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**MPD/S-5 : Issue Paper**

**Session 5: Environmentally Friendly Public Transport Planning**

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## Executive Summary

Public transport is an essential component of environmental sustainability, because by reducing the use of automobiles, it contributes to reductions in energy consumption as well as reductions in emissions of air pollutants and greenhouse gases.

Some encouraging trends have been observed in Asia. These include initiatives for rail-based systems, improvement in the quality of public transport services, and private-sector participation. However, many cities in Asia still face various challenges such as rapid increases in car ownership, failure to provide public transport, indebtedness due to high costs of investment in mass rapid transit (MRT) systems, shift of passengers from public transport to private automobiles, poor access by disadvantaged groups to public transport, and urban sprawl. The central challenge with respect to urban public transport is to identify the strategic objectives being sought by the city, and then to identify the means of implementing them that maximize the benefits and minimize the disadvantages listed above.

MRT comprises a wide spectrum of urban public transport modes (including metros, suburban railways, light rail transit, and busways) that either use specific fixed tracks or have exclusive and segregated use of potentially common-user roadways. Since Asian cities have a wide variety of public transport modes both between and within cities, there is no single solution for the cities in Asia. Rather, each city needs to choose its own strategic alternative, taking into consideration the objectives and role of MRT in the city, features of the various MRT technologies (cost, operational capacity, environmental impact, and applicability), ownership and financial mechanisms, and pricing scheme.

Public road passenger transport, such as conventional bus services and paratransit, play a crucial role in Asia. However, this sector is facing institutional issues and has negative environmental impacts that need to be addressed in promoting sustainable transport in the region.

Selection and integration of the right modes is not sufficient for the successful introduction of public transport. It is imperative that public transport planning be integrated with appropriate land-use planning to ensure that public transport covers a substantial percentage of transportation needs. In addition, public transport development would best be approached with rigorous traffic demand management measures as an integral part of the strategy.

Taking the above into account, the following items are suggested for further discussion or action:

Public transport plays a key role in improving environmental quality and meeting the mobility needs of people in Asian cities. Asian cities vary in their structures and socio-economic conditions, and there is no one-for-all solution to developing sustainable transportation. Each city faces its own challenges when identifying its long-term strategic objectives and developing its public transport plans. In developing plans for sustainable transport, common concerns may include:

- Selection of appropriate modes or an appropriate mix of modes, taking into consideration the costs, performance, and environmental impacts of each mode as well as the size and population distribution of the city;

- Development of effective networks among the various modes in terms of infrastructure and fares;
- Improvement of the paratransit and bus sectors and their integration with the public transport system;
- Development of sustainable funding plans to avoid indebtedness;
- Integration with long-term land-use planning to avoid uncontrolled sprawl;
- Integration with traffic demand management, such as congestion pricing and restriction of vehicle ownership.

## **1.0 Introduction**

Public transport is an essential component of environmental sustainability, because by reducing the use of automobiles it contributes to reducing energy consumption as well as reducing emissions of air pollutants and greenhouse gases.

The importance of developing environmentally friendly public transport is widely accepted and addressed by policy-makers in Asia. The Nagoya Statement on Environmentally Sustainable Transport in the Asian Region, in 2003, stated the need for much further expansion and improvement of urban and inter-city rail transit systems. The Seoul Declaration in 2001 addressed the importance of the government taking a leading role in more effectively integrating the different forms of transport in order to develop sustainable intermodal transport systems.

There is a high potential for public transport in Asia. Population density – a favorable factor for public transport – is higher in Asia than in other regions of the world. Attempts have been made to introduce environmentally friendly public transport in Asia, and cities such as Tokyo, Singapore, and Seoul are well known as transit-oriented cities. However, in reality, Asian cities are experiencing difficulties introducing effective public transport in the face of growing motorization.

This paper endeavors to facilitate the discussion to seek strategies to develop environmentally friendly public transport planning in Asia by examining (1) the rationales for providing sustainable public transport systems; (2) the characteristics of various modes of public transport and (3) the factors for successful introduction of public transport.

