

**Introduction**

**Part I Project Preparation**

**Part II Operational Design**

**Part III Physical Design**

**Part IV Integration**

**Part V Business Plan**

**► Part VI Evaluation and Implementation**

**Resources, Annexes, and References**



**Bus Rapid Transit  
Planning Guide**

June 2007

## Part VI – Evaluation and Implementation

### CHAPTER 19



Evaluation

### CHAPTER 20



Implementation plan

## 19. Evaluation

*“Never measure the height of a mountain, until you have reached the top. Then you will see how low it was.”*

—Dag Hammarskjöld, former UN Secretary General, 1905–1961

The true impact of new public transport system is not simply the physical system but rather the improvements that it creates in people’s lives. There are several reasons why the promoters of a new public transport system will want to evaluate the expected impacts of the system on traffic levels, on economic development, on

environmental quality, on social interactions, and on urban form.

Quite often, these evaluations are in fact required by financial institutions or development agencies. Governments and development agencies alike have a need for prioritising among good and bad projects. Further, decision makers need to know in advance what problems they may need to mitigate, and what possible benefits the system will bring to help sell the project to the public. This chapter reviews the standard evaluation methodologies that can be utilised in projects such as BRT initiatives.

The topics discussed in this chapter include:

- 19.1 Traffic impacts
- 19.2 Economic impacts
- 19.3 Environmental impacts
- 19.4 Social impacts
- 19.5 Urban impacts
- 19.6 Monitoring and evaluation

### 19.1 Traffic impacts

*“The new American finds his challenge and his love in the traffic-choked streets, skies nested in smog, choking with the acids of industry, the screech of rubber and houses leashed in against one another while the town lets with a time and die.”*

—John Steinbeck, novelist, 1902–1968

Planning a BRT system is generally an iterative process, and having some preliminary sense of the likely impact of the new BRT system on mixed traffic will play an important role in the design process. However, before a city opens a new BRT system, it is a good idea to have a clear idea of the specific traffic impacts of the project, so that the public can be prepared, and any adverse traffic impacts mitigated ahead of time. For this reason, the traffic impact assessment is generally a short term assessment of what will happen to mixed traffic soon after the system opens.

The initial modelling work used to select the appropriate corridors and generate the projected

BRT ridership numbers will be helpful but insufficient to do a traffic impact assessment and mitigation plan. Usually, during the preliminary design process, the planners will try to engineer the system in a way which not only improves the speed and capacity of public transport services, but also improves conditions for mixed traffic, cyclists and pedestrians. Such “win-win” design solutions are generally the best way to ensure the acceptance of the BRT system by the general public. However, such “win-win” solutions are not always possible, and frequently some compromises have to be made. Knowing the likely impact of different design decisions on mixed traffic speeds and pedestrian and cycling conditions is critical to helping the political leadership make difficult choices in the final design phase.

Once these difficult decisions have been made, and the initial design and planning work has been completed, it is appropriate to examine with greater precision how the new system will affect the city’s transport system. Motorists, taxi operators, and others currently using the



**Fig. 19.1**  
*In cities such as Pereira (Colombia), documenting the chaotic road conditions prior to the implementation of the BRT system can help to justify the project.*

Photo by Lloyd Wright

road network will want to be reassured that the development of the BRT system will not lead to deteriorating traffic conditions (Figure 19.1). Conversely, if a decision maker decides to go ahead and make mixed traffic conditions worse in order to increase public transport speeds, they should be prepared to justify this decision to the public rather than being taken by surprise by a negative public reaction. A traffic impact analysis can help provide the political reassurance that the system will deliver its promise.

Once the full operational plan of the system is completed, a traffic modelling exercise should be conducted to project how the designed system will affect all forms of traffic, not only public transport passengers. The design information from the operations and infrastructure plans are necessary as inputs into the model. However, the information required for the traffic model to design the BRT system is generally far more limited than what is required for modelling system-wide traffic impacts. Usually to design the system, planners can get away with fairly robust demand estimates for the BRT system itself, and not worry too much about what is happening outside the BRT system. Using this method, good designers use their judgement to

design a system that minimises adverse impacts on mixed traffic, but information about site-specific traffic impacts is probably not sufficiently detailed.

A detailed traffic impact assessment will be done differently depending on whether or not the city has a full traffic model for all travel modes, or just a more limited model of only the BRT system.

If the city has a fully calibrated traffic model, it should be possible to determine with reasonable precision the likely impacts on mixed traffic in the BRT corridor at site-specific locations. If the city does not have a fully calibrated traffic model, it should be possible for most engineers to use standard engineering parameters to estimate the impact on mixed traffic, based on the following:

- The amount of functional road space available to mixed traffic;
- The amount of road space available to cyclists and pedestrians;
- The capacity of the intersections for mixed traffic;
- The number of buses and paratransit vehicles that have been removed from the mixed traffic lanes.

Normally, if engineers know the current level of motorised passenger car equivalents (pcus) passing through the BRT corridor, the existing functional road space available to mixed traffic, and the signal phasing at the intersections, one can get a fairly good idea of how the new BRT system will affect mixed traffic speed and capacity.

It is also critical to know at this point what impact the new BRT system will have on existing bus and paratransit services. Because existing bus and paratransit services tend to stop frequently in one or more curb lanes, these vehicles tend to have a severe adverse impact on mixed traffic conditions (Figure 19.2). If all existing bus and paratransit services will be removed from the mixed traffic lanes and these trips relocated to the BRT system, then the number of PCUs in the mixed traffic lanes will also drop significantly. If, on the other hand, the chaotic stopping movements of paratransit vehicles in the BRT corridor are allowed to continue in the mixed traffic lanes after the BRT

system is opened, then the risk of adverse traffic impacts is much higher.

Finally, the above impacts of the new BRT system will have an influence on the level of modal shift that one can expect from the system. Estimating this modal shift is often important to justifying the project to funders concerned about greenhouse gas emission reduction benefits, such as the Global Environmental Facility (GEF).

If the speed and the capacity of mixed traffic lanes are severely compromised by the BRT system design, this will tend to increase the short-term modal shift that can be expected. Alternatively, if the system is well designed to minimise the adverse impacts on mixed traffic, it is highly likely that the short-term modal shift benefits will be minimal. In this case, the modal shift benefits will manifest themselves primarily in later years as the BRT system maintains its mode share, whereas normal bus services would be expected to lose mode share over time.

Most of the time, adverse mixed traffic impacts of new BRT systems are concentrated at either the station area, where more road space is needed for the BRT system, or at the intersections, where changes in signal phasing and the reduction of road space available to mixed traffic have the most significant adverse impact on mixed traffic speeds. In these locations, it is a good idea to suggest some additional mitigating measures.

Normally, in developing countries, there are a host of simple, standard traffic management measures that have not yet been implemented in the corridor that would dramatically increase the roadway capacity and speed for mixed traffic. Implementing these measures at the same time as the BRT system will make it quite easy to mitigate any adverse impacts on mixed traffic from the BRT system. These mitigation measures might include:

- Reducing the number of signal phases by restricting low-volume turning movements;
- Removing parking;

**Fig. 19.3**

*In building a station lay-by for the Quito Central Norte line, the planners cut away virtually all remaining space for pedestrians.*

Photo by Lloyd Wright



- Tightening enforcement of restrictions on vendor activity;
- Improving channelisation (i.e., separation of different modes);
- Adjusting the length and number of queuing lanes;
- Widening the road at intersections or at station area or both.

**▲ Fig. 19.2**

*The random and often unpredictable stopping patterns of existing public transport services can imply that a segregated busway will greatly improve conditions for private cars.*

Photo by Lloyd Wright



Unfortunately, traffic modellers rarely concern themselves with non-motorised transport (Figure 19.3). However, if a BRT system narrows sidewalks or increases mixed vehicle speeds, it can have a fairly adverse impact on non-motorised travel, and might contribute to blight in a corridor. When the Santa Amaru corridor was constructed in São Paulo, for example, the narrowing of sidewalks contributed to blight in the corridor. In some countries, notably India and China, simply segregating bicycle and bus traffic can lead to dramatic improvements in the safety, speed, and capacity of both bike and bus facilities.

Conversely, if a BRT system is implemented simultaneously with improved facilities for cycling and walking, the improved corridor may lead to significant modal shift from taxi to walking and cycling trips. This modal shift will help contribute to improved traffic speeds in the mixed traffic lanes. This phenomenon is observable in Jakarta and Bogotá, for example. As a general rule, as much pedestrian space and cycling infrastructure as possible should be provided in all BRT corridors, particularly where the corridor serves a large number of short trips, where there are heavy flows of cyclists and pedestrians, or where such heavy flows might be induced.

## 19.2 Economic impacts

*“Economic advance is not the same things as human progress.”*

—Sir John Harold Clapham, economic historian, 1873–1946

### 19.2.1 Economic evaluation of BRT projects

Development banks frequently require an economic analysis of any major infrastructure project. Economic analysis is usually performed to indicate that the economic benefit of the project is greater than its cost (including the opportunity cost of capital). As BRT projects generally fund the infrastructure investments from public sources, the public should be reassured that the project’s economic benefits will be greater than their economic cost. Currently, there are plenty of poorly conceived and planned BRT projects going forward that would never have passed a reasonable economic appraisal. As such, requiring any BRT project to demonstrate a reasonable economic rate of return should be a standard planning procedure for both governments and development institutions.

Because it will affect numerous decisions about financing, it is generally a good idea for the project promoter to decide early on which elements of the BRT project should be expected to be self-financing, and those elements which cannot be expected to be self-financing. As a general rule, BRT systems should be designed so that all operations including the cost of the vehicles are paid through farebox revenues (*i.e.*, self-financing). By contrast, the initial infrastructure investment and infrastructure maintenance is typically paid for by the public.

As such, the main cost that needs to be subjected to an economic appraisal is the cost of the infrastructure. Usually this includes the cost of the stations, the reconstruction of the right-of-way, the terminals and depots, signalling systems and any ITS applications, and the fare system. The engineering team in conjunction with the business plan team should generate these cost figures. Chapter 11 (Infrastructure) presented a infrastructure cost model that can assist in estimating infrastructure costs.

The benefits of the investment will then be calculated using standard cost benefit methodology. The primary benefits to be measured may include:

1. the decrease (or increase) in travel time of public transport passengers times total passengers,
2. the decrease (or increase) in travel cost faced by public transport passengers times total passengers,
3. the impact on travel time and travel cost of other forms of traffic, times the number of people affected,
4. the impact of the system on environmental quality (*e.g.*, air emissions, noise pollution) and any quantifiable benefits to health and/or productivity,
5. the impact of the system on accidents and the resulting reduction in injuries, loss of life, and economic productivity.

While some of this data can simply be taken from the traffic impact assessment, normally the traffic impact assessment is primarily concerned with what is going to happen to the traffic immediately after opening the system. By contrast, the economic evaluation will need to look at the projected system impacts for the

life of the capital asset, usually twenty years into the future.

The entire purpose of a BRT system is that it allows a single urban corridor to serve an ever growing number of passengers without diminishing travel speeds. This structure in turn makes possible the densification of the BRT corridor. For example, a new BRT system on a high-volume corridor will generally be designed in a location where the mixed traffic lanes are reaching capacity. Maybe these mixed traffic lanes currently handle some 2,000 to 4,000 passengers per hour per direction (pphd) at the peak hour (Figure 19.4). Normally, the capacity of the mixed traffic lanes would remain the same, whereas the new BRT lanes will now have the capacity to handle as many as 10,000 pphpd. If the system is using two lanes per direction, then capacities of 45,000 pphpd have been recorded (e.g., Bogotá’s TransMilenio). Not only does the BRT system make possible the densification of the corridor, it also virtually ensures that most new demand will be captured by the BRT system.

Defining and modelling scenarios for 20 years into the future with and without the new BRT system is a fairly typical traffic modelling exercise, with a few additional complexities. Normally, future trends are extrapolated from recent historical trends in population, employment, and vehicle ownership growth in the zones affected by the planned BRT corridor. Because the interactive nature of land use changes and public transport system improvements, one has to make certain reasonable assumptions about what will happen to population and employment growth in the corridor with and without the BRT project.

Without the BRT system, the 20 year projection should show a growth in motorised vehicular traffic and slowing speeds for both public transport and mixed traffic, until the lack of additional road capacity chokes off additional growth, at which point the assumption should be that new growth will go somewhere else. For



example, one might assume that population and employment growth in the corridor might relocate to some other location when traffic speeds drop below 10 kph.

With the BRT system, the 20-year projection would normally show a growth in motorised vehicular traffic and slowing speeds in the mixed traffic lanes until these lanes reach the design capacity. BRT vehicle speeds, by contrast, will be determined by the system design

**Fig. 19.4**  
*Mixed traffic lanes can generally only carry from 2,000 to 4,000 passengers per hour per direction at peak periods.*

Photo by Lloyd Wright



**Fig. 19.5**  
*While a mixed-traffic lane will reach saturation in a given period, public transport systems have a large capacity to handle continued corridor growth.*

Photo courtesy of ITDP

(ideally as high as 30 kph, at worst as low as 15 kph). These speeds should be assumed to be maintained throughout the 20-year life of the project, as the system should have been designed to comfortably handle 20 years of projected passenger growth (Figure 19.5). A safe general rule, therefore, would be to assume that the mixed traffic lanes will reach saturation, and that further growth in trips would be captured by the BRT system.

A primary difference between the BRT and non-BRT scenario in congested corridors would be that for the non-BRT scenario, after a certain number of years, population and employment growth in the corridor would stop, whereas in the BRT corridor it would continue at historical growth rates.

The economic appraisal of mass transit projects has been notoriously subject to manipulation by the project's promoters. One way to guard against abuse is to have the demand projections verified by an independent qualified evaluator. This entity should be a credible traffic demand modelling firm or agency whose results are trusted by banks.

Another way to minimise the risk of manipulation is to require that the demand estimate used in the economic benefits calculation be also used in the financial impact assessment, which in turn should be evaluated by private sector banking institutions.

To an extent, the business structure of BRT systems provides for a natural guard against overly-optimistic feasibility assumptions. In many toll road projects and metro rail projects, the system and its operations will ultimately remain in the public domain, and hence the losses incurred by wildly mistaken estimates must be absorbed by the hapless taxpayer. By contrast, with a BRT project, the private operator is typically responsible for vehicle procurement and must also absorb a significant share of the demand risk. Thus, when the private operator approaches a bank to lend money for the vehicles, the financial institution will likely insist upon some discipline with regard to the demand projections.

Once the 20-year scenarios (with and without the new system) have been developed, the difference in the net present value of the travel

time savings and cost savings of public transport passengers and the net present value of the travel time savings (or increases) and cost savings (or increases) for mixed traffic passengers can be compared.

Making this assessment requires giving a monetary value to time savings. This value can be calculated in several ways. The best way is to calculate the real value of time to existing public transport passengers. This value can sometimes be extrapolated from the traffic model based on observed behaviour. Otherwise, some reasonable value of time can be observed based on the observed demand on newly-introduced express bus services in the city, on new toll roads, etc. Alternatively, one can simply use a general rule, something between one-third and one-half of the average hourly wage rate.

If the net present value of the aggregate time and cost savings to public transport passengers and mixed traffic relative to the do nothing scenario is higher than the net present value of the cost of the infrastructure at a reasonable rate of return on capital, then the system is a good public investment.

As a general rule, if the BRT system serves a lot of existing bus passengers, and significantly increases travel speeds over existing conditions, the chances are good that it will perform extremely well in terms of the net present value calculation. On the other hand, if the BRT system is located on some elevated outer ring road with few bus passengers and no traffic congestion, the chances are that the economic rate of return will be extremely poor.

These measurements are fairly simple extrapolations from standard cost-benefit analysis techniques frequently employed in the transportation sector. However, cost-benefit analysis performs less well at estimating other important economic impacts, such as:

- Employment generation;
- Property values and land development; and,
- Technology transfer.

While these impacts are not generally included in a typical cost-benefit analysis, nor should they be, they are often important to decision makers and the impact of the BRT system on these issues needs to be considered.

### 19.2.2 Employment impacts

#### 19.2.2.1 System construction

The new BRT system will likely represent a dramatic transformation of the proposed corridors. As with any project of this magnitude, the system will generate a considerable amount of employment through the construction process. Based upon similar projects from the past, it is possible to project the amount of employment and the duration of the employment from the construction phase (Figure 19.6). An additional measure of interest, particularly in the developing city context, can be the number of persons being supported by each construction job.

Due to the emphasis on high-quality infrastructure and services, BRT employment can range from artisan work on stations to the direct labour applied to road work (Figure 19.7). Construction jobs can sometimes be an important area of employment for unskilled labour groups. Employment generated for these individuals can be especially important since there may otherwise be limited opportunities.

Since BRT construction is not fundamentally different than other types of public works initiatives in the transport sector. Thus, standard methods of calculating construction job creation are adequate.

However, in some developing-nation applications, more labour intensive construction techniques may be preferred from an employment-creation standpoint. In such cases, standard employment multipliers will not be sufficient.

#### 19.2.2.2 Operations

New BRT systems will often have dramatic impacts on the nature and level of employment among bus and competing paratransit operators. These impacts will vary greatly from system to system depending on:

- whether the BRT system incorporates former bus or paratransit operators into the new system,
- whether the new system simultaneously shifts the bus routing structure from direct services to trunk and feeder services or not,
- whether the new system offers new services previously not provided by the old public transport system,



Fig. 19.6

*The construction of the BRT corridors can be a significant employment generator.*

Photo by Lloyd Wright

- whether the new system encourages significant new ridership from former car users.
- In most cases, the new BRT system replaces a system of weakly regulated private bus or paratransit operators. These private bus operations are frequently not terribly profitable, as there is a lot of overlap in services particularly on the trunk corridors, leading to fairly few passengers per bus even during the peak periods. The most successful BRT systems generally shift existing public transport services on trunk corridors to trunk and feeder systems, which tend to increase the number of passengers per vehicle. This process can lead to the replacement of six

Fig. 19.7

*Workers putting the final touches on the Transantiago stations.*

Photo by Lloyd Wright



**Fig. 19.8**  
*Conditions for drivers can dramatically improve with a new BRT system.*

Photo by Lloyd Wright



or more smaller buses, and their accompanying drivers and conductors, with one much larger bus on the trunk corridor. All other things being equal, this would lead to a reduction in total employment in the public transport sector.

However, employees in the bus sector typically find themselves confronted with a downward spiral of deteriorating numbers of jobs, and a deteriorating wage level, as more and more people switch to private vehicles. As such, BRT may be the only proven mechanism for maintaining long-term employment levels in the public transport sector. By increasing vehicle speeds and reducing operating costs relative to private motor vehicle travel, BRT can actually help maintain bus sector employment levels into the future.

Furthermore, the reduction in the number of small vehicles operating on the trunk corridors does not tell the whole employment story. The

standard mini-bus will generally operate with its single set of employees for as much as 16 hours in a day. The BRT vehicle will actually involve three to four different shifts of employees operating the same vehicle. Thus, the number of drivers will not appreciably change. When the feeder service drivers are included, BRT may actually increase the number of drivers (Figure 19.8). However, the big employment boost from operations stems from the myriad of positions created from fare collection, security, information services, cleaning, maintenance, and management and operations (Figure 19.9). Most of these functions did not exist in the previous informal sector.

A BRT system also generally brings with it significant improvements in the quality of the employment as well. The improved efficiency and lower operating costs in the new system will improve overall profitability. The allocation of these profits between better services for the public, better wages and working conditions for the workers, and higher profits for private investors, is determined by a negotiated political process. Union and civil society engagement in the process is therefore critical to equitable outcomes. Typically, workers in the informal transport sector may not receive any type of benefits package whatsoever. Within the new formalised system, employee training, medical and dental care, holidays and vacations, and sick leave would all be expected.

While it is entirely possible to design a BRT system with severe adverse impacts on employment, generally it has been possible and politically necessary to design BRT systems to have either neutral or overall positive impact on total employment. To date, few systematic analyses of the specific employment impacts of new BRT systems have been conducted, and the key decisions affecting overall employment levels have been determined through the political process rather than through any systematic technical analysis.

