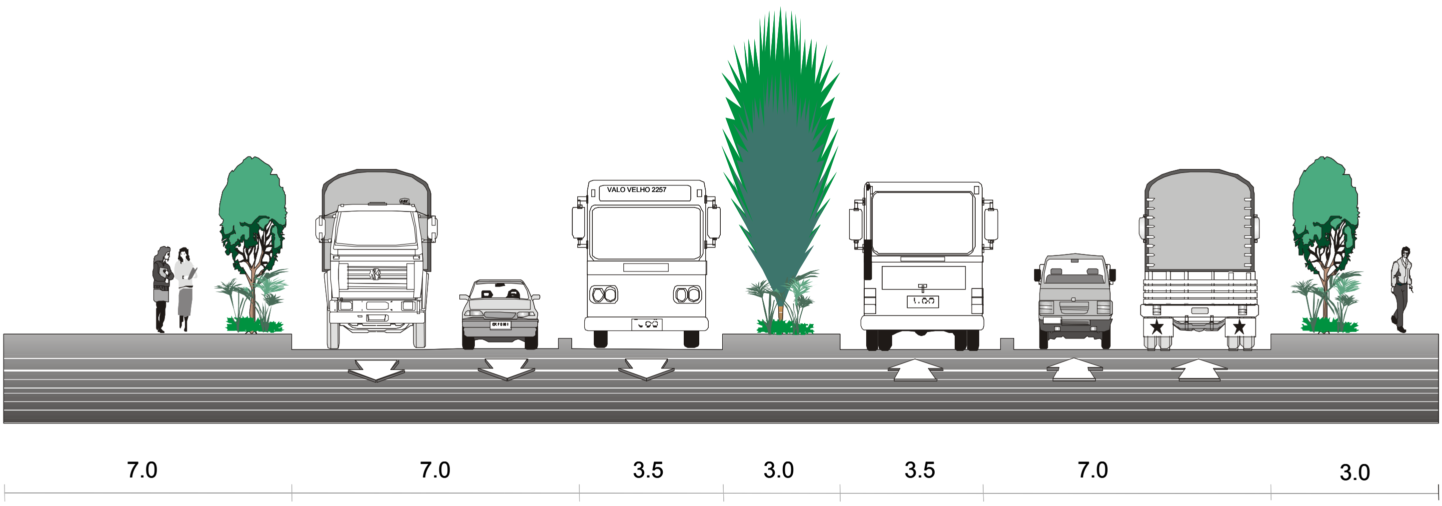


Fig. 5.5

A typical roadway configuration for a BRT corridor.

Fig. 5.6
The Ecovía corridor in Quito provides an example of a standard BRT road configuration.
Photo by Lloyd Wright

along with the brightly painted BRT lane still deter unauthorised use of the BRT space, but the semi-permeable nature of the bump allows vehicles to enter in case of blockage in the mixed traffic lane.

The Guayaquil Metrovía system also employs a system with just a single mixed traffic lane through the central portions of the city. However, in this case, a non-permeable barrier is utilised to separate the busway from the mixed traffic lane. The degree of physical separation can be culturally driven; much depends on the likely behaviour of motorists. If motorists are likely to violate a semi-permeable barrier and regularly infringe upon the busway, then a city may have no choice but to employ a non-permeable barrier. In Guayaquil, the system planners decided to prioritise public transport over private vehicles, given the limited spatial arrangements.

Fig. 5.7
BRT corridors can also function adequately with the provision of only a single lane of mixed traffic, as shown in this example from Rouen (France).
Photo courtesy of TCRP photo library

As the experiences of Guayaquil, Quito, and Rouen clearly demonstrate, narrow road space is not an insurmountable obstacle to developing a BRT system. In some instances, a limited road space can actually be seen as a positive attribute from the standpoint of reversing "induced traffic". If the BRT system is built in entirely unused right-of-way, there is no spatial incentive for mode switching from private vehicles. Research from road closings indicates that a certain percentage of vehicle traffic simply disappears when road space is no longer available (Goodwin *et al.,* 1998). This phenomenon, known as "traffic evaporation" or "traffic degeneration", occurs due to motorists balancing travel time against the available options. Thus, many motorists may switch to public transport or other alternatives as a reaction to the more limited road space. An outgrowth of these findings has been a realisation that overall traffic levels can remain roughly the same before and after changes in road widths.

5.3 Options for narrow roads

"We will either find a way, or make one."

—Hannibal, military commander and politician, 247 BC–183 BC

Areas with narrow road widths, such as central business districts (CBDs) and historical centres, present many challenges to BRT developers. The density of activity and architectural nature of these areas may imply less road space is available for a surface-based public transport system. At the same time, CBDs and historical centres are prime destinations for customers and thus such areas should be included in the system's network. Without access to central destinations, the entire system becomes considerably less useful to the potential customer base.

In general, there are at least ten different solutions to designing BRT system through an area with extremely narrow road widths:

1. Median busway and single mixed-traffic lane (*e.g.,* Rouen, France)
2. Transit malls and transit-only corridors
3. Split routes (two one-way services on parallel roads)

Fig. 5.8, 5.9, and 5.10
Transit malls, as applied in Zurich (top left photo), Bogotá (top right photo), and Pereira (bottom right photo), are both a viable corridor option as well as an attractive addition to the urban environment.
Zurich and Bogotá photos by Lloyd Wright
Pereira photo courtesy of the Municipality of Pereira

4. Use of median space
5. Road widening
6. Grade separation
7. Fixed guideway
8. Single-lane operation
9. Staggered stations / elongated stations
10. Mixed-traffic operation

5.3.1 Median busway and single mixed-traffic lane

As noted earlier, Rouen has had success with operating a median busway on a roadway with just one lane reserved for mixed traffic in each direction. A semi-permeable barrier between the busway and the mixed traffic lane allows private vehicles to encroach temporally onto the busway in case of lane obstruction. Guayaquil has successfully implemented a single lane option, even with an impermeable barrier between the busway and the mixed traffic lane.

This solution assumes a corridor has available right of way of at least 14 metres for vehicles plus an appropriate amount of space for pedestrians. Additional space is also required in areas with stations, which likely require at least another 2.2 metres of width.

This solution permits BRT operations to largely operate without a significant change to service levels. The system functions in a similar fashion to BRT operations on corridor sectors with wider right of way. However, this option is only viable where available road space is at least 14 metres. Further, this option requires either a cultural climate or an enforcement mechanism that prevents private vehicles from abusing access to the busway space. It will be easier to implement if the BRT vehicle frequencies are high, so that the lane does not appear empty. An empty BRT lane will be very tempting to cyclists, motorcyclists, taxis, and other vehicles.

5.3.2 Transit malls and transit-only corridors

There may be an opportunity in some instances to restrict a segment's access to only public transport vehicles. Private cars, motorcycles, and trucks are banned either entirely from the corridor segment or during public transport operating hours. A transit mall is a commercial corridor segment in which only public transit and non-motorized traffic are permitted. More broadly, a transit-only corridor is any such segment, whether in a commercial area or a residential area.

Transit malls are frequently an effective solution when a key corridor only has two lanes of road

Fig. 5.11 and 5.12
In Pittsburgh (left photo) and Ottawa (right photo), entire roadways are devoted exclusively to BRT operation.
Photos by Lloyd Wright

space available. Thus, segments with only seven metres of road space could be appropriate for a transit mall. However, a one-way transit mall can operate on as little three metres of space, as is the case with the "Plaza del Teatro" segment of the Quito Trolé.

Transit malls are particularly appropriate when the public transport service enhances commercial activity and integrates well into the existing land-use patterns. In such cases, the transit mall creates a calmed street environment void of traffic congestion. Transit malls permit a maximum number of customers to access shops and street amenities. Thus, transit malls typically reside in locations where shop sales are quite robust. The lack of mixed traffic encourages an environment friendly to pedestrians and street activity.

Examples of successful transit malls include central Zurich where the tram system provides easy access to shops, offices, and restaurants (Figure 5.8). Likewise, the Avenida Jimenez corridor of Bogotá's TransMilenio system represents a high-quality example of merging urban regeneration with a BRT system (Figure 5.9). In a similar manner, the 16th Street Mall in Denver (US) combines a bus-only corridor with an attractive pedestrian space.

Transit-only corridors, though, are not just restricted to central business and shopping districts. For example, some busways are essentially limited access roadways restricted to bus use. The West Busway in Pittsburgh moves through a bus-only corridor in largely residential areas (Figure 5.11). Likewise, portions of the Transitway service in Ottawa operate through residential destinations on an exclusive busway (Figure 5.12). In both the cases of Pittsburgh and Ottawa, the busways run along corridors with significant green space. Thus, there are no residential driveways entering

Fig. 5.13
The narrow right-of-way space and high passenger volumes at the Quito "Plaza del Teatro" station have necessitated the physical separation of the busway and the pedestrian space.
Photo by Lloyd Wright

Fig. 5.14
The volume of pedestrians along London's Oxford Street is such that the street may be better utilised as a pedestrian-only area.
Photo by Lloyd Wright

directly onto the corridor. Otherwise, these schemes would likely not be viable.

The open interaction between pedestrians and the transit service on a typical commercial transit mall will impact the travelling velocity of the system. Otherwise, accidents can occur or the system will dampen the usefulness of the public space. Thus, use of a transit mall design will likely reduce the average vehicle speed and thus increase transit times for passengers crossing the district. However, the "Plaza del Teatro" segment of the Quito Trolé avoids this problem by physically separating the pedestrian area from the busway (Figure 5.13). While this separation reduces the risk of accidents, it also makes the streetscape less socially pleasant to pedestrians.

In instances where pedestrian movement along a transit mall is quite high, then the presence of transit vehicles can become detrimental to the overall quality of the street. Conditions on the Oxford Street corridor in London have become difficult due to the pedestrian volume exceeding the provided footpath space (Figure 5.14). In this case, the space given to public transport vehicles (and taxis) may be better allocated entirely to pedestrians. Thus, at certain pedestrian volumes a street may be better utilised as a "pedestrian mall" rather than a "transit mall".

Perhaps the greatest challenge in making transit malls and other transit-only corridors work is access for delivery vehicles and local residents. The desire by some merchants to have round-the-clock delivery access is both a political and technical obstacle to implementing a transit mall. The loss of on-street parking and direct customer access by private vehicles may also be a worry for some merchants. In general, the experience to date has indicated that transit malls and pedestrian malls both tend to improve shop sales and property values. Thus, while merchants do tend to object to vehicle restrictions at the outset:

> "…they virtually never campaign for the abandonment of a scheme once it has come into operation. It is notable that, once a scheme has been put in place, traders are often the main people to voice a desire to extend its boundaries or period of operation" (Hass-Klau, 1993, p. 30).

Fig. 5.15
Non-motorised delivery systems, as shown here in Santiago, can help make a transit malls viable for local shop owners.
Photo by Lloyd Wright

A common solution is to establish delivery access for shops during non-transit hours. Thus, merchants are able to move large goods during the late evening and early morning hours. Smaller goods can typically be delivered at any time by carts and delivery services operating from the pedestrian area (Figure 5.15).

If the area is largely residential, then conflicts are usually with individuals seeking private vehicle access to their properties and parking. Such conflicts can sometimes be resolved with the establishment of nearby parking garages and access during non-operating hours of the public transport system. In both the cases of residential access and shop deliveries, the successful achievement of a transit mall is likely to require careful political negotiation.

5.3.3 Split routes

As an alternative to the transit mall, cities frequently consider splitting each direction of public transport service between two different (typically parallel) roads. The public transport system thus operates as two one-way links with each busway operating along the curb-side of the street. In this case, one lane of mixed traffic can typically be retained.

The chief advantage of splitting the route is the impact on mixed traffic, parking and truck deliveries. Private vehicles retain some form of direct access to corridor properties. Also, this

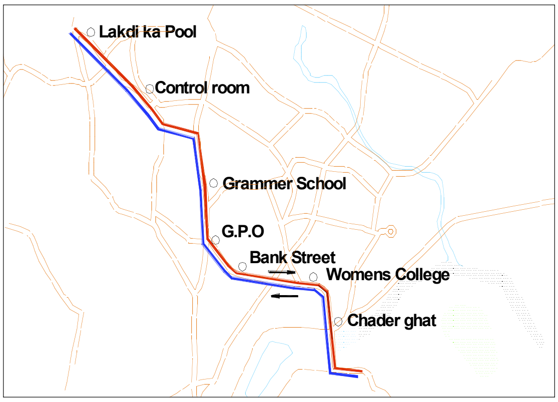
Fig. 5.16
Through the denser city centre area, the Guayaquil Metrovía system utilises a split route configuration with each direction of travel being provided on parallel streets.
Photo by Carlos González

type of configuration often mirrors the existing bus routes, and thus is potentially more acceptable to existing operators. Guayaquil has successfully utilised a split route configuration in the central areas of the city (Figure 5.16). Outside the denser city centre, both directions of the BRT system are recombined in a more conventional two-directional configuration.

In general, though, a split route configuration is less widely used than the transit mall design. While a transit mall does prohibit private vehicle access during operational hours, it does hold several other key advantages over split routes:

1. Transit malls provide a system more of a "metro" look by have both directions aligned in a single corridor
2. Encourage improved street environment and sociability by prohibiting cars and motorcycles
3. Create less confusion for system users by having both directional options in the same place
4. Reduce infrastructure costs by allowing a single station to serve both directions

Fig. 5.17 and 5.18
Dar es Salaam considered two options for its city centre BRT routing: 1.) A transit mall configuration with both BRT directions on the same street; 2.) A split route with each direction utilising a different street. In the end, Dar es Salaam chose the transit mall configuration since it more closely resembles a metro-like surface.
Images courtesy of the Dar es Salaam City Council



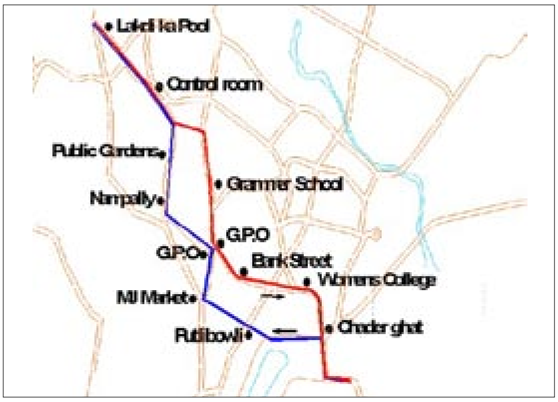


Fig. 5.19 and 5.20
Hyderabad also considered both single corridor and split route options, but in the end Hyderabad suspended its BRT efforts due to concerns over roadway space in the city centre.
Images courtesy of ITDP

5. Permit customers to easily change directions if necessary
6. Allow easier direct transfers when two corridors cross one another.

In the development of its new "DART" BRT system, the city of Dar es Salaam is designing a busway through its relatively narrow city centre. The city has considered both the transit mall and split route options. Figures 5.17 and 5.18 illustrate the two options.

In the end, the Mayor preferred the transit mall configuration because it looks more like a metro system. Also, the technical team felt the transit mall would work as there were fairly low volumes of mixed traffic on the road that would be reconfigured for public transport and pedestrian only access.

The developers of the proposed Hyderabad BRT system also considered both the transit mall and split route options for services through the city's central district. Figures 5.19 and 5.20 illustrate the two options.

In this case, the city decided neither option satisfactorily resolved their spatial limitations. The political pressures to retain road space for private vehicles ultimately undermined the project. At this point in time, Hyderabad's BRT plans have been shelved due to the space issue as well as due to an alternative proposal from a metro consortium. Hyderabad's experience clearly demonstrates the sensitivity of road space allocation decisions. For more information on road space allocation issues, Litman (2005) is a useful overview document.

5.3.4 Use of median space

Adverse traffic impacts will obviously be minimised if the new BRT system adds additional capacity to an existing road, and does not have to convert an existing lane of traffic to an exclusive bus lane. In the case of Bogotá, for example, most but not all of the TransMilenio BRT system was built in the medians of an extremely wide existing right of way that had been cleared of encroachments in the 1960s. The new BRT system in most corridors therefore did not reduce the number of lanes for mixed traffic.

In many cities of the developing world, roads exist where the right of way is much wider than the existing road. The median of the VDN corridor in Dakar (Senegal) holds the potential for BRT lanes (Figure 5.21). Certainly in such cases, BRT can be built with no adverse impact on the mixed traffic. Normally, such roads are scheduled for widening by national or regional authorities, and it is critical for BRT planners to

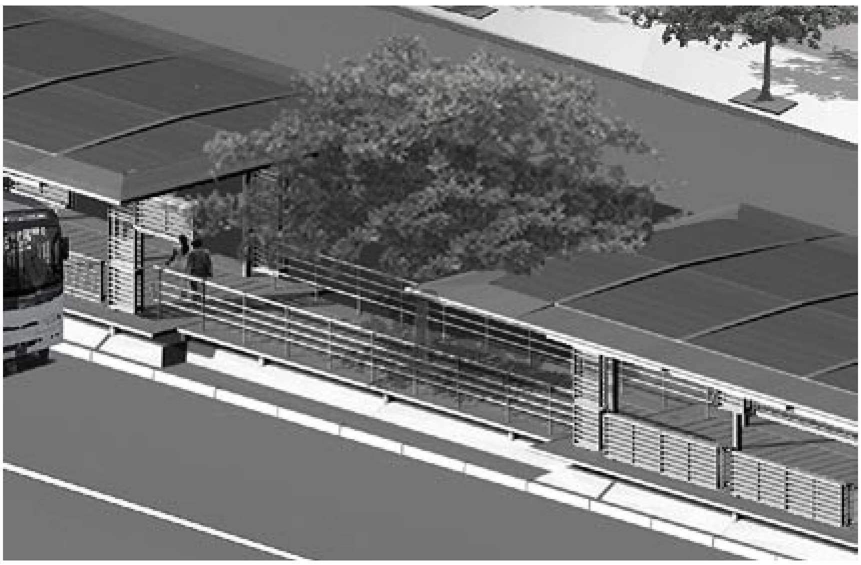
Fig. 5.21
The VDN corridor in Dakar will likely make use of available right-of-way space in the median to construct the BRT lanes.
Photo courtesy of ITDP

Fig. 5.22 and 5.23
Jakarta managed to minimise the system's impact on median trees through careful design.
Left photo by Karl Otta, courtesy of the GTZ SUTP CD–ROM;
Right photo by Karl Fjellstrom

coordinate BRT development efforts with any national road development initiatives.

