Public Transportation Systems for Urban Areas
A Brief Review

Dinesh Mohan
Transportation Research and Injury Prevention Programme
Indian Institute of Technology Delhi

PUBLIC TRANSPORTATION IN MODERN CITIES: STATE OF THE ART......................... 2
The Indian Scenario..................................................................................................... 3
Public transport and city character............................................................................... 4
Transit systems, catchment areas and feeder trips............................................................ 7
Financial viability........................................................................................................ 8
Public transport and access........................................................................................... 10
Metros, congestion and the environment........................................................................ 10
Cities, public transport and Bus Rapid Transit Systems (BRT)......................................... 11

COMMENTS ON CLAIMS REGARDING METRO SYSTEMS WITH SPECIAL REFERENCE TO DELHI ................................................................. 13

APPENDIX 1. SUMMARY OF SELECTED BUS RAPID TRANSIT SYSTEMS .................. 20
2. City: São Paolo  Country: Brazil  Population: 10 million.................................................... 20
3. City: Curitiba  Country: Brazil  Population: 2.7 million.................................................... 20
5. City: Quito  Country: Ecuador  Population: 1.8 million.................................................... 21

APPENDIX 2. SELECTED EXTRACTS FROM INTERNATIONAL REVIEWS.................. 24
PUBLIC TRANSPORTATION IN LARGE CITIES: STATE OF THE ART

Dinesh Mohan
Transportation Research and Injury Prevention Programme
Indian Institute of Technology Delhi

• “Bus Rapid Transit gives communities the best bang for their buck when it comes to investing in transit. This new system will better connect workers to jobs, shoppers to stores and Oregon to the rapidly growing economy.”

   Norman Y. Mineta, U.S. Secretary of Transportation.

• “The system in Bogota, though only three years old and still under development, already has one of the highest ridership rates in the world. Most large cities would benefit greatly from bus rapid transit systems”.

   International Energy Agency

• “Unfortunately sometimes rail systems are also chosen for the worst possible reasons... Rail system salesmen are legendary for the procedures they utilize for selling their expensive wares. Taking all other vehicles out of a few lanes, any city’s road network can be used to put in place bus based transit with capacities and speeds very similar to those of rail systems, at a small fraction of the cost...Finally bus systems are more flexible, an important asset in developing countries dynamic cities. As a city attraction center shifts, it is easier to adjust a bus system than a rail one.”

   Enrique Peñalosa, Former Mayor of Bogota, Columbia

• “A comprehensive bus system - which would help remove thousands of cars from the streets - can be set up for the same cost as constructing a flyover, which often only serves to shift a traffic jam from one point to another... It is crucial to give due consideration to the magnitude of a project in order to avoid the risk of presenting ‘show-case’ solutions which are conceived for the media and only benefit a minority of the inhabitants”.

   Jaime Lerner, Former Mayor of Curitiba, Brazil.

• “A sustainable city is one that wastes the least and conserves the maximum. Most importantly, it means making the existing system of people and resources work better—rather than throwing it away and trying to replace it with a single, capital-intensive project such as a subway or a rail-based system. Curitiba began with buses because it had buses; it did not have a subway”.

   Jonas Rabinovitch, UNDP

---

The Indian Scenario

Most Indian cities have the following characteristics:

1. Most Indian cities are expanding in a radial mode and are not likely to develop one concentrated high density business district in the foreseeable future. Most city plans include decentralisation of many trade activities with relatively low-rise development.

2. Maximum per capita income of about US $ 1,000 per year (say in Delhi) which is not likely to exceed US $ 4,000 per year in 2025. Therefore, all cities in India are likely to remain at “low income” levels by international standards for the next 20 years.

3. Very high ownership of motorised two wheelers. It appears that about 70 percent of families in Delhi own a motorised vehicle (Delhi has about 3 million families and 2 million vehicles\(^5\)). This is relatively new development internationally. When the metro systems were originally developed in Europe, USA and Japan (in the first half of the 20\(^{th}\) century), vehicle ownerships were very low. For example, in United States only 70% of the families had a car in 1955 and less than 70 % of the families owned vehicles in most European cities even in the 1960s.

4. The marginal cost of operating a motorised two-wheeled vehicle is about Rs. 0.70 – 1.00 per kilometre at 2005 prices. This determines the maximum fare box levels for public transport. It will be difficult to attract users to public transit systems if fares are set higher than this.

5. If we assume that at least 30 % of families in Indian cities earn less than Rs. 5,000 per month (2005 prices), then these families are not likely to spend more than Rs 5.00 per trip on transport (assuming that they can allocate only 10% of their income to transport, and that they need only 2 round trips per day). Low-income individuals are not likely to use public transit for short distances. Long distances trips on the metro would cost 3 to 4 times this amount. Therefore, metro transit is not likely to be affordable for a significant segment of Indian urban populations for some time to come.

6. Most Indian cities have mixed land use patterns and we are not likely to succeed in implementing strict zoning for land use, even if it were desirable. This means that many citizens live close to work places and can walk, bicycle, use para transit or buses quite conveniently.

The above issues have serious implications for the kind of public transportation systems we should develop in our cities. These are discussed in brief below.

Public transport and city character

Transport systems and city character are interlinked. Land use characteristics of a city can determine the type of transport system it needs, and once a transport system is put in place, it influences land use characteristics of the city over time. Therefore, the type of public transport system you want in a city will depend on the vision you have for the future of your city. If an economically vital large central business district (CBD) exists, it can become the main centre for both employment and retail, and thus contribute to the success of an urban rail system (if the system serves the CBD) because it can generate and attract trips onto the system. However, low-income neighbourhoods would still be unsuitable for urban rail operation.6

High-rise dense city

If you want your city to develop as a dense congested city with a large proportion of high-rise buildings and one very large central business district, then you should think of introducing very high capacity transport systems that can carry more than 40,000 people per hour per direction. This can usually be done by elevated or underground rail systems.