When setting the competitive bidding rules for private companies to operate the BRT system, it is possible to give additional points for firms which have greater capital participation from existing small bus operators as a way of encouraging the maximum level of participation in the

**Fig. 19.9**  
*A new formalised system can create many types of employment that never previously existed.*

Photo by Lloyd Wright



new system from workers from the old system. The new BRT authority should also set labour standards on all operating companies in the system to ensure equitable and just treatment of the work force.

### 19.2.3 Economic development impacts

As with all transport projects, there are frequently significant secondary economic development impacts that are more difficult to predict. Improving any transportation system reduces the costs of production and consumption in particular locations. Because a new BRT system can increase the total capacity of a road corridor by as much as ten times, this corridor can accommodate high levels of growth without any deterioration in travel speeds. As more and more families and firms co-locate along the corridor, the transport costs related to connecting employees with their place of work, producers with their suppliers and final markets, all drop. This reduction in total transport costs resulting from co-location are known by economists as “agglomeration economies”.

These agglomeration economies tend to be captured by firms in the form of higher profits, by families in the form of lower costs of living and higher incomes, and finally, by landowners in the form of higher land rent. The concentration of new apartment buildings, offices, and shopping complexes adjacent to BRT stations and terminals are evidence of a well designed BRT system that has resulted in agglomeration economies.

As noted in Chapter 2 (Transit Technology Options), property values have been shown to have increased along the busways in Brisbane and Bogotá. This evidence is also supported by previous research on property value increases near urban rail stations. Bogotá has already seen considerable activity in the development of commercial centres along the BRT corridor (Figure 19.10). The increase in property values mirrors the expected increases in customer numbers at stations and terminals. For this reason, there is evidence to suggest that shop vacancies decrease in the area, leading to employment opportunities.

However, if the BRT system is poorly designed, it is quite possible that a new BRT system can have negative impacts. Some busway corridors, such as the Novo de Julio/Santa Amaru



corridor in São Paulo, and the former busway along Avenida Caracas in Bogotá, were widely perceived as having blighted these corridors. In both cases, “open” busway systems tended to concentrate very high volumes of old, polluting buses into a single corridor. The excess of old buses led to slow bus speeds but very high levels of ambient air pollution in the corridor. Both corridors also ignored the importance of good pedestrian facilities. Both corridors have since been improved, modernising the bus fleet with cleaner vehicles and changing the routing structure to increase the number of passengers per bus and decreasing the total number of buses. The urban environment and property values along these corridors are now recovering.

There is no denying that these economic impacts can result, and that they are important. However, because of the uncertainty of any system’s impact on property values, the impacts are generally not included in the formal economic evaluation. Currently, few BRT projects are being blocked due to weak economic appraisals. It may at some point in the future emerge that a BRT system is refused financing from a development bank because the economic rate of return is too low due to these potential benefits are being excluded.

However, for the time being, the greater danger is that far more expensive metro projects will continue to use heroic assumptions about projected economic development benefits to justify

**Fig. 19.10**  
*A commercial centre under construction near a TransMilenio terminal.*

Photo by Lloyd Wright

**Fig. 19.11**

*A new system offers the potential to introduce advanced technologies into a city and a country for the first time.*

Photo courtesy of Advanced Public Transport Systems



projects of dubious economic benefit. As such, it is generally recommended that any economic development benefits for public transport projects be treated in a conservative manner.

#### 19.2.4 Technology transfer

As noted in Chapter 12 (Technology), the new BRT system can bring with it the introduction of many new technologies to the city's transport sector. These technologies include advanced transit vehicles, fare collection and fare verification devices, and intelligent transportation systems (ITS). The introduction of new technologies presents several opportunities for overall economic benefits. First, as noted with vehicle manufacturing, there is the potential for new investment and job creation through local production. Second, technology transfer can lead to establishing a local advantage in a particular technology that can lead to export opportunities. Third, the new technology can lead to spin-off opportunities with other applications for new businesses.

When setting the technical specifications for vehicles and fare systems to be used in the BRT system, appropriate technical considerations should be the first and foremost concern. However, it is possible to include in competitive bidding criteria additional points for vehicles that are locally assembled or manufactured, and for the use of other inputs with higher local value added content.

### 19.3 Environmental impacts

*“Because we don't think about future generations, they will never forget us.”*

—Henrik Tikkanen, author and artist, 1924–1984

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

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

LDVs – Gasoline		Blue cells = User-modifiable inputs White cells = calculations (better not to change)										
Variable	Region	Year										
		2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
<b>Annual LDV Passenger travel (bil passenger km/yr) LDV load factor from master LDV sheet used here</b>												
	OECD North America	6'596.4	6'734.8	6'991.0	7'417.0	7'820.6	8'100.2	8'343.6	8'563.4	8'766.3	8'955.7	9'135.8
	OECD Europe	2'956.8	2'853.6	2'710.9	2'550.8	2'438.1	2'368.3	2'343.1	2'315.9	2'287.9	2'260.3	2'232.9
	OECD Pacific	1'181.1	1'230.1	1'318.6	1'421.8	1'446.3	1'427.7	1'392.9	1'379.8	1'370.9	1'362.4	1'352.8
	FSU	572.9	663.2	780.5	934.4	1'136.3	1'270.3	1'435.3	1'583.3	1'701.0	1'809.7	1'898.6
	Eastern Europe	286.3	304.2	325.9	348.9	370.4	358.1	349.6	342.4	341.3	351.6	364.8
	China	296.8	405.3	575.6	822.5	1'164.2	1'506.1	1'955.9	2'488.6	3'099.5	3'833.0	4'678.4
	Other Asia	335.7	402.2	497.9	628.1	799.7	946.0	1'147.1	1'396.2	1'711.1	2'122.3	2'629.7
	India	107.4	154.9	220.8	309.4	425.8	524.9	654.4	818.6	1'037.3	1'340.9	1'744.6
	Middle East	151.4	171.1	203.5	249.8	310.9	362.1	421.9	480.9	538.0	598.9	659.3
	Latin America	646.2	795.0	980.3	1'204.5	1'470.6	1'624.4	1'852.4	2'121.6	2'442.9	2'835.5	3'272.2
	Africa	270.8	320.3	403.8	517.7	655.6	807.2	918.5	1'024.6	1'148.9	1'318.9	1'540.9
	<b>World Total</b>	<b>13'401.8</b>	<b>14'034.7</b>	<b>15'008.8</b>	<b>16'404.9</b>	<b>18'038.5</b>	<b>19'295.3</b>	<b>20'814.7</b>	<b>22'515.3</b>	<b>24'445.1</b>	<b>26'789.2</b>	<b>29'510.0</b>

**19.3.1 Environmental Impact Assessments (EIAs)**

*“We must learn to provide affluence without effluence... by consuming less from the environment, not more. We can use less, and have more. Consume less, and be more. The interests of business, and the interests of environment, are not incompatible.”*

—Tachi Kiuchi, former CEO of Mitsubishi

Impact analyses are often mandatory by law in terms of measuring the expected economic, environmental and social ramifications of the project. Completing an Environmental Impact Assessment (EIA) is also typically required by international lending agencies. The form of the EIA is generally well known but the practice of such assessments is still in its infancy in some nations. Currently, in developing countries and even in some developed countries, the environmental impacts that must be assessed according to law tend to focus mainly on the impacts of the construction process itself rather than on the longer-term traffic impacts. Similarly, to date, most BRT projects have completed EIAs following standard procedures established for any public works project. Since BRT should in most cases have quite positive environmental impacts and no more immediate adverse impacts from the construction process than any other civic work, from the standpoint of avoiding adverse impacts, this standard type of EIA is probably adequate.

Such a standard appraisal, however, will tend to ignore the significant environmental benefits of the system. Many funding agencies involved in financing BRT systems are doing so particularly because of environmental benefits. Thus, project developers should be motivated to measure the full actual and projected environmental benefits.

An EIA analysis of this type will typically involve comparing the baseline scenario (city without the public transport project) and the project scenario (city with project). Additionally, the EIA process may require the consideration of alternative options, such as road widening or other types of mass transit systems.

This sort of EIA, which is required in some countries when a new transport investment has to be demonstrated to be in conformity with prevailing ambient air quality standards, would normally use as an input the traffic impact analysis described above, and extrapolate the site specific emissions impacts from this traffic data. To do this properly generally requires inputting these traffic impacts into an emissions model, such as Mobile 5 created by the US EPA. Such models require additional information about likely tailpipe emissions under different operating conditions for the existing registered vehicle fleet. Most of these emissions models have not been calibrated for the diverse vehicle fleets frequently found in developing countries, so cruder methodologies for extrapolating the likely emissions impacts associated with the

**Fig. 19.12**  
*Excerpt from the IEA/SMP spreadsheet model.*  
Image courtesy of IEA/SMP

traffic impacts tend to be used. Typically, some values of emissions per vehicle-kilometre for different vehicle types will be available in studies, such as those studies produced through the World Bank's UrbAir programme.

Another useful source is the IEA/SMP spreadsheet model of the International Energy Agency and the Sustainable Mobility Programme (SMP) of the World Business Council for Sustainable Development (WBCSD) (IEA/SMP, 2004). The IEA/SMP spreadsheet is available on-line and provides reasonably good emissions data for most parts of the world (Figure 19.12).

**Fig. 19.13**  
*Vehicle emissions in Jakarta have a severe impact on health and quality of life.*

Photo courtesy of Swisscontact and the GTZ SUTP Photo CD



Once values of emissions per vehicle-kilometre can be obtained, an estimate of the new system's impact on each vehicle type using the corridor can be assessed.

The Environmental Impact Assessment should be conducted by an independent organisation with no relationship to the project or other input services to the project. Specialist consultants are thus frequently utilised to give an objective and independent analysis as well as to lend experience to the effort. An effective Environmental Impact Assessment can greatly aid the BRT development process by highlighting possible areas of concern and by suggesting design alternatives that will mitigate environmental impacts.

### 19.3.2 Local air emissions

#### 19.3.2.1 Emission impacts

Vehicle emissions are the predominant source of pollutants in many urban centres and are directly linked to severe health and environmental problems (Figure 19.13). In city centres, motorised vehicle emissions account for 95 percent of the ambient carbon monoxide (CO) and 70 percent of nitrogen oxides (NO<sub>x</sub>) (WHO, 2000). The vehicle fleet is also frequently responsible for a majority of the particulate emissions and some of the sulphur dioxide (SO<sub>2</sub>), which has particularly severe health impacts. The poor air quality in most developing cities limits economic growth and dramatically curtails quality of life.

The principal impacts from motorised vehicle emissions are:

- Health impacts, including respiratory illness, cardiovascular illness, and cancer;
- Economic impacts, including absenteeism and reduced productivity;
- Impacts on the built environment (*e.g.*, damage to buildings);
- Impacts on the natural environment (*e.g.*, harm to trees and vegetation);

Emission levels are set by national and international environmental agencies such as the US Environmental Protection Agency (US EPA), the European Commission, and the World Health Organisation (WHO). Emission

**Fig. 19.14**  
*Air quality in Shanghai on a normal day.*

Photo courtesy of Manfred Breithaupt and the GTZ SUTP Photo CD

standards include both ambient emission levels and tailpipe emission levels.

**19.3.2.2 Types of emissions**

“Local” or “criteria” pollutants refer to the types of air emissions that are most directly linked to impacts on human health. These pollutants include nitrogen oxides (NO<sub>x</sub>), sulphur oxides (SO<sub>x</sub>), carbon monoxide (CO), and particulate matter (PM). Additionally, vehicles emit air toxics, including benzene, formaldehyde, acetaldehyde, 1,3-butadiene, and acrolein. While emitted in relatively small concentrations, air toxics are highly dangerous carcinogens. Also, the combination of NO<sub>x</sub> and volatile organic compounds (VOCs) from vehicle emissions will combine in the atmosphere to form ground-level ozone (O<sub>3</sub>). Ground level ozone is also commonly known as photochemical “smog” and is associated with a host of pulmonary illnesses and the brown haze that permeates cities with excessive automobile emissions (Figure 19.14). Further, many developing countries still permit leaded fuels. Lead emissions are closely associated with several diseases including cancer and inhibiting the mental development of children. Although international efforts are under way to eliminate the use of lead, the majority African nations still utilise leaded fuels.

While cleaner engine technologies have somewhat mitigated these emissions in developed nations, the age and maintenance of developing-nation vehicles means that even relatively

**Fig. 19.15**  
*Air quality analysing equipment for NO<sub>x</sub>, CO, and PM.*

Photo courtesy of UNCRD



**Table 19.1: Air quality changes in Bogotá**

Pollutant	Daily average concentration before system, year 2000 (ppb)	Daily average concentration after system, year 2001 (ppb)	Per cent reduction in pollutant (%)
Sulphur dioxide (SO <sub>2</sub> )	6.8	3.8	44%
Nitrogen dioxide (NO <sub>2</sub> )	24.0	22.4	7%
Particulate matter (PM <sub>10</sub> )	50.8	38.6	24%

Source: Hidalgo, 2003

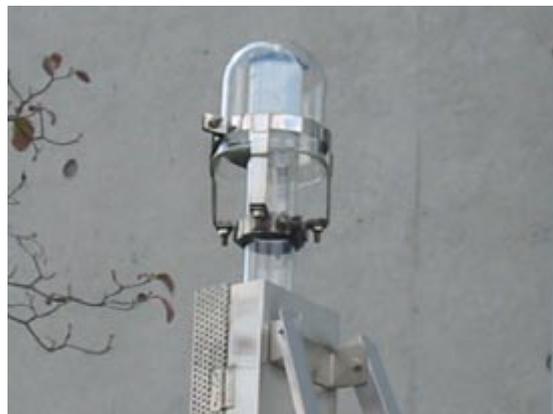
low vehicle numbers can create health and air quality problems.

**19.3.2.3 Air quality monitoring**

Ideally, an air quality monitoring system will already be in place prior to the implementation of the new public transport system. An established network of monitoring stations will facilitate before and after comparisons of air quality. Such stations in Bogotá helped to prove that the new BRT system indeed contributed to better air quality. Table 19.1 summarises the improvements in ambient air quality in Bogotá after the first year of TransMilenio’s implementation.

However, in many developing-nation cities, there may be an insufficient number of air quality monitoring stations or such stations may not exist at all. The cost of air quality monitoring systems can make it difficult for some local environmental agencies to install and maintain the devices. Further, some specialise training is required to ensure the air monitoring data is properly collected and analysed (Figure 19.15).

Discussions with both the national environmental agency as well as international organisations, such as the Clean Air Initiative, the World



**Fig. 19.16**  
*Air intake opening for monitoring of ambient air quality.*

Photo courtesy of UNCRD



**Fig. 19.17**  
*Spot monitoring of localised contaminant levels can be especially important for some key groups, such as informal vendors and traffic police, as evidenced with this image from Bangkok.*

Photo by Carlos Pardo

Bank, and regional development banks, should be undertaken to find a way of establishing an air quality monitoring network prior to the establishment of the new BRT system. In some cases, it may be necessary to add stations to strategic locations of the city in order to fully capture the mission impacts.

Air quality monitoring actually can encompass several different levels of measurement. Ambient monitors will capture the general background air quality levels of the city (Figure 19.16). These ambient measurements provide the basis for comparing to the established norms of the

World Health Organisation (WHO). However, there can also be reason to measure air quality levels at a much more localised level.

In many cases, the person walking along the street may experience contaminant levels well in excess of those experienced at the ambient level. Further, some susceptible members of society may be more exposed to contaminants than others. For example, the height of children means that they are actually more in the direct line of exhaust tailpipes. Low-income persons often work from informal stalls quite near the roadway, and may spend as much as 10 to 14 hours per day in an environment of intense emissions. Likewise, traffic police may spend long hours in direct contact with traffic and contaminants (Figure 19.17). For these special groups, spot monitoring of localised effects should be undertaken on a regular basis. In some cases, it may be possible to have individuals wear a personal monitor to record actual daily and weekly exposure levels.

Spot monitoring should also be conducted inside the BRT vehicles and stations as well. If ventilation is poor or if the station design creates a highly closed environment, air contaminants can build up to unsafe levels. With vehicles, there may be a difference in air quality between front-engine vehicles and rear-engine vehicles. For example, a front-engine vehicle may cause a higher concentration of emissions inside the vehicle. By monitoring the difference between such designs, the BRT authority can decide if they should alter their vehicle specifications.

Finally, vehicle emissions testing should be a formal part of the regulatory code, both for the new BRT vehicles as well as other existing public transport vehicles. Semi-annual or annual testing should be a base requirement to obtain an operating license for any vehicle. In addition, spot monitoring on the roadway can be a necessary measure. In some cases, operators may specially fix their vehicles to pass a known, one-off annual test. However, once the test is finished, the operators may remove filters and other emission reduction devices in order to improve fuel economy.



**Fig. 19.18**  
*Random, on-street spot monitoring of vehicles can be an effective way of ensuring regulatory norms are met in practice.*

Photo courtesy of UNCRD

Random street tests thus serve the purpose of ensuring the actual vehicle performance meets the regulatory standards (Figure 19.18).

**19.3.3 Greenhouse gas emissions**

*“Global warming is too serious for the world any longer to ignore its danger.”*

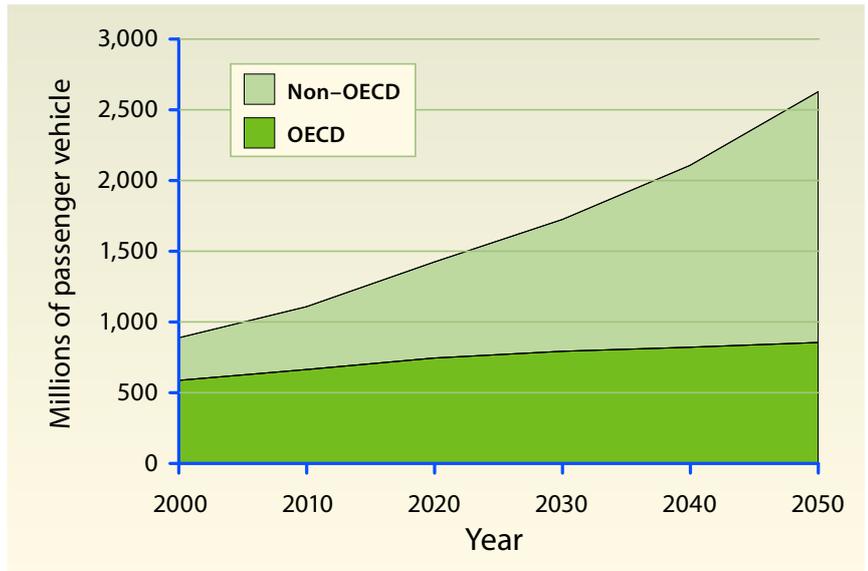
—Tony Blair, British Prime Minister, 1953–

**19.3.3.1 Global trends**

Vehicle emissions are the fastest growing source of greenhouse gas emissions worldwide. Emissions from the transport sector are growing at an annual rate of 2.1 percent worldwide and 3.5 percent in developing nations (IEA, 2002a). Representing 24 percent of greenhouse gas emissions from fossil sources, vehicle emissions have emerged as one of the most significant challenges in mitigating the effects of global climate change. In terms of total emissions from fossil fuel sources, the transport sector is second only to the generation of electricity and heat (39 percent) (IEA/OECD, 2003). Greenhouse gas emissions from motorised vehicles are predominantly carbon dioxide (CO<sub>2</sub>) but also include some emissions of methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O).

Much of the growth in transport sector emissions stems from the continued growth in the number of private motorised vehicles (*i.e.*, cars and motorcycles). The planet will soon reach a milestone of being resident to over one billion motorised vehicles. The International Energy Agency (IEA) and the World Business Council for Sustainable Development (WBCSD) has compiled a comprehensive set of spreadsheet analyses projecting transport trends between the year 2000 and 2050 (IEA/SMP, 2004).