However, use of existing medians can create other types of problems. A median may represent one of the few urban areas with greenery. In some instances, the trees planted in the median will be assets highly appreciated by civic and environmental organisations, public officials, and the general public. Accommodating the beautiful trees along the Sudirman Corridor in Jakarta meant that the BRT system had to minimise its impact on the median area (Figure 5.22). Some stations can even built around the trees and thus providing an attractive environment to customers (Figure 5.23). In many cases, the BRT system can actually enhance green space by providing a protective buffer against mixed traffic pollution. However, access to median space for roadway purposes can be limited due to the need for green space preservation.

Fig. 5.24
Station design can even be predicated upon the preservation of existing greenery.
Image courtesy of the Municipality of Barranquilla (Colombia)



5.3.5 Road widening

If a usable median space is not available and the existing roadway proves to be insufficient, then widening the road could be an option to consider. In cases where unused land or development of low intrinsic value borders a proposed corridor, then road widening could be a viable solution.

However, in central districts widening roads can be quite difficult for political, financial, and architectural reasons. Purchasing properties along dense corridors with office towers is likely to be prohibitively expensive. Further, any expropriation process can be wrought with social and legal difficulties. For more discussion on land acquisition, see Chapter 17 (*Financing*).

Additionally, any road widening in a historical centre will likely face opposition from groups wishing to preserve the architectural nature of the area. Ensuring that the new public transport system is physically congruent and complementary to the surrounding area should be a priority for system designers. Intruding upon the cultural fabric of an area by replacing architecture with roadway is not likely to be consistent with this objective.

Phase II of the Bogotá TransMilenio system has seen extensive road widening and property acquisition along its new "Norte-Quito-Sur" corridor (Figure 5.25). While the existing roadway was actually sufficiently wide for both BRT and mixed traffic lanes, the municipality wished to retain the same number of mixed traffic lanes after the BRT system goes into operation. However, the amount of expenditures on land acquisition has pushed up the corridor's cost consider-

Fig. 5.25
Road-widening along the "Norte-Quito-Sur" corridor in Bogotá did much to increase the total infrastructure cost.
Photo by Carlos Pardo

ably. Phase II of TransMilenio represents a near tripling of costs over the system's Phase I. In this case, the cost of road widening should perhaps be compared to using the same funds to simply extend the system to other needed corridors.

By contrast, selective land purchases in bottleneck points away from the central districts can make sense. Away from central areas, land prices are more affordable and there are likely to be fewer conflicts with historical buildings and infrastructure. In particular, areas with undeveloped land, parking lots, derelict buildings and/or illegal encroachments are clearly more cost-effective acquisition targets than areas with high-rise office towers and luxury apartments.

However, land cost should not be the only criteria when making land acquisition decisions. If land value is the only decision factor, then road widening will tend to impact lower-income groups more adversely than others. While it may be economically optimal to widen roads through a poor neighbourhood when building a BRT system, mechanisms for compensating poor families with only informal claims to their land will often be weak. The forced relocation of such families will cause severe hardships that should be avoided. Thus, some social criteria should also be included in any decision making on land acquisition or property expropriation.

5.3.6 Grade separation

Underground or elevated BRT systems may make sense for short segments where there is little other option for connecting key sectors. However, over a longer distance, such infrastructure does much to erode BRT's cost advantage against other transit technologies.

Fig. 5.26 and 5.27
Construction of an underground segment to the Quito Trolé at the Villa Flor area helped to significantly reduce customer travel times.
Photos by Lloyd Wright

Grade separation can make sense for BRT in the following circumstances:

- Roundabouts;
- Congested intersections;
- Segments of dense, central areas.

One advantage of BRT over some forms of rail transit is the ability to change from surface-based travel to underground or overhead travel within relatively short distances. The ability of BRT vehicles to negotiate incline changes lends itself to this type of flexibility.

Grade separation can dramatically improve average commercial speeds and travel times. The Quito Trolé system retroactively constructed an underpass at one of the more congested roundabouts in the system (Figures 5.26 and 5.27). The "Villa Flor" underpass immediately reduced terminal to terminal travel times by approximately 10 minutes (from 55 minutes to 45 minutes). The elimination of the discontinuities from the roundabout had a ripple effect through the operation of the system and thus produced this larger-than-expected time savings.

The use of grade separation also brings with it safety improvements as public transport vehicles are no longer vulnerable to accidents at intersections. During the opening phase of the Houston LRT system in 2003 and the Los Angeles Orange Line (BRT line), both systems incurred several initial accidents between the public transport vehicles and cars. Motorists may be unaccustomed to the presence of the public transport system and thus traffic violations (such as turning on a red light) can become major accidents. While such accidents would likely occur even without the new public transport system, the events tend to become major media stories when involving a public transport vehicle. The resulting bad publicity can harm the overall image of the system and dampen enthusiasm with potential new users. The use of an underpass at an intersection essentially eliminates this risk.

Likewise, grade separation removes the dangers to pedestrians from transit vehicles. The separation allows the vehicles to travel at normal speeds through areas that would otherwise require speed reductions for safety reasons.

The use of an underpass at an intersection does carry with it restrictions on the location of the nearby station. In such instances, the station would typically be located away from the intersection at a point where the busway again rises to the surface level. However, there are exceptions to this restriction as the Quito Villa Flor station is actually below and inside the roundabout.

If the intersection involves two intersecting BRT corridors on perpendicular routes, then the underpass could complicate interchange options. Nevertheless, there are solutions even to this set of circumstances that can permit both grade separation and ease with customer transfers (Figure 5.28).

If the bypassed segment is larger than a simple intersection or roundabout, then a tunnel may be required rather than just an underpass. Systems in Seattle (US) and Boston (US) both

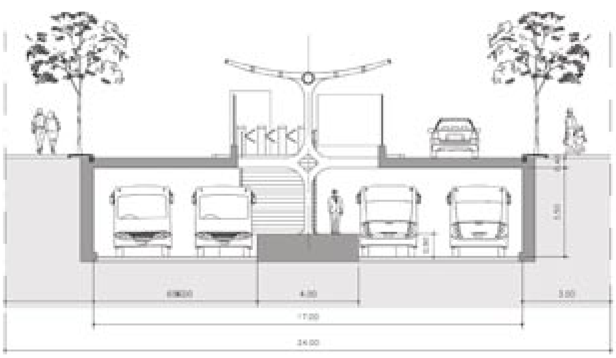


Fig. 5.28
By placing fare collection and the station entrance at the surface level, this design utilises an escalator system to allow customers to access the underground platform.
Image courtesy of Logit Engenharia

Fig. 5.29
The "Big Dig" in Boston included priority infrastructure for BRT.
Photo courtesy of the TCRP photo library

make use of tunnelling to avoid dense city centre infrastructure (Figures 5.29). The Seattle Bus Tunnel is actually in the process of being converted to an LRT tunnel. In the case of Boston, tunnelling is used along the Waterfront segment of the Silver Line BRT system as well as to permit the vehicles to traverse under the city's bay. The advent of these various experiments with underground BRT segments has made the terms "surface metro" and "BRT" no longer synonymous, and thus has continued to blur the previous distinctions between rail-based and rubber tyred-based systems.

Elevated BRT systems are also a possibility. Short-distance use of flyovers to avoid congested intersections is being considered in the current planning of the Bangkok BRT system. In case of two-lane flyovers, the BRT system would gain complete use of the flyover infrastructure, leaving mixed traffic to negotiate the intersection at the surface level. While this design would be unpopular with motorists, it does much to improve the relative travel time advantage of the transit system. In the case of four-lane flyovers, the overpass would have sufficient space for both dedicated transit lanes and a mixed traffic lane in each direction. Flyovers share the same complications with underpasses in terms of location of boarding and alighting stations. Stations are likely to be located away from the intersection at a point where the busway is level with the street surface.

In general, flyovers are likely to be a less favourable solution than an underpass, especially given the negative aesthetic impact such visual intrusions have upon an urban area. Unlike underpasses, though, flyovers do avoid complications regarding water drainage.

Fig. 5.30
The Yurikamome line in Nagoya utilises an elevated roadway structure to avoid any conflicts with street level traffic.
Photo by Lloyd Wright

Longer elevated segments in the manner of a monorail or elevated rail system are also possible. The Nagoya Yurikamome Line is a 10 kilometre elevated BRT system, serving a key residential and commercial corridor as well as linking with the city's regional rail and metro systems (Figure 5.30). The elevated stations along the corridor are accessed through escalators and elevators. At one point, a concourse takes passengers directly from the BRT station to the Nagoya Dome sporting facility. The elevated nature of the system means that there are no delays along the route due to mixed traffic or intersection signalling. However, at approximately US$22 million per kilometre, the Yurikamome line is one of the world's most expensive BRT corridors.

São Paulo also began constructing an elevated busway in the 1980s, which is likely to be completed finally in 2007. The "Furo Fila" elevated busway is being constructed over a river. Like other segments of the São Paulo busway system, the Furo Fila corridor does not penetrate the

Fig. 5.31 and 5.32
Quito makes extensive use of underpasses at major intersections, and as the experience of Quito shows, such underpasses are not always prohibitively expensive.
Photos by Lloyd Wright

city centre, so the time savings resulting from the elevation will not be that significant. Nonetheless, having already made the investment, Mayor Serra had the outer part of the corridor redesigned as a surface BRT, and decided to complete the system by 2007. Problems of passenger evacuations during vehicle breakdowns, increased construction and maintenance costs, and other issues can limit the applicability of elevated corridors.

Thus, grade separated solutions (underpasses, tunnels, overpasses/flyovers, and elevated corridors) do offer substantial speed and safety advantages. The cost of these structures, though, can do much to undermine the cost advantage of BRT relative to rail systems. Thus, cities employing such infrastructure may find a rail system to be of a similar cost. However, the new Quito "Central Norte" BRT line has achieved grade separation at a remarkably economic price. Virtually every major intersection along the central stretch of the corridor features a BRT underpass (Figure 5.31). The average cost for this infrastructure was a rather economical US$1 million per underpass (Figure 5.32). Using calculations of time savings benefits to public transport customers and reduced congestion impacts on mixed traffic, the Quito underpasses have delivered a swift return on investment. Further, the approximate US$1 million per underpass did not appreciably affect the overall infrastructure cost of the corridor. Thus, in the developing-nation context, where construction costs may be significantly lower, grade separation could be a valid option to consider in the right circumstances.

Fig. 5.33 and 5.34
Nagoya's elevated BRT line utilises a mechanical guidance system to reduce the required roadway width.
Photos by Lloyd Wright

5.3.7 Fixed guideways

Since a BRT vehicle is typically 2.6 metres in width, it is possible that a lane just slightly wider than this amount could suffice. Under normal operating conditions, a driver will require a road width of approximately 3.5 metres to safely maintain position within the lane, and 3 meters at the station, since the driver must pull adjacent to the boarding platform in any case. However, if a vehicle is physically restrained by a guidance mechanism, then a lane width of 2.7 metres is possible.

Physical guidance systems are employed on BRT systems in Adelaide, Bradford, Essen, Leeds, and Nagoya. A side-mounted guidance wheel maintains the vehicle's position within the lane (Figures 5.33 and 5.34). A slight trench in the roadbed has also been used reasonably successfully in the Netherlands for short sections. Likewise, optical or magnetic guidance systems are also possible.

Thus, in instances when reducing lane width by approximately 0.9 metres is of great value, then a fixed guideway system can be an option to consider. Guidance systems also provide other advantages, such as safer vehicle operation and higher operating speeds. The chief disadvantage is the added infrastructure cost associated with the side-wheel and the guidance track.

Some cities, such as Bangkok, are only considering the guidance system in areas with extremely narrow road widths. For example, stations constrain road space due to the floor width of the station. Bangkok is thus considering mechanical guidance only at the station area. Fixed guidance at the station also provides the advantage of accurately aligning the vehicle to the station doorways.

5.3.8 Single-lane operation

In some special cases, a short stretch of narrow busway could be operated with a single lane. Thus, a single lane would provide service to both directions on an alternating basis. To ensure that two vehicles would not try to use the one-lane segment at the same time, a special traffic control system is usually employed.

Single-lane operation is being studied for applications in Seoul and Eugene (Figure 5.35). This option works best when limited to just short road segments and bus frequencies are low. As the length of the one-lane operation is increased, the greater is the possible disruption to operation of the overall system. This option is also not likely to be viable in systems with high vehicle frequencies and high passenger demand.

However, in some circumstances, single-lane operation can be used to overcome obstacles spanning short road segments. A single-lane tunnel or bridge or a narrow historical street may appear as insurmountable obstacles and therefore cause planners to forgo an otherwise ideal corridor. Single-lane operation can be an option to consider in such situations.

5.3.9 Staggered stations / elongated stations

The physical placement of the stations and the physical dimensions of the stations can be manipulated to reduce spatial width requirements. The station area is likely to be the critical point in terms of width along the corridor. This area must not only accommodate the width of the runways but also the floor width of the station. As noted above, road widening and fixed guideways are options for addressing spatial constraints in the station areas. However, in many instances, these options may not be either possible or sufficient to overcome the spatial limitations. Altering the station placement or design may thus be another option for overcoming the spatial constraints of station areas.

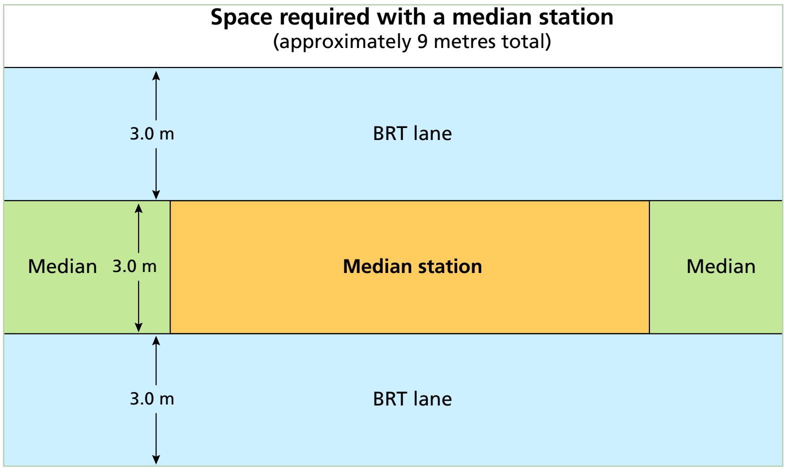
▲ Fig. 5.35

Eugene has considered single lane operation for portions of its proposed corridor.

Image courtesy of Lane Transit District

5.3.9.1 Staggered stations

Historically, the roadway configuration for the BRT stations has taken one of two different options. In one case, a single station in the roadway median can act to serve both directions



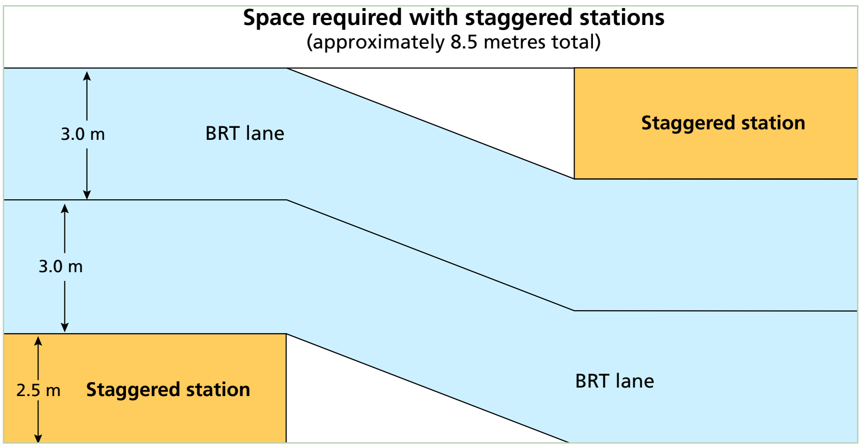


Fig. 5.36 and 5.37

Relative space requirements for roadway configurations with median stations and staggered stations.

of corridor travel (Figure 5.36). Alternatively, stations can be split with a different station serving each direction of travel (Figure 5.37). This second option, the staggering of stations for each direction, will likely provide a marginal space savings in terms of road width. The station will only have to accommodate approximately half as many passengers for a single direction, and thus a reduction in width is possible.

While requiring a somewhat wider floor area, the single station in the median is by the most useful in terms of customer convenience and system design. With a single station serving both directions, customers are able to change directions by simply crossing the station platform. Separated stations will require either complicated connecting infrastructure (underground pedestrian tunnels or overhead pedestrian bridges) or a more costly fare system to recognise customers leaving and re-entering the system from nearby stations. Additionally, building two stations instead of a single median station will tend to increase overall construction costs.

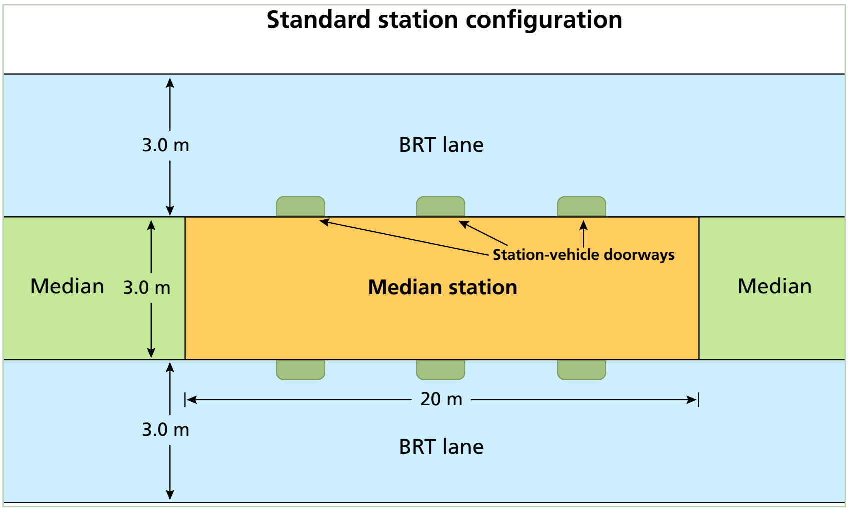
Thus, the marginal width gained from a staggered configuration usually is not a significant benefit in comparison to the operational disadvantages associated with this type of arrangement.