On the other hand, if you put in place a high capacity rail system in a city that is not yet high-rise, then the rail system will ensure that over time a very dense and congested high-rise city develops where the rail lines converge. This happens because space becomes very expensive and the economics dictate that buildings go high-rise. In India, Mumbai is a good example of how the existence of the rail system has resulted in south Mumbai going high-rise and developing into a very dense and congested business district.

Low rise, multiple business centre cities

Cities which have multiple business districts and in which buildings are 2-5 stories high cannot feed very high capacity mass transit systems. Such cities do not need and cannot sustain very high capacity systems. Transit systems capable of transporting 15,000 to 25,000 passengers per direction per hour operating on all major corridors would be adequate. Such systems would not alter the character of the city. Such a demand can be met by modern bus rapid transit systems.

Observations stated above are supported by international experience.

---

International experience

Table 1 shows share of public transport in four metropolitan cities around the world. These cities are considered to be among the most successful in providing rail based public transport. However, only in Tokyo and Hong Kong is public transport able to capture close to 50% or more of trips in the city. This shows that it is not easy for public transport systems to cater for a majority of urban trips if people own private vehicles. Short access trips, safety from road traffic injuries and crime have to be ensured for people to use public transport. In addition, both the origin and destination need to be close to the transit stops. This is why density and land use issues become important. It is only when a city has a large and dense central business district that a large number of people who happen to live on a particular corridor need to travel in the same direction. Figure 1 shows average modal shares of trips in cities in different regions of the world. It is interesting that even though European cities have built many rail based systems, they do not have higher public transit shares than Asian cities, many of which are bus based.

Figure 1. Modal shares in cities around the world (Transit figure for low income Asian cites includes para-transit)

An international review of rail systems conducted for the US government concludes that, “Central Business Districts have traditionally been the foci of transit systems and have the highest mode shares. At the broadest level, urban structure refers to the extent to which employment is concentrated in a single dominant centre (i.e., the CBD), in multiple centres polycentric urban form), or in numerous locations at very low densities (the dispersed pattern). A number of studies make clear that CBDs are most supportive of transit, while job decentralization, either in polycentric

<table>
<thead>
<tr>
<th>City</th>
<th>Market Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hong Kong</td>
<td>61.11%</td>
</tr>
<tr>
<td>Tokyo</td>
<td>48.98%</td>
</tr>
<tr>
<td>Singapore</td>
<td>31.21%</td>
</tr>
<tr>
<td>Paris</td>
<td>26.98%</td>
</tr>
<tr>
<td>London</td>
<td>26.33%</td>
</tr>
</tbody>
</table>

Table 1. Share of public transport in five mega cities

---

8 Urban Mobility, Jean-Paul Rodrigue, 2005-01-14
http://people.hofstra.edu/geotrans/eng/ch6en/conc6en/ch6c3en.html
regions or in dispersed patterns, results in less use of transit for all trip purposes. A study of 63 office relocations in London showed that decentralization resulted in 107 percent more automobile trips and 25 percent fewer bus trips than if the offices had not decentralized.

Figure 2. Changes in modal shares in Mexico City between 1986 and 2000 (adapted from Schipper, 2004)

It is clear that exceedingly large central business districts are essential for success of high capacity rail based transit systems. For example, Tokyo, New York, Paris and London, each have central business districts with more than 750,000 jobs. Tokyo has one of the world’s largest central business districts, with approximately 2.3 million jobs, with an employment density of approximately 58,600 per square kilometre, and almost all of central Hong Kong is a business district. This is why rail transit is so successful in these two cities. The massive central business district employment numbers and densities support a high degree of substitution by rail of automobile use that is not possible in smaller central business districts (because there is too little demand and it is too dispersed).

When business districts are dispersed and incomes relatively low as in Asian cities (compared to cities in high income countries), the situation is even worse for rail-based high-capacity transit systems. Shanghai City has about 82 kilometres of metro and light-rail lines, but rail transport only accounts for 2 percent of the local traffic volume. Mexico City (population 10 million) has 201 km of metro rail and it is the cheapest in the world, but it carries only 14% of trips (see Figure 2). The metro share has reduced as the share of mini-buses and collectivos has increased. Kolkata

---

has a 17 km metro line, but even after a decade of completion the system carries about 10% of its projected capacity.14

Experience from existing rail-based transit systems indicates that they are successful in utilizing their maximum capacities only when implemented in cities that have the following characteristics:

- High density habitation with at least one major very high density, high rise central business district.
- Relatively high per capita income.

Cities with low per capita incomes, together with multiple dispersed business districts are unable to attract high ridership shares, and so rail based systems do not perform to capacity. Therefore, the size of a city should not be used as a sole criterion for deciding the type of technology to be used for transit systems.

Transit systems, catchment areas and feeder trips

Public transit systems have to compete with para-transit modes and private vehicles to attract passengers. The latter modes transport people from origin to destination without the need for long walking trips, changes in transport modes, or long waiting times. Research studies show that proximity is perhaps the strongest determinant of a resident’s likelihood of riding rail transit. Distance had even a stronger effect on the likelihood of rail commuting at the worksite-end of a trip.15 Based on research in the U.S., some generalized conclusions about pedestrian access to transit can be made. Between a distance of 0.8 and 2.4 km, the proportion of transit riders who walk to or from transit steadily decreases and rail’s mode share falls about 1.1 percentage point for every 30 m increase in walking distance to stations up to a distance of 1.6 km.9 Data from the Netherlands suggests that, (a) ridership starts declining from a distance of about 150 m and beyond, and (b) 500 m should be considered a reasonable catchment radius for a walking trip to the station.16 For the bus, tram and metro, mean access and egress times have been found to be 5.9 min for walking, which translates to an average distance of 393 m to the rail or bus station.17