Figure 19.19 shows the expected trends in vehicle ownership levels. There are two striking features of this graphic. First, despite the existing saturation of vehicle ownership in countries like the US, growth in ownership in these countries is expected to continue through 2050. Second, the rate of growth in developing countries is significant, resulting in the number of developing-nation vehicles surpassing the number of

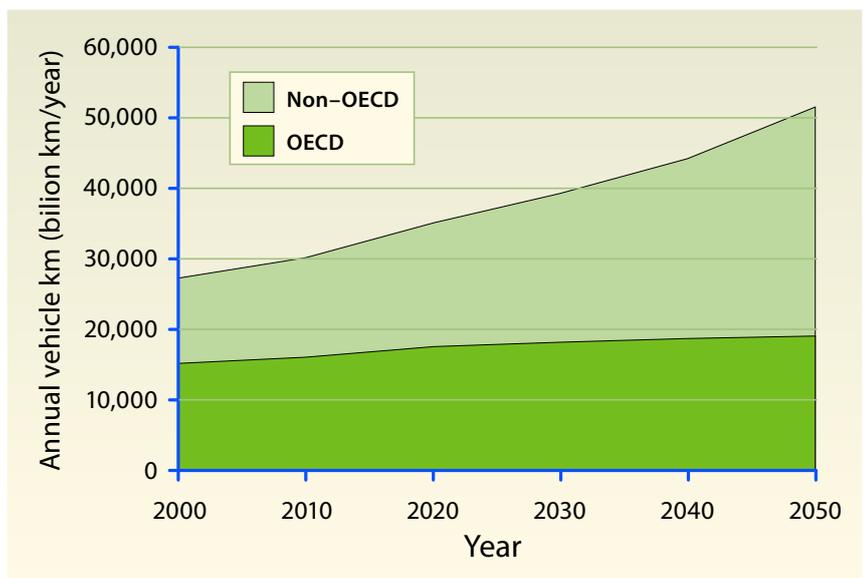


**Fig. 19.19**  
*Vehicle ownership by region*  
Source: IEA/SMP, 2004

vehicles in the OECD by 2030. Currently, there are approximately 982 million passenger vehicles worldwide; by 2050 this figure is projected to be 2.6 billion.<sup>1)</sup>

The growth in motorised vehicle ownership has largely followed trends in per capita income. Dargay and Gately (1999) show that in the per capita income range of US\$2,000 to US\$5,000 vehicle purchases jump sharply. Other factors affecting vehicle ownership growth are population growth, urbanisation levels, importation regulations, and the quality of alternative transport services. The relative lower cost of suburban housing versus urban housing can also increase the demand for private vehicles. Several major developing nations are entering the income zone of rapid motorisation.

**Fig. 19.20**  
*Vehicle usage by region (vehicle-kilometres travelled)*  
Source: IEA/SMP, 2004



1) “Passenger vehicles” include cars, motorcycles, three-wheelers, mini-buses, and buses. This value does not include freight vehicles, train carriages, water transport, or air transport.

**Fig. 19.21**  
*A generalised emissions equation that also notes the constituent components of emission sources.*  
 Graphic courtesy of Wright and Fulton (2005).

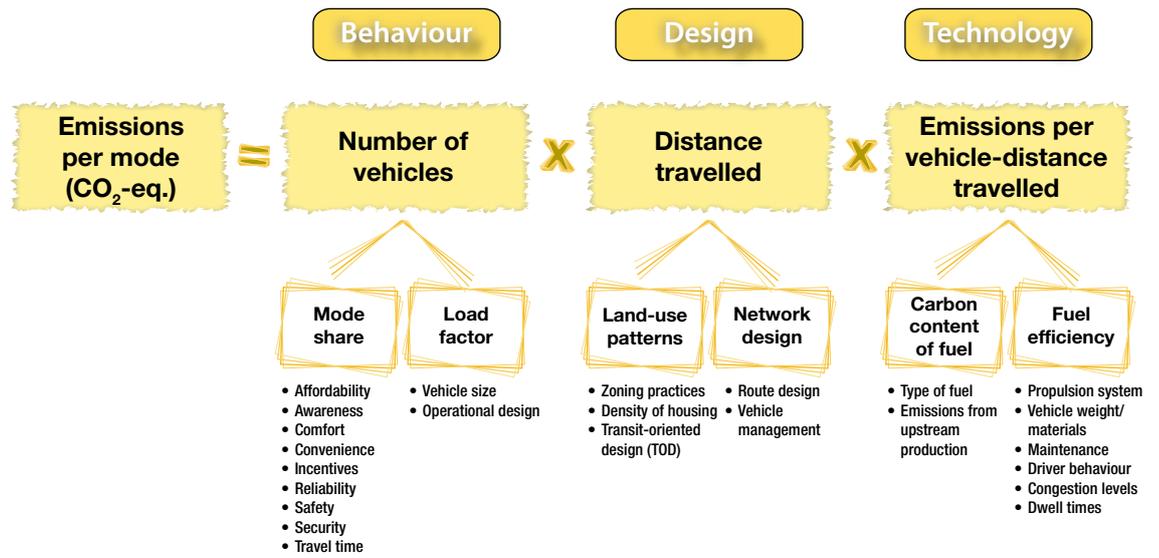


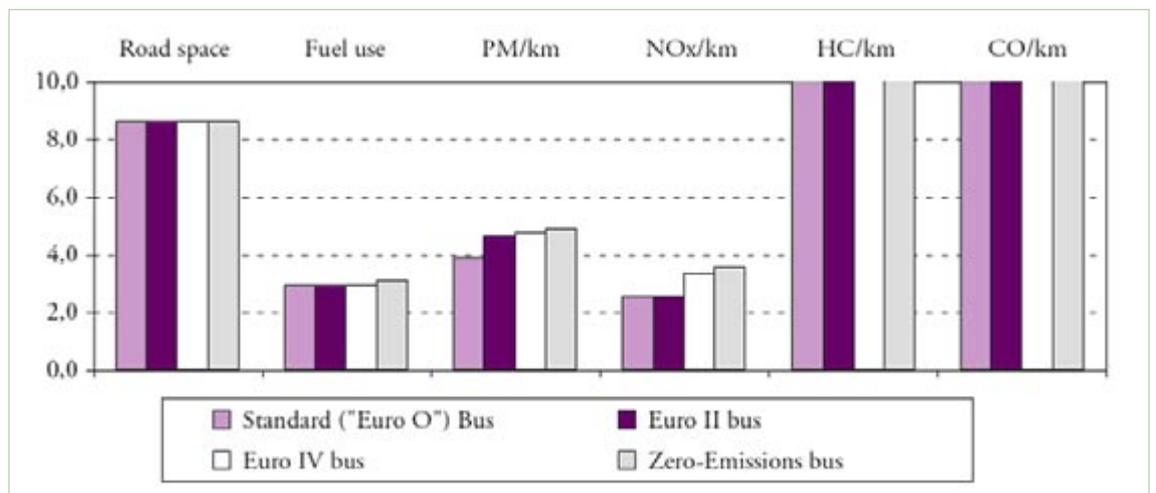
Figure 19.20 provides a projection of vehicle usage levels through 2050 for both OECD and non-OECD nations. Like vehicle ownership, vehicle usage is expected to grow for both OECD and non-OECD countries, with the highest growth rates in the developing world.

**19.3.3.2 Emissions model**

Figure 19.21 provides an overview of the general relationship between transport activity and emissions (Wright and Fulton, 2005). Figure 19.21 specifically provides the relationship between vehicle performance and carbon dioxide (CO<sub>2</sub>) emissions, but the equation given can also be extended to other pollutants as well. Each of the three principal elements, behaviour, design, and technology, has a basic role to play in minimising emissions. In reality, the emission profile of each pollutant type is

fairly complex. The ambient emission levels will likely vary by time of day, day of the week, and the season of the year. Climate, topography, vehicle use patterns, maintenance practices, and driving behaviour will all play a role. Additionally, interactions between different pollutants will also change the composition and level of pollutants.

The broadly-defined variables defined in Figure 19.21 each relate to constituent components that can be influenced to reduce emissions. For example the mode share component of the behavioural variable is affected by all the factors related to customer satisfaction, including affordability, comfort, convenience, safety, security, and travel time. By improving the quality of these components, more car users are likely to switch to public transport. Likewise, the design of the network and the resulting land-use



**Fig. 19.22**  
*Impacts of mode shifting to public transport*

**Table 19.2: Emission reduction costs for fuel technology scenarios**

Scenario type	Fuel/tech. type	CO <sub>2</sub> reduction	Incremental vehicle cost (\$US)	Incremental operating costs (US\$/km)	Refuelling infrastructure investment (US\$/vehicle)	Incremental fuel costs	Estimated cost (US\$/tonne of CO <sub>2</sub> )
Pessimistic	CNG	0%	30,000	0.02	20,000	Equal	NA
Optimistic	CNG	10%	20,000	0.02	10,000	Equal	442
Pessimistic	Hybrid-electric	5%	100,000	0.02	0	5% less	1,912
Optimistic	Hybrid-electric	20%	65,000	0.02	0	20% less	148
Pessimistic	Fuel cell	30%	1,000,000	0.05	50,000	100% higher	3,570
Optimistic	Fuel cell	75%	250,000	0.03	20,000	50% higher	463

Source: Wright and Fulton, 2005

patterns influence the number of trips and the average distance travelled. Transit oriented development (TOD) and good mixed-use design will influence both how people travel as well as their daily travel patterns. Finally, technology plays a role in terms of fuel quality and the fuel efficiency of the vehicle. A complete emissions reduction effort would likely address each one of these variables.

**19.3.3.3 Emission reduction potential of mode shifting**

The International Energy Agency (IEA) has conducted research to determine the relative impacts of mode share in comparison to different fuel and propulsion technology options. The IEA examined the emission impacts of shifting mode share by the capacity equivalent of one bus with a total capacity of 120 passengers. Even with the rather modest assumption of only a 50 percent load factor for the bus and only 8 percent of the passengers having switched from private vehicles, the resulting emission reductions were substantial. The projected reductions in hydrocarbon and carbon monoxide emissions per kilometre were over ten times the emissions of a single bus (IEA, 2002b). The reduction per kilometre of particulate matter, nitrogen oxides, and carbon dioxide (fuel use) ranged from two times to four times the emissions of a single bus (Figure 19.22).

Remarkably, the level of emissions reduced did not change significantly with buses of strikingly different emission standards. Buses with Euro 0, Euro II, Euro IV, and fuel-cell technology all produced roughly the same results. This result occurred because the relative impact of the tailpipe standard (and thus the fuel and propulsion

choice) was overwhelmed by the impact from mode switching. The IEA study notes that:

“Regardless of whether a bus is ‘clean’ or ‘dirty’, if it is reasonably full it can displace anywhere from 5 to 50 other motorised vehicles...” (IEA, 2002b, p. 12)

“Certainly, a cleaner bus will yield lower emissions, but in this scenario the emission reductions from technology choice are overshadowed by reductions from mode switching (and the resulting ‘subtraction’ of other vehicles)... Dramatic reductions in road space, fuel use, and most emissions can be achieved through displacing other vehicles with any bus, even the ‘Euro 0’ buses typically sold in the developing world.” (IEA, 2002b, p. 48)

The IEA results do not imply that fuel and propulsion technology should be ignored in achieving lower emissions. However, the results do suggest that these technologies alone only address a relatively small portion of the total emission reduction potential. Improving the efficiency of the transport sector and reducing emissions revolves around a full set of factors, including the many factors that are most important to customers such as cost, comfort, convenience, and security.

Further research has supported this analysis. In a comparison of the cost per ton to achieve carbon dioxide (CO<sub>2</sub>) reductions, fuel technology options were found to be significantly more costly than mode shifting options (Wright and Fulton, 2005). Table 19.2 summarises projected emission reductions costs for different fuel technologies (CNG, diesel hybrid-electric, and fuel cell technology). Given the uncertainty of the future improvements in these technologies, both an optimistic and pessimistic case is presented.

**Table 19.2: Impact of mode shifts on CO<sub>2</sub> emission reductions**

Scenario name	Mode shares	Tonnes of CO <sub>2</sub> over 20 years (thou.)	Tonnes of CO <sub>2</sub> reduced from baseline (thou.)	Cost of infrastructure	Cost per tonne of CO <sub>2</sub> (US\$ per ton)
BRT mode share increases from 0% to 5%	Automobile 19% Motorcycle 4% Taxi 4% Mini-bus 48% BRT 5% Walking 19% Bicycle 1%	47,409.7	1,905.5	US\$125 million (50 km of BRT at US\$2.5 million per km)	\$66
BRT mode share increases from 0% to 10%	Automobile 18% Motorcycle 4% Taxi 3% Mini-bus 45% BRT 10% Walking 19% Bicycle 1%	45,086.8	4,228.5	US\$250 million (100 km of BRT at US\$2.5 million per km)	\$59
Walking mode share increases from 20% to 25%	Automobile 19% Motorcycle 4% Taxi 4% Mini-bus 47% BRT 0% Walking 25% Bicycle 1%	45,888.7	3,426.6	US\$60 million (400 km of pedestrian upgrades at US\$150,000 per km)	\$17
Bicycle mode share increases from 1% to 5%	Automobile 19% Motorcycle 4% Taxi 5% Mini-bus 48% BRT 0% Walking 19% Bicycle 5%	47,393.3	1,922.0	US\$30 million (300 km of cycle ways at \$100,000 per km)	\$15
Bicycle mode share increases from 1% to 10%	Automobile 18% Motorcycle 3% Taxi 5% Mini-bus 46% BRT 0% Walking 18% Bicycle 10%	45,154.9	4,160.4	US\$60 million (500 km of cycle ways at \$100,000 per km, plus \$10 million promotional campaign)	\$14
Package: BRT, Pedestrian upgrades, Cycleways	Automobile 15% Motorcycle 3% Taxi 3% Mini-bus 34% BRT 10% Walking 25% Bicycle 10%	36,917.5	12,397.8	US\$370 million (BRT \$250 million; Footpaths \$60 million; Cycleways \$60 million)	\$30

Source: Wright and Fulton, 2005

The lowest cost emission reduction option under this analysis is the optimistic case for diesel hybrid-electric technology, which produced a value of US\$148 per metric ton of CO<sub>2</sub> reduced. The highest cost emission reduction option is the pessimistic case for fuel cell technology, which produced a value of US\$3,570 per metric ton of CO<sub>2</sub> reduced.

By comparison, a set of mode shifting scenarios produced far more cost competitive emission reductions (Wright and Fulton, 2005). Table 19.32 summarises the results of the mode shifting scenarios, based upon the conditions and emission factors from Bogotá. The specific modes focussed upon in the analysis are BRT, cycling, and walking.



**Fig. 19.23**  
*Promoting mode shifts to both public transport and non-motorised options, such as walking and cycling, will likely produce the most cost-effective emission reductions.*

Photo by Karl Fjellstrom

Each of the mode shifting scenarios resulted in relatively cost-competitive emission reductions with no costs higher than US\$70 per ton of CO<sub>2</sub> reduced. By contrast the lowest cost fuel-based strategy was US\$148 per ton of CO<sub>2</sub> reduced.

Ideally, an emission reduction scenario would produce both large emission reductions as well as low-cost reductions. Each of the non-motorised options produced results under US\$20 per ton of CO<sub>2</sub> reduced. A US\$60 million investment in bicycle infrastructure produces a projected emission reduction of 4.1 million tons of CO<sub>2</sub> over 20 years at a cost of approximately US\$14 per ton.

However, the package of measures bundled together (BRT with pedestrian upgrades and cycleway investment) was the most effective combination of large and relatively low-cost reductions. The scenario with the package of measures produced over 12 million tonnes of CO<sub>2</sub> reductions at a cost of approximately US\$30 per ton. As an individual measure, BRT was more costly than the other scenarios at US\$66 per ton while the non-motorised options alone did not produce the largest reductions. This result is due to modal assignment between the different options. In the case of BRT or non-motorised options working individually, each will tend to suppress the mode share of the

other. For example, improved public transport (e.g., BRT) will tend to attract previously non-motorised users in addition to targeted trips by private vehicles. The net emission reductions will not be as great as compared to a scenario in which public transport and non-motorised transport increase together. In the bundled scenario, trips by BRT, walking, and cycling are all promoted and supported, and thus the loss of market share between these modes is minimised (Figure 19.23).

Finally, another interesting finding from this research has been the relative sensitivity of emission reductions from small changes in motorised mode share. A single percentage point reduction in motorised mode share and a subsequent gain by either non-motorised options or public transport is substantial in terms of greenhouse gas impacts. In the context of the stated reference case, a single percentage point reduction in mode share of private automobiles represents over one million tons of CO<sub>2</sub> through the 20-year project period. This finding implies that even shifting relatively small percentages of mode share to more sustainable options can be worthwhile.

It should be noted that the cost estimates generated in tables 19.3 and 19.3 are approximations based upon generic conditions and assumptions within project and baseline scenarios. The actual values will vary greatly depending on local

circumstances and a range of factors, including baseline mode shares, local infrastructure costs, and cultural preferences for particular modes. The scenarios presented here also did not account for any induced travel that may occur due to the availability of road space following a shift to lower-emitting options. Further, the final total cost of attempting to convert such reductions into tradable “Certified Emission Reductions” will also involve additional transaction costs as well as measurement and monitoring costs. Nevertheless, the results of these initial scenarios for mode shifting do appear promising from the standpoint of cost competitiveness.

#### 19.3.3.4 Global emission reduction efforts

*“In our every deliberation, we must consider the impact of our decisions on the next seven generations.”*

—Iroquois Nation Maxim

To date, two major international agreements have been brought forward to curb greenhouse gas emissions. At the 1992 United Nations Conference on Environment and Development (UNCED), member nations developed the United Nations Framework Convention on Climate Change (UNFCCC). By 1994, a sufficient number of countries had ratified the convention to put the document into force. Although the convention was essentially a non-binding agreement, the UNFCCC did include a mechanism allowing participation by developing nations

in emission-reducing projects. The mechanism, known as “Activities Implemented Jointly” (AIJ), encouraged investment towards developing nation projects as a means to stimulate a future emissions trading market. Remarkably, though, of the 186 AIJ projects put forward, none addressed emissions in the transport sector (JIQ, 2002).

Subsequently, in 1997, the Kyoto Protocol was drafted. The protocol calls for developed nations to reduce emissions by an average of 5.2 percent from a 1990 baseline. Despite the absence of two major emitting nations, the US and Australia, the agreement came into force on 16 February 2005. Progress on the Kyoto Protocol is tracked by the UNFCCC Secretariat as well as through regular meetings of the members states (Figure 19.24).

The Kyoto Protocol offers a mechanism, known as the “Clean Development Mechanism” (CDM), that allows mitigation projects in developing nations to earn “Certified Emission Reductions” (CERs), which will have a monetary value. The Protocol also includes a mechanism known as “Joint Implementation” (JI) to promote emission reducing projects in “economies-in-transition” (*i.e.*, Eastern Europe). Thus, although developing nations and economies-in-transition do have not reduction requirements under the Kyoto Protocol, these nations can sell credits gained through CDM and JI to other nations that do have Kyoto emission reduction requirements.

However, early indications from project proposals indicate that transport will not be a major area of investment. CDM and JI projects are being supported by many institutions, including the governments of Finland, Japan, and The Netherlands, as well as the World Bank through its Prototype Carbon Fund. Through February 2007, a total of 1,743 CDM projects and 155 JI projects had been registered with the UNFCCC. Only three of these projects were related to the transport sector. Of these, only one project, Bogotá’s TransMilenio BRT project, was related to urban passenger transport (Fenhann, 2007).

The most frequently cited reasons behind the lack of greenhouse gas mitigation projects in the transport sector are the complexity of transport baselines and the cost-effectiveness of the

**Fig. 19.24**  
*Country officials and interested groups regularly meet through Conference of the Parties (COPs) to discuss progress with the Kyoto Protocol.*

Photo by Lloyd Wright



projects. Projects encouraging shifts to lower-emitting modes depend upon modelling projections that are possibly not sufficiently rigorous to meet the standards of Certified Emission Reductions (Sandvik, 2005). Further, the duration and timing of transport emissions may also be at odds with the CDM process. Busways and infrastructure for bicycles and pedestrians will have a lifetime of 25 years or longer, and thus the initial capital costs are amortised through the emissions reduced over this period. CDM project periods only cover 7 or 10 years, and thus do not permit the full emission reduction in a single reporting period. Additionally, the nature of the CDM implies the presence of a motivated investor with a discrete product. Private sector opportunities largely reside in fuels and vehicles while upgrades such as improved customer service either do not have well-defined commercial opportunities or such opportunities are local in nature.