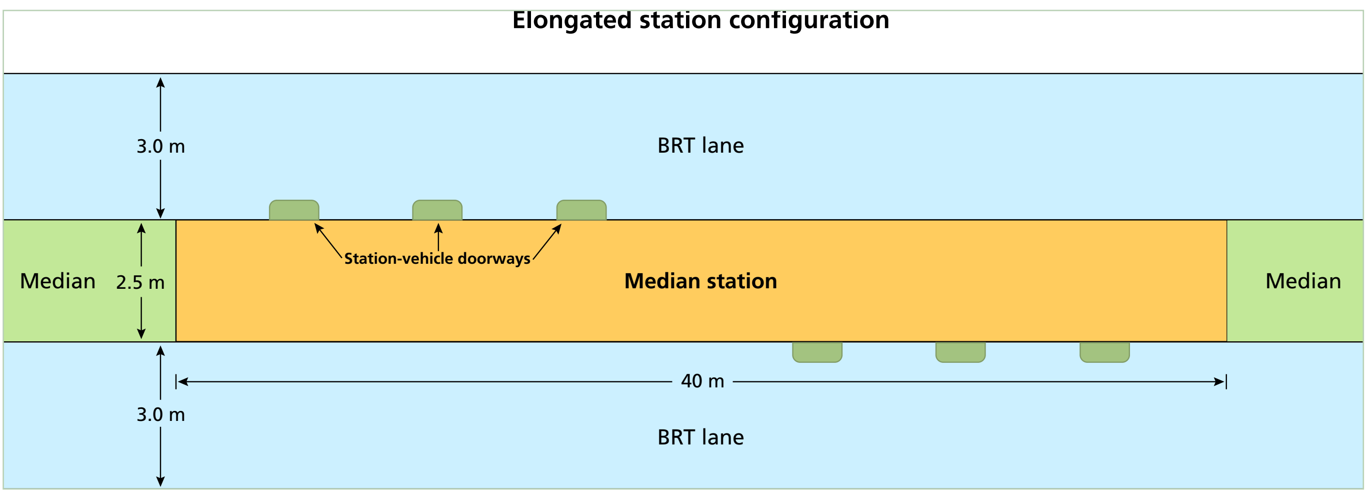
5.3.9.2 Elongated stations

The required width of a station is largely a function of the projected peak passenger volume. The peak number of boarding and alighting passengers will determine how much station floor space will comfortably accommodate all customers. With a median station configuration, there is the possibility that two vehicles will stop at the same time, and thus exacerbating the peak station load. If the station doors for each direction are situated opposite one another, then space will be at a premium with a simultaneous arrival of vehicles for each direction. In such cases, the station width must be increased to meet the capacity demand.

Alternatively, the station itself can be elongated to offset the placement of the station doors for each service direction. Thus, instead of the station doorways being directly opposite one another for each corridor direction, the doorways are staggered somewhat (Figure 5.38). In order to accommodate this doorway configuration, the stations must be somewhat longer than a station with doorways directly opposite one another. However, the advantage is a reduction in the required station width. Quito's Ecovía corridor makes use of this technique in order to fit the system into a relatively narrow roadway (Figure 5.39). Thus, an elongated station con-

Fig. 5.38 and 5.39
Comparison of a standard and elongated station configuration.





figuration allows a fairly narrow station with the favoured median station location.

5.3.10 Mixed traffic operation

As perhaps a last option to narrow road space, a BRT system can operate in mixed traffic for certain segments of a corridor. If the corridor is not congested and future congestion can be controlled, or if the political will to restrict mixed traffic access is simply not present, then a temporary mixing of BRT vehicles with traffic may be unavoidable. However, if the link is congested, then this choice will have a detrimental impact on travel times, system control, and the overall system image.

Near the Usme terminal of the Bogotá TransMilenio system, the BRT vehicles operate in mixed traffic lanes. This design choice is due to two factors: 1. Limited road space (two lanes in each direction) and limited right of way; and 2. Relatively light mixed traffic levels. Since the Usme terminal area does not see high congestion levels, the BRT system co-exists with the mixed traffic in a way that does little to affect public transport operations. In this case, the mixed traffic operation has a negligible impact on system performance.

By contrast in Beijing, the BRT segment with mixed traffic is near the famous Forbidden City portion of the corridor, and this area incurs both considerable mixed traffic congestion as well as fairly high public transport ridership. The result is a significant negative impact on the travel time performance of the BRT system (Figure 5.40). However, Beijing is currently examining options to widen the roadway in this area and/or create a transit mall prohibiting mixed traffic access. As BRT was a new concept to Beijing, the initial political confidence did not exist to deliver a fully segregated solution at the project's outset.

Mixed traffic operation can also become necessary when a BRT vehicle must traverse around a flyover or other obstacle. The plethora of flyovers in Bangkok will likely make this type of lane crossing necessary within the system design. As the BRT vehicle moves to the centre median, it must temporarily mix with cars descending from the flyover. While this set of circumstances is undesirable from a travel time and system control standpoint, the congestion usually does not occur at the bottleneck or flyover, but prior to it. Providing public transport vehicles with separated facilities up to the flyover will allow them to jump the queue with little detriment to overall travel time.

Fig. 5.40
Beijing operates its BRT system along mixed traffic lanes at a crucial segment of the corridor, and thus travel times and system control are negatively affected.
Photo by Karl Fjellstrom

Thus, short and selected points of mixed traffic operation can likely be tolerated without undermining the functionality of the entire system. However, longer periods of mixed traffic operation can render the BRT system as indistinguishable from a standard bus system. The impact of such a design is not just on the performance and operational control, but also on the psychological image of the system. The exclusive, priority lane given to a BRT vehicle is the principal physical feature that sets it apart as a higher-quality form of transport. The segregated lane is what allows customers to develop a "mental map" of the system in their minds. Removing this segregation from significant portions of the system greatly diminishes the metro-like nature of BRT and makes it far less attractive to discretionary riders.

5.4 Framework for comparing corridors

"The only relevant test of the validity of a hypothesis is comparison of prediction with experience."
—Milton Friedman, economist, 1912–2006

The initial step in the corridor selection process has been identifying areas with key origins and destinations. A survey of corridor characteristics in these areas then helps to inform decision

Table 5.1: Factors comparing potential BRT corridors

Factor	Impacts / indicators
Time savings benefit to transit users	• Labour productivity • Quality of life
Time savings benefit to mixed traffic vehicles	• Labour productivity • Delivery efficiency for goods and services
Fuel savings from transit operations	• Fuel expenditures
Fuel savings from mixed traffic vehicles	• Fuel expenditures
Air quality improvements (CO, NO_x, PM, SO_x)	• Human health • Preservation of built environment • Preservation of natural environment • Labour productivity
Greenhouse gas emission reductions	• Global environment
Noise and vibration reductions	• Human health • Labour and educational productivity • Built environment
Urban development considerations	• Streetscape improvements • Transit-oriented development • Property values, shop sales, etc.
Social considerations	• Equity for low-income groups
Planning and infrastructure costs	• Planning costs • Infrastructure costs
Political considerations	• Time required for political approval • Time required for construction

makers on the feasibility of BRT operations. In the next step, as the potential BRT corridor is identified, project developers may wish to attempt to quantify the relative benefits of each corridor.

This section thus presents a framework for evaluating different corridors. By using such a framework, project developers can roughly rank each corridor in terms of quantitative and qualitative benefits.

Table 5.1 summarises the potential factors comprising a comparative analysis of corridor qualities.

In many instances, it is possible to monetarise the factor. Monetarisation can allow a cost-benefit analysis to be conducted across many different factors. Factors such as "time savings" can be calculated in a fairly straight-forward manner.

By contrast, factors such as such as street sociability or traffic safety are more difficult or problematic to monetarise. However, qualitative factors can still play a role in the corridor and route selection process. The Quito Municipality chose the "Seis de diciembre" corridor for its Ecovía line in part because of the presence of a children's hospital. The contamination from existing fleet of older buses created a serious air quality problem within and around the hospital. The new Ecovía corridor allowed all such vehicles to be displaced from the area, and thus the new system created a healthier environment for the hospital's patients. If the corridor selection was based on only one parameter, such as time savings, then the value of the children's health would not have been part of the decision-making process.

Thus, the final disposition of any corridor under consideration will likely be the product of both a quantitative and a subjective analysis. Corridors can be potentially scored by a weighted ranking, with the weighting based on the relative importance a city gives to each factor.

5.4.1 Time savings benefits to public transport passengers

The relative benefits of one corridor over another corridor will be mainly a function of the affected passenger demand on the corridor, and the degree to which the public transport service and the urban conditions are improved. Public transport service improvements result from reducing congestion delays and boarding and alighting delays. Thus, the worse the congestion and the larger the number of existing bus passengers along the corridor, the higher will be the benefit of implementing a BRT system. The economic impacts from these effects are typically calculated through time savings analysis.

To calculate the time savings benefits to public transport customers, then estimations on passenger numbers and vehicle speeds, both before and after the new system, are required. The average vehicle speeds will directly relate to the amount of travel time for a particular journey. Equation 5.1 provides a framework for calculating the passenger time savings.

Equation 5.1 Passenger time savings

$$\textbf{Total time savings} = P * (Tp - Tf)$$

P = number of passengers
Tp = present travel time
Tf = future travel time

Because benefits will vary quite a lot not only between corridors but within corridors, it is necessary to add up the benefits on each link in the corridor. These benefits will also likely vary according to the time of day and the day of the week. A calculation of this type is most readily accomplished with the assistance of a traffic model. However, a simple spreadsheet analysis with inputted survey data can also suffice. The more complete time savings formula is given in Equation 5.2.

Equation 5.2 Detailed time savings calculation

$$\textbf{Total time savings} = \Sigma_i \Sigma_h P_{ih} * \Delta H_h * (Tp_{ih} - Tf_{ih})$$

Where:

i = link
h= period (morning peak, off peak, night, etc.)
P_{ih} =passenger flow on the link (pas/hour)
ΔH_h = duration of period h in hours
Tp_{ih} = present travel time on link i period h
Tf_{ih} = future travel time on link i period h

$Pi_h * \Delta H_h$ produces the total number of passengers on a particular link during a particular period. This value multiplied by the estimated time savings yields per link produces the total number of hours saved to public transport passengers. This value can then be multiplied by a monetary value of time, or it can be left in the form of hours saved.

The existing transit vehicle speeds and passenger counts should have been collected during the demand analysis work noted in Chapter 4 (*Demand analysis*). Likewise, the boarding and alighting surveys during this analytic phase should have produced values for both peak and non-peak periods.

Future average vehicle speeds and passenger demand will depend on the system's design. If value for future average vehicle speed is not known, then as a first approach, the off-peak speed for the present transit system may be used as a conservative estimate. Future passenger volumes should be based on a combination of existing passenger volumes in conjunction with the size of any expected mode shifting.

5.4.2 *Time savings benefits to general traffic*

Corridor selection will have a significant impact on whether a BRT system can improve mixed traffic flow, have no impact on it, or make it much worse. The three most important indicators of the likely impacts are the current traffic mix, the available right of way relative to the existing road, and the possible behavioural and travel changes of motorists once the new public transport system is in place.

5.4.2.1 Current traffic mix

Normally, for a BRT system to be considered an option, there is likely to be significant congestion on at least part of the corridor. As a general rule, the greater the current contribution of public transport vehicles to the current congestion problem, the greater will be the chance that a new BRT system will actually decongest the mixed traffic lanes. If current congestion is caused primarily by private motor vehicles, the risks are high that the new BRT system will not significantly improve the situation, at least in the short run (Figures 5.41 and 5.42).

Fig. 5.41 and 5.42
An exclusive busway on the road left (Dallas) will likely make congestion for mixed traffic worse. An exclusive busway on the road right (Bangladesh) would make mixed traffic less congested.
Left photo by Richard Stouffer (iStockphoto)
Right photo by Karl Fjellstrom

In developing countries, public transport vehicles frequently have a disproportionate impact on congestion relative to private vehicles. This impact occurs because of higher bus volumes, because the vehicles often stop and go at undesignated bus stops, and because the vehicles sometimes stop two and even three abreast to pick up passengers. Bringing these public transport operators into a new BRT system therefore frequently offers the opportunity to decongest mixed traffic lanes even if a full lane or two becomes exclusively used by buses. In such cases, the new BRT system can easily produce a somewhat counterintuitive result: *Taking away road space and giving a priority lane to public transport can actually give motorists more space and produce less overall congestion*.

The specific congestion impact of the BRT system will depend on which transit vehicles are incorporated into the new BRT system, and which are excluded. The more transit trips that can be incorporated into the BRT system, the less adverse impact the remaining transit trips will have on the mixed traffic lanes.

5.4.2.2 Methodology for estimating impacts on mixed traffic

As a rough estimate, one can calculate the likely impact of a planned exclusive busway on mixed traffic in the following manner. The existing traffic flow at the most congested point of the road (based on traffic counts) should be converted to passenger car units (PCUs) for each available road lane. If the road lanes are not delineated, then this PCU conversion should be done for every 3 metres of road width.

Normally, lanes with a width of 3.0 to 3.5 metres can handle approximately 2,000 PCUs per hour. The more the PCUs over 2,000 per lane, the more congested the road will become.

Table 5.2: PCU calculation for BRT scenario

Vehicle type	Traffic volume	Average passengers per vehicle	Total passengers	PCU equivalent	PCU total
Cars	1,200	2.5	3,000	1.00	1,200
Taxis	500	1.2	600	1.00	500
Motorcycles	170	48.0	8,160	2.00	340
Remaining buses	300	1.5	450	0.25	75
Total	**2,170**	**–**	**12,210**	**–**	**2,115**

This level of existing congestion should then be compared to the scenario with the BRT system in place. Some of the current public transport vehicles will be relocated onto the new BRT system, and others will remain in the mixed traffic lanes. All the vehicles that will not be incorporated into the BRT system, including the buses not incorporated into the system, then need to be converted into PCUs, and allocated to the remaining number of lanes (or 3 metre road widths). Table 5.2 provides an example of this type of analysis.

If the PCUs of the BRT scenario are higher than the PCUs of the pre-BRT scenario, then the new BRT system will tend to increase congestion of the mixed traffic lanes. If it is lower, it will lead to lower congestion levels. Because the PCUs of buses are generally double that of private cars and taxis, and eight times as high as motorcycles, the more buses in the existing traffic stream that are relocated to the new BRT system, the greater will be the degree to which the remaining mixed traffic lanes are decongested. A more detailed and accurate calculation of traffic congestion impacts can be obtained through a traffic software model.

Once the level of traffic is estimated for both the baseline case and the BRT case, then the amount of time savings for occupants of mixed traffic lanes can be calculated. Box 5.1 provides a overview of the time savings calculation.

5.4.3 Implementation costs

In general, the more complicated the physical aspects of a corridor, the more costly the planning and construction will be. Any of the following infrastructure components along a proposed corridor can cause costs to escalate:

- Road widening;
- Use of median;
- Relocation of utilities;
- Underpass or tunnel;
- Flyover, overpass, or elevated segment;
- Bridges;
- Large roundabouts.

Road widening can be particularly costly, especially when any property acquisition is factored into the equation.

At the same time, the necessity of these types of infrastructure components should not

Box 5.1: Calculating time savings for vehicle occupants in general traffic

On some critical sections (i) present general traffic volume on peak periods (j), will exceed the road's capacity, by certain amount: DSij. The total general traffic prejudice on that point "i" is then estimated by equation 5.3.

Equation 5.3 Time savings for general traffic

$TGC_j = \Sigma_i(\Delta S_j * Tcong_{ij}\text{^}2/2*Ki)*np_i$

i = point of evaluation where one of the following effects takes place:

1. The point is the bottle neck of the corridor
2. The point is not the bottle neck, but future capacity (after BRT) will fall below present peak volume

j = some specific peak hour. There are normally two peak periods, a morning peak and an evening peak. A velocity survey for cars will more accurately identify the peak periods.

TGCj = Total time savings for general traffic

$\Delta\Sigma j$ = the amount of change on capacity to the new scheme. This value will be negative value if there is a reduction in capacity; this value will be positive if there is an increase in capacity.

$Tcong_{ji}$ = duration of the congestion period being considered. The peak period can be better estimated by traffic velocity surveys that show when travel times increase more drastically. Usual values are around 0.5 to 3 hours.

Ki = reflects a group of factors derived form network analysis and demand elasticity.

It should be noted that reductions of capacity on two successive nearby points are not independent. However, usually the more congested point should be considered the important one.

Example:

If for example on this case of two connected points A and B, B has a greater capacity reduction than A, then we should consider that:

KB = 1 and

KA = 500/(500 + 2000) = 0.2 because the 2000 will in each way be congested on point B.

Npi = average number of passenger per pcu.

automatically negate a corridor option. As Quito has demonstrated, in some cases, underpasses and complicated roundabouts can be handled without extravagant costs. If a corridor is of significant importance to providing a complete set of origins and destinations, then it can be worth a bit of engineering effort in finding a cost-effective solution to infrastructure challenges. However, corridors with highly complex physical challenges, even if vital to the overall transit network, may not be the best choice for a project's first phase. Development and construction teams will undergo a learning process from one phase to the next. A physically easier initial corridor may hone the technical capacity needed to take on more challenging corridors.