## **2.0 Current Status of Public Transport in Asia**

### **2.1 Need for public transport in Asia**

Public transport includes various services that provide mobility to the general public in shared vehicles. Public transport is an essential component of environmental sustainability, because by reducing the use of automobiles it contributes to reducing energy consumption as well as reducing emissions of air pollutants and greenhouse gases. Some other important attributes of public transport include more efficient transportation in urban areas, wider consumer options and greater equity, more efficient land use, greater resilience and security, and the fostering of community development (Litman, 2002).

In actuality, public transport is still limited in Asia. In Hong Kong, Singapore, Seoul and Tokyo, around 70% of total person trips are made by public transport. In Bangkok, Jakarta, and Manila, between 40% and 60% of total person trips are by public transport. On the other hand, many cities have failed to provide services to match the ever-increasing demand and they continue to rely on road-based systems (UNESCAP, 2002).

In cities without public transport, the rich use private automobiles while the relatively poor first use bicycles, then shift to motorcycles (Vietnam and Indonesia), then to taxis (China and Indonesia), and ultimately to inexpensive cars as their incomes increase. Lack of public transport generates a burgeoning small-vehicle paratransit sector that can contribute to maintaining accessibility, but may also have adverse consequences for congestion, air quality (pollution), and urban structure (World Bank, 2002).

Therefore, it is essential for Asian cities to seek appropriate strategies to provide adequate sustainable public transport systems.

## **2.2 Current trends in public transport in Asia**

Some positive public transport trends in Asia were reported by UNESCAP (2002). These include initiatives for rail-based systems, improvement of public transport, and private sector participation.

### **(1) Initiatives for rail-based systems**

Governments in many countries have begun studying or implementing projects to develop rail-based transit systems in response to the shortcomings of road-based transport systems and to meet growing demand in very large cities. Bangkok (Thailand), Pusan, Incheon and Seoul (Republic of Korea), Kolkata (India), Kuala Lumpur (Malaysia), Manila (Philippines), and Beijing, Guangzhou, Shanghai, Shenzhen, and Tianjin (China) have implemented new projects or are undertaking major extensions to their existing systems, while cities such as Bangalore, Dhaka, Hyderabad, Karachi, Mumbai, and about 10 cities in China are understood to be actively considering rail-based systems.

### **(2) Improvement of public transport**

Increased attention is being given to raising the quality of bus transport services through the improvement of existing services and by the introduction of new services. Improvement of public transport includes introduction of premium (air-conditioned) bus services in a large number of cities in the region; introduction of higher-quality buses in Bangkok, Kuala Lumpur, Shanghai, and Shenzhen; introduction of advanced technologies, such as low-floor, “kneeling” buses in Hong Kong, Singapore, and many Japanese cities; and integration of public transport services (e.g., integrated underground and bus systems) in Singapore and Hong Kong.

### (3) Private sector participation

Increased participation of the private sector in providing urban transport infrastructure and services is an encouraging feature of transport development in many Asian cities. The private sector is assuming a greater role in developing rail transit systems in Bangkok, Kuala Lumpur and Manila and providing bus services in Bangkok, Dhaka, Lahore and Rawalpindi/Islamabad.

## 2.3 Challenges in Asia

Even with those positive trends regarding public transport, many cities in Asia are facing challenges:

- The number of motor vehicles in Asia is rapidly increasing. For details of motorization, please refer to section 1.2 of Issue Paper 1 “Strategic Planning for Promoting EST in Asia with Both Long-Term Vision and Short-Term Actions”.
- Many cities have not been able to provide adequate public transport to meet their transport needs, as discussed in section 2.1.
- Costs of investment in MRT are quite high and often require subsidies, which could cause indebtedness of local governments.
- Even in cities where public transport services are provided, people turn to private vehicles because of dissatisfaction with the level or quality of public transport.
- Disadvantaged groups have poor access to public transport services, and they find it difficult to have their basic mobility needs met.
- Urban sprawls are generating excessive transport demands that are difficult for the public transport sector to meet on its own.