These findings illustrate why rail based systems are more successful in high rise cities. Figure 3 shows the differences in walking distances between access to high rise and low rise buildings. A large number of passengers exiting from a metro station can be accommodated close by in high rise buildings. A person going to the 30th floor has to walk the same distance as one going to the 1st floor. Moreover, the access trip to the 30th floor is in a lift which is free, safe, protected from the weather and non tiring. On the other hand, persons employed in low rise buildings (3-6 floors)

---

may have to walk 1-2 km to reach the 5th to 10th building (equivalent of the 30th floor) or take a bus. If a bus is used for the feeder trip, then the passenger has to spend extra time waiting for the bus and the passenger or the metro authorities have to pay for the bus trip. In this case, it is possible that these people may not opt to use metro rail and continue to use their cars or two-wheelers.

What is true of work end trips is broadly true of home-end trips also. It is quite clear that for high capacity rail systems to capture enough riders to justify their high capacities, they must operate on dense residential areas also where a significant number of people live in high rise buildings. This is only possible at relatively high incomes when cities can be planned to accommodate middle class families in high-rise buildings. This situation is not likely to be common in Indian cities in the near future.

The converse also seems to be true. If a high capacity rail based public transit system is put in place in a city, it forces the city to go high-rise and become more congested. This is because land and property prices increase along the metro corridor and businesses move to these locations. In addition, more people start coming into the city from areas outside the city.

Financial viability

Motorcycles, scooters and mopeds comprise 60-80 percent of motor vehicle fleets in Indian cities. In a city like Delhi approximately 60-70 percent of families own a motor vehicle (at least one car, motorcycle, scooter or moped). This means that motorised two-wheeler ownership has become possible for the main wage earner of lower middle class households and college students belonging to middle class families. A family earning about Rs. 10,000-15,000 per month (US$ 200-300) can own a motorised two-wheeler. This is a new development in urban living. When European and North American countries and Japan had similar levels of income vehicle ownerships were very low and people were forced to use public transport. With such high levels of vehicle ownership it will be every difficult to attract people to public transport unless the latter is made very convenient and inexpensive.

The marginal cost of running a motorcycle or scooter is about Rs.0.50-0.70 per km. It is unlikely that two-wheeler owners will use public transport unless the fare is about the same or less than the Rs.0.50-0.70 per km. Use of a two-wheeler also gives freedom in mobility, it is easy to park at home and close to place of work. Two-wheeler riders can also negotiate traffic snarls better than car drivers and can get to the front of the line at traffic lights.
Public transport fares in Indian cities cannot be higher than about Rs. 0.50 per km (2005 prices). At present, most city bus fares are around this range. Any system which has operating costs above this amount will have to arrange for subsidies which are not regressive in nature. Research results show that public transport demand is relatively sensitive to fare changes, so that policy measures aimed at fare reduction (subsidisation) can play a substantial role in encouraging the use of public transport, thus reducing the use of private cars. This rules out the use of most rail based high cost systems.

---

Public transport and access

Public transport stations must be close to origin and destination of commuters. Preferably within 500 m of both home and work place. Only road based systems can do this. Rail based systems, on an average, usually add another 200-300m of walking inside stations including staircases. This reduces the acceptance of rail based systems compared to surface bus systems especially for children, the elderly, health impaired (heart disease, arthritis, etc.) and the physically disabled. The latter group can account for 20-30% of the population on any given day.

Metros, congestion and the environment

Reviews of the metro systems around the world conclude that rail based systems do not reduce congestion or improve the environment:

- “None of the systems (rail based) appear to have reduced the problems caused by the car… None of them caused a decline in overall bus usage…None of the systems caused reduction in car usage, congestion relief, or improve air quality.”

- “Public officials tend to exaggerate the consequences of (widely unpopular) metropolitan traffic congestion for political gain…Public transit investments are unlikely to meaningfully reduce congestion…Public officials can cynically use congestion as a rationale for funding for high-profile, politically-popular transportation (and, increasingly, public transit) projects. Put simply, public transit expenditures in the name of congestion reduction are growing because they are broadly popular and not because most people believe that they are effective ways to reduce traffic congestion.”

---

• “There is evidence from the literature that expenditure on new rail-based schemes can divert resources away from bus routes used by low-income people with no alternative mechanized mode of travel. There are now some signs of a shift from light rail to bus-based systems, following on from the earlier shift from metro to light rail. To sum up, it seems that the impacts of many of the new urban public transport systems are much smaller than those anticipated by those promoting them. The expectations of the systems developed more recently seem to be more modest, but overall the expectations do not seem to be being met”.

• Figure 4 shows that availability of metro systems in Tokyo and US cities has not increased city road speeds.

Cities, public transport and Bus Rapid Transit Systems (BRT)

“In many urban areas in both developed and developing countries the SMP (Sustainable Mobility Project) believes that there are important opportunities for increased utilization of bus and “bus-like” systems (including paratransit) to take advantage of the flexibility inherent in road-based systems. Advantage should also be taken of opportunities to incorporate new vehicle technologies (including propulsion systems) and new information technologies into these “bus-like” systems”.