By contrast, simply converting a mixed traffic lane to a BRT runway without any of these complications can reduce both planning and infrastructure costs. Corridors with a concrete base instead of asphalt may particularly make BRT implementation a less costly endeavour. However, corridors should not be selected principally based upon ease of construction. In many cases, such "easy" corridors do not host significant demand. The proposed Kaset Narawin BRT corridor in Bangkok was selected expressly because it has no congestion issues. Officials felt that the BRT system would thus have no negative impacts on mixed traffic in this corridor. Unfortunately, there is also extremely limited public transport demand in the corridor as well. The corridor will eventually connect with residential areas, but through the Kaset Narawin portion there will be relatively little customer value.

Likewise, several Chinese cities are contemplating placing BRT runways along ring roads. Again, much of the reasoning is related to the existing right-of-way space and the relative ease of construction. However, customer access to a ring road station (both in terms of horizontal and vertical distances travelled) can be difficult. Building these "easy" infrastructure projects may eventually undermine the BRT concept. A BRT system with few customers may seem to operate quite smoothly, but it will not be cost effective and unlikely to move public opinion to support future expansion.

5.4.4 Political considerations

While this chapter has stressed the need for a rational decision-making process, it is recognised that corridor and route decisions are frequently based on far more subjective rationale with sometimes little analytical consideration. Some past decision-making rationale have included:

- "On this corridor we will have a metro one day… so we should choose another."
- "The President or another important official lives on this corridor… so we should avoid… or we should build here."
- "This corridor may not have much demand but it has a lot of space… so we will build it here."
- "Connecting these locations will be an important symbol of integration."

Such capricious decision-making not grounded in analysis of actual travel demand can result in costly mistakes that do little to support a quality service for the customer (*e.g.,* Lima's Tren Eléctrico). At the same time, it is recognised that political considerations can be quite appropriate in augmenting technical data. In fact, democratically elected officials have a responsibility to utilise their judgements in making determinations between different sets of costs and benefits. Some of the key instances requiring political inputs include:

- Preference to place initial corridors in a high visibility location in order to promote the BRT concept more widely;
- Preference to locate corridors initially in low-income communities in order to promote greater social equity;
- Avoidance of corridors that may conflict with other infrastructure plans or with other governmental entities;
- Avoidance of corridors requiring extensive re-organisation of many existing formal and informal public transport operators.

A purely technical analysis of the corridor attributes can miss some of the more subtle political considerations that may greatly affect the project's viability.

However, the existence of competing infrastructure plans or a complex operator environment does not mean a corridor should not be considered at all. There may be solutions to these difficulties or there may still be much reason to consider such corridors for a later project phase.

Frequently, the most difficult problem is that the corridors with the highest existing public transport volumes have already been included in a master plan for a future metro project. Decision makers are reluctant to plan a BRT on a future metro corridor in the fear of foreclosing the possibility of future national government funds for a metro. In such cases, it is usually best to first propose putting BRT in the corridor as a temporary measure, to be upgraded to metro or light rail at some unspecified future date. This rationale was utilised successfully with TransJakarta Corridor I as well as in Kunming and Curitiba. The low infrastructure costs of a BRT system can make it a fairly effective transitional technology to a future rail system. Further, the BRT infrastructure can actually help physically prepare the area for the future rail corridor. For example, an LRT system will require a right of way similar to that of a BRT system. Likewise, an elevated rail system will require median space for support columns.

In other cases, the political environment may simply not permit BRT consideration in a future metro corridor, even if the metro line is unlikely to be realised in any foreseeable time horizon. The next best solution is to select a corridor that will complement the planned metro system. The BRT systems under consideration in Guangzhou (China), Ahmedabad (India), and Delhi, and some BRT lines in São Paulo, have been intentionally planned outside of potential future metro corridors. However, these BRT systems have been expressly designed to provide complementary integration with the planned rail systems.

Political inputs can be particularly appropriate when cultural or social issues are at stake. In Hyderabad, the presence of a Muslim graveyard on both sides of the road creates an unfortunate bottleneck on the main highway bisecting the city from the northwest to the southeast. An engineering solution may call for expropriating parts of the graveyard for road widening. However, for a Hindu-dominated government to relocate this graveyard would likely be both politically and socially dangerous. Thus, a reasoned political judgement may be needed to curtail any discussion of road widening.

In Jakarta, the initially planned routing of the Second BRT corridor would lead it directly through the Senen Bus Station. However, this design would have required the removal of several hundred street vendors who are illegally occupying public space but are nonetheless organised into a sort of mafia. Several policemen were killed trying to relocate the vendors, and the decision was made to select a sub-optimal route. This political obstacle will cost the new BRT system approximately 25,000 passengers a day. The Senen station example is not unique as many developing-nation arterials are illegally encroached upon by both the rich and politically connected, as well as the poor and desperate. Political negotiation to reclaim these areas for the BRT system can often add significant delays and increase the risk of turmoil.

It may also be advisable in Phase I not to disrupt too many existing public transport routes that are not going to be incorporated into the new system. Negotiations with existing transit operators are a delicate part of BRT planning, and it is generally advisable not to take on the entire private sector transit industry all at once. Corridors with a large number of existing separate bus operators will make the negotiations for reforming the system a lot more complex than corridors where there are only a small number of operators. This consideration was a determining factor with the Insurgentes corridor in Mexico City, and is also a factor in the planning of the Dar es Salaam system.

5.4.5 Social considerations

Social considerations may be a leading determinant in corridor decision making. Public transport systems perform many key social functions in a city and have often played a central role in regeneration efforts. Political leaders and project developers may thus seek to target areas that would most benefit from a public transport investment.

Focussing an initial phase upon a low-income community can produce several economic and social equity benefits. The new public transport system will connect these residents to jobs and public services in the city's central areas. The system itself will also likely produce both direct and indirect employment opportunities for the community. Recent studies from Bogotá indicate that the significant reductions in travel costs resulting from TransMilenio have greatly expanded the potential job market for lower income residents, increasing employment and wages among lower income groups.

A new public transport system can also do much to attract investment into lower income areas. Additionally, the presence of the system can instil a sense of pride and community into areas that previously felt abandoned and ignored. For these reasons, Bogotá purposefully located its initial BRT corridor in between the central area and the lower-income south of the city.

Access to BRT can also increase land values, which can be a double edge sword for the poor. Recent studies indicate that TransMilenio led to significant increases in property values in areas served by a TransMilenio feeder bus. For poor families without land title, the benefits of lower transportation costs may be lost to higher rents. It is therefore a good idea to prioritise efforts to give poor families land title in planned BRT corridors so that the resulting property value increases can be captured by the families instead of by land speculators.

At the same time, there are also social and environmental reasons for including middle- and upper-income communities within a project's early phases. While Bogotá did target the lower-income south of the city, the Mayor also intentionally included a corridor extension into the more affluent north of the city. The wealthier areas of a city are obviously the locations of higher vehicle ownership. Thus, from

Fig. 5.43
Bogotá's TransMilenio system has successfully attracted users from a wide spectrum of the society.
Photo by Lloyd Wright

the standpoint of shifting car users to public transport, there is greater emission and congestion reduction potential in targeting car-owning households. Further, Mayor Enrique Peñalosa of Bogotá also saw significant social benefits from encouraging greater interactions between economic classes. Peñalosa has noted that: "A public transport system may be the only place that the rich and the poor interact with one another." In terms of propagating understanding and awareness between social groups, a high-quality public transport system can thus be a potential social unifier within a city (Figure 5.43). Having the new system also serve higher income groups also helps to encourage political buy-in to the system by influential families.

Social and equity issues may also be central to loan pre-requisites from major international financing organisations. Most development institutions, such as the World Bank, justify investments in terms of poverty alleviation. Thus, ensuring that a reasonable number of BRT passengers are below median income is important to linking the system to broader goals of poverty alleviation.

5.4.6 Multi-criteria analysis for corridor selection

As noted throughout this section, the final selection of a corridor will ultimately be made by a political decision-maker, who will likely incorporate political and social considerations into the decision. Nevertheless, an analytic framework can contribute much to this process. A cost-benefit analysis incorporating the benefits from time savings, fuel savings, and environmental improvements can do much to help shape the eventual decision. Quantifying these benefits will also improve the project's attractiveness to many financial institutions.

As the name implies, a cost-benefit analysis calculates the ratio of a project's benefits to its costs. The larger this ratio, the more attractive a project is likely to be to decision makers and financing organisations. Equation 5.4 provides the framework for calculating the cost-benefit ratio.

Equation 5.4 Cost-benefit ration

$$BC = (Btp + Btm + Bfp + Bfm + Be)/Ci$$

With,

- **BC** = Total benefit cost ratio
- **Btp** = Time savings for transit passengers
- **Btm** = Time savings to occupants in mixed-traffic vehicles
- **Bfp** = Fuel savings to transit vehicles
- **Bfm** = Fuel savings to mixed-traffic vehicles
- **Be** = Environmental benefits
- **Ci** = Implementation cost.

Box 5.2 provides an example of a multi-criteria analysis using two of the factors presented in this section.

Box 5.2: Calculating the benefit to cost ratio

As a simplified example of this calculation, the table below presents a hypothetical example of time savings benefits for BRT vehicles and mixed-traffic vehicles. The "weighting" factor indicates how much consideration is given to each stakeholder group (transit users and car users). In this first case, each group is given an equal weighting.

Table Time-savings benefits, Scenario 1

Corridor	Time-savings benefits			Cost	Benefits to cost ratio
	BRT	Cars	Total		
Weighting	1	1			
A	50	-6	44	10	4.4
B	2	0	2	5	0.4

In the above scenario, corridor A attracts a high-volume of ridership. The benefits awarded to transit users in this case will greatly exceed the costs to car users. Corridor B is a low-ridership area but with little congestion and therefore no time impact on car users. In this case, the time benefit to transit users is quite small. From these two options, the benefit to cost ratio for corridor A is 11 times greater than the same ratio for corridor B. Thus, from a time savings perspective, corridor A would be the chosen corridor.

If political officials were concerned about reactions from car owners, then the weighting for this group might be increased to five. However, as the table below indicates, even this amount of prioritisation to car interests would not change the overall result.

Table Time-savings benefits, Scenario 2

Corridor	Time-savings benefits			Cost	Benefits to cost ratio
	BRT	Cars	Total		
Weighting	1	5			
A	50	-6	20	10	2.0
B	2	0	2	5	0.4

However, if officials were particularly worried about car owner reactions and therefore gave a priority weighting of 10 to private vehicles, then the result would change.

Table Time-savings benefits, Scenario 3

Corridor	Time-savings benefits			Cost	Benefits to cost ratio
	BRT	Cars	Total		
Weighting	1	10			
A	50	-6	-10	10	-1.0
B	2	0	2	5	0.4

In this scenario, corridor A would be a less desirable choice than corridor B. However, with the low benefit ratio for transit users, corridor B would risk doing little to promote the future prospects of BRT development in the city.

An expanded benefits table could be constructed to also factor in impacts from fuel savings and environmental improvements.

5.5 Corridor length

"Time is the longest distance between two places."

—Tennessee Williams, dramatist, 1911–1983

Once the principal corridors have been selected, the question arises over the optimum length of the corridors. In general, passenger demand will tend to fall as the distance from the city centre destinations increases. At a certain point, the demand will become insufficient to maintain profitable operations and the justification for infrastructure investment in an exclusive busway may become more difficult. Additionally, beyond a certain point, other services, such as feeder services, may become more economically practicable. Finally, farther out it is likely that congestion will be less severe, making segregated lanes less necessary. Thus, the corridor service may continue but beyond this point the service will operate in mixed traffic and not with the benefit of an exclusive busway.

In systems utilising feeder services, the decision on where to terminate the exclusive busway (*i.e.,* trunk corridor) may depend in part on the availability of land for a terminal site (Figure 5.44). A terminal is required to facilitate the transfers between feeder and trunk line operations. Additionally, depots for vehicle parking and maintenance are normally located near the terminal site in order to facilitate rapid and cost-effective entry of the vehicles into service. Given the relatively large amount of land required for terminal and depot sites, property acquisition costs will likely be a major part of the decision on where to locate the sites. Social considerations may also play a role in the length of a corridor. If low-income communities at the city's periphery are to be targeted for service for social equity reasons, then the corridor may be extended to cater to these groups. Thus, while passenger demand will be a principal determinant, other factors such as terminal and depot siting as well as social considerations, will also play a part in determining the length of a busway corridor.

The starting point, though, for determining the corridor length will likely be a cost-benefit analysis related to passenger demand. Once the optimum corridor length is determined based on passenger demand, then the decision can be adjusted to account for other factors such as terminal and depot siting as well as social equity factors.

The basis for the cost-benefit analysis of corridor length is typically the time savings generated by the exclusive busway. Once the exclusive busway no longer provides a net time savings benefit in comparison to the construction costs, then the point has been reached when the exclusive busway is no longer cost justifiable. As the number of passengers fall with the distance from the city centre, the total time savings benefit is reduced. Further, since congestion levels will also likely fall with distance from the city centre, the travel time advantage of an exclusive busway will likewise fall. Table 5.3 provides an example of

Fig. 5.44
The availability of land for terminal and depot space can be a consideration of the end point for a specific corridor.
Photo courtesy of TransMilenio SA

a cost and benefit results plotted against a corridor's length.

Of course, this time savings benefit will tend to increase over time as congestion worsens. Since a BRT system is likely to last a long time, it is standard practice to roughly estimate the likely congestion along the corridor in the next ten to twenty years rather than simply assuming that current congestion conditions will prevail long into the future.

In the example given in table 5.3, the corridor would end after segment "H" if the decision was based only on benefit to cost considerations. After segment "H", the benefit to cost ratio falls below a value of 1.0, meaning that the costs of extending the exclusive busway corridor outweigh the time savings benefits.

5.5.1 Feeder service length

If feeder services are to be employed in the system, then length of these services would likely be based on a similar cost-benefit analysis as well as several other considerations, such as social-equity factors. Since feeder services typically employ smaller vehicles and do not require exclusive busways, the cost of extending the feeder service is principally based on operating costs such as fuel and driver salaries. At a certain distance from the terminal site, a feeder service will cease to be economically viable as the passenger demand drops below a certain value.

However, in many cases, feeder services may be extended into lower-density areas for reasons of social equity reasons. Some communities may have no other transport services, and the existence of feeder services may be vital for connecting people to employment opportunities and social services such as education and healthcare. In these cases, though, formal feeder services may be just one of many options to connect residents to major transport corridors. As will be discussed in Chapter 13 (*Modal integration*), other options such as bicycles, pedicabs, and taxi services may also be options to consider for linking the system to areas with lower population densities.

5.6 Number of corridors

"There are several paths one can take, but not every path is open to you."

—Claire Bloom, actress, 1931–

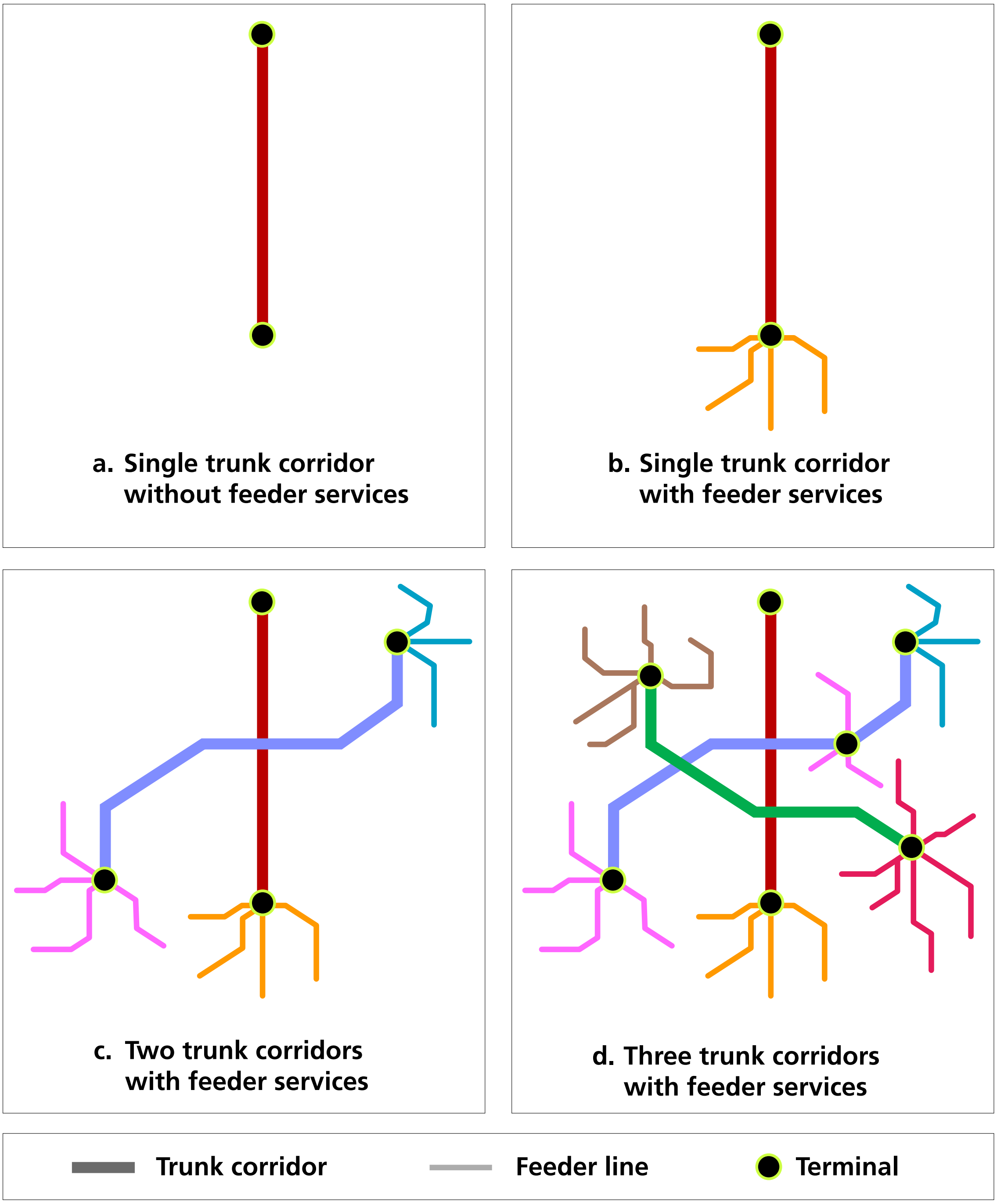
A second corridor in the initial plan does not simply translate into a doubling of the possible destinations. Rather, the math of public transport corridors tends to behave in an exponential manner. The math of transport corridors means that one plus one does not equal two but is instead equal to four. This result is due to the added permutations of trips possible with each leg of the corridor. Figure 5.45 illustrates the progression of increasingly greater destination possibilities that are achieved by adding each new corridor.