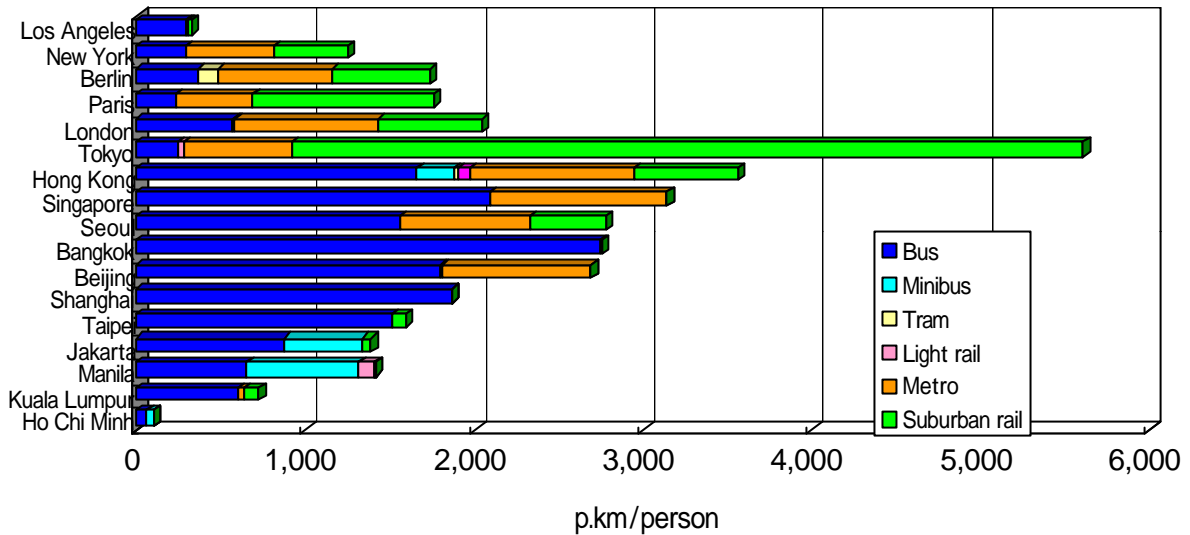
The central challenge with respect to urban public transport is to identify strategic objectives sought by the city, and then to identify their means of implementation that best secure the benefits and evade the disadvantages listed above (World Bank, 2002).

## 3.0 Modes of Public Transport

### 3.1 Overview

Asian cities have a wide variety of public transport modes, both between and within cities. These public transport modes include existing urban sections of generally old, interregional rail systems; new urban rail or mass transit systems; small and large buses with or without air conditioning; van transport operating point-to-point on fixed routes or on non-fixed routes; taxis; small, motorized two- and three-wheeled vehicles, including motorcycle taxis; and nonmotorized transport (NMT) vehicles providing access to trunk line bus and rail systems. These individual modes provide a variety of qualities and levels of service and charge different fares, thus catering to different market niches (ADB, 2003). In Asian cities, buses and minibuses play very important roles, even in the wealthier cities such as Hong Kong, Singapore, and Seoul (Fig. 1).

This section discusses modes of public transport with special attention to the planning and financing aspects. The following discussion draws mainly on the work of World Bank (2002).



(source: Hayashi, 2003)

**Figure 1 Public transport passenger-kilometers per capita in selected cities (1995)**

### 3.2 Mass rapid transport (MRT)

MRT comprises a wide spectrum of urban public transport modes (including metros, suburban railways, light rail transit, and busways) that either use specific fixed tracks or have exclusive and segregated use of potentially common-user roadways. MRT usually has superior operating capacity and performance compared with unsegregated road-based public transport (such as buses, taxis, and paratransit). Rail-based metro systems in developing countries make about 11 billion journeys a year, surface rail systems make about 5 billion, and light rail systems make about 2.5 billion.

Because there is a wide variety of city types, city objectives, MRT technologies, and pricing and financing mechanisms, there is no single solution for the cities in Asia. Rather, each city needs to choose its own strategic alternative. In many cases, the problem is not simply that of an exclusive choice *between* technologies, but more that of selecting the optimum mix of technologies and the optimum phasing of MRT capacity expansion. An appropriate strategic stance is thus not to be “for” or “against” MRT, or any particular variant of it, but to properly appreciate the critical factors affecting choice of technologies and operating, financing, and ownership arrangements, and to ensure that the choices made are consistent with city characteristics, objectives, and economic capability.