International evidence suggests that with modern communication systems, smart card ticketing, GPS, intelligent transport technologies and computer optimisation techniques it has become possible to serve urban transport needs with modern bus rapid transit (or high capacity bus systems) very adequately. These bus systems have the following advantages:

i) Bus rapid transit (BRT) systems can serve the needs of medium sized cities all the way up to mega cities.

ii) BRT systems can easily reach capacities of 20,000 passengers per direction per hour. These capacities are very adequate for cities which have multiple business districts and medium rise buildings. In such cities higher capacity systems will never run at peak capacity. However, experience from cities like Bogota and Sao Paulo demonstrates conclusively that capacities up to 40,000 persons per hour per direction are feasible when catering to high density central business districts.

iii) BRT can be implemented at a fraction of the costs involved in building metro rail transit and light rail systems. BRT systems use existing right-of-way on urban corridors and so the modifications involved do not disrupt the city significantly.

iv) A major advantage of BRT is its flexibility in meeting changes in the city development and in changes in demand in quality and quantity. Expanded or new

services can be introduced whenever needed. The BRT does not fix the city structure for ever like fixed track systems.

v) Rail systems can only serve a very limited area of a city. Not one developing country city subway system serves more than 10% of population. BRT systems can achieve very high coverage at low investment costs. As they are road based they can go very near homes and destinations and cover most of the city as planned for 80% of Bogota residents. This would not be possible technically or financially with rail systems.

vi) When road systems are modified for BRT, it results in complete urban renewal as a part of the BRT project. This does not happen in case of rail systems.
COMMENTS ON CLAIMS REGARDING METRO SYSTEMS WITH SPECIAL REFERENCE TO DELHI

Dinesh Mohan
Transportation Research and Injury Prevention Programme
Indian Institute of Technology Delhi

1. CLAIM: Road-based systems like buses/ trams/ electric trolley buses can only cater to traffic loads up to 10,000 -12,000 peak hour peak direction passenger trips (phpdt).

Fact: This information is outdated and factually incorrect. Modern bus rapid transit systems in many cities are carrying far higher numbers (See Appendix 1 for details).

Evidence

Bogota, Columbia: Maximum of 45,000 passengers per hour, per direction
São Paolo, Brazil: Maximum of 21,600 passengers per hour, per direction
Porto Alegre, Brazil: Maximum of 25,600 passengers per hour, per direction

2. CLAIM: Metro systems cause no air pollution

Fact: Rail based transportation systems do not cause pollution from emissions of the vehicle but do from all the services provided at stations, especially if they are underground (e.g. air-conditioning systems, etc.). Similarly, if electric trolley buses are used on the surface they also would not have local emissions. Therefore, this is not the preserve of rail based systems. The statement also does not account for emissions from power plants which provide energy to the rail based system. In any event, metro systems do not result in reducing road use, and therefore, have little effect on pollution levels.
3. **CLAIM:** One line of metro system carries the same amount of traffic as 9 lanes of buses.

**Fact:**
See point 1 above. Modern bus rapid transit systems operate on 1 or 2 lanes in each direction. Single lane capacities can reach 20,000 and 2 lane capacities 45,000 pphpd.

4. **CLAIM:** A rail based Metro System is inescapable (sic)… World-over the practice is that when the population of a city reaches 1 million mark, the studies and investigations needed for a metro System are taken up.

**Fact:**
There is no such agreement among transportation planners. There is no evidence that the type of transit system is determined by population size alone. Land use patterns and income levels are far more important irrespective of the population.

**Evidence:**
There is extensive debate on this issue over the past decade and the general agreement is that high cost rail based systems are not only unviable but do not solve city problems as projected. This why international agencies like the World Bank have stopped funding rail based metro projects – “Where they are politically acceptable, busways should often be the first step in mass MRT (rapid transit system) development, and for many cities they will remain the MRT system for the foreseeable future” (See Appendix 2). There are no rail base MRTS systems being built in South America or Africa. All rail based projects have been cancelled in Colombia. On the other hand most large cities in S. America (Lima, Santiago, Cali) and a few in Africa (Dar-es-Saalam, Nairobi, Cape Town) are planning new bus based systems.

The Sustainable Mobility Working Group of the World Business Council for Sustainable Development in their report states “Compared to its investment in urban roads and railways, the private sector expresses little interest in busways, yet they are among the most cost-effective means of improving urban mobility. The great benefit of dedicated busways is their ability to move large numbers of passengers — typically up to 25,000 passengers per hour per direction — at relatively low cost, typically $1 to $3 million per kilometre, 50 to 100 times cheaper than subways”.

**Statements from other experts:**

i) “There are now some signs of a shift from light rail to bus-based systems, following on from the earlier shift from metro to light rail. There is evidence from the literature that expenditure on new rail-based schemes can divert resources away from bus routes used by low-income people with no alternative mechanized mode of travel… To sum up, it seems that the impacts of many of the new urban public transport systems (rail based) are much smaller than those anticipated by those promoting them. The expectations of the systems developed more recently seem to be more modest, but overall the expectations do not seem to be being met.”

ii) “The justification for such high quality systems (rail based) is usually in terms of their positive image and their role in reducing road congestion and stimulating development. Neither of these effects have been substantiated. Such systems are very expensive and are unlikely to be used to capacity. Hence there is a need to consider lower cost alternatives, for example, bus-based systems… In fact, according to the junior Minister of Transport the UK government does

---

now appear to recognise that light rail is very expensive and that considerable improvements in cities could be obtained using guided busways and lighter rapid transit”.23

iii) "Virtually any public benefit that has been achieved through urban rail could have been achieved for considerably less by other strategies. Virtually no traffic congestion reduction has occurred as a result of building new urban rail systems. Yet, virtually without exception, urban rail systems have been promoted to public office holders and voters as a means of reducing traffic congestion in highly automobile oriented urban areas".24

5. **CLAIM: Countries like China are planning extensive metro systems to solve their urban transport problems**