Apart from the UNFCCC mechanisms, the Global Environment Facility (GEF) is amongst the world's largest grant-making facilities to fund projects alleviating global environmental problems. The GEF's resources of over US\$2 billion are intended to catalyse demonstration initiatives that eventually lead to replication globally. However, the transport sector was one of the last sectors that the GEF climate change programme has addressed. Further, the GEF's operational strategy for transport was largely prepared by special interests from the fuel cell industry, and thus has focused much of the early investments towards fuel and propulsion system solutions (GEF, 2001).

Through February 2005, of the 566 registered GEF projects related to climate change, only 13 were in the transport sector. Six of these projects are focused on fuel cell technology. The fuel cell initiatives involve a US\$60 million investment by UNDP to finance 46 fuel-cell buses in developing cities such as Beijing, Cairo, Mexico City, São Paulo, and Shanghai. The actual project cost totals US\$120 million when matching funds from private sector fuel and vehicle firms are included. Thus, the end result is 46 buses at a cost of approximately US\$2.6 million per bus. However, given that in nations such as China the hydrogen for the fuel-cell buses will likely

be derived from largely coal-based electricity, the overall greenhouse gas emissions will actually be higher than if a standard diesel vehicle was utilised. If instead the US\$60 million GEF investment was applied towards BRT systems, then anywhere from 20 to 30 cities could have received funds to fully plan BRT systems. In response, the GEF is now moving towards a more systems-based approach to transport initiatives. The World Bank is currently leading GEF-financed BRT projects in Lima, Mexico City, Santiago, and Hanoi with additional projects being planned for cities in China, Colombia, Mexico, Brazil, and Argentina.

#### 19.3.3.5 TransMilenio emission reductions

The Bogotá TransMilenio system is the first public transport initiative to be brought forward for consideration of international emission credits. Under the registration of the TransMilenio project with the UNFCCC, phase II through phase IV of TransMilenio is eligible for the emission credits. The first crediting period runs for seven years beginning on 1 January 2006. The TransMilenio system and its partners are projected to reduce approximately 247,000 tons of CO<sub>2</sub> per year under the application to the UNFCCC for emission credits. In turn, the revenues generated from the sale of the "Certified Emission Reductions" can then be applied to further expand the TransMilenio system.

As a system-based approach to public transport, the TransMilenio system is able to address virtually all the possible components in an emissions reduction effort, as outlined earlier in Figure 19.21. Specifically, TransMilenio is achieving emission reductions through the following mechanisms:

- Increasing the share of public transport ridership by dramatically improving the quality of service (in terms of travel time, comfort, security, cleanliness, etc.);
- Replacing 4 to 5 smaller buses with a larger articulated vehicle;
- Requiring the destruction of 4 to 8 older buses for every new articulated vehicle introduced into the system;
- GPS controlled management of the fleet allowing the optimisation of demand and supply during peak and non-peak periods;

- Encouraging transit-oriented development around stations and along corridors; and,
- Emission standards currently requiring a minimum of Euro II emission levels with a future schedule requiring eventual Euro III and Euro IV compliance.

Bogotá is one of the few cities in the world that is achieving a significant increase in public transport ridership. Approximately 20 percent of ridership on Bogotá’s BRT system comes from persons who previously drove a private vehicle to work. The quality of TransMilenio is such that even middle- and higher-income travellers are utilising the system. The older mini-buses that dominated Bogotá prior to TransMilenio were largely not an option that discretionary public transport users would frequent (Figures 19.25 and 19.26).

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

Other cities have since been influenced by Bogotá’s vehicle scrapping programme. For

example, the Guayaquil Metrovía also requires any private operator wishing to enter the system to scrap a certain number of vehicles (Figure 19.27).

Each articulated vehicle in TransMilenio has a capacity of 160 passengers. The vehicles are currently achieving a load factor of approximately 80 to 90 percent. The older public transport vehicles in Bogotá come in a variety of sizes, from micro-buses to full-sized conventional buses. Table 19.4 summarises data collected on characteristics of public transport vehicles in Bogotá.

The differences in “passengers per vehicle-kilometre travelled” are quite telling. The relative efficiency of operating a coordinated system in larger vehicles translates into economic advantages for the operators. By closely controlling the supply of vehicles during peak and non-peak periods, TransMilenio avoids wasteful trips.

#### 19.3.4 Noise

The existing older vehicles in most developing cities not only produce high levels of contaminant emissions but also generate considerable noise pollution. The inefficient engine technologies in conjunction with poor noise dampening devices means that noise levels can exceed safe levels. Further, the large number of smaller

**Fig. 19.25**  
*The transformation of Bogotá’s public transport system from this...*



**Fig. 19.26**  
*...to this, has resulted in significant emission reductions.*

Top photo by Lloyd Wright  
Bottom photo courtesy of Fundación Ciudad Humana (Human City Foundation)





**Fig. 19.27**  
*Like Bogotá, Guayaquil has also implemented a vehicle scrapping requirement for private operators wishing to participate in the system.*

Photo by Lloyd Wright

public transport vehicles means that existing systems have high numbers of noise generating mini-buses. BRT helps reduce vehicle noise by:

- Replacing 4 to 5 mini-buses with a larger public transport vehicle
- Using quieter engine technologies
- Managing the system to produce “smoother” vehicle operations
- Employing noise dampening devices
- Encouraging mode shifting from private vehicles to public transport.

Projecting the potential reduction in noise levels can be difficult since there may be no baseline noise levels collected for the city. Thus, baseline decibel measurements may be a recommended part of a pre-project evaluation of the existing environment. The projected external noise levels of new vehicles are typically specified by the vehicle manufacturers. This information in conjunction with the average noise level of an existing public transport vehicle can produce an initial estimation of the projected benefits.

**Table 19.4: Characteristics of public transit vehicles in Bogotá**

Vehicle type	Passenger capacity	Fuel consumption (km/litre)	Passengers per vehicle-kilometre travelled (IPK)
TransMilenio articulated bus, Euro II diesel	160	1.56	5.20
Conventional bus, diesel	70–80	2.14	1.00–2.27
Conventional bus, Gasoline	70–80	1.53	1.00–2.27
Medium-sized bus, diesel, models 1595-2004	27–45	5.02	0.90–2.24
Medium-sized bus, diesel, 1580 model	27–45	3.96	0.90–2.24
Medium-sized bus, gasoline, 1580 model	27–45	2.64	0.90–2.24
Micro-bus, diesel	13–15	5.54	0.60–1.44
Micro-bus, gasoline	13–15	3.43	0.60–1.44

Source: Martínez, 2004



**Fig. 19.28**  
*A waste recycling facility at the Usme depot of TransMilenio.*  
 Photo by Lloyd Wright

### 19.3.5 Liquid and solid wastes

Transit operations will also generate a variety of liquid and solid waste products. Waste oil, other lubricants, and industrial solvents should be recycled or disposed in an approved manner. Liquid wastes that are not properly treated can endanger water supplies. These wastes can be a particular danger to residents living near transit depots and other repair shops. Solid waste products such as worn tires and failed components should also be disposed in a safe manner.

A formal transit system, such as a BRT system, can help to reduce and control these emissions by providing standard procedures and a more controlled environment. While informal operators may dispose of waste products in an uncontrolled fashion, concessioned BRT operators must follow procedures stipulated in the contractual agreements. The TransMilenio depots in Bogotá include infrastructure to facilitate the recycling and proper disposal of wastes (Figure 19.28).

## 19.4 Social impacts

*“Humans have always had a complex relationship with technology. Automobiles, for instance, changed the nature of life in America, where we live, how we work, what we can do with our leisure time. But they have also brought us traffic jams and contributed to global warming. The impact of information*

*technology may be equally profound, and these are things we need to think about and study.”*

—Michael Quinn, historian, 1944—

As with other indicators, the social impacts of a BRT system will depend on how the system is designed, so project specific appraisal is generally necessary. Some development institutions require a social impact assessment for major projects like BRT, either as part of an EIA or as part of an assessment of the poverty alleviation impacts.

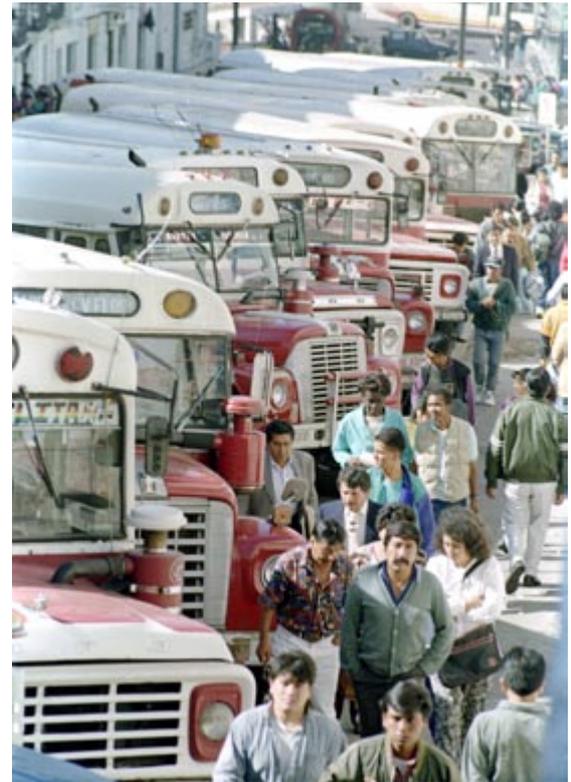
### 19.4.1 Types of social impacts

#### 19.4.1.1 Property expropriation and resettlement

Usually, the greatest concern in social appraisal of infrastructure projects is with property expropriation and involuntary resettlement. Normally, BRT systems will be designed in such a way as to minimise involuntary resettlement, and in fact BRT systems frequently make it possible for municipalities to put off or stop all together new road projects which would have much higher levels of involuntary resettlement. Nevertheless, some BRT systems may require some involuntary resettlement, and in such circumstances the involuntary resettlement guidelines drafted by institutions such as the World Bank should be followed. Chapter 11 (Infrastructure) discusses good practice procedures for addressing property expropriation issues.

#### 19.4.1.2 Displacement of paratransit workers

Of much greater concern with BRT projects is what will happen to the former paratransit operators and the families that rely on them for income. In most BRT systems, negotiations with existing bus operators have been tense. In the best cases, like in Bogotá, Guayaquil, and Jakarta, major social upheaval was avoided by negotiation and compromise which ensured that at least some existing operators enjoy the benefits of the new system, while at the same time not holding the public interest hostage to the demands of these private interests (Figure 19.29). In the worst case, like in Quito, a general strike by the former bus syndicates shut down the transit system for five days and the military had to be called in to avoid further violence (Figure 19.30).



**Fig. 19.29**

*In Guayaquil, a negotiated concession process meant that existing owners and drivers embraced the new system.*

Photo by Lloyd Wright

Certainly, if all the most lucrative public transport routes in a major city are taken away from local paratransit operators who own their own vehicles, and these routes are given to a foreign multinational corporation who brings in replacement workers from an even poorer country, and divests the profits, the social impact of a BRT system could be quite negative. The former paratransit drivers, who have put their life savings into their minibuses, now are holding a worthless asset. Such a decision would no doubt lead to significant social upheaval.

For this reason, most BRT systems do not completely turn private bus operations over to international competitive bidding, but rather structure the terms of the competitive bid to ensure that a significant number of the existing bus operators in the corridor affected are re-incorporated into the new system. How this is done specifically will vary depend on the structure of the existing paratransit industry.

In Bogotá, for example, the companies bidding on becoming the operators of the new BRT system got extra points for “experience operating buses in the corridor”. Also, each bidder had to destroy several of the old paratransit buses for each new vehicle that they procured. This

requirement forced the bus enterprises to buy from the small individual bus owners their old buses, so that they would be able to recoup the value of their only capital asset. Some of them accepted cash and some of them accepted shares in the new company.

**19.4.1.3 Poverty alleviation**

For certain sources of international financing, including ostensibly all World Bank financing, the project must demonstrate some sort of poverty alleviation impact, while others (US AID Housing Guarantee Loans, for example) require that the principal project beneficiaries are below median income levels. In the past, some members of the World Bank staff have questioned the viability of urban mass transit investments for lack of clear evidence that they benefit the poor.

Certainly, this is a valid criticism of many new metro systems in developing countries, where the cost of the new metro service tends to be several times higher than traditional bus services, while the wealthy tend to be disproportionately represented among the beneficiaries.

The same cannot be said of most BRT systems, however. Most BRT systems have managed to keep fares in line with normal bus services while dramatically improving service quality and speed.

**Fig. 19.30**

*By contrast, in Quito private operators parked their vehicles and blocked the new Trolley system from initially operating.*

Photo courtesy of El Comercio.

**Fig. 19.31**

*In the planning of new BRT systems in South African cities such as Johannesburg and Tshwane, the emphasis is on bringing quality public transport to previously disadvantaged communities.*

Photo by Lloyd Wright



Lower operating costs allow BRT systems to be self-financing at much lower fare levels, making it possible to keep the system in private hands while providing services affordable to the poor.

Further, many new systems have focussed initial corridors on the lowest-income neighbourhoods. This emphasis helps ensure that the new system will play a role in improving access to jobs and public services (Figure 19.31).

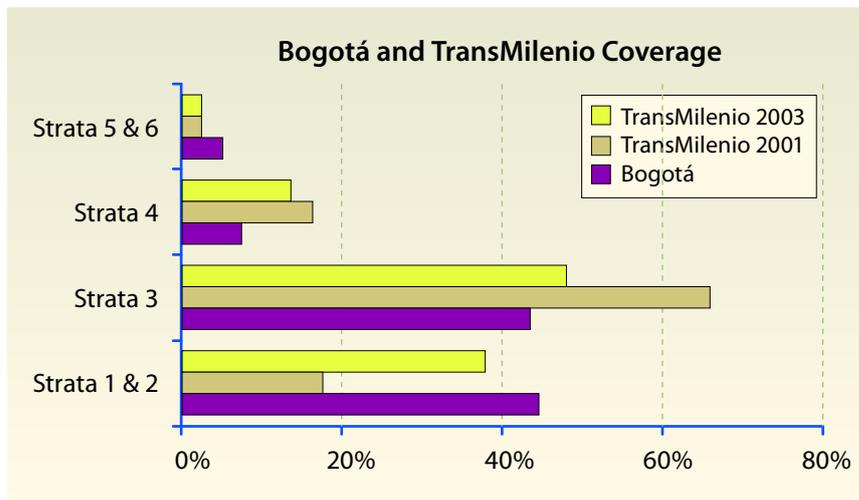
Colombia divides its population into six income groups. Category one and two are considered “poor” under Colombian law. Of all TransMilenio passengers, 37 percent are from these two lowest income categories, 47 percent are from category three (which represents 66 percent of the total population), 13 percent are from category four, and 3 percent are from categories five and six (Figure 19.32). On average,

TransMilenio passengers save roughly US\$134 per year in travel costs and 325 hours per year in time savings. In a separate survey, TransMilenio found that much of the time savings meant more time was spent with children and other family members.

Similar data has been collected for the TransJakarta system. From a sample of 350 system users, this study found that approximately 40 percent of passengers were defined as “low income” based on proxy indicators. Some 87 percent of respondents said their travel time was reduced while only 2 percent reported a longer travel time. In terms of travel cost, 47 percent said their travel cost was slightly lower, 29 percent said it was the same, and 21 percent said their travel cost was higher than before.

**Fig. 19.32**

*Income levels and BRT usage in Bogotá.*



#### 19.4.1.4 System sociability

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 (Figure 19.33). This role as a common public good can be quite healthy in creating understanding and easing tensions between social groups.

The new system may also mean that persons who previously had no travel options now can visit the entire city. In Bogotá, approximately 9,000 trips per day are made in TransMilenio by persons who had some form of physical

disability preventing them from using the previous public transport service. In the new system, the platform level boarding and ramps to the stations means that a whole new world has opened up to these individuals.

#### 19.4.1.5 Crime reduction

Some evidence suggests that public transport upgrades can also reduce crime. Improvements in station lighting and nearby footpaths as well as the presence of security cameras and security personnel can do much to create a different urban environment (Figure 19.34).

The development of the Bogotá BRT system contributed to an environment that experienced dramatic reductions in crime. In 1999, the year prior to the introduction of TransMilenio, 2,058 robberies were recorded in the city. By 2002, this figure had dropped to 1,370, a reduction of 33 percent. The city also experienced a 32 percent reduction in personal assaults and a 15 percent reduction in homicides over the same period. These impressive reductions were achieved through a combination of innovative measures, of which the BRT system and accompanying improvements in public space were just one component. Thus, the credit cannot be directly given to the BRT system, but it is likely that the system has contributed to creating a safer and more pleasant environment in the city.

#### 19.4.1.6 Safety

The separation of public transport vehicles from mixed traffic and the improvements to pedestrian crossings and traffic signalisation are measures typically employed to make a new BRT operate efficiently. These same measures also tend to produce significant safety benefits. Thus, reductions in vehicle accidents and pedestrian accidents often accompany the implementation of a new system.

Figure 19.35 summarises the safety improvements emanating from the implementation of the Bogotá TransMilenio system.



#### 19.4.1.7 Estimating social impacts

Predicting the likely beneficiaries of a BRT system is generally quite simple. As one can safely assume that the majority of BRT passengers will be drawn from existing bus and paratransit passengers using the same corridor, surveys of the income characteristics of existing bus and paratransit passengers in the corridor should provide a very close estimate to the population of beneficiaries for the final system. If the system primarily serves upper income neighbourhoods, the chances are that the beneficiaries will be similarly predominantly from among the upper income groups, and if it primarily serves

Fig. 19.33

*A public transport system's ability to bring together people from all walks of life helps increase social understanding between different classes.*

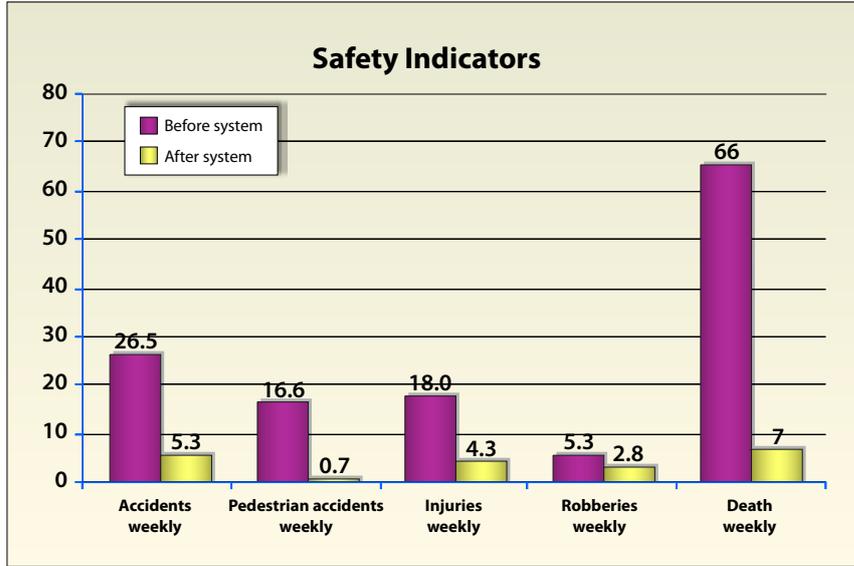
Photo by Lloyd Wright



Fig. 19.34

*Lighting upgrades along the Guayaquil Metrovía corridors helps to create a more secure urban environment.*

Photo by Lloyd Wright



**Fig. 19.35**  
*Changes in key safety and security statistics before and after the implementation of the Bogotá TransMilenio system.*

Graphic courtesy of TransMilenio SA

lower income neighbourhoods it will tend to serve lower income groups.

A rough estimate of the impact of the new BRT system on lower income groups can generally be calculated by assuming that the poor will have the same level of representation among the BRT system's ridership as they have among the current bus and paratransit ridership in the same corridors. This result has been borne out by empirical research. The net benefits calculation would then be applied to this share of the population to calculate the benefits among the poor. A more detailed analysis can be done

with a traffic model by looking more closely at the impact of the new system on origin-destination pairs among the lowest income zones throughout the city.