Clearly, scenarios (a) and (b) in Figure 5.45 provide the customer with relatively few destination options. In these instances, many customers will continue to use their existing transport

Table 5.3: Benefit-cost analysis of corridor length

Corridor segment	Length of segment (km)	Demand along segment (x 1000)	Time savings (minutes)		Cost		Benefit	Benefit / cost ratio (B / C)
			Total	/ km	Total	/ km	/ km	
A	3.0	13.0	6.0	2.00	5	1.67	26.00	15.61
B	2.0	12.0	4.0	2.00	4	2.00	24.00	12.00
C	1.5	13.0	5.0	3.33	3	2.00	43.33	21.67
D	3.0	11.0	4.0	1.33	4	1.33	14.67	11.00
E	1.8	9.0	1.2	0.67	2	1.11	6.00	5.40
F	3.1	7.5	2.5	0.81	4	1.29	6.05	4.69
G	2.3	6.0	0.5	0.22	3	1.30	1.30	1.00
H	1.5	4.5	0.6	0.40	2	1.33	1.80	1.35
I	3.1	3.0	1.0	0.32	5	1.61	0.97	0.60
J	1.9	2.2	0.2	0.11	3	1.58	0.23	0.15

Fig. 5.45
The impact of adding more corridors.



options, even if they spend some of their travel time on the new transit system's single corridor. However, scenarios (c) and (d) begin to provide a service that will compete quite well with other modal options. In these scenarios, many customers will be able to fulfil all their travel needs within the new BRT system. If only scenarios (a) or (b) are followed in the project's first phase, then there will be a high degree of risk regarding the system's future.

5.7 Station and lane placement

"The three most important things in real estate are location, location, and location."

The location of the segregated busway within a specific roadway is a design decision that holds more options than might be immediately apparent. The lanes may be placed in the median or along the sides of the road. Additionally, both lane directions could be placed on the same side of the roadway. In some cases, the busway may be given the entire roadway space, as is the case with transit malls.

5.7.1 Median lanes and stations

The most common option is to locate the busway in the centre median or in the centre two lanes (Figure 5.46). 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 easier integration between busway routes, particularly when two routs cross on perpendicular streets. 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. In the case of busways along the sides of the roadway or with staggered stations in the busway median, the difficulties in providing pedestrian infrastructure that connects all the possible transfer permutations can be quite difficult (Figure 5.47). An alternative is to provide a full set of route permutations that connects each possible routing from each station. However, when attempting to connect all permutations, the route structure becomes unrealistically complicated with just a single set of crossing intersections (Figure 5.48).

As noted earlier, the use of a single median station is far more conducive to ease of transfers.

Fig. 5.46
A median busway with a single median station has become the standard for high-quality BRT systems.
Photo courtesy of TransMilenio SA

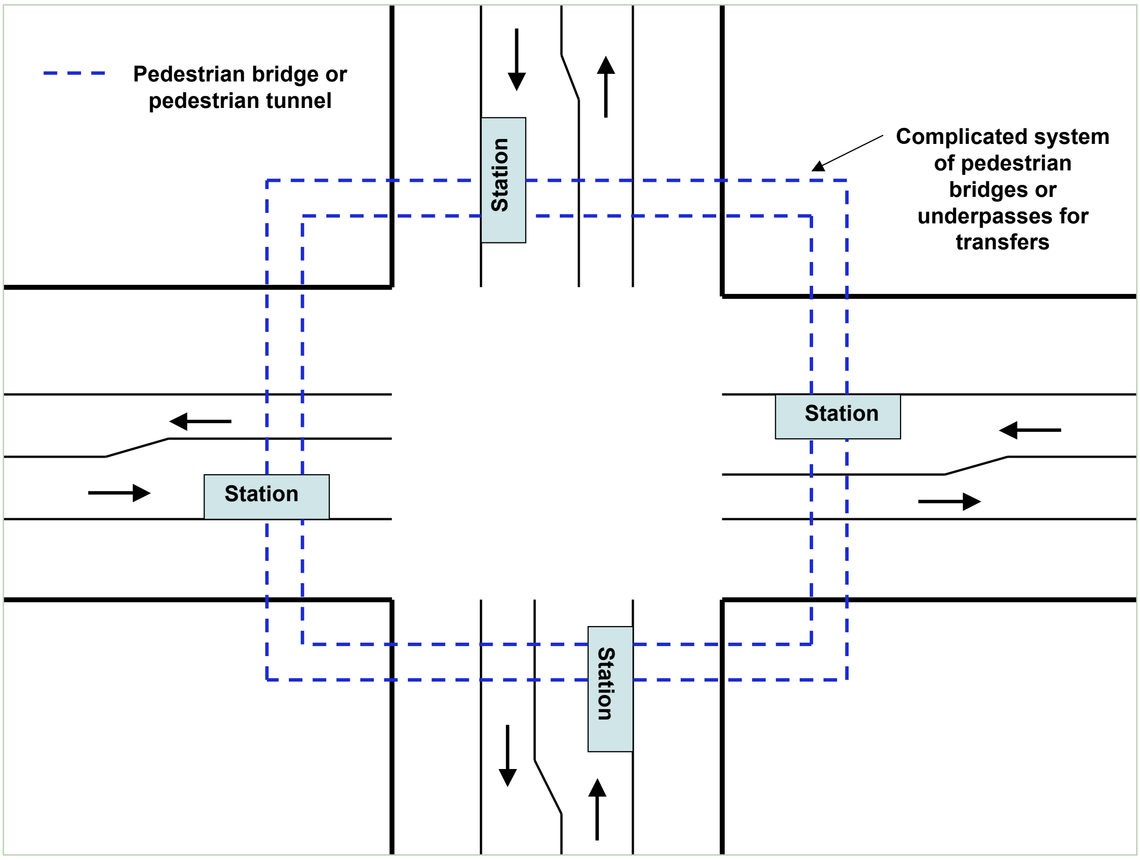
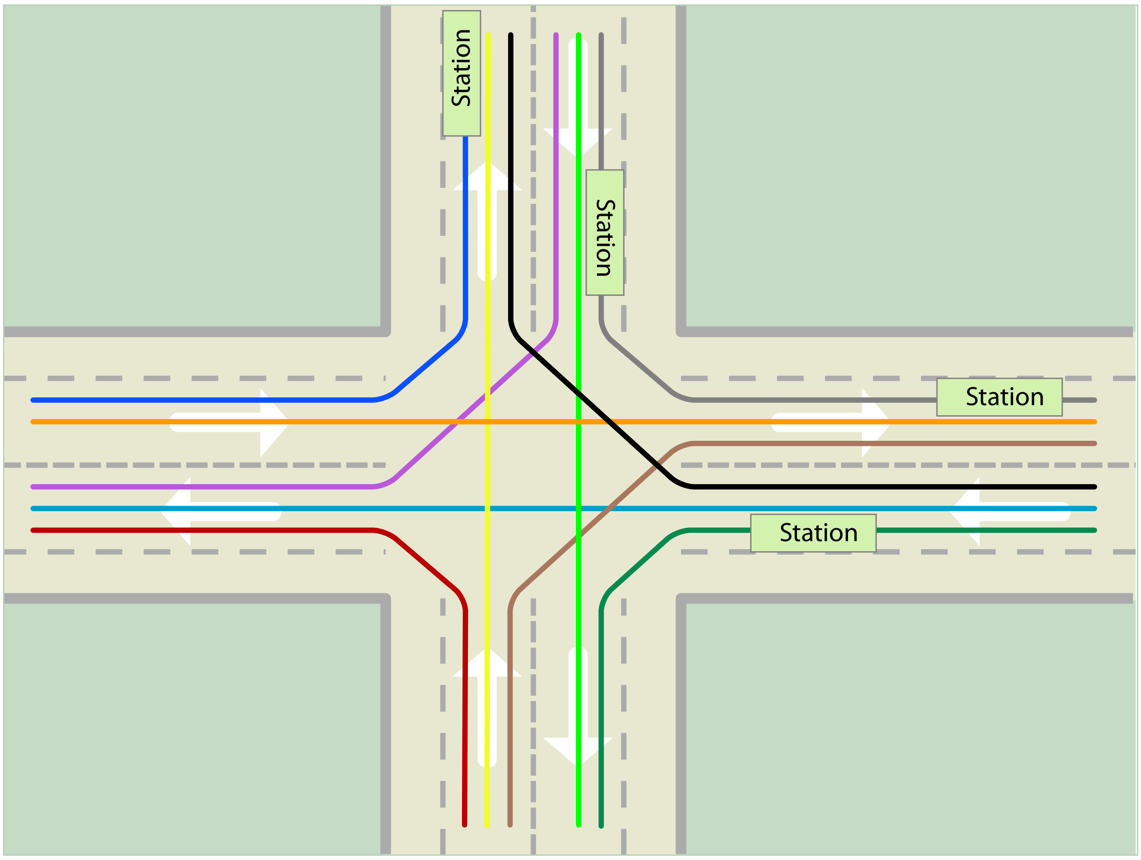


Fig. 5.47
Split stations and side aligned stations make customer transfers quite difficult. An elaborate set of bridges or underpasses would be required to make closed transfers possible in such an arrangement.

Fig. 5.48

An alternative means of connecting split and side-aligned stations is to provide a full set of route permutations. However, the required number of permutations becomes excessive, even for just a single intersection.



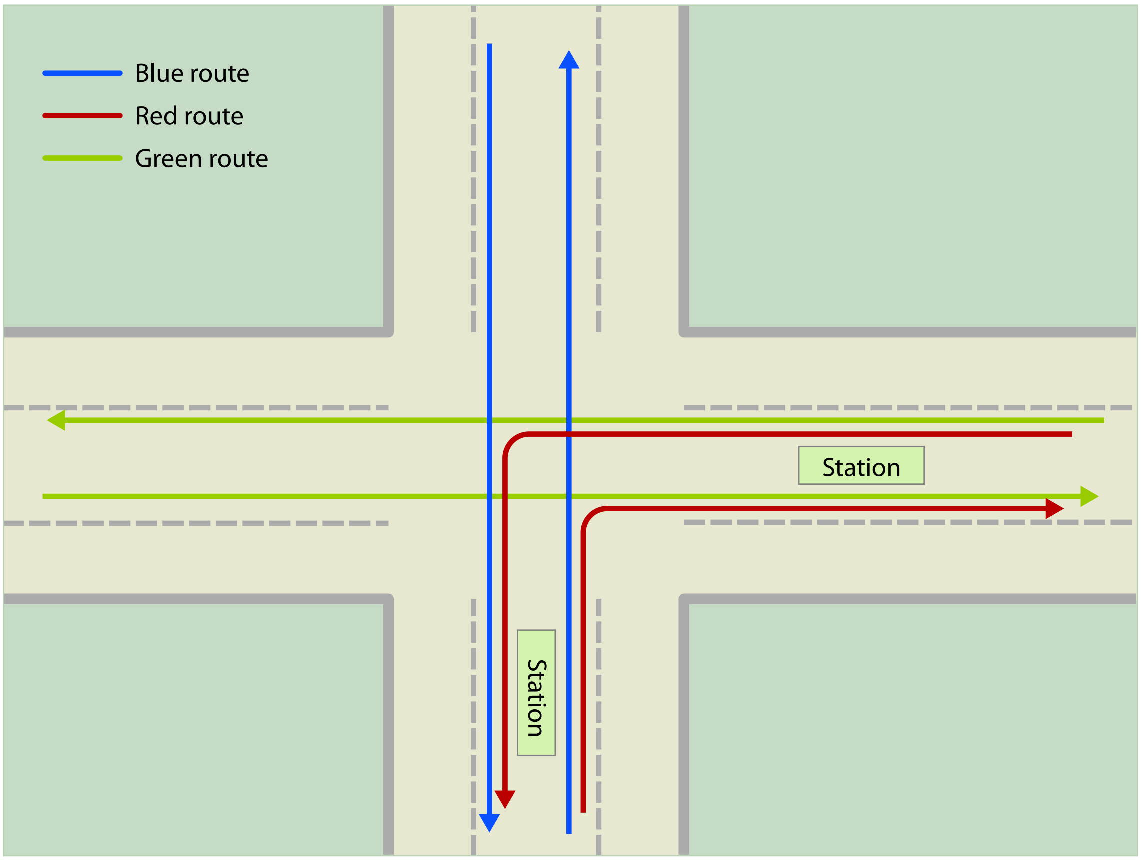


Fig. 5.49

Median stations permit easier platform transfers and multiple route permutations.

A median station permits customers to select multiple routing options from a single station platform. Figure 5.49 provides the same number of possible route permutations as that shown in Figure 5.48. However, the use of a median station greatly simplifies the route combinations.

5.7.2 Curbside stations

While typical to find typical bus lanes at the curbside, it is rare for BRT to place the busway on the sides of the roadway (Figure 5.50). BRT systems generally do not utilise this configuration primarily because of the conflicts with turning traffic, stopping taxis, delivery vehicles, and non-motorized traffic (Figure 5.51). Such conflicts will greatly inhibit the system's capacity. Achieving capacities over 5,000 passengers per hour per direction is quite difficult if turning vehicles are frequently interfering with busway operations. Curbside busways create the potential for the entire busway to be stopped due to a single taxi picking up a passenger, a policeman temporarily parking, an accident, or a turning vehicle trapped behind high pedestrian crossing volumes.

Fig. 5.50
Curbside bus lanes are quite common in conventional bus systems, but often fail due to traffic congestion and poor enforcement.
Photo by Lloyd Wright

Fig. 5.51
In this image from Quito, the Trolé BRT vehicle is operating in an "exclusive" curbside lane, but is blocked by merging traffic from a side street. A median busway would largely avoid these types of conflicts.
Photo by Lloyd Wright

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. Alternatively, passengers could be forced to walk across busy intersections and pay a second fare to enter a different corridor.

Fig. 5.52
In many respects, the Hangzhou system is a well-designed and modern busway system. However, the choice of curbside stations limits flexibility integrating future routes and corridors.
Photo by Kangming Xu (http://www.brtchina.org)

However, customers will clearly not want to pay twice merely to change directions.

For systems with just a single corridor, the curbside stations do not inhibit transfers since there are no other corridors for transfers to take place. However, systems that start with just a single corridor first phase, almost invariably grow to incorporate more parts of the city. Thus, the problems associated with curbside stations can become evident once the additional corridors are constructed and transfers become necessary. Hangzhou has developed an impressive phase I busway system that includes very modern vehicles and stations. However, the choice of curbside stations will likely create future limitations with the system (Figure 5.52).

5.7.3 Busway-only corridors

"Bus-only" or "transit mall" corridors are effective options in giving complete priority to public transport. Such corridor segments are typically employed in central areas where space restrictions limit the ability to share space between both public transport and private vehicles. In such cases, transit malls can greatly contribute to high-quality public space for pedestrians.

Fig. 5.53
An exclusive busway runs under the Mater Hill Hospital in Brisbane.
Photo courtesy of Queensland Transport

Fig. 5.54
Public transport vehicles are given exclusive use of Denver's 16th Street Mall.
Photo courtesy of NBRTI

Fig. 5.55
In suburban locations, Brisbane is able to fully segregate its busway to the side of an existing roadway.
Photo courtesy of Queensland Transport

Cities such as Bogotá and Quito employ bus-only corridors in selected locations. Likewise, Brisbane, Denver, Ottawa, and Pittsburgh also have developed bus-only corridors (Figures 5.53 and 5.54).

5.7.4 Multiple lanes along corridor side

While side-aligned busways generally fail due to turning conflicts with mixed traffic, placing multiple busway lanes along the side of the roadway can work for certain roadway segments. If a roadway is bordered by green space (*e.g.,* a large park), water (*e.g.,* ocean, bay, lake, or river frontage), or open space, then there may be no turning conflicts for long distances, in which case side alignment may actually be preferable to median alignment.

The Miami busway system places lanes for both busway directions along the same side of the roadway. In Brisbane, busways connecting suburban locations pass along relatively open areas where fully segregated infrastructure alongside the existing roadway is possible (Figure 5.55).

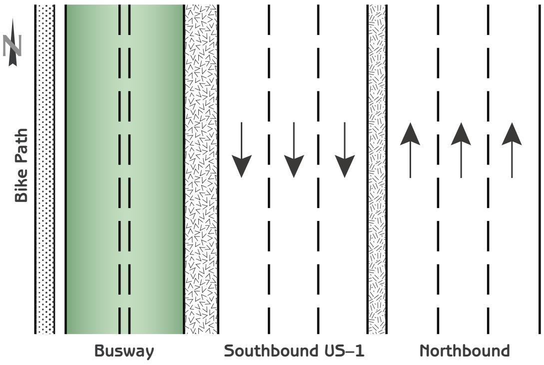


Fig. 5.56
The Miami busway is situated entirely along one side of a major expressway.
Image courtesy of the US FTA

In the case of Miami, non-intersection turning movements for private vehicles are not allowed along the corridor (Figure 5.56). In Orlando (US), the central Lymmo system occupies two of the three downtown lanes (Figure 5.57). Mixed traffic is given only a single one-way lane. In this configuration, access to shops on the BRT side is limited to the hours that the system is not operating. Thus, shops must make vehicle deliveries in the late evening.