**Fact:**
This claim is misleading as China is planning BRT systems in many cities.

**Evidence**

i) **Rapid transit beats Shenyang metro**
Shenyang, the capital city of Northeast China’s Liaoning Province is planning to turn to a bus-rapid-transit (BRT) system after a costly proposed subway project has remained stalled for 10 years, leading government officials say. "There are many successful examples of BRT for us to follow. This is also the first step for Shenyang to become a modern international metropolis," Shenyang’s Mayor Chen Zhenggao said at a rapid transit forum held last Tuesday.25

ii) **China Sustainable Energy Program has funded BRT projects in 3 cities:**26
- Beijing Transportation Development & Research Center: To develop strategies for bus rapid transit (BRT) system promotion and segment demonstration.
- Chang An University: To support the Xi’an municipal government to develop strategies for bus rapid transit (BRT) system promotion and segment demonstration.
- Chengdu Institute of Urban Planning & Design: To support the Chengdu municipal government to develop a Transit-Oriented Development (TOD) plan and Bus Rapid transit (BRT) system.

iii) **A growing number of cities in China are taking part in the BRT programme.** Shanghai has begun a sustainable transport partnership created by World Resources Institute (WRI)... Yangzhou and Changzhou have followed the ecocity planning and management programme set up by municipal government and the Deutsche Gesellschaft fuer Technische Zusammenarbeit (GTZ), Xian, Chengdu, Tianjin, Wuhan, Xiamen, Shengyang, Suzhou and other cities are investigating the feasibility of integrating BRT into their road systems. It is only natural therefore that BRT, an economical and low cost choice, is being implemented in these cities.27

iv) See Appendix 1, Sections 8 & 9 for BRT plans in Beijing and Chonqing.

6. **CLAIM: Is there any other choice available to our cities?**

It is argued that Delhi, Kolkata and Mumbai need high capacity rail based metro systems other cities will need medium or light capacity bus systems. The argument is based solely on the population levels of Indian cities that cities with

---

26 http://www.efchina.org/programs.transport.list.cfm, Jan 05.
more than 5 million population become candidates for high capacity rail systems and those with less population medium or light rail.

**Fact:**

The size of a city does not necessarily dictate what kind of a system it will need. High capacity metros have only been successful in high rise dense cities with a large and dense central business district. The Kolkata metro is attracting only 10% of its projected capacity though it was constructed on a very highly travelled route. Bus rapid transit systems are successful in large cities: Sao Paulo, Bogota, Taipei, Jakarta, etc. Light rail systems are not necessary as in most situations a modern BRT can carry as many passengers at a fraction of the cost.

**Evidence:**

i) High Capacity metro rail systems are only successful in cities like Hong Kong, New York, Tokyo etc. According to Wendel Cox “Exceedingly large central business districts are necessary to serve metro rail systems. For example, Tokyo, New York, Paris and London Each of the examples have central business districts with more than 750,000 jobs. Tokyo has one of the world’s largest central business districts, with approximately 2.3 million jobs, with an employment density of approximately 150,000 per square mile. Virtually no other urbanized area in the developed world has a central business district with more that 400,000 jobs, and most are in the range of 50,000 to 200,000. The massive central business district employment numbers and densities support a high degree of substitution by rail of automobile use that is not possible in smaller central business districts”.24 No Indian city has a central business district that supports such a large number of middle class jobs.

ii) In low and middle income countries, it is not necessary that a rail metro system gets used by a large proportion of the commuters. For example, Mexico City (population 10 million) has 201 km of metro rail and it is the cheapest in the world, but it carries only 14% of trips.28,29

7. **CLAIM:** Direct comparison of costs are not correct between road systems and metros… If 35 to 40% of the cost of the Metro Project could be met by the Government…the main burden of the of financing such projects should be the responsibility of the city itself with the Central Government taking over 50% of the Government coverage.

**Comment:**

Comparison of costs between alternate systems is essential for any public expenditure:

i) The average cost projected for 274.6 km of metro for all projects proposed is Rs. 130 per km.

ii) The total cost of Bus Rapid Transit Systems (including complete refurbishing of roads involved, signaling systems, disabled friendly road surfaces

---

and facilities, bus stations, road side furniture including lights, and low floor modern buses) is Rs. 10-15 crores per km including buses depending on the corridor.

iii) Bus Rapid Transit Systems are at least 10 times less expensive as metro systems. This means that for the same cost BRT systems can reach more than 10 times the number of people in a city than metro systems.

8. **CLAIM:** Property development can offset capital expenditure on metro systems.

**Comment**

Property development for raising resources cannot be justified only for metros. If this is justified for metros, then the same should facility should be available to bus operators who have large properties available at depots, or even universities and schools who have been given large tracts of land by the government.

9. **CLAIM:** Metro expenses would be much lower if all import duties, excise and other taxes were waived for metro systems.

**Comment**

If all the concessions proposed were applied to bus transit companies, it is very likely that they can acquire the most modern systems immediately and even make “profits”. BRT systems are also open to public private partnerships.

10. **CLAIM:** Expenses on metro systems are justified as a public good

**Comment**

Rs. 35,692 crore have been requested for 274.6 km of metro systems for Indian cities as first phase.

For the same amount of money more than 2,500 km of modern bus rapid transit corridors can be built in Indian cities including purchase of 12,500 modern low floor buses. Such a development would alter the look and shape of our cities and would be the most extensive urban renewal project ever as street furniture, street lights, drainage systems, all get a tremendous facelift as a part of the BRT project.
Comments on stated Benefits of the Delhi MRTS Project – Phase 1, 3 routes, 65.8 km

- **“21.82 lakh commuter trips per day will be siphoned off the roads”**
  
  Fact: Te DTC of Delhi transported an average of 20.58 lakh passengers per day on all its 814 routes (about) in mid 2004! It is obvious that 3 routes of the metro covering 65.8 km cannot “siphon off” all the passengers and more from all the 2,000 plus buses from all the routes operating in Delhi. **Therefore, the MRTS projection is a gross overestimate.** On the first completed route MRTS is transporting only about 1-1.2 lakh passengers a day. It is impossible hat 3 routes will carry 20 times the number of passengers.