The location of the poor in the urban area will tend to make different fare structures more or less equitable. In most developing-country mega-cities, the poor tend to live at the periphery of the city. In such circumstances, a flat fare structure such as that utilised in Bogotá, Guayaquil, and Quito will tend to cross subsidise long distance low-income trips. On the other hand, there are some exceptions, where the poor are more randomly distributed throughout the greater metropolitan area, or where the poor occupy the central city. In these rare instances, a distance-based fare structure may be more equitable.

With all the various social indicators, recording existing data on critical indicators prior to implementation will help to set an appropriate baseline by which the system can later be evaluated. Thus, ensuring that data on indicators such as safety and security are measured along the planned corridors will provide a point of future comparison.



**Fig. 19.36**  
*High-rise development in Curitiba takes place only along the BRT corridors.*

Photo courtesy of the Municipality of Curitiba

## 19.5 Urban impacts

*“Because I believe a lot of people share my feelings about the tragic landscape of highway strips, parking lots, housing tracts, mega-malls, junked cities, and ravaged countryside that makes up the everyday environment where most live and work. A land full of places that are not worth caring about will soon be a nation and a way of life that is not worth defending.”*

—James Howard Kunstler, author and social critic, 1948–

### 19.5.1 Types of urban impacts

The relationship between BRT and land use can have long-lasting impacts on the form of the city. Busways can play an important role in concentrating new development in strategic locations which minimise the long term cost of providing transit and other urban services to these households and firms.

For example, the BRT stations in Curitiba are development nodes, which act to attract mixed commercial and residential development that reduces necessary vehicle kilometres travelled through co-location. Curitiba’s zoning system was closely linked with the BRT system’s development, and much higher density development was allowed along the BRT corridors than was allowed along the mixed traffic arterials. This policy ensured that as the city grew, it grew in a reasonably compact manner along the BRT corridors (Figure 19.36).

In Bogotá, while there was minimal link between TransMilenio and zoning changes, low-income housing sites were located near TransMilenio terminals, and connected to these terminals by pedestrian and walking-only facilities. In this way, the city is growing up around low-cost cycling and walking facilities closely linked to TransMilenio (Figure 19.37).

In fact, the busways and development nodes are mutually beneficial. The strategic siting of BRT stations improves customer access to shopping, employment, and services while the high-density centres ensure sufficient passenger traffic to maintain cost-effective busway operations. Curitiba has also coordinated new residential construction around bus arterials.

The end result is that the municipality can deliver basic infrastructure such as water, sewage, and electricity at a significant cost



**Fig. 19.37**  
*High-quality pedestrian and cycleway facilities connect low-income communities with the TransMilenio system in Bogotá.*

Photo by Lloyd Wright

savings to areas with concentrated development. While mixed use, high-density planning does not always guarantee a sustainable urban environment, integrated planning efforts between land use and transport can provide a win-win situation for municipal officials, commercial developers, and residents.

### 19.5.2 Predicting changes in urban form

Estimating the projected changes in urban form induced by a new BRT system is difficult. Some transport-land use models have been developed, but such models are not very robust, and few have been calibrated for use in developing countries. It is probably easier to make fairly simple and plausible assumptions and embed these assumptions in the 20-year traffic projection. It is common among metro project promoters to make fairly heroic assumptions about possible land development in the corridor as a way of justifying the massive investment, but it is probably wiser to make fairly modest assumptions about future development in the corridor. After all, if the system is poorly designed, operated, or maintained (much of which will be difficult to determine in the early planning stages), it may be that there will be disinvestment rather than investment into the corridor.

## 19.6 Monitoring and evaluation plan

*“Do not believe in anything simply because you have heard it. Do not believe simply because it has been handed down for many generations. Do not believe in anything simply because it is spoken and rumoured by many... Do not believe in anything merely on the authority of teachers, elders or wise men. Believe only after careful observations and analysis, and when you find that it agrees with reason and is conducive to the good and benefit of one and all, then accept it and live up to it.”*

—Buddha, spiritual leader, 560 BC–480 BC

### 19.6.1 Fundamentals of monitoring and evaluation

In many respects, the success or failure of a system can be apparent from public reactions to the system. The customer’s opinion is perhaps the single most important measure. However, to obtain an objective and quantifiable indication of a system’s overall performance, a defined monitoring and evaluation plan is fundamental. The feedback from such a plan can help identify system strengths as well as weaknesses requiring corrective action.

The identification of a full set of system targets and indicators is a first basic step in the development of a monitoring and evaluation plan. A baseline value should be created for the relevant indicators. Thus, the evaluation work will begin prior to the development of the system. By noting such factors as average vehicle speeds,

travel times, and public transport usage prior to the system’s development, it will be possible to quantify the benefits gained by the new system. Most indicators will be quantitative in nature, but qualitative assessments can also be accommodated through survey work.

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

Baseline data may also need to be collected across several different points of time. Some baseline factors will likely vary by time of day, day of the week, and months of the year. The original modelling process is another rich source of potential baseline data. Evaluating the projections from the demand modelling process will also be helpful in determining the accuracy of the model for future applications.

### 19.6.2 System performance indicators

The potential indicators for evaluating system performance include:

- Mode shares (public transport, private vehicles, walking, cycling, taxis, motorcycles, etc.);
- Average travel times;
- Average public transport vehicle speeds;
- Average private vehicle speeds;
- Passenger capacity of roadway;
- Peak capacity of public transport system;
- Average wait times;
- Total travel cost;
- Public transport subsidy levels;
- Number of positive media reports on system/ number of negative media reports on system;
- Customer satisfaction (Figure 19.38).

**Fig. 19.38**  
*Customer satisfaction is perhaps the most important indication of a system’s success or failure.*

Photo courtesy of TransMilenio SA



### 19.6.3 Economic indicators

The potential indicators for evaluating economic impacts include:

- Employment created during the construction phase;
- Employment created in the operational phase;
- Economic value of travel time savings;
- Economic value from the reduction of congestion;
- Property values near stations and corridor;
- Shop sales near stations and corridor;
- Vacancy rates of properties near stations and corridor;
- Creation of private firms producing BRT technologies (*e.g.*, vehicles, fare collection technology);
- Employment generated from local production of BRT technologies.

### 19.6.4 Environmental indicators

*“Not everything that counts can be counted, and not everything can be counted counts.”*

—Albert Einstein, physicist, 1879–1955

The potential indicators for evaluating the environmental impact of the system include:

- Levels of local air pollutants (CO, NO<sub>x</sub>, SO<sub>x</sub>, PM, toxics, O<sub>3</sub>);
- Emissions of greenhouse gases (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O);
- Noise levels;
- Hospital admissions for respiratory illnesses (Figure 19.39);
- Indices of asthma in city;
- Number of older buses retired from service.

### 19.6.5 Social indicators

The potential social indicators for evaluating the system include:

- Percentage of public transport passengers from each socio-economic grouping;



- Percentage of household incomes required for transport;
- Crime levels along corridor;
- Crime levels within public transport vehicles;
- Vehicle accidents on corridor;
- Pedestrian accidents, injuries, and fatalities.

### 19.6.6 Urban indicators

The potential indicators for evaluating impacts on urban form include:

- Number of new property developments along corridor;
- Opinion surveys on quality of public space along corridor.

### 19.6.7 Political indicators

The potential indicators for evaluating political impacts include:

- Change in number of political officials supporting project over time;
- Re-election success rate of officials supporting system.

**Fig. 19.39**

*Health indicators can say much about the actual effectiveness of any new public transport system.*

Photo courtesy of Swisscontact and the GTZ SUTP Photo CD

## 20. Implementation plan

*“Plans are only good intentions unless they immediately degenerate into hard work.”*

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

The production of a planning document is not the end objective of this process. Without implementation, the planning process is a rather meaningless exercise. And yet, too often significant municipal efforts and expenditures on plans end in idle reports lining office walls, with little more to show for the investment.

The planning process should instead provide a confidence boost to leaders and ensure that sufficient considerations have been taken to ensure a successful implementation. Thus, this final stage of the BRT planning process is the critical point to ensure that the spirit and form of the plans can be brought to completion in an efficient and economic manner.

During the planning process, the team of planners, engineers, and business professionals likely operated within an organisational structure that was tailored to delivering a high-quality plan. As the project turns to implementation, the new oversight organisation (e.g., a BRT authority) will take on different roles and responsibilities. Thus, an organisational framework must be

developed to maximise the efficiency of the long-term entity. Ultimately, the organisation’s success or failure will likely rest upon the type of persons recruited. Therefore, the hiring process must be conducted in a manner to attract the best professionals possible.

Once the body of the operational design, physical design, and business plan are complete, a political commitment will be required to move towards construction and full implementation. The designation of an agency to oversee implementation should be made well before the planning process ends. Also, many contractual agreements will be required in order to legally release the implementation work. These contracts will cover areas such as construction, maintenance, and operations.

If the construction process itself results severe traffic congestion and general city-wide chaos, the new system may acquire a negative public image even before it is opened. Thus, construction itself requires a fairly well-defined schedule and operational plan to minimise disruptions.

Finally, the system will require some maintenance and upkeep activities right from the start. A well-articulated preventative maintenance plan can help ensure the new systems appears “new” for as long as possible.

The topics discussed in this chapter include:

### 20.1 Implementing agency

### 20.2 Operating contracts

### 20.3 Construction

### 20.4 Maintenance

### 20.1 Implementing agency

*“The implementation is what has to be done next, and sometimes a fresh eye is what is needed for that. I see this as a good time to retire.”*

—Helen Krause, animal rights activist, 1904–1999

All the planning might be completed, and it still may not be clear who is responsible for implementing the project. Normally, the institution responsible for the planning of the system will become the agency responsible for the managing the operational contracts, though this progression

is not always the case. The planning might be done by private consultants under contract to a project management office inside a municipal government or national government agency.

#### 20.1.1 Appointing the implementation agency

*“Men often oppose a thing merely because they have had no agency in planning it, or because it may have been planned by those whom they dislike.”*

—Alexander Hamilton, statesman, 1755–1804

The critical first step in implementation is therefore for the Mayor or the Governor to decide on which government agency or agencies are going to implement the project, and if there are multiple agencies, how they are going to relate to each other. If it is decided that a new agency is to be set up to implement the project, this agency needs to already have been established by the time implementation begins, because the agency will need to have the legal power to issue contracts. If a new agency is to be set up, work on this must begin early, as this process can be legally complex.

Responsibility for implementation is generally divided between the construction aspects of the project, and the operational aspects of the project. Responsibility for managing the construction is generally under the department of government normally responsible for large urban road works. This responsibility often lies with a municipal department of public works, but sometimes a municipal department of transportation, or even a provincial or national department of urban roads. Responsibility for the operational aspects of the BRT system is normally under a new BRT authority, a pre-existing public transport authority, or a department of transportation. Responsibility for coordination must rest with a person with direct access to the principal decision-maker, either the Mayor or the Governor, or the relevant national or provincial Minister (Figures 20.1 and 20.2).

The decision regarding which agency should be responsible for implementation needs to be chosen based on both technical and political

criteria. Most important is to choose the agency which has the most competence in implementing similar projects of this size and scope, and the regulatory power to implement the project without complex inter-governmental approvals. The larger contracts generally run in the tens of millions of dollars rather than the hundreds of millions, and the smaller contracts in the millions of dollars, so the agency selected should have experience managing contracts of this size.

However, sometimes the agency with the most experience has a conflict of interest. A typical issue, for example, is that the agency responsible for regulating the existing public transport service, often a department of transportation, may raise considerable revenue (both licit and illicit) from the existing regulatory structure, and may be highly resistant to change. In other cases, a poorly run public bus company may exist, and it may not be desirable to encumber the new system with the poor management of the old system. It may be politically more expedient in this situation to create a new BRT authority than to reform an entrenched agency. In other cases, a new BRT project may be the impetus for the creation of a public transport authority with broader powers. The important issue is that whichever agency is responsible focuses its primary attention on the successful implementation of the BRT project, or else the project will risk failure.

**Fig. 20.1 and 20.2**  
*Ultimately, the project's momentum will depend upon the drive of the top leadership, such as Mayor Myung-Bak Lee of Seoul (left photo) or Governor Sutiyoso of Jakarta.*

Left photo by Erik Möller  
 Right photo by Michael Replogle



### 20.1.2 Case studies

*“Those who cannot remember the past are condemned to repeat it.”*

—George Santayana, poet, 1863–1952

#### 20.1.2.1 Bogotá

In the case of Bogotá, it was decided early in the project to create a special BRT authority called TransMilenio to manage the bus operations. It was decided that the project would not be put under the administration of the Secretary of Transport and Transit (STT), the existing public transport regulator. This division was made since they wanted the staff to be able to work full time on the BRT project, and not be encumbered with other duties. Also, it was perceived that the existing public transport regulator was an entrenched bureaucracy with a vested interest in revenues earned from the issuance of bus routing licenses (Figure 20.3).

TransMilenio started out in January of 1998 as just a project office in the Mayor’s office, with three young engineers. By August of 1998, a senior businessman was hired to head the new office, and the staff grew to five. They prepared a law for the Mayor to submit to the City Council which would authorise Mayor Peñalosa to establish the BRT agency, TransMilenio SA. This law was not actually approved by

the City Council until February of 1999, and TransMilenio SA was not actually created until October of 1999.

Prior to the establishment of TransMilenio SA, the project was run out of a “virtual” BRT agency under the senior businessman’s leadership, in an office directly under the Mayor. Once TransMilenio SA was created as a legal entity, a new Managing Director was hired. All the former staff members of the “virtual” agency became employees of TransMilenio SA. The previous director of the virtual agency became the Mayor Peñalosa’s representative for the project.

Since TransMilenio SA had not yet been created as a legal entity at the beginning of the planning, the contracts for the planning and conceptual design were not done under contract to TransMilenio SA. The system design consultants, the investment banks, and the lawyers were hired under contracts that were legally under the Transport and Transit Secretary (STT), but in practice the supervision of these contracts rested with temporary director of the virtual agency. The contract with the management consultants was a contract directly with the Mayor’s office, and it was also supervised by virtual agency.

By consolidating the control of the supervision of all of the relevant contracts under his authority, the Mayor essentially created a new government agency composed of new direct hires and all the relevant consultants. The Institute for Urban Development (IDU) was essentially the Department of Public Works for Bogotá. Even though the IDU would eventually take responsibility for the actual construction, it was not directly involved at this early stage. The consulting firms worked independently from the public works department (IDU) and the existing public transport regulator (STT), but both agencies were instructed that they had to cooperate with the consulting teams in full, and this clear instruction from the Mayor, and oversight by his direct representative, ensured full cooperation from both the public works department and the existing public transport regulator.

By the time Bogotá was ready to implement TransMilenio, however, TransMilenio SA had been created as an agency. TransMilenio SA became mainly responsible for the operational side of

**Fig. 20.3**  
*It was felt that the public transport regulator in Bogotá had too many entrenched interests with the existing bus operators, so a new agency was created for the new BRT system.*

Photo by Karl Fjellstrom, courtesy of the GTZ SUTP Photo CD



TransMilenio as well as the development, completion, and tendering of the operating contracts.

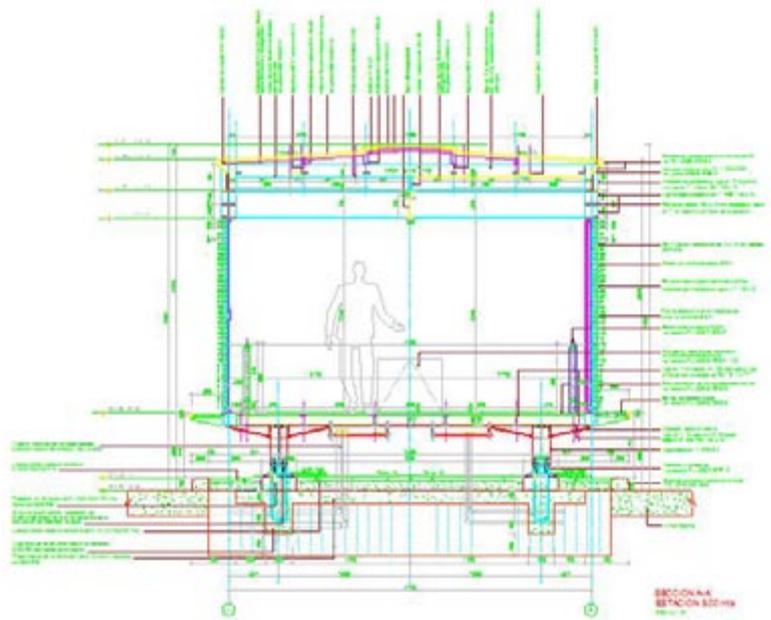
The detailed conceptual design for the infrastructure was designed by the original planning consultants (Figure 20.4). At the implementation phase, these designs became the basis of contracts drawn up by the public works department so that a new set of firms could do the detailed engineering and actual construction. The public works department then handled the actual bidding process and signed the contracts with the winning bidders.

The structure of the various departments was such that coordination problems were successfully avoided. First, the director of TransMilenio SA, the Mayor’s project representative, and the Mayor himself were all members of the Board of Directors of the public works department, which met every two weeks to discuss the progress of the construction on the BRT project, and on other related urban development works. Second, there was a weekly meeting between TransMilenio SA and the public works department, to go over the detailed physical designs and ensure that the detailed designs stayed true to the conceptual design. This meeting was attended by the Mayor’s project representative and the Deputy Director of the public works department. Finally, there was a weekly meeting between Mayor Peñalosa, the Mayor’s project representative, and the director of TransMilenio SA to review progress and discuss any problems. At this meeting, Mayor Peñalosa would bring in the relevant persons from other agencies should coordination problems arise.

**20.1.2.2 Jakarta case study**

In the case of TransJakarta, the Provincial Governor put the responsibility for the physical infrastructure into the hands of the Department of Transportation, (DisHub), which had an infrastructure unit. Planning was nominally the responsibility of an inter-agency task force chaired by a senior advisor to the Governor.

In practice, as the budget for project implementation for both the infrastructure and the operators was passed entirely through the Department of Transportation, the project was tightly controlled by that department, and the influence of the inter-agency task force was nominal at best.



**Fig. 20.4**

*The detailed design work performed by the consultants became the basis for the subsequent efforts of the public works department.*

Image courtesy of TransMilenio SA.

The head of this task force later became the head of TransJakarta, the operating authority, but this operating authority had much weaker powers than TransMilenio, and most key decision making authority remained with the Department of Transportation. In this way, the project managed to achieve a certain level of coordination within the Department of Transportation.

**20.1.2.3 Dar es Salaam**

In the case of Dar es Salaam, the project is planned by a team of international consultants answering to a Project Management Unit under the Dar es Salaam City Council, answering to the Mayor. Unlike with TransMilenio, the planning taking place in Phase I will bring the

**Fig. 20.5**

*In Jakarta, the Governor himself chaired the inter-agency task force.*

Photo by Michael Replogle





**Fig. 20.6**  
*Small-scale model  
of the proposed  
Delhi system.*

Image courtesy of the Indian Institute of Technology-Delhi (IIT-Delhi).

project to the point of having detailed engineering designs. Though not yet fully decided, the implementing agency for the operational contracts is likely to be a new government agency under the National Ministry of Local Government, probably incorporating many members of the current project management unit. Infrastructure will either be the responsibility of a national roads agency called TanRoads, or an upgraded provincial-level branch of TanRoads to be called DarRoads. The final decision will require a Cabinet Paper identifying the powers of the new agency.

#### 20.1.2.4 Delhi

In the case of Delhi, the designs were done by a consortium under contract to the Transport Commissioner. There are no operational changes planned in the early stages, so operations will continue to be divided between the existing public bus authority, the Delhi Transport Corporation, and small private operators. Management of the construction work is likely to be split between agencies, depending on which agency has jurisdictional responsibility for the particular road. In the first phase, the Delhi Municipal Corporation will manage the construction work since this organisation controls the roads for that phase. However, later corridors will likely fall under the control of the Delhi Development Authority. Such split responsibilities over the construction work can lead to problems with project co-ordination and design compatibilities, if not carefully managed.