Fig. 5.58
A counter-flow bus lane as utilised in the central business district of Johannesburg.
Photo by Lloyd Wright

Fig. 5.57
The Orlando Lymmo system utilises two of the three lanes available in the city's central district.
Photo by Lloyd Wright

5.7.5 "With-flow" and "counter-flow" options

In addition to the different roadway configurations, system designers can opt for either "with flow" or "counter-flow" bus movements. "With flow" means that the vehicles operate in the same direction as the mixed traffic in the adjoining lanes. "Counter flow" means that the vehicles operate in the opposite direction of mixed traffic. "Counter flow" is sometimes used if the doorways on the existing buses require the bus to drive on a certain side. Obviously, it is preferable to derive the vehicle design from the optimum busway design, but this situation is not always possible. "Counter flow" set-ups do have a potentially serious problem with increased pedestrian accidents. Pedestrians can be unaccustomed to looking in the direction of the counter flow lane and thus cross unknowingly into a dangerous situation.

Counter-flow bus lanes are used in various conventional bus systems around the world (Figure 5.58). Often, counter-flow designs are employed to discourage private vehicles from entering the

Fig. 5.59
Quito briefly employed counter-flow design on its "Ecovia" line since the initial vehicles had doorways on the wrong side.
Photo by Lloyd Wright

Fig. 5.60, 5.61, and 5.62
Curitiba utilises a variety of roadway configurations. Each street's design depends upon the local circumstances.
Left and right photos by Lloyd Wright
Centre photo courtesy of URBS and the Municipality of Curitiba

bus lane. However, the counter-flow lane may simply result in busway congestion if private vehicles nevertheless decide to enter the area.

Counter-flow systems are generally not employed in BRT systems, particularly due to concerns over pedestrian safety. Quito briefly utilised counter-flow movements for its "Ecovía" corridor since its only available vehicles possessed doorways on the wrong side (Figure 5.59). However, once the new vehicles arrived from the manufacturer, Quito converted the corridor back to "with-flow" movements.

5.7.6 Mixing different configuration options

Like many other design decisions associated with BRT, there is no one correct solution to roadway configuration. Much depends upon the local circumstances. Additionally, it may be possible to use several different configurations in a single system. Curitiba, Brazil uses centre lanes, both lanes on the side, and streets exclusively for BRT (Figures 5.60, 5.61, and 5.62). Curitiba essentially tailors the roadway configuration to the particular situation on the given road segment.

In most cases the only limitation is to keep the doorway on the same side, so that one has the flexibility to use the same buses on multiple lines. However, even this caveat has been circumvented in some cases; Eugene, Porto Alegre and São Paulo utilise buses with doorways on both sides to allow maximum flexibility (Figures 5.63 and 5.64).

Fig. 5.63
São Paulo utilises buses with doorways on both sides of the vehicle in order to service both median and curb-side stations.
Photo by Lloyd Wright

Figure 5.64
Vehicles with doorways on both sides permits Eugene to share a single lane for both directions at a station.
Image courtesy of Lane Transit District

6. Communications

"The greatest compliment that was ever paid me was when someone asked me what I thought, and attended to my answer."

—Henry David Thoreau, author, 1817–1862

Communications play an essential role in planning, implementing and operating a BRT system. Communications also play a role in attracting riders to use the system. Developing a communications plan can be as important as any other critical activity like road engineering, transportation demand modelling, or project financing. A comprehensive communications plan facilitates the interaction between project leaders and the various stakeholders involved in the process, namely, transport providers, passengers, and the general public. The communications plan is a helpful tool for facilitating a revision of entrenched ideas, notions, and perceptions regarding public transport. An advisor to the planning team for the Mexico City Metrobus has emphasised:

> "Do not spend any money testing emissions or fuel / drive train combinations and fuel economy; spend everything you can on outreach" (Lee Schipper, 2003).

Overcoming the challenges and problems associated with a BRT system does not simply involve building new roads, buying new vehicles, restructuring operational methods, or modifying organisational models. Changing the general public's notions and perceptions about public transportation during the transformation process is fundamental to building project support.

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-nation 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 chapter provides some preliminary guidance to help the BRT team develop an effective communications strategy and public participation process. The contents of this chapter include:

6.1 Stakeholder analysis

"Alone we can do so little; together we can do so much."

—Helen Keller, deaf-blind author and activist, 1880–1968

6.1.1 Stakeholder identification

The first step to developing an effective communications strategy is to identify the key stakeholders. Typically, the most significant barrier to the implementation of a BRT system is neither technical nor financial in nature, but political. While firm political will is necessary to overcome the many political obstacles, a good communications strategy can significantly minimise political opposition and increase public support for the project, and improve the quality of the final BRT system.

The pre-planning period is the time to begin identifying key groups and organisations that should be included in the planning and development of the system. Specific agencies, departments and political officials will all have varying opinions and interests with regard to developing a new public transport system. Non-governmental and community-based organisations are often important resources to draw upon as well. Organisations that might be included in the stakeholder identification process include:

- Existing transport operators, and operators' and drivers' associations (formal and informal);
- Proponents of competing or complimentary rail projects;
- Motorists and their organisations;
- Construction industry and other potential industry supporters;
- Customers (including current public transport users, car owners, non-motorised transport users, students, low-income groups, physically disabled, elderly);
- Municipal public transport departments;
- Municipal environmental departments;
- Municipal health departments;
- Municipal urban development and public works departments;
- Roads agency;
- Economic development agencies;
- Business and merchant associations;
- Resident associations;
- Traffic and transit police;
- Relevant national agencies;
- Public transport experts and consultants;
- Non-governmental organisations;
- Community-based organisations;
- Ward and district councils;
- News media (television, radio, newspapers, etc.).

Public transport stakeholders are often categorised as either Public Targets (users, general population) or Private Targets (service providers, drivers, and employees). Public Targets, also known as Passive Targets, consist of service users/consumers and the general public, while Private Targets, or Active Targets, include agents actively involved in the provision or regulation of transportation services, either in the public or the private sector (Pardo, 2006).

A stakeholder analysis should seek to understand what are the main concerns of each group, their interest in the project, and their ability to influence, either positively or negatively, the development of the project (technically called their "resources" and "mandates").

The inclusion and active participation of many interested parties is a simple way of avoiding much of the potential opposition to project development down the road. No one stakeholder group should be allowed to hold the project hostage, or compromise the public interest. On the other hand, participation should also not be conducted in a token manner. If agencies or groups feel that their inputs are not being considered seriously, then again the same counter-productive reactions may occur. More importantly, stakeholder groups can significantly help to improve the quality of the project. Each stakeholder has a unique view on public transport issues and holds the potential to contribute to an improved final product.

6.1.2 Stakeholder positions

In general terms, stakeholders' positions may be summarised as is shown in the Figure 6.1. A stakeholder can be in the position of fully supporting a project or completely opposed to it. Nevertheless, all these positions must be taken into account in a stakeholder analysis, since the goal of doing this exercise is to know what each stakeholder thinks about a project, and to know what each stakeholder can do to promote it or to stop it. It is also important to note that the stakeholder analysis is a tool for knowing the population, rather than "convincing them" of one aspect or the other of BRT.

Table 6.1 lists the various stakeholders potentially affected (negatively or positively) by a BRT initiative as well as the possible position taken by the stakeholder. Actual positions by these stakeholders will clearly depend upon the local context.

A full analysis will likely include the following elements:

- Stakeholder identification;
- Interests and motivations of stakeholder;
- Likely position to be taken on project;
- Resources and mandates;
- Perceived problems;
- Solutions to perceived problems.

By going through this analytical process, a strategy can be crafted which addresses the concerns of each stakeholder. Table 6.2 outlines a partial stakeholder analysis that was conducted for a public transport project in Palmira.

Fig. 6.1
Spectrum of stakeholder positions

Table 6.1: BRT stakeholders and expected project position

Stakeholder	Possible position
Municipal departments	
Department of Planning	Possibly a supporter of transit priority measures but the reaction will vary by individual predisposition
Department of Transport	Some staff may prefer rail transit while others will see BRT as a good opportunity for bus sector reform
Department of Public Works	Some engineers may have a preference for rail or car-based infrastructure projects, but a busway project could be of interest
Department of Health	Likely to be highly supportive of measures that reduce accident victims and improve air quality
Department of Environment	Likely to be highly supportive of measures that reduce air contamination and noise
Department of Sports and Recreation	Likely to be highly supportive of measures that reduce air contamination
Department of Commerce / Economic Affairs	Concern will be expressed over economic impacts, but likely to be persuadable if given sufficient evidence
Traffic police	Sometimes un-supportive of transit priority projects; may see such projects as creating additional congestion for mixed traffic
Private Sector	
Existing transit operators	Deeply suspicious of any changes from the status quo; will require a concerted information campaign to persuade, can be an important opponent of the system if not properly addressed.
Rail project proponents	May be most serious source of opposition to a BRT project, or may support a BRT project integrated with their network.
Construction industry	Generally highly supportive
Real estate industry	May or may not be supportive
Chamber of Commerce	Likely to be quite persuadable if the right economic case on congestion relief can be made
Car dealerships, petrol stations, car repair shops	Opposed to any initiatives that may contribute to a reduction in vehicle ownership
Insurance industry	Highly supportive of measures that reduce accidents and improve overall health
Retail shops	Concern will be expressed over impacts on sales
Telecommunications, water, and sewer companies	Will be concerned about any possible displacement of their utility lines.
Large industrial and business complexes	Will be supportive if project helps improve employee access and reduces congestion hindering current deliveries
Public services	
Schools and universities	Supportive if improves student access; research staff can help to plan project and document its impacts
Hospitals	Likely to be supportive if potential use of priority lane improves response times by emergency vehicles
Civil Society	
Environmental NGOs	Highly supportive of measures that reduce pollution and noise
Community-based organisations	Highly supportive of measures to improve safety and the aesthetic quality of street
International NGOs and foundations	Highly supportive of cities creating best practice examples with potential for replication elsewhere
User groups	
Car owners	Concerned about loss of road space for private vehicles
Public transport users	Highly supportive of BRT-type improvements
Physically disabled persons	Supportive if appropriate access is provided

Table 6.2: Stakeholder analysis table for public transport project in Palmira

Group	Interests	Resources & mandates	Problems perceived
Passengers	To have a reliable low-cost public transportation system	• Willingness to pay for reliable bus transportation	• Poor reliability of bus transportation • Drivers do not drive carefully • Frequent accidents • Frequent passenger injuries • Frequent breakdowns • Drivers are rude
Non-passengers	Reduction of traffic jams	• Some willingness to use bus system if reliable	• Frequent traffic jams
Bus Drivers' Union	Better working conditions for bus drivers	• Strong influence on bus drivers; membership is 100% • To represent the interests of its members in collective bargaining	• Low salaries • Extended working shifts • Vehicles in poor condition • Streets and roads in poor condition
Public Bus Company	To provide an essential, safe, cost-efficient public service	• Fleet of buses • Operating budget, including municipal subsidy • To provide an essential, safe, cost-efficient public service	• Vehicle fleet is old • Buses are poorly maintained • Fares charged cover only 75% of operating costs • Decrease in demand • Many passenger complaints
Public Works Department	Improve roads in Palmira	• Annual operating budget allocated by City Council/Mayor • To build and maintain adequate roadways within Palmira city limits (including far-away neighbourhoods)	• Roads are in poor condition • Budget is insufficient • Increasing traffic congestion
Mayor of Palmira	• To have a reliable low-cost public transportation system • Decreased congestion	• Commands popular support • Has veto power over City Council decisions • To serve the best interests of the City of Palmira • To serve as chief executive and city manager	• Increasing congestion. • Many citizen complaints about transportation system
Palmira City Council	• Decreased congestion • To have a reliable public transportation system	• Approves and has oversight of annual Palmira budget • To serve the interests of the residents of Palmira • To make the final decision regarding all projects presented to be financed by the Palmira budget	• Increasing congestion

Source: http://www.iadb.org

6.1.3 Existing public transport owners and staff

"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, political philosopher, 1469–1527

6.1.3.1 Public transport owners

Typically, the most difficult negotiations for developing a BRT system will be with the existing transit operators. Change is never easy and likely will be resisted regardless of the benefits of the intended change.

This set of circumstances is typically true for BRT and existing transit operators. BRT can improve profits and working conditions for existing operators and drivers. However, in many countries, the sector is unaccustomed to any official involvement, oversight, or taxation, and operators often carry a distinct distrust of public agencies. In cities such as Belo Horizonte (Brazil), São Paulo (Brazil), and Quito (Ecuador) proposed formalisation of the transport sector has sparked violence and civil unrest. In Quito, the existing operators blocked the functioning of the new Trolé system. Finally, the military was ordered into the situation in order to restore order (Figures 6.2, 6.3, and 6.4).

Fig.s 6.2, 6.3, and 6.4
Existing operators in Quito violently protested the 1995 opening of the Trolé system. The week of unrest only ended after the intervention of the Ecuadorian military.
Photos courtesy of El Comercio

Existing transit operators may be quite sceptical of any change, especially when the change may have ramifications on their own profitability and even viability. In many 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. The existing operators can effectively compete to win operational concessions within the proposed BRT system. Fleet operators and owners typically gain through the synergies of network development that produce improved profitability.

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

In many cases, an effective outreach effort with the operators can help dispel unfounded fears. Visits to cities with existing BRT systems can be quite appropriate for private transport operators

Fig. 6.5
Victor Raul Martinez, owner of TransMilenio operating company Si99, talks to a delegation from Johannesburg.
Photo courtesy of Lloyd Wright

(Figure 6.5). Many of the fears that the operators may hold about BRT can be successfully dispelled with a first-hand view of a system. Further, private operators are probably most convinced by speaking directly with operators in other cities which have already experienced a conversion from conventional services to BRT. Discussions between different private operators are thus a very effective mechanism to create an atmosphere of support and trust.

That being said, it is critical that the political leader of the BRT project not allow the former transit operators to hold hostage the public interest. Developing the new system will inevitably require difficult and contentious negotiations with transit operators. Allowing the new system to be defined by the narrow interests of the transit operators can significantly compromise good quality public transit service.

6.1.3.2 Drivers, conductors, and other existing staff

"Finding a good bus driver can be as important as finding a good musician."
—Reba McEntire, singer, 1955–

The transit company owners, though, are not the only persons directly affected by the re-organisation of the sector. Employees, such as drivers, conductors, and mechanics, will all be quite concerned about how the changes will affect their livelihood. Since these workers are typically from low-income communities, any employment or income impacts will carry with them considerable social equity concerns.

The most common concern of the employees will be any job loss or reduction in wages stemming from a conversion to BRT. Since BRT vehicles typically hold greater customer capacity than existing transit vehicles, drivers and other employees will fear that there will be a significant reduction in employees. A single articulated bus will have a capacity of 160 passengers while a standard minibus or midi-bus may only hold a capacity of 16 to 35 passengers. Thus, a new BRT vehicle may end up replacing anywhere from 5 to 10 existing vehicles. With the spectre of potential job retrenchments, the drivers themselves may take to the streets to protest against the development of a BRT system (Figure 6.6).

However, any negative employment impacts from BRT re-organisation are often offset by

Fig. 6.6
Public transport workers in Cuenca (Ecuador) protest against regulatory changes.
Photo courtesy of El Comercio

Fig. 6.7, 6.8, and 6.9
The upgrading to BRT brings with it many workplace benefits to the system's staff, including locker and shower facilities, lounges, and recreational areas.
Photos by Lloyd Wright

other factors and new employment opportunities. Quite often, existing drivers may work very long hours in order to make a marginal income. In many developing-nation cities, a driver will essentially rent the vehicle from an owner for a fixed daily fee. The driver thus has an incentive to work as long as possible in order to recoup this daily investment. As will be seen with the BRT business model later in this Planning Guide, the incentive to work excessive hours is eliminated with BRT. Instead drivers make a fixed salary and work a more rational shift schedule. Thus, instead of a single driver worker a single 16-hour shift, the new system may employ four different drivers to work four 6-hour shifts. Further, the efficiencies gained from BRT operations typically mean that the drivers will gain a higher income even within the reduced working hours. Additionally, the BRT system will bring with it improved work conditions, health care, training, uniforms, and other benefits (Figures 6.7, 6.8, and 6.9).

BRT re-structuring will likely not only bring with it "better" jobs but also "more types" of jobs. There are many types of employment that existing systems may simply not include in their operational make-up. For example, existing services may not include any security staff, or existing drivers may double as fare collection staff. There may be only a minimum of maintenance and administrative staff in an existing operation. With the conversion to BRT, all these unfilled or under-filled positions are fully formalised (Figures 6.10 and 6.11). Thus, the creation of new positions can also do much to mitigate any potential job reductions elsewhere.

For these reasons, many new BRT systems have actually increased and not decreased employment. Nevertheless, it is not inconceivable that a set of circumstances could arise in which job reductions may occur. Given the sensitivity of transit-sector employment, it is highly recommended that cities foresee these possible circumstances and take strong measures to mitigate employment impacts. If some employment reduction cannot be avoided, at the very least cities should implement remedial actions such as re-training programmes and job placement support.

6.1.4 Rail interests

After transit operators, the next most likely opposition to a BRT project are competing project proponents, frequently proponents of an alternative rail-based technology. Ideally, the selection of an appropriate mass transit technology should follow a rational weighing of alternative costs and benefits of different systems, and the best alternative for each corridor established and grounded in a master plan for an integrated long term mass transit network. In such cases, BRT and rail interests may both be providing critical links in a network, and be mutually supportive.

Fig. 6.10 and 6.11
Formalising the public transport system brings with it new employment opportunities that were previously not part of the operations. Security staff (left photo) and maintenance workers (right photo) may be some of the new positions created.
Left photo by Carlos Pardo
Right photo by Lloyd Wright

In other cases, however, particularly when a middle income city is developing its first mass transit system, there is likely to be competition for the most profitable mass public transport corridors. Well-funded rail project proponents will sometimes disseminate misinformation about BRT which can be highly convincing to decision makers and highly damaging to public support.