- **“2,600 less buses on the roads.”**
  
  Fact: The total DTC fleet is about this size. It is not possible that 3 routes of the metro will replace 2,600 buses which operate all over the city.

- **“Increasing in average speed of road buses from 10.5 km/h to 14 km/h”**
  
  Fact: With increasing vehicle population in Delhi (about 15%-20% a year) speeds are continuously decreasing. Speed of buses (without dedicated BRT lanes) depends on number of vehicles on the road and not on the metro. If vehicle speeds on roads increase, the number of vehicle owners opting for public transport will decrease. International experience suggests that road speeds have not increased anywhere where metros have been built.

- **“Saving of 2 million man hours per day due to reduced journey time”**
  
  Fact: If the calculation regarding the shift of passengers from buses to metro is a gross exaggeration, then this calculation is also exaggerated. As number of private vehicles increases, time spent on roads will also increase. In addition, if the time spent in walking inside metro stations and access trips is not included, then this number has no meaning.

- **“Saving in fuel cost worth Rs. 5 billion per year”**
  
  Fact: Same comment as above.

- **“More comfortable & safe travel for the commuters”**
  
  Fact:

---

Scientific studies show that public transport users have more than 9-10 times the chance of a fatal accident as pedestrians on their access trips, than inside the transit vehicle. The MRTS authorities have not made any changes in the city to make pedestrian access trips any safer. Therefore, the assertion of safer trips is also unscientific. In addition, if use of surface vehicles increases and more high speed roads are built, accidents will increase if special safety measures are not instituted. Road accidents depend on surface conditions and not on additional underground transport.

- “Reduction in atmospheric pollution levels by 50%”
  “Reduction in accident rates”
  “Improvement in the Quality of life”

Fact:
None of these assertions can be made as pollution and accident rates depend on the number of vehicles and speeds of these vehicles on the road. Accident and pollution calculations are based on the number of vehicles removed from the road. Since the calculations on number of buses removed is exaggerated, so would be the calculations regarding pollution and accidents. Secondly, it is well known that there is enough latent demand in the society to fill up roads with vehicles when supply is increased. For these reasons, in general, congestion and pollution does not reduce in cities due to construction of metro systems alone.

- At present, Line 1 from Shahdara to Rithala has become fully operational. Total Kms - 22.06 Km

Comment:
High capacity MRTS systems are justified on the logic that they can carry up to 60,000 passengers per hour per direction. Therefore, a line should carry a total of about 12 lakh passengers per day (on the basis of 10 times peak capacity) in both directions. According to newspaper reports, the Delhi metro is transporting about 1 to 1.2 lakh passengers per day – this amounts to about 10% of projected capacity.

Therefore, there is no reliable evidence that the Delhi metro project can be justified on economic criteria.
APPENDIX 1. SUMMARY OF SELECTED BUS RAPID TRANSIT SYSTEMS


Description
TransMilenio opened in 2000, with Phase 1 completed in 28 months. By May 2003 the system was comprised of 41 km of exclusive busways, 61 stations, 470 articulated buses and 235 feeder buses providing service to up to 792,000 passengers daily. Currently under expansion, 40 additional kilometers and 60 stations will be added to the line. The bus fleet will also increase by 335 additional articulated buses and 170 feeder buses. These additions are being gradually introduced between 2003 and 2005. In 2002, 207 million passengers were transported by TransMilenio. By July 2003 the system was transporting 744,000 weekday passengers at a rate of up to 45,000 passengers per hour, per direction. Each bus moves an average of 1,596 passengers per day. Eleven percent of riders own cars. Future plans: The overall expansion will continue until 2016, when the system will be 388 km in length. When complete, more than 80% of Bogota’s citizens will live less than 500 meters from a TransMilenio line.

2. City: São Paulo Country: Brazil Population: 10 million

Description
The busway system consists of 28 km of median busways and 137 km of dedicated bus lanes that are separated from traffic by heavy studs. Passing lanes are employed on some of the busways. Peak bus flow is 300 buses per hour. Daily ridership among busway lines ranges between 38,000 and 230,000 passengers a day (up to 21,600 peak hour passengers per direction). Operating speeds range from 16 to 22 km/hr. The Jabaquara Busway operates in the Sao Mateus-Jabaquara corridor, serving an industrial area. The line has a ridership of 230,000 passengers per day and transports 21,600 peak hour peak direction passengers. Speeds 22 km/h.

3. City: Curitiba Country: Brazil Population: 2.7 million

Description
Five bus transit corridors were planned and by 1982 the transit corridors were complete. The entire system is comprised of 54 km of exclusive bus lanes. About 70% of commuters use the transit system daily, despite one of highest automobile ownership rates in Brazil. Along each of the five arteries there is a trinary road system, comprised of middle express bus lanes with vehicle lanes on each side for local auto traffic and parking. ITS features along the running way include signal priority. Currently, 75% of all weekday commuters now travel by bus. Curitiba’s bus lines serve more than 1.9 million passengers per day, over fifty times more riders than in the 1970’s. The average operating speed of biarticulated buses (all-stop) is 20 km/hour and direct bus speeds are 30 km/hour. Sul Busway line carries 156,231
passengers per day and 13,014 peak hour passengers per direction. *Future Plans:* Future plans to extend the rapid bus network will reduce the need for conventional bus services.

4. **City: Porto Alegre  Country: Brazil  Population: 3.7 million**

*Description*
Porto Alegre's rapid transit system, which first opened in 1978, consists of seven busways (see separate entries for descriptions of individual busways). The public transport agency EPTC manages the busways, with bus service provided by 14 private companies and one public company. The most recent busway opened in 2004. Farrapos Busway is one of seven busways operating in Porto Allegre - 25,600 passengers per hour, per direction in the mornings and 21,100 passengers per hour, per direction in the evenings.