#### 20.1.2.5 Ahmedabad

In the case of Ahmedabad, the operations are likely to be managed by the public transport corporation that already largely contracts out bus operations to private operators. The construction contracts are probably going to be issued by the Ahmedabad Municipal Corporation's engineering department, but a separate management contract for a private firm may later be issued. The detailed design is being done by the system's planners, CEPT, with some engineering details being done under contract to consulting firms. The construction contractor is responsible for the traffic re-routing during construction.

#### 20.1.3 Co-ordinating operations and physical infrastructure

Care must always be taken to ensure that there are not coordination problems between the operational design and the construction design. Normally, it is best to have an overall project manager answering directly to the Mayor or Governor with direct responsibility to make sure that these two activities are done in a complimentary and coordinated manner.

*The implementation of the operational plan and the implementation of the construction plan must be done simultaneously.* It is a common problem that municipalities, more comfortable with construction projects than with difficult management decisions, move forward on construction greatly in advance of the implementation of the operations. This partial implementation has resulted in more than one case of the BRT infrastructure being completed long before there are any buses to operate in the system or any companies to operate them. In Cali (Colombia), for example, the new BRT system as of this writing continues to sit vacant of want of buses, after almost two years (Figure 20.7 and 20.8).

Likewise, Ciudad Juarez in Mexico built a 3.5 kilometre corridor, but for various reasons it is not actually operating after over a year of possessing the infrastructure (Figure 20.9). Without a coordinating committee chaired directly by the Mayor or Governor to make sure that the construction contracts and operating contracts are carefully coordinated, projects can become badly stalled.



**Fig. 20.7 and 20.8**  
*The Cali (Colombia) system is an example of infrastructure development being far ahead of the business model. Without a business model in place, no vehicles can be purchased by the operators, and thus, the costly infrastructure is going unused.*

Photos courtesy of Metrocali

Ensuring that construction is completed and that the vehicle operating systems and fare systems are all ready simultaneously is no easy task. In the case of TransMilenio, the Mayor’s representative had detailed information on the progress of the construction contracts. The construction contracts had very stiff penalties

**Fig. 20.9**

*Despite possessing vehicles and the infrastructure, the Ciudad Juarez system is not actually operating.*

Photo by Oscar Diaz



for late completion. The director of Trans-Milenio SA had very up to date information on the progress on the vehicles operations and fare system operations, and these contracts also required start of operations or penalties would be incurred. The contracted firms faced, as a worst case, the cancellation of the contract with the responsibility to pay more than US\$1 million in fines and being barred for signing any contract with the Colombian State for five years. In fact, deadlines were indeed pushed back, but

not until the very last minute and all parties were bullied and threatened with penalties and threats. The Mayor’s representative tightly controlled all this information, telling the construction companies that the bus operators were ready, and telling the bus operators that the construction companies were nearly finished.

### 20.1.4 Agency staffing

*“In the end, all business operations can be reduced to three words: people, product and profits. Unless you’ve got a good team, you can’t do much with the other two.”*

—Lee Iacocca, former CEO of Chrysler, 1924–

As the project moves closer to implementation, the full establishment and staffing of the BRT authority will be required. While a staff of three to ten persons may be sufficient at the planning stage, to develop the full management organisation a wider range of positions and skills will be

needed. The build-up of staff will likely occur in a phased manner with certain key positions being filled initially.

The formal establishment of the BRT authority should follow from the structures detailed in Chapter 15 (Business and Institutional Structure). This structure has the BRT authority to the mayor’s or governor’s office either directly or through a representative board of directors. As noted above, the legal process to form the management entity should be completed well before the system is launched.

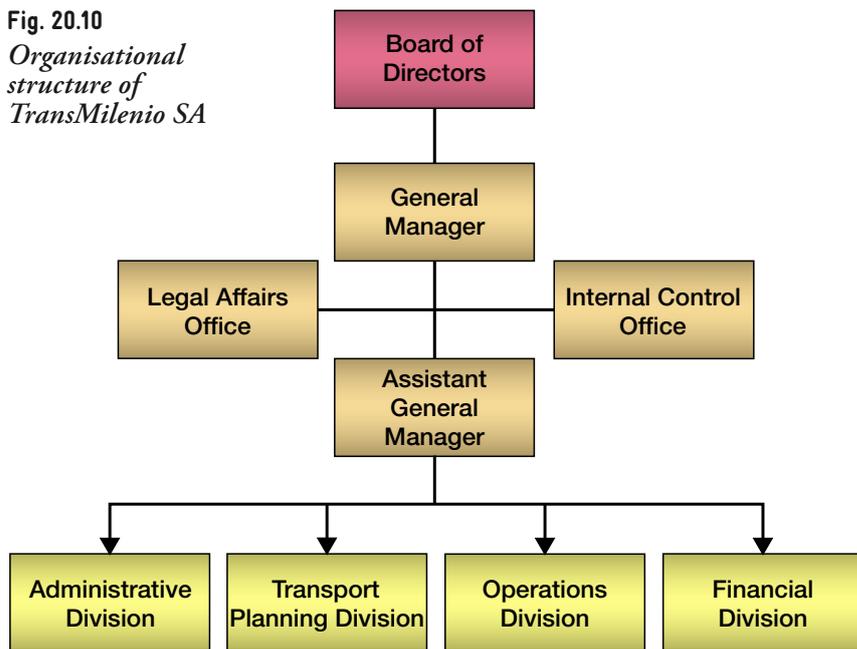
The organisational structure of the management entity should promote clear lines of responsibility and should provide logical sub-units pertaining to the major functions of the organisation. Such units may include administration, financial control, legal affairs, operations, and planning. Figure 20.10 outlines the internal organisational structure utilised by TransMilenio SA.

The General Manager position has overall responsibility for developing and implementing the organisation’s strategy. The General Manager reports directly to the Board of Directors, and is the organisation’s principal interface with other governmental agencies and with private entities. The Assistant General Manager directly manages the day-to-day activities of TransMilenio’s four divisions: Administration, Planning, Operations, and Finance. The Internal Control Officer ensures that TransMilenio’s internal financial operations are conducted in a proper manner in accordance with the regulations established by the Board of Directors and the municipality. This position also oversees the fulfilment of the internal financial audit. The Legal Affairs Officer ensures that legal documents and contracts are in compliance with all local and national laws.

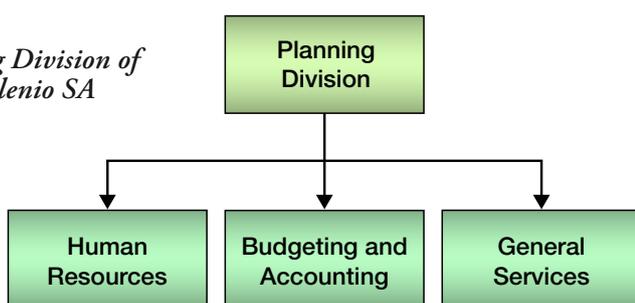
The Planning Division of TransMilenio is focused upon the planning activities required for the expansion of the system. The Planning Division thus takes the lead on new corridor projects. Figure 20.11 indicates the structure of the Planning Division.

The Operations Division of TransMilenio ensures that the system functions in an efficient manner. The Operations team monitors the performance of the private bus operators, the functioning of the control centre, and the

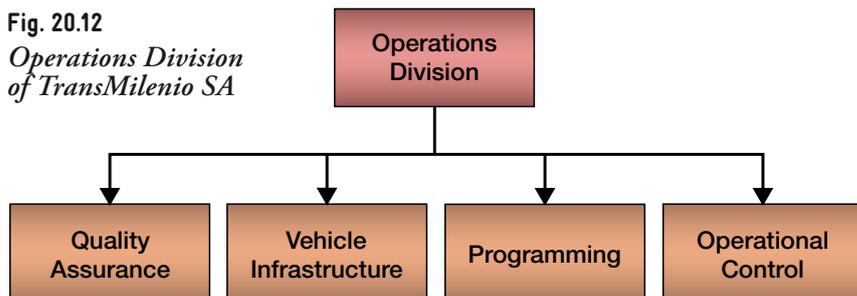
**Fig. 20.10**  
*Organisational structure of TransMilenio SA*



**Fig. 20.11**  
*Planning Division of TransMilenio SA*

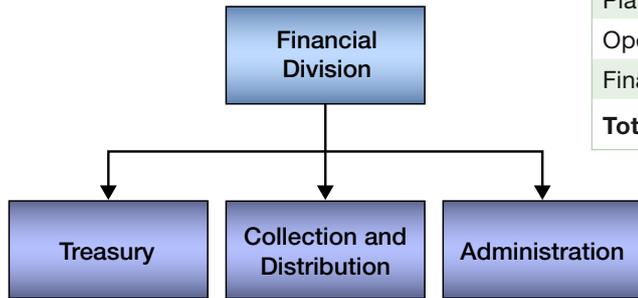


**Fig. 20.12**  
*Operations Division of TransMilenio SA*



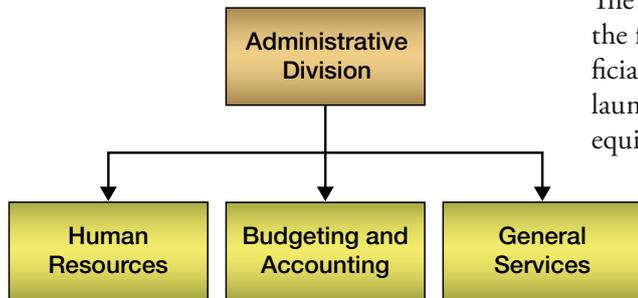
overall service quality of the system. Figure 20.12 provides an outline of the structure of the Operations Division.

The Financial Division of TransMilenio monitors the system’s cost structure to ensure the proper levels of technical fares and customer fares. This division also oversees the private operator with the fare collection concession. Figure 20.13 gives the structure for the Financial Division.



**Fig. 20.13**  
*Financial Division of TransMilenio SA.*

The Administrative Division provides support services to TransMilenio SA in terms of human resources, budgeting, and general services. The structure of the Administrative Division is given in Figure 20.14.



**Fig. 20.14**  
*Administrative Division of TransMilenio SA*

During Phase I, TransMilenio managed to fulfil its mandate with a staff of approximately 80 persons. The simplicity of BRT systems along with the increasing prominence of information technology have permitted large public transport systems to be administered by relatively lean management agencies. Table 20.1 lists the number of staff by functional area during the first phase of the system’s operation.

**Table 20.1: Employees by functional area during TransMilenio’s Phase I**

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

Source: TransMilenio SA

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

**20.2 Operating contracts**

*“We think in generalities, but we live in detail.”*  
—Alfred North Whitehead, mathematician and philosopher, 1861–1947

The contracts for the vehicle operators and the fare operators must be completed and officially registered well before the system is to be launched. Obviously, operators cannot purchase equipment (e.g., vehicles) until a signed contract is in hand. Since equipment delivery time may require as much as 12 months of lead time, the contracts must be finalised at least one year prior to the launch of the system. This timing is critical to a successful opening.



**Fig. 20.15**  
*Without providing effective contracts in a timely manner, the system’s implementation will be in jeopardy.*

Photo courtesy of iStockphotos

**20.2.1 Bogotá operational contracting**

The drafting of the bidding documents and the negotiation of the operating contracts can require a good deal of effort and time. In the case of TransMilenio, it took eight months of discussion and research before the first public draft of the operating contracts for the trunk lines, the feeder lines, and the fare system, were produced and released for discussion. The posting of this official draft was the first time the private bus operators and fare system vendors had an idea of what to expect from the TransMilenio operational system. From that point, it took another six full months to draft these contracts. This drafting process was done in communication with bus operators and fare system vendors, but the decisions were made by TransMilenio.

The city of Bogotá did not have their own legal department, so they had to contract skilled outside legal experts to draft the actual bidding documents. These bidding documents required also strong leadership from TransMilenio SA because the lawyers needed to understand clearly the goals of the operating agency. In Phase II, this process took much less time, only one month, because they already had worked out the basic system structure, and had model contracts that they only needed to modify. An outline of a Phase II contract for trunk operators of TransMilenio is given in Annex 5.

Once the tender documents were released, companies were given three months to prepare their bids. The potentially bidding firms require an adequate amount of time in order to prepare themselves properly. Existing private bus corporations may not fit the bidding requirements laid

out in the contracting guidelines and in all probability will have to form new legal entities. The private bus operators may have limited experience operating a modern bus company, competing in a tendering process. These companies may be little more than a leasing operation with no experience in scheduling, vehicle maintenance, labour management, or driver training. Management consultants are generally required to help with this process. The BRT authority may wish to provide training assistance to small firms in order to prepare them for the tendering process.

Once the winners of the bid were announced it took another 38 days to award the contract. The tendering documents were almost identical to the contract, but not completely identical. The final contract had to be written but the contents were already locked in by the bidding process, and not subject to further negotiation, so it did not take long. However, it took some 38 days to go through the government internal procurement procedures, and to hold a formal award ceremony.

After they had the contracts, it took two months to put together the financing for the vehicles. This financing becomes easier in later phases, but in any first project phase this process can be very difficult and time consuming. In Bogotá, the operators could not secure financing until they had their operating contracts from the city in hand, as this is the basis of the revenue for the new company (Figure 20.16). This financing did not happen automatically, and was a matter of constant worry for the Mayor. The Mayor did not want to offer municipal guarantees since he wanted to keep the risk on the operators. The Mayor’s office spent a lot of time and energy locating possible sources of financing for the vehicle procurement which did not require municipal government guarantee, and finally they succeeded. The procurement of the vehicles by the private operators was very important to making sure that the company making the profits also bears some of the risk of project failure.

Once the private operators secured the financing, it took another six months to produce and deliver the vehicles. This process could take longer if the vehicles are not standard, are coming from a smaller-scale manufacturer, or are being shipped to a more distant location.

**Table 20.2: Timetable for operational contracting**

Activity	Amount of time required
Hiring process for personnel to draft operating contracts	4 months
Preparation of draft operating contracts	8 Months
Completion of formal tender documents	6 months
Preparation of bids	3 months
Awarding of bids and signing of contracts	1.5 months
Identifying financing for bus procurement	2–3 months
Bus manufacturing and shipping	8–10 months
<b>Total</b>	<b>32.5–35.5 months</b>

In summary, from the time that TransMilenio began to prepare the operating contracts until the time vehicles were rolling on the street took a full twenty eight and a half months. In the case of TransMilenio this process was relatively fast-tracked, meaning no expenses were spared in terms of legal fees and management consultants.

While it can be done much faster, the shortcuts are likely to lead to significant operational problems or political problems. Many systems going forward today are moving rapidly on the physical infrastructure, while the operational contracting is being left to the last minute. A full 29 months should be considered the minimum amount of time required to set up a well managed system of private BRT operations. It can be done in less time if the structure of an existing system is more or less copied or if public procurement is used for the vehicles. The exact time will depend on the tendering rules of the particular country or city.

### 20.2.2 Jakarta operational contracting

In the case of Jakarta, the operational contracts were drawn up somewhat at the last minute. The Governor determined that it was politically necessary to have the system up and running by a certain date, January 2004. Without such a date, he feared the bureaucracy would continually delay the project. As is typically the case, the project was initially thought of largely in terms of the physical infrastructure, and the politically difficult and awkward negotiation of the operating contracts with the bus operators was left until the last minute.

With the system opening in January of 2004, TransJakarta had still not decided in July of 2003 whether the operators would be a single private entity, a public operator, or multiple entities. Around August it was finally decided that the operator would be a single private operator, a consortium to be formed largely of the bus operators currently controlling the bus routes along Corridor I. This decision, typical of Curitiba, Quito, and Mexico City (though a public operator shares some 20 percent of the routes in Mexico City) is usually taken not because it is in the interest of the system's users but because it is politically expedient to avoid conflict with bus operators. The legal entity that this consortium became was not actually



**Fig. 20.16**

*Until the operators actually possessed the official contracts, they were not able to obtain financing for the vehicles.*

Photo by Lloyd Wright

created until January of 2004, just days prior to the beginning of operations.

Because there was no legal entity able to procure the vehicles, there was no other option available than having the government procure the vehicles directly, in this case the Department of Transportation. This procurement meant that the municipal government had to incur the entire cost of the vehicles using public revenues (Figure 20.17). It also meant that the municipality remained the owner of the vehicles, and the incentive of the operators to maintain the vehicles was not strong. Nor did the municipality have the technical expertise to select the optimal vehicle, so the buses were over-powered, overly-heavy, causing needless fuel consumption and road damage.

There was not even enough time for the government to buy the buses using normal municipal competitive bidding rules. As a result, the Department of Transportation had to use a



**Fig. 20.17**  
*In Jakarta, the urgency of implementation forced government procurement of the vehicles.*

Photo by Karl Otta, courtesy of the GTZ SUTP Photo CD-ROM

**Fig. 20.18**  
*Bogotá gave a lump-sum contract to the fare system company to both purchase the fare equipment and to operate the system.*

Photo by Klaus Banse, courtesy of the GTZ SUTP Photo CD-ROM



clause in the law that allows the Governor to go around the normal competitive bidding rules in the case of “exceptional circumstances”, a clause normally intended to allow the city to cope with natural disasters. This action made the procurement subject to suspicions of government impropriety and subjected the municipal administration to an invasive investigative procedure and a near lawsuit. Though no impropriety was found, this investigation tarnished the reputation of the project politically.

The sole-source contract that was signed with a consortium of the existing bus operators created a monopoly that had a very strong bargaining position relative to the government.

TransJakarta, the operating agency, was also created at the last minute, and its powers were tightly restricted. It had to agree to pay the companies a very high fee per vehicle kilometre to convince the operators to cooperate. These firms had no experience in running a BRT system, or even experience running a formal sector corporation. Many of the drivers were initially operating the vehicles without any clear labour contract and some of the drivers hired turned out not to be competent or trustworthy. This situation led to labour disputes in the early months, with staff walking off the job and disrupting services. Neither the operators nor the operating authority had any experience with bus service scheduling, so the vehicles left at almost random times, leading to bunches of vehicles arriving at stations simultaneously during some periods, and then long periods where no vehicles would arrive.

### 20.2.3 Fare system contracting

Problems with the contracting of the fare system equipment and operations can also lead to operational difficulties. In the case of TransMilenio, there was a single lump sum contract with a single company to provide all of the fare system equipment and to operate the fare system equipment over a period of eight years. This lump sum contract approach to the fare system did ensure that there were no problems between the fare system operator and the owner of the fare system equipment (since they were one in the same). However, it turned out to be a very expensive way for TransMilenio to procure fare system equipment, and the system implemented was extremely simple and had operational problems at the beginning (Figure 20.18).

In Jakarta, the Department of Transportation procured the fare system equipment directly and then TransJakarta hired a separate operator who was responsible for running the system. In a rush to implement the system, Jakarta did not take good care in negotiating this contract, and the fare system equipment seller provided no guarantees to turn over the secret codes needed for programming the system to the company overseeing fare operations. It also did not include penalties for major system failure, and the system had every type of failure imaginable, from failure of the smart cards to failure of the fare readers to failure of the equipment to send

information to central computers. The weakness of the contracts and the division between the two companies made it very difficult to penalise either company when major problems arose.

Despite all the problems that can occur, and some negative publicity that can result, it is easier in some political systems to just start operating the system, and then fix the problems as they become readily apparent and a crisis exists. Nevertheless, proper planning can avoid many of these problems.

### 20.3 Construction

*“The whole difference between construction and creation is exactly this: that a thing constructed can only be loved after it is constructed; but a thing created is loved before it exists.”*

—Charles Dickens, novelist, 1812–1870

#### 20.3.1 Construction contracts

*“Society is indeed a contract. It is a partnership in all science; a partnership in all art; a partnership in every virtue, and in all perfection.”*

—Edmund Burke, statesman and philosopher, 1729–1797

##### 20.3.1.1 Overview

Construction actually involves four separate activities, and the way contracts for implementing these activities are packaged varies:

1. Detailed conceptual design;
2. Detailed engineering design;
3. Construction;
4. Maintenance.

Furthermore, BRT systems involve several different types of construction, not just roads. Unlike with a standard road project, a BRT system will involve fairly distinct types of construction, including:

1. Runways;
2. Stations;
3. Intermediate transfer stations, terminals, and depots;
4. Control centre and administrative buildings;
5. Pedestrian access infrastructure;
6. Integration infrastructure such as footpaths, bike lanes, and parking garages.