Determining how to situate a new BRT project with respect to previously developed rail proposals on high demand corridors is often one of the most difficult political decisions the BRT proponent will need to make. Ultimately, if corridors can be found that will be financially viable and likely to yield political acceptance of BRT with less opposition than other corridors, certainly these corridors might be considered in phase I. Because BRT systems can be built quickly, rapid implementation of a good BRT system is the most important thing.

If a BRT system is being introduced in competition with a rail project in a similar corridor, it is generally a good idea to call on government officials to conduct an open and transparent alternatives analysis, where both project proponents make public the detailed plans. BRT proponents must be ready to provide the public with accurate facts about the potential of their own proposal, but they also must demand full public disclosure of competing proposals, and be ready to challenge the often exaggerated claims of competing proposals. Metro, tram, or monorail proponents might make very public claims that they will require no government subsidies, will attract large numbers of motorists from their cars, and take away no road space from private motorists. BRT proponents must be ready to challenge these claims. Chapter 2 on transit technology options provides some materials that should give planners some reasonable expectations about the possibilities of competing transit technologies.

6.1.5 Motorists

While lobby groups representing automobile interests can sometimes create powerful political opposition to BRT implementation, their opposition should not be taken for granted. Providing motorists and their organizations with accurate information about the planned BRT project and its projected impact on motorists can sometimes turn a misinformed opposition into a supporter. Motorists are generally not happy about traffic congestion and feel something should be done. Some motorists may be looking for a high quality alternative to driving for at least some trips. Most motorists support mass transit, if only in the hope that it will be used by others. In some cases, BRT will actually improve private motor vehicle travel.

While in the developed world automobile owners may represent a majority of the population, in developing countries, automobile owners may represent less than 15% of the population. The political power of motorists is disproportionate to their numbers, however, because they usually include the wealthiest, most influential socio-political grouping. The degree to which private motorists are organised varies greatly from country to country. Sometimes BRT projects have been implemented with little resistance from motorists, and other times motorists have raised significant concerns, often through the media. Some private motorists will view BRT development as an expropriation of their own transport infrastructure, while others will be enthused about the development of a high-quality mass transit alternative.

The idea of prioritising road space to public transport may appear to be counter to the interest of private vehicle owners. However, sometimes separating public transit vehicles from other traffic will improve conditions for private vehicles. Since public transit vehicles stop more frequently, and may represent the majority of vehicles on the road in some countries, the separation of these vehicles from mixed traffic can actually improve flows for all.

The specific impact on mixed traffic will depend on local circumstances. This impact can be predicted in advance. Getting accurate information to the motoring public can prepare motorists with reasonable expectations about the new system. If the system has been designed well, it is likely that there will be minimal adverse impacts to motorists, and sometimes there will actually be positive impacts. If the new system really does create negative impacts for motorists, then project proponents should be ready for this and prepare a campaign to justify the project anyway on equity or environmental grounds (Figure 6.12).

6.1.6 Public transport users

Existing public transport customers are obvious allies in gaining the political will to push a transit improvement project forward. Public transport users are likely to be the single most forceful group with the most to gain from improved services. Unfortunately, in many cases, public transport users are not well-organised into strong lobbying groups. However, when public transport users do join together as a single voice, their influence can be significant. The Bus Riders Union of Los Angeles has been successful in gaining the notice of public transport decision makers (Figure 6.13).

In cities such as Quito, passenger demonstrations have proved to be a counterpoint to the demands of the private operators. Passenger groups may protest against fare increases while private operators request such increases in order to provide a better service. To a certain extent, such tensions can stimulate a healthy debate. However, in other cases, it can lead to political gridlock and violence (Figures 6.14 and 6.15).

Fig. 6.12
Staff of the TransJakarta BRT system disseminate information to motorists about the new system.
Photo courtesy of ITDP

6.1.7 Municipal departments

With any new project, deciding which government agency or agencies will be in charge of the project, or if a new agency needs to be created, is likely to be a contentious process. Agencies and their staff that are excluded from the planning and development process may react in ways that will be detrimental to eventual implementation. Some groups may interpret their exclusion as evidence that the new transit project is counter to their interests. Excluded agencies may also feel threatened that their domain of responsibility and influence is being eroded. In such instances, the excluded

Fig. 6.13
The Bus Riders Union of Los Angeles has proven to be a powerful voice of change in improving public transport conditions.
Photo courtesy of the Bus Riders Union

organisations may oppose and even obstruct the project development process. This is especially relevant since local authorities have many legal and administrative tools to stop the project. If they are properly addressed in future steps of the pre-planning process, they can use these tools to contribute to the project's success.

Most contentious is generally the role of the regulatory body responsible for the existing public transport operators. Often the allocation of route licenses and operating licenses generates both licit and illicit revenues for government officials, and the potential loss of these revenues is frequently a major concern to the regulatory body. If this same agency is given responsibility for the BRT project, it may be that the agency itself is covertly attempting to undermine the project. A powerful mayor, backed by public interest groups, can generally overcome these problems with enough political will.

6.2 Developing a communications strategy

"The greatest problem in communication is the illusion that it has been accomplished."

—George Bernard Shaw, playwright, 1856–1950

Communications on a BRT project has two components. First, a strategy is needed for communicating with direct stakeholders, or "active targets", including:

- Public transport operators;
- Other government agencies involved or affected by the project;
- Internal project team.

Secondly, a strategy is needed for communicating with the general public, or "public targets".

Normally at the very beginning of a project, it is advisable to release general information to both stakeholders and the general public about what BRT is. Since BRT is a relatively new concept, it is quite likely that few of the stakeholders will have a detailed understanding. Information about the successful systems in cities such as Bogotá and Curitiba usually serves this purpose well. Speaking engagements and press briefings from representatives of existing BRT systems are frequently good mechanisms to begin public understanding (Figure 6.16). Inviting key stakeholders and media representatives on study tours of cities with successful BRT systems has also been an effective way to further the education process (Figure 6.17).

A political announcement that a BRT project is underway is an important milestone in a BRT project. Once the political leadership announces that a BRT project will be built, there will immediately be much public interest in the project. Thus, well before this announcement is made, a full communications strategy should be well articulated. The likely reactions of all the major stakeholders should be considered prior to placing the public spotlight on the project.

6.2.1 Setting up the communications team

One of the first full-time employees selected for a project should be a communications director. Communications within the project team will be a principal determinant in the effectiveness and efficiency of the planning process, and communications with outside stakeholders can be determinant in whether the project is approved for full implementation.

Fig. 6.14 and 6.15

Proposed increases in bus fares in Quito lead to violent protests.

Left photo by Alfredo Lagla
Right photo by Diego Pallero
Photos courtesy of El Comercio

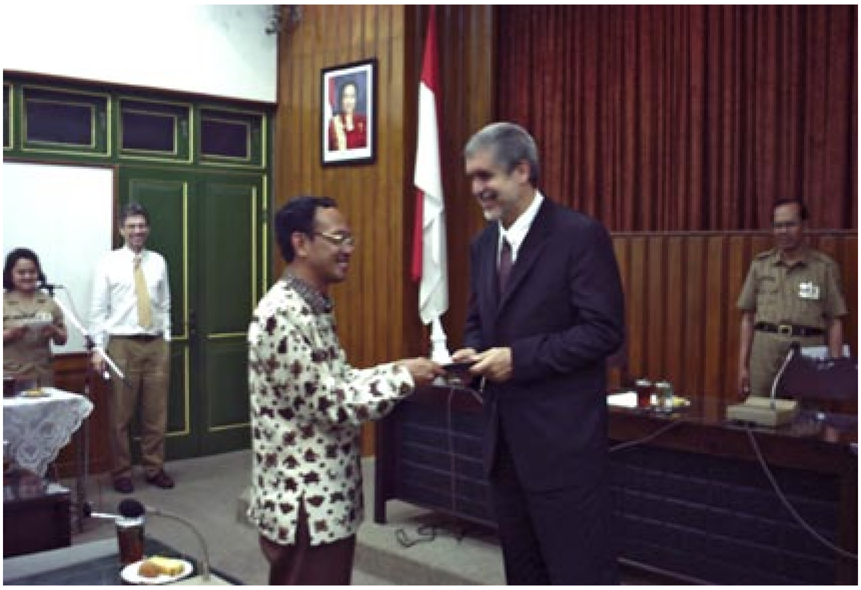


Fig. 6.16
Former Bogotá Mayor Peñalosa discussing the political advantages of TransMilenio with Jakarta Vice Governor Budihardjo, 2001.
Photo courtesy of ITDP

Fig. 6.17
TransMilenio staff explaining the system to Jakarta Governor Sutiyoso, 2003.

Given the different levels of communications, several spokespersons could be appropriate, especially when differentiating between internal and external communications. As a high-profile public project, the main political leader (whether it is the Mayor or Governor) will have a significant stake in the project's progress and outcome (Figure 6.18). Thus, the political leader may designate a specific spokesperson to handle the critical lines of communications, especially with regards to the news media. This spokesperson will be empowered to answer questions on behalf of the political leader with regard to the project. The political leader and their appointed representative are generally responsible for ongoing communications with the project steering committee as well as mayor stakeholder groups such as the news media.

The project spokesperson may be a communications expert or it may be one of the departmental directors overseeing the planning. The chosen person should have a strong command of the project details as well as a high degree of verbal communications skills. The official spokesperson or spokespersons for the project will be the public face of the project, necessitating public statements before television, radio, and other media outlets.

If a project spokesperson is not clearly named by the political leaders, then multiple persons related to the project may be placed in positions to provide information to the public and other stakeholders. However, without a carefully scripted set of replies to media and public inquiries, then the communications message can be inconsistent, and worse, sometimes incorrect. Ultimately, this lack of a communications strategy leads to confusion amongst the stakeholders and reduces public confidence in the project.

Internal communications amongst the project team and the project steering committee also need to be carefully managed. If communications are infrequently provided, then steering

Fig. 6.18
As suggested by the amount of news media attention given to the project, the Jakarta BRT initiative had significant political ramifications for Governor Sutiyoso.
Image courtesy of ITDP

committee members will feel disenfranchised from the project. In such cases, obtaining project approvals to proceed at specific milestone points will be more difficult. Providing regular project updates to all, either through verbal or electronic mediums, helps to ensure everyone remains involved and informed.

For some critical stakeholder groups, such as existing public transport operators, the project team may designate a person to specifically handle those communications on a full-time basis. This sector-specific spokesperson will likely remain in close contact with the political leader to ensure the direction of the stakeholder relationship remains consistent with official policy.

The information campaign targeted at the general public is generally best led by competent public relations professionals. In a large municipality, a press office may also play a role in this process. However, given the importance of a new public transport system to a city, procuring a professional public relations team with an outside perspective is usually the recommended course. Some of the activities to be undertaken by the public relations team will include:

- Preparation of press materials;
- Organizing press conferences;
- Development of a media strategy.

Social scientists may also be part of the public relations team, especially when there are sensitive issues that have been shown in the stakeholder analysis (for example, the concern for job loss from existent operators).

In the case of TransMilenio, the Director of the TransMilenio Project was a direct appointee of the Mayor, and was empowered to speak on all matters related to TransMilenio on the occasions when the Mayor himself was unavailable. He was assisted by project staff, and also by time and effort donated by a large bank for a public relations campaign. This individual summarised his communications activities with:

> "As Director of the TransMilenio Project, I dedicated a great deal of my time to discussing the new transportation system and explaining its benefits to political, business, and religious leaders as well as other associations and interest groups. I attended a number of round table discussions, panels, and conferences. I was also interviewed by different media, prepared official press statements, and attended several debates and forums in order to discuss the issues" (de Guzmán, 2005).

In the case of TransJakarta, no official spokesperson was designated, and the public received conflicting information from the Department of Transportation and the head of the TransJakarta Task Force. However, prior to the system launch, the Governor did hire a consulting firm to organise press events and also to design and disseminate television and radio advertising. NGOs also played a key role in TransJakarta in both disseminating information about the project, as well as criticising mistakes being made by the planning team.

In the case of Delhi, a professional public relations firm was contracted out by the project team headed by the Indian Institute of Technology.

In the case of Dar es Salaam, the project management unit had a project director responsible for managing the project as well as a project coordinator, who was responsible for communicating with all the key stakeholders. The ultimate spokesperson for the project, however, was initially the Mayor.

A budget for publicity and advertising should be assigned, and every other resource available should be used to increase marketing opportunities.

6.2.2 Promotional materials

Promoting the new BRT system with both private interests and the general public generally requires the development of some fairly standard promotional materials. While this material should be crafted to particular political needs, certain materials are fairly standard:

- Branding and logo;
- Images of the new system;
- Three dimensional models;
- Route map;
- Simulation videos.

The system branding, logo, and slogan should be crafted with great care and marketing insight by a professional marketing firm. Chapter 18 of this Planning Guide provides more detail on the development of a full marketing package.

Fig. 6.19
This rendering of a proposed BRT station in Las Vegas helps to convey a positive and modern image to the public and helps relate the new system to the local community.
Image courtesy of the City of Las Vegas

Because the general public will likely have relatively little knowledge of BRT, a package of visual materials may be an effective mechanism for introducing the concept. *Visual renderings* of the new system are a standard part of any public relations campaign. The better the quality of the rendering, the more useful it is for public relations. Some excellent renderings of the planned Las Vegas BRT stations show how the system will incorporate traditional neon signs evoking the glamour of Las Vegas connect the planned system with a sense of municipal pride (Figure 6.16). Showing people how their city can be transformed by the new BRT system can generate lots of enthusiasm and a strong desire on the part of the public to see the project implemented.

With the advent of affordable and user-friendly software, such visual renderings can be accomplished fairly quickly at a modest cost. In most cases, the special enclosed stations with pre-board fare collection as well as the modern vehicles make BRT a visually appealing option, especially to developing-nation residents accustomed to sub-standard bus services. Thus, sophisticated renderings of the system can do much to stimulate public enthusiasm for the project.

Three dimensional models can also be quite effective ways of explaining to both the public and to stakeholders how the BRT system is likely to work, and giving them a sense of what it might look like (Figure 6.20).

The future route map is a fundamental part of the BRT public relations campaign. The route map creates a sense among stakeholders that the new system is indeed likely to be implemented (Figures 6.21). Getting a mayor or a governor to publish a future proposed route map for a BRT system, particularly a route map that has a similar appearance to a metro map, will be a

Fig. 6.20
Three-dimensional model of the new Dar es Salaam BRT system.
Photo courtesy of ITDP

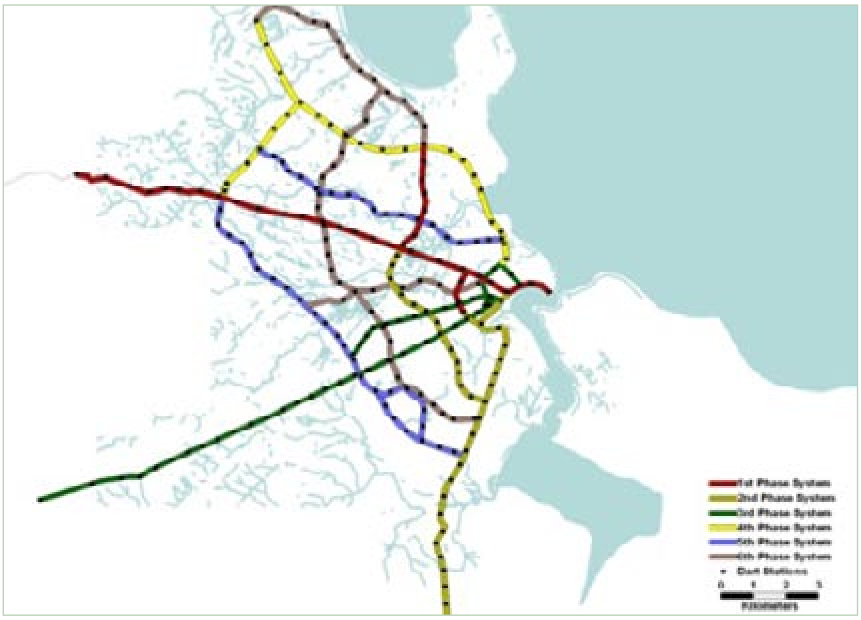


Fig. 6.21
First full future corridor map for the DART system, Dar es Salaam.
Courtesy of Logit Engenharia

signal of political seriousness, and create a sense of project inevitability which will be critical to winning over the general public. The route map shows commuters how they will benefit from the new system. For this reason, it is important to not only indicate the Phase I routes but also the likely routing for the entire completed network.

Finally, it is increasingly viable to economically produce a simulation video about the problems with the current transportation system and the proposed future BRT system. TransMilenio of Bogotá made a series of short videos about the future BRT system that aired on national television. Such videos often discuss the current conditions faced by public transport users and provide a visual portrayal of the future system. A successful technique is to trace the movements of customers as they make their way through the system. A successful video will allow the public to gain a sense of what it would feel like to ride on the new BRT system.

6.2.3 Communications strategy for active targets

"Active targets" or "private targets" refer to those stakeholders with direct financial interest or direct planning involvement in the project. These stakeholders will likely have an intimate engagement with the entire planning process. Frequent and detailed communications with these groups will be essential to avoid creating opposition and delays to the project. As a minimum within any BRT initiative, tailored communications strategies should be devised for three critical active targets:

1. Existing public transport service providers;
2. Local authorities; and the
3. Internal project team.

6.2.3.1 Existing transportation service providers

The communications strategy with key private stakeholders serves two crucial functions. First, targeted messages to these groups can help dispel concerns and preoccupations that could evolve into resistance to the project. Thus, these communications can help pre-empt potential future obstacles to implementation. Second, communications with these groups can lead to better design and execution based on their own observations and recommendations.