5. **City: Quito  Country: Ecuador  Population: 1.8 million**

*Description*
There are currently two busways operating in Quito. The first, El Trole, began service in 1996. Electric trolley buses are employed on the line and were chosen over diesel buses due to air pollution concerns (diesel engine emissions were not fully controlled in the 1990's). An extension of the El Trole line was completed in 2000. Construction began in early 2002 on a second busway, Ecovia, which is now operational. Diesel buses that meet strict emissions requirements were chosen for this busway. There is a combined ridership of 240,000 daily riders on the El Trole and Ecovia busways. *Future Plans:* A third busway, the North Central runner, is under construction and should be operational in 2005. The fourth busway, Eastern South runner, is in the planning stages.

www.quito.gov.ec/DMT/dmt_inicio.htm

6. **City: Kunming  Country: China  Population: 4.6 million**

*Line: Bus Lanes*

*Description*
Kunming is the first city in China to develop bus lanes. The initial section of busway opened for service in April 1999, improving downtown traffic flow. By January 2004, 20 km of bus lanes were operational in three corridors. When complete, 40 km of bus lanes will be in service. Ridership - The passenger capacity of buses using the corridors has increased by nearly 50%, to 8,000 hourly passengers/lane. Overall bus capacity of the city has increased nearly 50%, from 500,000 riders a day prior to bus lanes (1999) to a million a day in 2004. The bus transit mode share has increased from 8% to 14%; a large portion of this shift was due to increased ridership by former bicyclists. However, since the bus lanes have opened car volume has nonetheless decreased by 20%. *Future Plans:* An additional 41 km of rapid bus service is planned.
7. City: Los Angeles Country: USA Population: 12.3 million

Description
Metro Rapid design began in the summer of 1999 and service was implemented less than a year later, in June 2000. The initial two lines, Ventura and Wilshire-Whittier, are part of the Federal Transit Administration's BRT Demonstration Program (Los Angeles is a consortium member). Planners chose the Wilshire-Whittier and Ventura corridors for the demonstration because of high passenger demand. Service was designed to complement, not replace, local bus service. Twenty-four additional Metro Rapid lines have been planned and seven are currently in service. Ridership increased by 25 to 30% in the two demonstration corridors (Wilshire-Whittier and Ventura). The remaining seventeen lines are being constructed at a rate of four per year, with the final lines scheduled to open in 2008. Currently, a total of nine Metro Rapid lines (two demonstration lines and seven extension lines) serve over 140 miles in Los Angeles County. When all lines are constructed, Metro Rapid will operate over 450 miles of roadway in the Los Angeles area. Future Plans: Seventeen additional corridors are being developed, adding roughly four new lines per year.


Description
Beijing is the most congested city in China, with 14 million people. Over 21 million trips are made daily, and 80% increase from 1986. Currently there are over 2 million cars (and 12 million non-motorized vehicles). Beijing is implementing a transportation improvement program that includes construction of a rapid bus transit system, to be completed before the 2008 Olympics. The pilot corridor should be fully operational in 2005. When fully complete, the new bus system will measure 187.5 miles (300 km) in length and will provide links to the metro system and the 2008 Olympic Game facilities. Capacity is anticipated to be 210,000 passengers/day. Buses are anticipated to reach an average speed of 20-25 km/hr for local bus service, 25-30 km/hr for limited stop service and 35 km/hr for express service. This will be 20-50% faster than conventional buses. Future plans: Initial plans include construction of ten BRT lines over 200 km.


Description
Chongqing's new bus service will be developed in two phases. The first is a 12 km, 6-lane exclusive busway, the second a 3 km busway along a mixed-traffic road. The total bus system will be 15 km in length and will serve the Central Business District, the Hi-tech Development Zone and the University area. The current bus system will be converted to express and feeder buses. Passenger capacity is anticipated to be 102,600 per day. Trip speeds are anticipated to increase from 17.05 km/hr to 25 km/hr. The estimated speed from a bus test run was 23-24 km/hr.


Description
Lima is implementing a new government-run bus system to replace the current privately operated system of public transport. 42,000 buses are now in Lima's
private fleet with microbuses comprising nearly 90% of this number. The new plan will implement a rapid transit system with feeder routes in order to improve efficiency. 28.6 miles of busways will be built along a north-south axis, from Independencia in the north to Chorrillos in the south. Feeder routes will serve the end terminals from the low income areas at edge of Limaen commute, lessen congestion and reduce the accident rate.
APPENDIX 2. SELECTED EXTRACTS FROM INTERNATIONAL REVIEWS

World Bank Urban Transport Strategy Review - Mass
Rapid Transit in Developing Countries
Final Report
July 2000

Halcrow Fox in association with Traffic and Transport Consultants
http://wbln0018.worldbank.org/transport/

Capacity. Busways, depending on specification, have a practical capacity of 10 - 20,000 passengers per hour per direction (pphpd), or occasionally higher. There are no examples of LRT carrying flows in excess of 10,000 pphpd, and there is reason to doubt whether they can achieve much higher flows. Metros by comparison carry very large passenger volumes – 60,000 pphpd or higher; and high-specification suburban rail can typically carry 30,000 pphpd.

Ability to segment the market. Bus systems have this ability, by running basic and air-conditioned / guaranteed seated/express buses. Rail systems exceptionally provide women-only carriages, but otherwise do not segment the market.

S1.2.11 While implementation is quite demanding (in terms of institutional co-ordination and traffic engineering/control skills), the evidence is that thereafter the operational performance is robust. Cost is relatively low – the infrastructure is typically US$ 1- 1.5mn/km and the all-in cost including buses at the top end of the range is US$5mn/km. A major advantage of busways is their flexibility in implementation and operation. While continuous, segregated busways are desirable, short discontinuities (where the road cross-section does not allow implementation) can be overcome using traffic management techniques. Busways can be implemented incrementally as funds allow, and their performance can be upgraded over time.