The contracting strategy may involve bundling different elements of the four construction phases, and almost all combinations are possible with different benefits and risks. Guidance on how best to group these activities together has



**Fig. 20.19**

*A flawed tendering process with the Jakarta fare system meant many operational problems at the outset.*

Photo by Karl Otta, courtesy of the GTZ SUTP Photo CD-ROM

not yet been fully systematised, but some experiences to date are given in this section.

The structure of the contracting should be done in a way that:

- Minimises the government’s cost of engineering and construction;
- Minimises the risk of unexpected increases in the construction cost;
- Minimises financing cost;
- Minimises construction delays and transaction costs;
- Minimises coordination problems;
- Minimises the risk of substandard construction;
- Achieves other social and political goals.

How these objectives can best be achieved will depend on local circumstances.

##### 20.3.1.2 Bundled contracts vs. separated contracts

The implementation process can involve a single large contract with all activities bundled together. In such cases, a large construction consortium would likely oversee the entire process. At the other extreme, each aspect of the process can be divided into many different contracts. There are also many possible permutations in between these two options. This section discusses some of the different considerations in choosing the structure of the contracts. Figure 20.20 summarises the different issues with each option.

**Minimising overall engineering and construction costs**

If a government is not entirely sure it wants to go ahead with a BRT project, one way to minimise the cost of the project is to separate the conceptual design from the detailed engineering. Likewise, the city can separate detailed engineering from construction. A government might be ready to spend the money on design and detailed engineering but not yet on the construction. A government may also not need to borrow money to implement the project if the total cost of the work package is kept under a certain minimum cost. Separating these steps would allow the government to pay for the design and construction more incrementally.

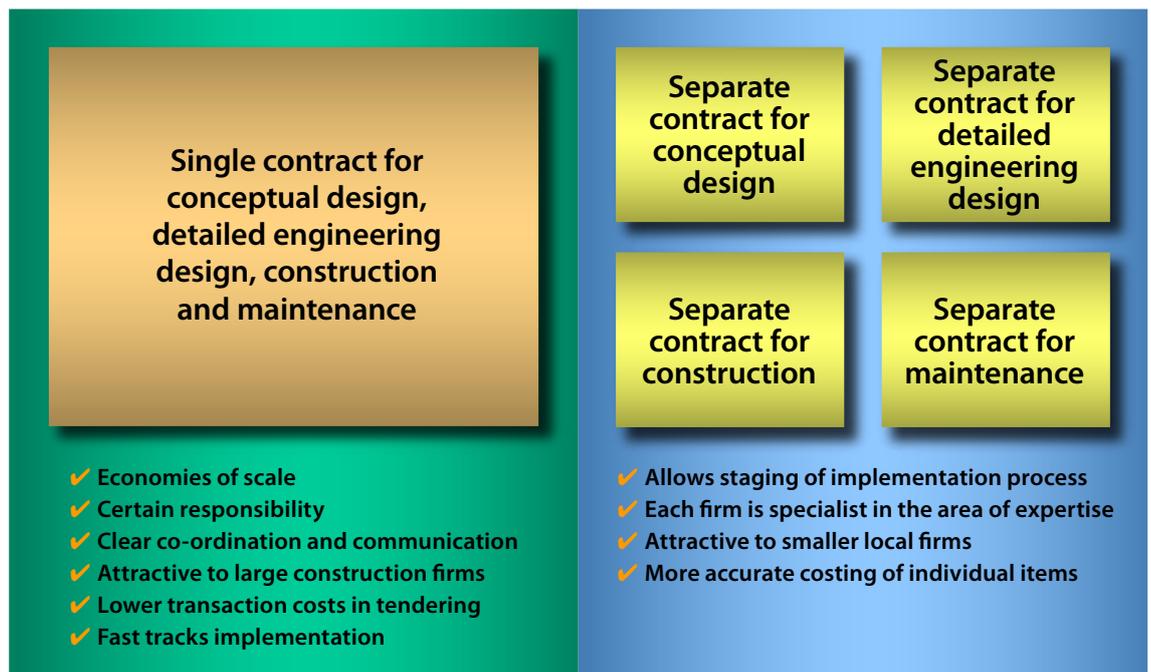
In other circumstances, a government may be in a great hurry to implement the system during a single political term of office, and may wish to lump together the design, engineering and construction all into a single contract to speed up the contracting process, even if it increases costs and risks. A single contract may also ensure there is commitment to full implementation, even if subsequent political administrations are less enthused about the project.

The size of construction firms operating in any given country will also vary, and their capacity to handle large projects will be a factor. Any major construction job requires certain fixed costs, such as the hiring of project personnel,

and certain variable costs, such as the construction materials. The larger the job, the less these fixed costs will be as a share of total costs. If contracts are broken down into very small project pieces, the loss of scale economies could significantly increase project overheads. In Delhi, the initial decision to break up the construction of the first corridor into two phases dramatically increased the total project cost due to the need to retain certain fixed costs over a longer period of time. If the contracts are too small, the project may also not be able to attract the interest of the largest construction companies that may have lower total costs due to returns to scale.

If a project is sufficiently large, it can actually increase the cost of locally procured construction materials by bidding up the price of these materials in the local market. BRT projects can be large enough to have such impacts. For this reason, for very large construction projects, international competitive bidding for the construction may be desirable. International construction firms are often able to mobilise resources from all over the world for a single project very rapidly, without significantly adversely impacting the local construction industry.

On the other hand, competition is also a factor. Governments generally like to have a reasonably large group of contractors available that can



**Fig. 20.20**

*The implementation contracting can be either bundled together or separated into individual pieces. Each approach carries specific advantages and disadvantages.*

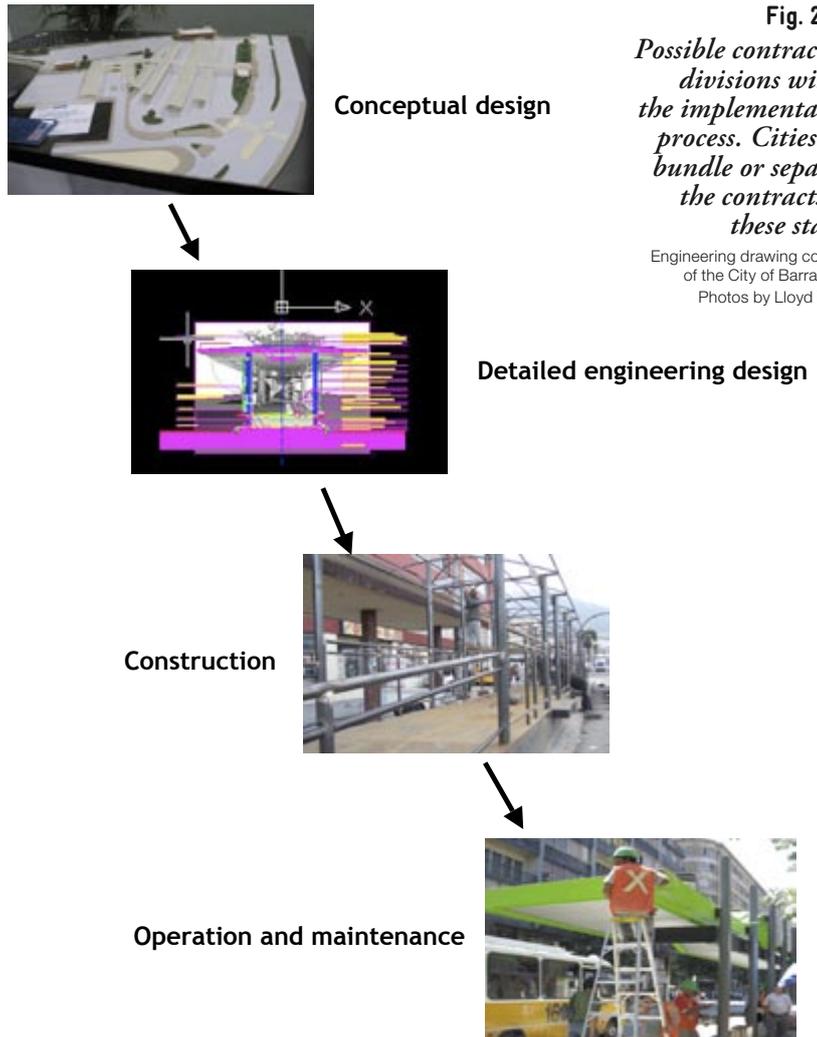
provide any given government service so as to ensure solid competition during a competitive bidding process. If the size of the BRT construction contract is too large, the number of firms that will be able to bid will be limited. If too many activities are bundled together, the number of firms able to provide all these services is likely to be limited, forcing firms to create consortiums, and these consortiums are sometimes unstable and unpredictable entities.

Breaking up different parts of the construction job to different companies will also create a sense of competition among government contractors. The municipality will be able to judge the performance of each company, and thus make decisions about the best performing firms for future contracts. This comparative analysis will likely spur a better performance from each of the participating firms.

**Minimising the risk of unexpected construction cost increases**

Like any major infrastructure project, one of the most difficult problems faced by governments is how to anticipate the actual cost of construction in the face of enormous uncertainties. Because no firm is actually sure what will be discovered once the ground is dug up, it is typical for all sorts of unexpected problems to be discovered once construction begins. Many construction companies take advantage of this uncertainty to systematically increase their billing on government contracts.

Predicting actual construction costs before the work begins is difficult even for normal road projects. BRT projects may be more difficult since many construction elements can be unique. Both governments and construction companies may have limited experience with such projects, and thus will not readily be able to estimate the cost based on previous projects. The station costing can vary widely depending on what sort of station has been designed by the architects, the sort of material used, etc. Street furniture, bike lanes, decorative lighting, landscaping and other amenities that usually accompany reconstruction in a BRT corridor



**Fig. 20.21**  
Possible contractual divisions within the implementation process. Cities can bundle or separate the contracts for these stages.

Engineering drawing courtesy of the City of Barranquilla  
Photos by Lloyd Wright



**Fig. 20.22**  
*The sub-surface of any street can be a complicated environment, creating uncertainty in full construction costs.*

Photo by Lloyd Wright

may also vary widely in cost. A standard road construction firm may have no idea how to cost out stations, street furniture, and the like, but may also not want to bring in an outside firm once they have already received the contract in order to maximise their profits.

As a result of these problems, it is fairly typical for actual construction costs to be double original estimates. In the case of TransMilenio Phase I, the construction costs were on average 50 percent higher than original estimates. In the Delhi BRT project, for instance, the firms responsible for the detailed engineering had no experience with BRT infrastructure components. Ultimately, the actual bids by construction companies came in some 30 percent higher than the designers had estimated, and insufficient funds had been allocated in the budget. In turn, more funds had to be secured from the government, and the bidding process had to be repeated.

In lower-income developing countries, the cities may not have recent topographical surveys upon which to base the detailed engineering design, and the quality of local topographical surveying may not be high. In the case of

the Dar es Salaam BRT project, the completion of

proper topographical surveys took six months longer than anticipated, creating great uncertainty about financing options. The detailed conceptual design was already completed in December of 2005, but as of a year later, the detailed engineering design was still not completed, so detailed cost estimates for the construction were also delayed.

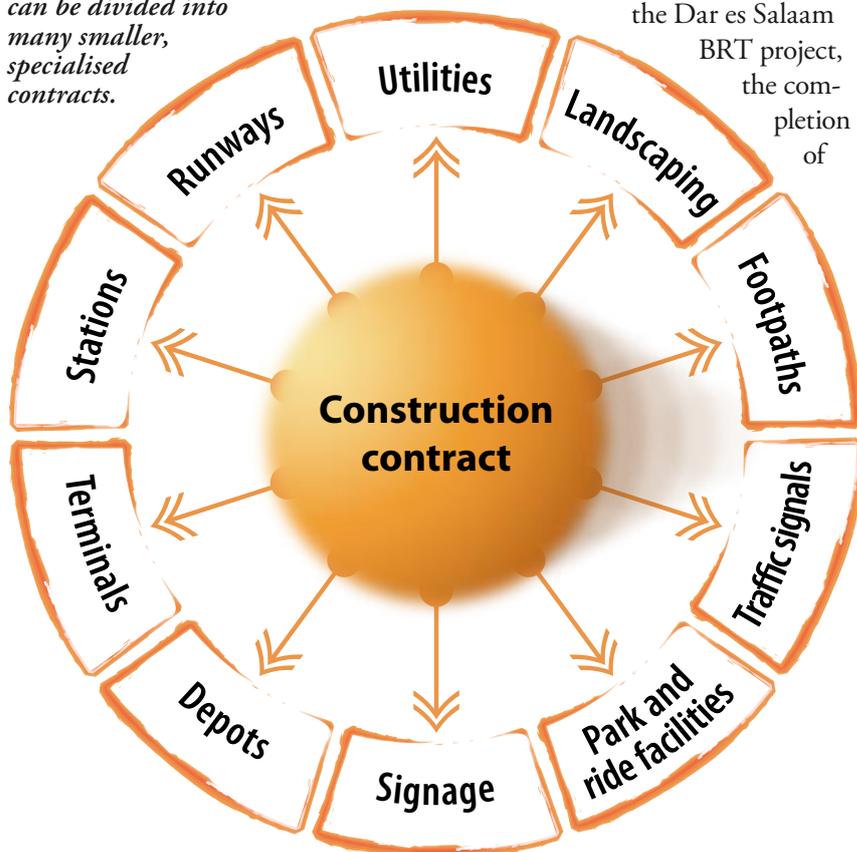
Government agencies managing a public works contract typically have to carefully monitor that both the technical specifications are met and also that any cost overruns are justified.

The first step in avoiding unanticipated construction cost overruns is to break out the contracts so that firms with experience with similar types of construction prepare the cost estimates. Firms with experience in building roads may have no idea how to estimate the cost of a BRT station, a depot, or a terminal. Government agencies with experience in managing road contracts and estimating their prices may similarly be unable to estimate likely reasonable costs. Thus, in some cases cities choose to split these different infrastructure components (runways, stations, landscaping, etc.) into separate contracts (Figure 20.23).

There are also some basic ways of using the construction contracts to place a limit on the total exposure of the government to unanticipated cost increases. One way to do this is to separate the detailed engineering contract from the construction contract. The firm that does the detailed engineering design has to produce a cost estimate, and is then not allowed to bid on the actual construction. This firm would be expected to establish a reasonable upper limit for the total cost of construction, or a "global price".

Once this global price is established, the actual construction contracts would be bounded within this upper price limit. If there are any allowances made for cost increases, they would be highly restricted to very specific circumstances. The construction contractor would then be paid a lump-sum contract. The monitoring role of the government on such a contract then becomes a matter of watching very carefully that the technical specifications are met, but there is far less concern about cost overruns. In this case, if the company's own risk assessment for cost overruns turn out to be too low, they bear

**Fig. 20.23**  
The construction contract itself can be kept as a single concession with "wall-to-wall" responsibilities, or it can be divided into many smaller, specialised contracts.



the financial risk. If the company over-estimates the risk, they benefit.

If the detailed engineering design is separated from the construction, then if a problem arises, it is not clear whether the engineering or the construction firm is responsible. Separating the contracts in this way therefore requires a four-month pre-construction phase. In this process, the bidding construction firms know what the top limit on the price of the contract will be, and they also know the minimum technical specification. Once a firm wins the bid, however, they cannot start work immediately. The firm is allowed to further explore the costing and make some modifications in the engineering specifications to meet the minimum technical standard, but these changes must be approved by the authorities. Once these final changes are made, the construction company assumes full legal responsibility for the designs, and there can be no question about their full responsibility for the final engineering designs.

#### Minimising financing costs

The structure of contracts may also be influenced by financial considerations. Many development banks and bi-lateral lending agencies are willing to offer low-interest financing for BRT projects, but under the condition that the implementing government is willing to follow the contracting rules required by the financial institution. Bi-lateral donor agencies may offer very low-interest loans, but may restrict bidding to firms with partners from the donor country, and may require that the tender documents are structured in a way that favours firms from that nationality (Figure 20.24).

Multi-lateral development banks generally have very detailed bidding requirements, with most of them requiring international competitive bidding. The contracting rules of the multi-lateral development banks are carefully negotiated by governments on behalf of the interests of large contractors from the donor countries, so sometimes the bidding rules tend to favour large international companies over multiple smaller contracts. This tendency has frequently led in the past to lumping many of the various elements of BRT construction into a smaller number of larger contracts. On some World Bank financed BRT projects, for instance, major



construction works have been linked with BRT design and construction contracts into a single large competitive bid.

#### Minimising construction delays and transaction costs

Given the opportunity, contractors may under certain circumstances delay the implementation of contracts. A huge contract might require a firm to add a lot of additional staff that it does not believe it can retain over the medium term, for instance. For all kinds of reasons, firms may be late in finishing construction. Given the enormous political importance of having the infrastructure completed in a timely manner, both for political reasons and to minimise traffic disruption, BRT construction contracts generally should include very stiff penalties for implementing the project late. In the case of late completion of a TransMilenio contract, the construction firm faced a US\$1 million fine, the suspension of the contract, and being barred from bidding on government contracts for five years.

Accurate cost assessments are also as important to avoiding delays as they are to minimising government exposure to cost overruns. In Delhi, under-estimation of the construction costs required a new request for government funds, which delayed the implementation of the project by six months.

In some countries, the procedural rules for contracting out work packages are cumbersome and time consuming. Breaking out detailed conceptual planning, detailed engineering, construction, and maintenance to separate firms, and contracting out different elements of the construction to separate firms, can cause

**Fig. 20.24**  
*Bi-lateral donors, such as the Japanese International Co-operation Agency (JICA), will sometimes wish to favour construction firms and consultants from their own country.*

Photo by Lloyd Wright

**Fig. 20.25**

*The construction contracts may be organised in a way so that firms with specialist skills, such as station construction, are able to focus solely on one infrastructure component.*

Photo by Lloyd Wright



considerable delays, especially if each stage must go through its own competitive bidding. Each new firm taken on for the next phase needs to re-learn the project from the beginning. Each separate tendering process also incurs transaction costs for lawyers and staff to prepare and manage the tender. If time is of the essence, and transaction costs are an issue, it may be easier to lump more of the contracts together into a smaller number of lump sum contracts.

**Minimising coordination problems**

The importance of coordination is also a factor. Breaking up the construction contracts into numerous small contracts may be desirable for spreading the benefits of the contracts among a wide range of constituents, but it may introduce problems of coordination between firms. If the government administration is weak, it may be that giving a single firm many of the project’s construction projects to coordinate will yield a better result than if this is done by an agency of the government with no core competency in some areas of the project.

**Minimising the risk of sub-standard construction**

The quality of construction and long-term maintenance is as important as the cost of

construction. The quality of construction and long-term maintenance of a BRT system is more important than for normal roadways because fixing the road frequently requires shutting down the entire system, or diverting buses out of the exclusive busways temporarily. Such closures and diversions can result in significant revenue losses. If the busway uses electric trolleybuses with overhead electric conduits, the maintenance issues become even more important, as a single vehicle failure can obstruct the entire system.

Governments can do a lot to ensure good-quality construction. The first step in ensuring good-quality construction is to structure the contracts in such a way that the best firms can bid for the most appropriate elements of the BRT system. Lumping all the BRT design and construction contracts together may result in having firms with backgrounds primarily in road works managing construction projects for public space, terminals, stations, and other project elements about which they lack experience and expertise.

Governments may structure the contracts so that those elements of the contracts for which they need international help and are therefore willing to subject to international competitive

bidding will be lumped together, whereas contracts where local competence is sufficient may be kept separate.