In the process of transforming a city's public transportation system, existing transport service providers are key agents. Although they may become obstacles to the transformation process, they can also represent an important group of supporters if handled properly. The operators stand a very good chance of realising a significant improvement in their long term profitability from the new system. Being able to communicate effectively with all the people involved in their operation (business leaders, bus owners, bus drivers, and administrative personnel) is essential. These operators also possess critical system information, and securing their support will make the planning process much easier. Addressing their concerns is also crucial to the viability of the system in the long term (Figure 6.22).

The communications team should strive to get existing service providers involved in the transformation process in order to minimise their opposition to change. Transportation service providers are not usually organised as a homogeneous coalition. In fact, there are several agents with several distinct interests within the transportation industry. It is necessary to investigate and analyse the interests of each identified agent, their concerns and resources. For instance, the driver's interests are different from those of a bus owner, while the latter also differ from the interests of executive managers or administrators of transport companies. Moreover, when one encounters unions or coalitions, the interest group's leader may have different interests than the group's individual members.

Just as engineers carry out technical designs and economists plan financial strategies, a team of specialists in strategic analysis, communications, and negotiation processes must lead all discussions with existing transport service providers. In Bogotá's case, a team of eight people was assembled featuring economists, lawyers, psychologists, sociologists, and negotiation experts. This team was in charge of handling discussions with existing transport service providers during a period of two years.

The team members' first task should be to learn everything there is to know about a city's transportation industry, in order to create a socio-political map. A *socio-political* map is a tool which provides profiles of all key agents in the transportation industry, be it individuals, companies, or groups. It is quite helpful for analysing each agent's particular concerns and its implications. The map should feature background information, interests and positions in the process, associations, dealings, strengths, and weaknesses. Gaining a deep understanding of the way a city's transportation industry operates is essential when trying to transform it. Becoming an expert is the only way in which one can trace the correct path towards change and develop the according strategy.

In TransMilenio's case, a dossier with profiles of each one of Bogotá's seventy transportation companies was created. The files included their background, history, relevant documents, names, routes, and financial statements, among other details. The files also included information on transportation interest groups, associations, and each one of their respective leaders. At the end of the research period it could be said that the team knew better the industry and company details than the industry members.

Once the socio-political map is in place and the stakeholder analysis has been developed, a detailed communications plan and strategy must be laid out. The plan should be used as a flexible guide, as constant revision and updating will be needed. The plan should list all required activities and the person responsible for their execution as well as the respective due dates, duration, and correlation, as this information is needed to develop an activity critical path. With this plan, it will be easier to control the work team's activities as well as monitoring all progress towards achieving the desired results and goals.

Direct interaction and discussions between the project managers and existing transportation service providers are indispensable. However, this activity is a time consuming task that requires constant attention. The process involves attending interest group meetings and various union assemblies, as well as holding discussions with all of the transportation service providers' executive management teams and boards of directors. Attending the aforementioned events is important because the subject matter being discussed is vital to the existing transportation

Fig. 6.22
The public transport sector as it appeared prior to TransMilenio in Bogotá. Engaging the existing operators and demonstrating the benefits of an improved system is fundamental to making a BRT project happen.
Photo by Lloyd Wright

Fig. 6.23
Dar es Salaam BRT project team leaders discuss the proposed DART BRT system with an association of Daladala owners.
Photo courtesy of ITDP

service providers and to the project, in its own right. Also, direct conversations create an atmosphere of trust, commitment, and transparency among the parties involved. This interaction in turn, provides Project Managers with deeper understanding of the other parties' motivating factors, interests, positions, and aspirations. Also employing the direct discussion method excludes all unnecessary intermediaries and avoids any interest group agendas or political mediation (Figure 6.23).

All subject matter should be studied carefully prior to discussion. Also, a team member should be made responsible for keeping minutes that summarize the main issues discussed at every meeting.

The communications strategy should be developed around a select number of key themes. In Bogotá's case, the main messages developed included:

1. Industry failure
   "The transportation industry in Bogotá has failed to keep up with industry changes in other cities and other industries. Currently, the transportation industry employs obsolete technology and uses outdated employment practices, financial plans, and management strategies." The aforementioned tendencies were constantly explained, in depth, at forums and assemblies. Finally, members of the transport industry, themselves, realised the nature of the crisis and concluded that change was necessary, at least for a group of managers that generated a critical mass.
2. Urban form and efficiency
   "A transportation system, as a fundamental public service, significantly affects a city's structure and functioning. Transportation service providers are not always conscious of the great impact their businesses have on people's daily lives. An outdated, unorganized, poorly run transportation industry affects each citizen's quality of life negatively. City mayors and public officials must intervene in the transformation process, in order to assure the greater good is being served." This message should strive to explain the reasons behind the city's intervention in transforming the industry.
3. Social well being
   "Society's well being is above that of any individual. This basic civic concept conveys the fact that the transformation process is taking place to serve society's interests, which supersede those of a select few, like incumbent transport service providers. This concept will set a precedent for future discussions with members of the transportation industry. It will make it clear to them that imposing those conditions, which solely favour their interests and aspirations, is not acceptable."
4. Inevitability of industry transformation
   "Change ***will*** happen, whether incumbent service providers participate in the process or not, and even if they challenge it. A social modernisation process that to sets out to appropriately meet society's needs is inevitable. Opposing such change will imply taking on higher risks and costs than cooperating with and being part of the process." This was a key message in the communications with the industry, because it sent a message that they could be a key partner but that they were not going to be delaying the overall goal.
5. Opportunity
   "Within every crisis lies an opportunity. This message suggests that in every crisis some may suffer, but others, who seize available opportunities successfully, can emerge from the crisis in a stronger position." The message invites people to choose whether they want to come out of the transformation process as victims or as winners.

All of the communication plans' activities, discussions, and negotiations, should be carried out following a strict professional practice standard. It is best to follow one of the many available negotiation strategies instead of allowing personal feelings to steer the process.

Discussions with existing transport service providers should be educational. Project success depends on whether or not the industry can change its way of thinking, professional practices, and operating methods.

While direct discussions are an effective instrument in achieving this purpose, trips abroad to view other transportation systems can be an excellent complement. This way, operators can witness actual examples of alternative and successful operating systems first hand. The operators should also be made aware of means that might help them make all the required changes, such as training on financial analysis, human resources management, and customer service.

6.2.2.2 Local authorities

New projects of this nature will clearly need some approval from at least one level of government, be it city, state, or federal. Communicating effectively with government officials will allow the project to run smoothly and will prevent internal opposition.

The objective is to receive the necessary project approval, construction permits, debt consent, legal faculties, and financial resources from governmental entities in order to complete the project. One must also seek permission to make any changes or adjustments deemed necessary.

Interaction with government officials demands specialised professionals, familiar with all formalities and procedures, so that approvals and permits can be obtained from the competent government agencies. It can be useful to hire specialised lawyers and individuals with political insight of the city's key players and their respective interests, positions, and aspirations.

Socio-political mapping should be done again, this time focused on city norms, procedures, formalities, processes, requisites, waiting times, and competent agencies. The socio-political map is an essential tool in guaranteeing the project's success as quickly as possible. Even extraordinary projects have failed because they could not effectively deal with the bureaucratic apparatus. A plan listing required activities, responsible parties, due dates, estimated duration, interrelation, will help in tracing the project's critical path. It will also prove to be an indispensable tool for monitoring, controlling, and executing tasks or activities.

The communications plan must revolve around trying to secure as much political support as possible, both from the party in power and the opposition. The new system must be portrayed as a city project, as its design, development, and completion might take several years, with different stages of development possibly taking place under several administrations. One must always keep in mind that the project does not solely consist of building an initial set of corridors, stations, or roadways, but rather, that its main focus is creating a comprehensive citywide system. Employing long-term forward thinking from the project's inception is important, so that future expansion permits and budget approvals can be incorporated into the urban development plan, making room for the project's future growth.

In Bogotá's case, approval was secured for a fifteen year plan that included earmarking a significant percentage of a petrol tax to finance the new system. A deal with the national government was also signed whereby it agreed to finance the 60 percent of project's cost for eight years. The deal was extended later for an additional seven years, and allowed systems expansion. In Transantiago's case, in Chile, a legal and financial structure that would integrate all bus, feeder, and corridor networks to the city's Metro system was achieved.

6.2.2.3 Internal project team

Creating a new BRT authority and new private bus operators does not simply involve filling a corporate charter or opening a bank account; it primarily entails putting a team of capable individuals together.

Internal communications serve the purpose of getting the work team on the same page when it comes to supporting the project's vision and mission statement. It allows the work team to share a modern urban philosophy, designed around modern transportation systems and the concept of public space.

The project director's individual leadership is not enough. The director must get the work team to believe the dream is achievable, if hard work and a sense of urgency are in place. Provoking social changes requires effort and involves overcoming numerous obstacles and opposition forces. Also, figuring out all the details associated with the implementation of a new transportation system demands creative ideas and critical thinking. Success depends on putting together a creative, cohesive, professional and dedicated work team.

Sufficient resources and time should be dedicated to selecting the members of the project team. Having highly qualified and experienced individuals is an asset, but intangible qualities such as being open minded, creative, optimistic, forward looking, and not afraid of change are probably of even greater importance.

Work should be divided among multidisciplinary teams, as transportation systems are very complex, and can encompass legal, judicial, economic, engineering, and sociological aspects among others. They key to a successful system transformation lies in employing a collective creative process.

As noted earlier, developing a BRT system is a full-time job. Team members cannot be expected to deliver a quality system if they have numerous other project responsibilities. Focussing the minds of everyone on the task at hand is one of the principal organisational tasks of the project director. In Bogotá's case, aside from constant teamwork regular planning sessions were held on both Mondays and Fridays in order to review progress and plan next steps. Subject matter used in these sessions was often more conceptual than evaluative or practical. There was a continual effort to instil a uniform city concept and urban philosophy that would inspire the work team and be reflected in their efforts.

Fig. 6.24
Street campaign organised for TransJakarta helps to build awareness for the new BRT system in a lively and engaging manner.
Photo courtesy of ITDP

6.2.3 Communications strategy for the general public

"It is insight into human nature that is the key to the communicator's skill. For whereas the writer is concerned with what he puts into his writing, the communicator is concerned with what the reader gets out of it."

—William Bernbach, advertising executive, 1911–1982

The communications strategy for the general public ("public targets") is quite different from the strategy for "active targets" in both its aims and its objectives. The purpose of the public communications strategy is to:

- Educate the public about the benefits of the new system;
- Prepare the public for the difficulties they are likely to face during construction and the transition;
- Win ridership for the system when it opens;
- Isolate critics and strengthen the hand of the project designers in the negotiation process;
- Develop a mechanism for ongoing consumer input.

The development of a communications strategy for the general public is more frequently handled by public relations professionals, but generally this is still lead by the BRT authority or the project office. Whether the public relations strategy is led by a public relations office in the Mayor's office, or by a private firm contracted to the Mayor's office or the BRT authority, information about the project to be released to the general public must be carefully developed and scrutinised before being released to the public.

Establishing a schedule for when the media can reasonably expect further detailed system information should be a principal first step. Usually, because the preparation of the plans is done under contract, the general timing of the release of new reports is known, and press briefings and public hearings can be planned accordingly.

The general public will have little prior knowledge of the BRT concept, and thus basic educational materials and campaigns will be required. The instruction process requires the use of specialised media with the capacity to reach target audiences. The language used must communicate instructions precisely, accurately and as simple as possible to target individuals and communities. If possible, easy to understand illustrations should be used. These communications should also include relevant contact information for persons seeking further details.

Fig. 6.25
Creative approaches to public outreach, such as through mimes and entertainers, can be a highly-effective mechanism for disseminating information in a memorable manner.
Photo by Lloyd Wright

Information is effectively passed on to target audiences through television, radio and printed press. The agency in charge of promoting the project should regularly supply the press with images, maps, written press releases, and statements from authorised personnel, so that this information can be released to the general public at an opportune time.

However, direct outreach, while sometimes costly, is probably the most effective in delivering a memorable message. Given the array of commercial messages the public receives on a daily basis, it can be quite difficult for the new public transport system to compete for attention. Street campaigns and personal contact directly with the public can raise awareness of the system beyond the normal level of commercial marketing (Figure 6.24).

In Bogotá's case, the city utilised a programme known as "Mission Bogotá" to conduct personal outreach to members of the public. The city employed more than 300 young people from low-income communities to serve as outreach ambassadors for the proposed system. The campaign began six months before TransMilenio was commissioned and it mainly took place at bus stations and aboard regular buses, but also included civic gathering places and local schools. At these locations, the outreach team of Mission Bogotá would discuss the project directly with the public and personally answer any questions or concerns. The programme also made use of many highly creative forms of outreach mimes, comedians, and puppets. Many cities now utilise these techniques to impart transport information in a congenial and light-hearted manner (Figure 6.25).

Bogotá officials also made a special effort to target children as a principal outreach group. Children are often more receptive to new information than adults and can thus become real champions of a new public transport system. Effectively communicating a project to children through in-school outreach initiatives may also be the best mechanism to ultimately reach parents and other adults. Children are often quite excited to explain new information to others. In Bogotá, the communications team organised educational materials and encouraged activities such as drawing contests. The communications team also prepared jigsaw puzzles and

Fig. 6.26
Before the system was launched, Transantiago has already posted a website informing all stakeholders of the system's characteristics.

Lego-style toy buses for use in schools. Brochures, magazines, and videos were developed in order to provide educators with appropriate educational tools.

Additionally, key social actors and organisations may be appropriate for a targeted outreach. Civic, business, and community organisations represent potential first-mover adaptors who can be influential in mainstreaming a new project. Direct, individual sessions with the leadership of these organisations as well as with the membership itself can reap many dividends in terms of educating the wider public.

Educating the general public and public transportation users is a gradual process, which must be carefully planned and executed in order to be successful. Logical messages must be repeated until they have been learned and successfully adopted.

The educational process should not only seek to modify habits and customs, but it should also aspire to encourage civic values like respect. Examples of some of the value-driven messages can include:

- Wait in line out of respect for those who arrive first;
- Offer seats to a pregnant woman out of respect for the life she is carrying;
- Offer seats to the old and young to ease their comfort;
- Refrain from vandalism and show respect for public goods;
- Place litter in a trash receptacle and maintain the quality of the system;
- Do not smoke out of respect for the health of others.

The educational campaign's budget must be calculated during the project's initial stages in order to assure that it is allocated with the required financial resources. Expert consultants should be considered for many of these activities.

The stronger the hand of the system designers in relation to existing bus operators, the better deal they will be able to negotiate for the public. In the case of TransMilenio, the communications team issued press releases almost on a daily basis not only about the future system, but also illustrating the many problems with the status quo. Whenever a pedestrian was killed by a private bus operator, or a private bus operator crashed due to poor vehicle maintenance, another press release would be issued. This generated a lot of political pressure on the private operators to reform the system.

A system website can also be a useful tool in terms of both disseminating basic information as well as acting as a feedback tool with future customers. The website should contain a list of Frequently Asked Questions (FAQ) for the system in order to quickly address the most common inquiries. The website may also have a form for users' questions about the system, and it should be revised and answered (if possible, also published in the website itself) as frequently as possible (Figure 6.26).

6.3 Public participation processes

"Tell me and I'll forget. Show me and I'll remember. Involve me and I'll understand."
—Confucius, philosopher, 551–479 BC

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.

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

Though public participation may sometimes seem a superficial approach that will have little effect in the project's success, it is a key element in the long term. For instance, if people's concerns are not addressed properly or a particular group is unsatisfied with the process, there can be negative effects such as vandalism, riots or legal measures taken against the system and its development. The communications process is one step towards achieving this goal, but there are other permanent tasks from the project's management which can ensure a more "integrative" approach at the system's planning and development.

Once the project is in place, one of these actions is to include a representative of the general public in the system's Board of Directors, who can be appointed by a relevant municipal authority, the system management or the public itself. This step will ensure that all users' are "represented" in the decisions that are being taken regarding the system. The position of the public representative should be open to election on a periodic basis.

Various mechanisms can be utilised to facilitate participation from community members. These mechanisms include:

- Neighbourhood information sessions;
- Interviews with specific NGOs and community-based organisations;
- Town hall meetings;
- Focus groups;
- Polling of existing public transport passengers;
- Telephone outreach;
- Website and email communications.

Fig. 6.27
Public participation session in Manila for a project supported by USAID.
Photo by John Ernst

Each of these options carry with them different cost implications. In general, the more personal the participation process, the more costly it will be. However, in comparison to other system components, expenditures on public participation processes will be modest. Further, the design and operational advice gained from actual public transport users can be invaluable to the system's long-term performance.

Individual sessions directly with user groups or other interested organisations are amongst the most productive in terms of information gathering. Under the leadership of a skilled facilitator, these sessions can be particularly illuminating (Figure 6.27).

A somewhat more specialised participation technique is known as focus groups. This technique can improve knowledge about the population which will take part (active or passive) in the BRT project. It is similar to a group interview, in which specific topics (focus points) are addressed by a person moderating the discussion between participants.

The focus group interview is a means to recollect briefly but in depth, a significant volume of qualitative information. It is based on a discussion with a group of people, who are guided by an interviewer to express their knowledge and opinion regarding specific topics. In the case of BRT, the focus group can revolve around user satisfaction, characteristics of the system, proximity to work and study, safety issues, health issues and perceived performance of the system. Focus groups usually have the following methodological characteristics:

- Consists of 6 to 12 people;
- Sessions require around two hours of time.

The typical procedure for a focus group is as follows:

- Introduction of the topic by the moderator;
- Instructions on the dynamics of the meeting;
- Emphasis on the objective being to understand the group's experiences and impressions;
- Development of the interview: starting with general themes and then introducing the specific topic of the meeting, focussing on the most important issues;
- Closing of the interview: summarising the findings and checking notes taken during the meeting.

To achieve a greater success of a focus group, it should be developed by professionals in social sciences who are external to the project management and organisation, but they must have detailed information of the system's characteristics. It is also important to note that a focus group is not a tool to persuade people, but rather to know their points of view in order to address them appropriately in system planning and in the communications campaign.