S1.3.6 Busways are clearly beneficial to the poor. Many of the poor use buses and busways create major accessibility benefits for them, particularly when they live in the outer city areas, and particularly with ‘open’ systems, or ‘trunk-and-feeder’ when there is through-ticketing. If ‘greener’ busways were developed, then the poor in particular would benefit from this through better health (they often spend long hours living, working or travelling in the street environment), but maybe at the expense of higher tariffs.

S1.4.17 Incorporating Attitudes to MRT – there often appears to be a gulf between the results of apparently rational technical analysis and what is actually
implemented, and this often points to a weak project development process. This particularly concerns the support for rail systems compared with bus systems by politicians, when analysis shows bus systems to be more affordable and more readily implemented.

**S1.4.21 Forecasting Requirements** – we have reported on the poor record of forecasting costs, ridership and revenues, and have analysed the probable causes. This has created a heavy burden of expectation, and then produced problems when they have failed to materialise. To some extent forecasts will always be uncertain, but much can be done to avoid them being misleading.

**S1.5.2 Busways** – where they are politically acceptable, busways should often be the first step in MRT system development, and for many cities they will remain the MRT system for the foreseeable future. We have seen that they can – in the right environment, effect major improvements in accessibility, benefiting most of the city’s population, and particularly the poor. And they can achieve this quickly and incrementally as conditions and funding allow.

### TABLE S1 THE MRT OPTIONS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>BUSWAY</th>
<th>LRT</th>
<th>METRO</th>
<th>SUBURBAN RAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Applications</strong></td>
<td>Widespread in Latin America for 20+ years</td>
<td>Widespread in Europe Few in dev' g cities, none with 'high' ridership</td>
<td>Widespread, skewed to Europe and North America</td>
<td>Widespread, skewed to Europe and North America</td>
</tr>
<tr>
<td>Segregation</td>
<td>At-grade</td>
<td>At-grade</td>
<td>Mostly elevated/u’ gd</td>
<td>At-grade</td>
</tr>
<tr>
<td>Space req’ t</td>
<td>2-4 lanes from existing road</td>
<td>2-3 lanes from existing road</td>
<td>Elevated or u’ gd, little impact on existing road</td>
<td>-</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Flexible in both imp’ n and op’ s, robust operationally</td>
<td>Limited flexibility, risky in financial terms</td>
<td>Inflexible and risky in financial terms</td>
<td>Inflexible</td>
</tr>
<tr>
<td>Impact on Traffic</td>
<td>Depends on policy/design</td>
<td>Depends on policy/design</td>
<td>Reduces congestion somewhat</td>
<td>May increase congestion when frequencies high</td>
</tr>
<tr>
<td>PT Integration</td>
<td>Straightforward with bus operations. Problematic with paratransit</td>
<td>Often difficult</td>
<td>Often difficult</td>
<td>Usually existing</td>
</tr>
<tr>
<td>Initial Cost US$mn/km</td>
<td>1-5</td>
<td>10-30</td>
<td>15-30 at-grade 30-75 elevated 60-180 u’ gd</td>
<td>-</td>
</tr>
<tr>
<td>Practical Capacity</td>
<td>10-20,000</td>
<td>10-12,000? (no examples)</td>
<td>60,000+</td>
<td>30,000</td>
</tr>
<tr>
<td>Operating Speed Kph</td>
<td>17-20</td>
<td>20? (no examples)</td>
<td>30-40</td>
<td>40-50+</td>
</tr>
</tbody>
</table>
What future for the busway and urban rail?

Busways are among the most cost-effective means of improving urban mobility. The great benefit of dedicated busways is their ability to move large numbers of passengers — typically up to 25,000 passengers per hour per direction — at relatively low cost, typically $1 to $3 million per kilometer, 50 to 100 times cheaper than subways.

Latin America is a pioneer in dedicated busway deployment, led by Brazil and the storied example of Curitiba. Today, busways exist in Quito (Ecuador), Bogotá, Lima, Santiago, and the Brazilian cities of Recife, Porto Alegre, Goiania, São Paulo, and Belo Horizonte. Beyond being relatively cheap, busways can be deployed quickly, which makes them popular in cities enduring difficult political and financial conditions.

Bogotá: It is Never Too Late to Start Improvements

Bogotá’s “Transmilenio,” which started operation in December 2000, was built upon the concept of “Troncales” (busways) drawn from Curitiba. Bogotá’s first “troncal” was actually built in the 1980s on Caracas Avenue. Although never operated as originally designed, this two-lane-per-direction busway was used by nearly 500 buses and carried, under difficult conditions, an estimated 35,000 passengers per hour per direction — astounding levels for a busway, surpassing the practical ridership levels often obtained by metros. The Transmilenio project modified the infrastructure and operational standards of Caracas Avenue and implemented busways on two other main arteries. Current costs of busway development are estimated at $5 million per kilometer, with financing coming from a 20% increase in the gasoline tax as well as from national government transfers. Currently, 20 additional corridors for busway development are being considered to expand the system. The stated goal of the city government is eventually to have 85% of the city population within 500 meters of a bus stop.

Bogotá has also taken important steps toward building a “car-free” culture. For example, “Pico y Placa” restricts the use of 40% of the private autos during weekday peak hours. To date, Bogotá has avoided many of the negative consequences that plague a similar program in Mexico City. In addition, the city implemented two car-free days (in February 2000 and 2001), aimed at educating the population about alternative ways to move in the city. Building on the relative success of these initiatives, the city government put its policies to the test in a public referendum,
which the voters approved. The referendum includes the “celebration” of a “Car-Free Day” the first Thursday of every February, and the restriction of all private autos during weekday peak hours starting in 2015. The government has also embarked on an aggressive program to link the entire city by nearly 200 kilometers of bike lanes.