**Using construction contracting to achieve social objectives**

Finally, political considerations will always play a role. Often these political considerations are largely about awarding patronage to political supporters, but sometimes these considerations attempt to address legitimate social concerns. In Cartagena, for example, current plans are to give the construction of the TransCaribe BRT system out to a separate construction company for each kilometre, in order to ensure that smaller scale local firms are able to bid, and to spread political patronage among a wider diversity of different groups. More numerous, smaller contracts may increase the chances that women-owned or minority owned firms have the chance to win the contract, or that the benefits of the project are more broadly spread among different interest groups. Given the enormous social ramifications of having a poorly designed and/or constructed BRT system, however, it is generally not a good idea to try to embed too many conflicting social objectives into a BRT construction contract. Rather, contracts should be given to firms offering the best quality construction at the lowest price.

**20.3.2 Bogotá case study**

**20.3.2.1 TransMilenio Phase I**

In the case of TransMilenio, the BRT Plan prepared by the principal consulting firm (Steer Davies Gleave) and its subcontractors was a detailed conceptual design. This plan provided overall technical specifications for the system. However, the detailed engineering design plan was left to be done as part of the construction contract. The public works department drew up the bidding documents for the detailed engineering and actual construction. Separate contracts were also drawn up for:

1. Stations;
2. Roads (by section);
3. Footpaths and pedestrian infrastructure;
4. Urban design and construction for the transit mall in the city centre;
5. Maintenance.

Many of these contracts were broken up into sections of the corridor. The entire roadway was rebuilt with concrete to handle the heavier axle



**Fig. 20.26**  
*The Calle 80 corridor in Bogotá.*

Photo courtesy of TransMilenio SA

loads of the TransMilenio articulated vehicles. The use of concrete was also done in hopes to reduce long-term maintenance costs.

In Phase I, TransMilenio road construction contracts were packaged as follows. Phase I consisted of four sections: 1.) Calle 80 section (12 km); 2.) Autopista Norte section (10 km); 3.) Avenida Caracas section (23 km); and, 4.) Eje Ambiental section (2 km).

On the “Calle 80” section, there were two contracts for the trunk lines and improvements on the mixed traffic lanes adjacent to the busway. The contracts were for roughly two years, 1998 to 2000. There was a separate contract for the detailed design and construction of the Calle 80 depot, a separate one for the Calle 80 terminal, and four separate contracts for the footpaths and pedestrian overpasses.

**Fig. 20.27**  
*The Avenida Caracas/ Autopista Norte corridor in Bogotá.*

Photo by Lloyd Wright



On the “Autopista Norte” section, there was only one contract for repaving the trunk roads and the adjacent mixed traffic lanes. There was one contract for the depot, and one contract for the terminal and for 1 kilometre of roadway leading to the terminal.

On the “Avenue Caracas”, there were four contracts for trunk lanes and the adjacent mixed traffic lanes, there were two contracts for two depots, two contracts for two terminals, and 12 contracts for footpaths and pedestrian facilities.

The “Eje Ambiental” section represented a short 2-kilometre segment that passed through the city centre. For this section, there was one special contract for a detailed urban design given to an architectural firm and a separate contract for construction. The urban design element on this particular stretch of road was critical, and thus was deemed worthwhile to bring in a separate architectural firm for a more detailed urban design.

The detailed design and construction of the stations was done by five separate firms. There were also three separate maintenance contracts for the roads for a period of five years after the completion of the system.

Separating the detailed conceptual design contract from the detailed engineering design and construction contracts, avoids any conflict between the design and the detailed engineering. However, separating these contracts did lead to confusion about who was responsible

when problems emerged. Separating responsibility for maintenance from responsibility for construction also created the risk that the construction company could cut corners on the construction, hoping that problems will not emerge until later, with earlier than anticipated “maintenance” needs.

In fact, when only three months after TransMilenio opened, there were already problems of cracking pavement, the construction company blamed the conceptual designers and the conceptual designers blamed the construction companies. The construction company also claimed that it did not have any responsibility for maintenance under the contract.

### 20.3.2.2 TransMilenio Phase II

The problems experienced in Phase I of TransMilenio convinced the city to alter the contracting structure. In Phase II in TM they changed the contracting structure to a type of “concession” agreement. This change was done to make sure that the same firm responsible for construction was also responsible for five years of maintenance. This structure also had the added benefit of using the construction companies to finance the infrastructure, rather than paying the companies in a single lump-sum payment.

In Phase II responsibility for the detailed design was separated from the responsibility for construction. As noted, responsibility for construction was given to the same firm as the responsibility for long-term maintenance (five years). Furthermore, the design of the footpaths and street amenities were no longer separated from the rest of the roadway design. The firm doing the detailed design of the corridor did the designs from wall to wall, not just either the road or the footpaths. Similarly, the firm doing the construction did the whole section of the road wall to wall, rather than having one firm for the roadways and another firm for the footpaths.

The packaging of the construction contracts and the maintenance contracts was linked in Phase II to a change in the financing. The government had less money to finance the public works. If the normal pay-as-you-go financing used in Phase I had been implemented in Phase II, the construction would have been spread out over five years instead of over two. Phase II

**Fig. 20.28**  
*The Eje Ambiental corridor in Bogotá.*  
Photo by Lloyd Wright



construction contracts were therefore written as concession contracts. The companies did not collect toll revenue. However, the construction company had to pay the construction costs up-front, and the roads had to be completed within 18 months. The construction companies secured loans from banks, and the government reimbursed the company over a period of five years as part of the maintenance contract. This contracting structure increased financing costs somewhat but it also ensured that capital would be available to build the entirety of Phase II in just two years, when using the budget alone would have taken five years due to restrictions on total borrowing. This contract structure also had the advantage that if maintenance problems arise, the government has the power to withhold payment.

Specifically, Phase II of TransMilenio had four different sections: 1.) Calle 13 (4 km); 2.) Americas and Avenida Cali (7km); 3.) Norte-Quito-Sur (21 kms); and 4.) Suba (12 km).

On the “Calle 13” section, there was one contract for detailed design and one contract to build from wall to wall and maintain the section for five years. On the “Americas and Avenida Cali” section, there was one contract for detailed design, and three contracts to build everything wall to wall and provide five years of maintenance, one contract to design the depot and the terminal, and one contract to build the depot and the terminal. On the “Norte-Quito-Sur” section, there was one contract to do the detailed design, and three contracts to build everything wall to wall and provide five years of maintenance, and one contract to build both the depot and the terminal. On the “Suba” section, there was one contract for detailed design, two contracts to build everything wall to wall and provide five years of maintenance, and one contract to build both the depot and the terminal.

**20.3.3 Timeframe for construction**

The timeframe for detailed engineering design and construction can vary widely depending on the size and complexity of the construction works that need to be undertaken, the size of the firms involved, and the governmental procedures required for any public works project. The only particular difficulty with a BRT project is that the relative complexity of the works being



**Fig. 20.29**  
*Construction on the Americas corridor in Bogotá.*

Photo by Lloyd Wright

undertaken may make it difficult to estimate in advance the time it will take.

Table 20.3 gives the timetable for constructing the first phase of TransMilenio. This time line indicates that 28.5 months is the minimum realistic time frame for going from no background with BRT to the completion of the construction.

In the case of TransMilenio, construction in Phase I was actually broken into two separate components. Phase I was defined based on the minimum system size required to make the system financially viable. However, the first part of

**Table 20.3: Timetable for construction of TransMilenio Phase I**

Activity	Minimum amount of time required
Preparation of Conceptual Design–SDG	8 months
Completion of Formal Tender Documents–IDU	4 months
Preparation of Bids	3 months
Awarding of Bids and Signing of Contracts	1.5 months
Detailed Engineering and Construction	12–28 months
<b>Total</b>	<b>28.5–44.5 months</b>

**Table 20.4: Timetable for constructing Phase II of TransMilenio**

Activity	Amount of time
Preparation of Conceptual Design–TMSA	3 months
Detailed Engineering Designs-Consultants hired by IDU	6 months
Completion of Formal Tender Documents–IDU	4 months after the design had been finished (However, 6 months were spent preparing the legal and financial concept at the same time that the engineers performed design work)
Preparation of Bids	3 months
Awarding of Bids and Signing of Contracts	1 months
Pre-construction	4 months
Construction	12-18 months
Maintenance	5 years
<b>Total</b>	<b>33–39 months (without maintenance)</b>

Phase I was defined based on what could realistically be constructed during the Mayor’s term in office. The total Phase I was to be a 44 kilometre system. However, the first part of Phase I totalled just 18 kilometres. In the timetable above, 28.5 months was for the completion of the smaller first part of Phase I. The full completion of Phase I took an additional 16 months.

The timetable for Phase II of TransMilenio is given in Table 20.4. In Phase II, the conceptual design took less time, because Phase II did not significantly modify the conceptual design established in Phase I. Separating the detailed

engineering design from the construction took a bit more time, and required a four month “pre-construction” phase. Nevertheless, once construction began it went faster, and the problems with sub-standard construction were significantly reduced.

Normally, construction delays are related rather to contracting and budgeting issues. Most countries and most financial institutions require the works to be competitively tendered following specific tendering procedures. The time this process takes varies from country to country. Normally, the tender is published and bidders are allowed a fixed amount of time to give an expression of interest. Then a short list is drawn up, and detailed bids are solicited. This process can take anywhere from three to six months even if there are no problems.

**20.3.4 Communications plan for construction**

The construction process represents a great risk to the image and future of the new public transport system. The closing of roadways, the construction noise, and the blowing dust can all give the new system a negative first impression to the population (Figure 20.30).

A communications public education plan can also help to keep affected parties well informed in a timely manner. Before construction begins, a communications plan must be designed and it should feature meetings with local business associations and residential communities. The purpose of these meetings is to assess the potential negative impacts and their duration, so that affected stakeholders can work out the measures necessary to cope with the process.

Providing proper instructions during the system’s implementation stage facilitates the decision-making process for the parties involved. Instructions also help to minimise risks associated with construction, changes in operation schemes, and cultural acceptance of the new system. A detailed program containing alternate routes and traffic re-direction schemes must be released during the system’s construction phases. The program must include applicable date ranges, specific routes, signage formats, and a plan for its wide release to the general public. It is vital to define changes in public service routes, bus stops, and schedules.

**Fig. 20.30**  
*Road-widening work taking place on the Santa Rosa corridor in Santiago.*

Photo by Lloyd Wright



Businesses and communities in close proximity to construction sites are usually affected by noise pollution, construction equipment, interruptions in the provision of utilities, and scarce road availability. In the narrow streets of the city centre, businesses may lose both customer access by cars as well as limited means to bring in deliveries (Figure 20.31).

A good communications plan must incorporate feedback mechanisms so that complaints, claims, and other comments can be acknowledged and addressed. Feedback mechanisms act as a complement to instructions by helping people evaluate and deal with the negative impacts related with the construction process. Nevertheless, continuously restating the future benefits the project will bring to the city and to the temporarily affected communities is essential. Also, feedback from users can be used to appropriately address their concerns and integrate them into the planning process.

### 20.3.5 Construction plan and mitigating impacts

“Vision without action is merely a dream. Action without vision just passes the time. Vision with action can change the world!”

—Joel Arthur Barker, author and management consultant

Organising the construction work in a city-friendly manner should be a top consideration. While planning the construction of the BRT infrastructure is not fundamentally different than planning any other public works project, there are a few differences:

- BRT construction involves many more different types of construction than simple road projects;
- The speed and quality of the construction are more important than for standard road projects;
- Long-term maintenance of the BRT infrastructure is also more important than for a standard road project.

Normally, responsibility for a good construction implementation plan rests with the construction companies, though some traffic impact mitigation measures may have been prepared by the firm doing the conceptual design. Proven experience with developing a successful construction



**Fig. 20.31**

*Construction can be a major disruption to city centre businesses, as shown here during the construction of the Pereira Megabus system.*

Photo by Edgar Enrique Sandoval

implementation plan should be a factor in selecting the construction firms.

A construction plan should be developed in conjunction with the contracted firms. Each step of the process should be mapped out to minimise the negative impacts. The manner of the construction process should also be noted in the construction contract. Structuring the road construction through a concession structure may give greater leverage to limit adverse social impacts. It is also possible to include financial incentives to construction firms that successfully minimise negative impacts of road closings and construction dust and noise.

In some cases, construction at nights, weekends, and holidays may be the best options for avoiding the prolonged closure of key connecting roads. It may also be best to work on a segment by segment basis rather than closing the entire length of a particular corridor. However, the particular strategy will depend much upon local circumstances.

The management of traffic re-routing and traffic control during the construction should be coordinated between the construction firm, the police, and the public transport agency. Particular care should be taken in handling intersection and underpass construction since significant congestion and inconvenience can occur when closing off entire intersections (Figure 20.32).



**Fig. 20.32**  
*Re-routing traffic around intersections that are under heavy construction can be particularly challenging.*

Photo by Lloyd Wright

Phase I of TransMilenio was very popular, but received some criticism for adverse impacts resulting from chopping down trees, and disrupting businesses and residential life along the corridor during the construction (Figure 20.33). For that reason, Phase II had much more detailed programs to reduce adverse social impacts, and minimising these impacts were the responsibility of the construction company. There was a special set-aside for social impact mitigation within the lump sum contract, around 10 percent of the total contract value.

## 20.4 Maintenance

*“A beautiful woman and a wooden boat are very expensive in maintenance.”*

—Dutch proverb

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

### 20.4.1 Maintenance of vehicles

The maintenance of system equipment, such as vehicles, fare systems, and ITS equipment, will depend on the ownership structure. Since vehicles are almost always owned and managed by the private operators, responsibility for the maintenance of the vehicles will rest with these private operators (Figure 20.34).

However, there will still be a role for the BRT authority to ensure that the quality of the vehicles is maintained. Maintenance and quality standards should be explicitly stated in the original contractual agreements with the operators. Certain aspects of the vehicle are likely to require regular maintenance and upkeep. The



**Fig. 20.33**  
*The disruption to traffic and businesses during Phase I construction of TransMilenio did receive some criticism. More mitigation measures were subsequently applied in Phase II.*

Photo courtesy of TransMilenio SA

pneumatic doorways are particularly prone to occasional failure. Likewise, the quality of the seating may deteriorate with use and any vandalism. Windows that are scratched or discoloured will appear functional but nevertheless will affect the image of the system.

Fare system and ITS equipment may be privately or publicly owned, depending on the nature of the system’s business structure. If privately owned, then the operating contracts should clearly delineate responsibility and timeliness over any maintenance issues. If publicly owned, then the city may elect to establish a private sector maintenance contract for these items.

Since BRT stations are relatively narrow due to median width restrictions, there is typically only space for a few fare readers and turnstiles. Thus, if one reader/turnstile should fail, the functionality of the entire station is greatly diminished. For this reason, there should always be stipulation that a certain number of units and/or spare parts are held in reserve. There should be contractual language requiring the maintenance firm to react within a certain time period to any breakdowns.

**20.4.2 Maintenance of infrastructure**

The maintenance of system infrastructure components (busways, stations, terminals, depots, and control centre) will depend on the nature of the original construction contracts. As noted in the previous section, maintenance may or may not be linked to the original construction contracts. There are trade-offs between separating and linking the contracts. Thus, responsibility for maintenance may be held by either the private construction firms or the municipality.

**20.4.2.1 Basic principles of maintenance**

Maintenance practices should ensure that any problems are addressed as they occur. A damaged roadbed will not only create discomfort for passengers but also increase maintenance costs for public transport vehicles. Maintenance teams should be constantly on the watch for graffiti and other types of system vandalism. If vandalism is not repaired immediately, it can create an impression that such actions are tolerated and will thus encourage even more acts of vandalism (Figures 20.35).



In some cases, the failure to act upon maintenance issues can result in significant legal and financial liability. If roadways are improperly maintained and thus damage the vehicles, the private operators may file a legal suit over the cost of vehicle repair. Likewise, if emergency equipment is not functioning properly, there could be serious ramifications (Figure 20.36).

**Fig. 20.34**  
*The maintenance of the vehicles is almost always the responsibility of the private sector operating companies, with some provisions for inspection and oversight from the BRT authority.*

Photo by Lloyd Wright



**Fig. 20.35**  
*Graffiti, as shown in this example from Quito, can do much to tarnish the image of the system.*

Photos by Lloyd Wright

**Fig. 20.36**

*These emergency telephones in a Johannesburg terminal are ripped out, potentially leaving system users in peril. The system operators may have a substantial legal liability for failure to maintain the equipment.*

Photo by Lloyd Wright



The external surfaces of station and terminal facilities are subjected to both environmental pollution as well as the variances of the climate. Rain, wind, heat, and contaminants can all lead to premature weathering of the station appearance. Often a treated coating is applied to the surfaces to slow the effects of corrosion and discolouration. The maintenance contracts should foresee the necessary reapplication of coating materials prior to any major deterioration in appearance (Figures 20.37 and 20.38).

**Fig. 20.37 and 20.38**

*Untreated surfaces or neglected surfaces can rapidly decay due to the influences of corrosion, as these images from Quito indicate. Such problems should be prevented before the appearance and image of the system is compromised.*

Photos by Lloyd Wright



Likewise, the original infrastructure design should accommodate easy cleaning and upkeep (Figure 20.39). Vaulted ceilings and artistic curves can be pleasing to the eye but challenging from a maintenance standpoint. The original infrastructure design plans should be evaluated for maintenance viability prior to the approval of the architectural plans.

If certain infrastructure components are requiring frequent maintenance actions, then this information should be incorporated into decisions on future extensions of the system. A maintenance logbook should thus be kept by all maintenance contractors with copies submitted to the public transport agency or the public works department. Analysing maintenance actions and the nature of the problems can possibly help in devising future solutions.

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

#### 20.4.3 Maintenance contracts

The way the contracts are structured, and the type of incentives they include will strongly affect the effectiveness of the system's maintenance and upkeep. If construction firms have no responsibility for maintenance, then their



incentive may be to ignore future maintenance problems. Instead, the contractors will have an incentive to only worry about a rapid and low-cost delivery and not whether the product is still functional in a few years.

The best mechanism to ensure a higher-quality and more durable product is to make the same firm responsible for construction also responsible for maintenance over the first several years. The firm that builds the busway or station can be contractually required to maintain it to specific standards. If the firm has a five to ten year maintenance contract, then automatically the company will want to build the infrastructure to endure. If the construction is delivered in poor quality, then the firm will have higher costs maintaining the infrastructure over the entire period of the contract.

Giving a construction firm responsibility for maintenance, however, must be accompanied by a shift in the contract structure to a lump-sum contract. Otherwise, if the firm has the ability to continually return to the government and ask for additional funds for unanticipated maintenance costs, the purpose of linking the construction contract to the maintenance contract is effectively undermined. Linking construction and maintenance contracts, therefore, tends to be done as part of an overall concession-oriented approach to road construction contracting.

In Phase I of TransMilenio, the construction firms were not responsible for long-term maintenance. Thus, when severe road construction faults occurred after only three months of operation, the city had limited legal recourse to hold the private companies as the responsible party (Figure 20.40). The firms did have to carry insurance in case of a major construction problem, but this insurance partially insulated the company from the full risk of a construction problem. With this lesson in mind, TransMilenio restructured the Phase II contracts in order to link construction and maintenance together.

The EMTU busway in the State of Sao Paulo also faced maintenance issues. This busway had overhead conduit wires maintained by the electrical company, and the roads were maintained by the State roads agency. When maintenance was done poorly, the private bus operators faced significant losses in terms of lost passengers and



**Fig. 20.39**

*The original station design should include an appropriate plan for dealing with routine upkeep requirements.*

Photo by Lloyd Wright

vehicular damage, but they had limited recourse. Eventually, most buses stopped using the electrical conduits due to frequent maintenance issues. The problem was resolved in this case by shifting responsibility for the maintenance of the conduit and also the road bed to the bus operator. The bus operators do not have a core competency in road maintenance, but they had a powerful vested interest in avoiding damage to their vehicles, so they ensured that the contracting out to construction firms was done well. This approach was also reasonably successful. The costs of maintenance were still covered by the government, but in the form of a higher payment to the bus operators per bus kilometre.

*“When you want something, all the universe conspires in helping you to achieve it.”*

—Paulo Coelho, novelist, 1947–

**Fig. 20.40**

*Severe cracking and subsiding of the TransMilenio busways in Phase I led to legal battles over responsibility.*

Photo courtesy of Diego Velazquez