### 3.2.1 Objectives and role of MRT within a city-development strategy

In planning the introduction of MRT, clarifying the objectives and role of MRT is important. Possible objectives include (1) permitting the continued development of city-center activity while allowing total movement volumes on the main radial links to increase to levels that would have produced intolerable inner-city congestion in the absence of MRT (structural impact); (2) maintaining the quality of access to the city center; (3) providing basic accessibility in poor cities without alternative means of transport; and (4) reducing congestion and maintaining the central city, and predominantly carrying middle-class passengers.

### 3.2.2 Choice of MRT technology

The selection of technology is the most controversial element in planning MRT. Costs, performances, and environmental impacts vary from location to location according to such factors as stop spacing and vehicle and system design. Table 1 compares general characteristics of MRT; Table 2 gives data from systems recently completed or still under construction.

#### *Busways or BRT (Bus Rapid Transit)*

Busways or BRT are systems that emphasize priority for and rapid movement of buses. BRT systems are extensively developed (and now being extended) in a number of Latin American cities including cities in Brazil, Colombia, and Ecuador. In Asia, they are operated in Istanbul, Kunming, Nagoya, and Taipei (GTZ, 2002).

**Cost:** BRT systems are the least-expensive form of MRT. As indicated in Table 1, initial costs range from 1- to 8-million US dollars per kilometer, compared with 10- to 30-million for light rail transit systems (LRT), and 60- to 180-million for underground metro systems.

**Operational capacity:** Large, well-designed buses (bi-articulated buses in Curitiba, Brazil), off-vehicle ticketing, passing lanes at bus stops, and even platform operation can bring effective capacity up to 20 000 pphpd (passengers per hour in the peak direction). The original four-lane busway on Avenida Caracas in Bogotá managed 36 000 pphpd, albeit with reduced speed performance.

**Environmental impact:** Good system design and specification of state-of-the-art clean and efficient vehicles, as in Curitiba, can change both the environmental image and the reality. Electric trolley vehicles, as used in Quito, can further reduce both air and noise pollution, at the expense of a near doubling of total system costs.



**Table 1 Characteristics of MRT systems**

Characteristic	Busway	Light-rail transit	Metro	Suburban rail
Current applications	Becoming widespread in Latin America	Widespread in Europe, few in developing countries	Widespread, especially in Europe and North America	Widespread, especially in Europe and North America
Segregation	Mostly at-grade	Mostly at-grade	Mostly elevated or underground	Mostly at-grade
Space requirement	2–4 lanes taken from existing road	2–3 lanes taken from existing road	Little impact on existing road	Usually separate from roadway corridors
Flexibility	Flexible in both implementation and operation, robust operationally	Limited flexibility, somewhat risky in financial terms	Inflexible and financially risky	Inflexible and somewhat risky
Direct impact on traffic (apart from mode-switching benefits)	Depends on design/available space in roadway corridor	Depends on design/available space in roadway corridor	Does not take space away from roadway	Depends on design/location, but usually does not take away space
Integration with existing public transit system	Usually a straightforward upgrade of bus operations; Some bus and paratransit routes may need rerouting to establish feeder system	Depending on design/location, may displace some existing bus transit operations; Some rerouting to establish feeder system may be needed	Depending on design/location, may displace some existing bus transit operations; Some rerouting to establish feeder system may be needed	Depending on design/location, may displace some existing bus transit operations; some rerouting to establish feeder system may be needed
Initial cost (million \$/km)	1–8	10–30	15–30 at grade 30–75 elevated 60–180 underground	Varies widely, depending on infrastructure requirements
Typical capacity (passengers/h/direction/lane)	15 000–35 000	10 000–20 000	Up to 60 000	Up to 30 000
Operation speed (km/h)	15–25 (higher for some commuter systems)	15–25	30–40	40+

Note: Passenger capacity and speed data also depend on the frequency of service, space between stations and extent of dedicated infrastructure (for buses). No comparisons that hold these factors constant were available.  
(source: IEA, 2002)

**Application:** In cities where roads are wide and the bus industry fairly concentrated, BRTs can provide an affordable and flexible MRT alternative that is acceptable both to passengers and to the traditional carriers. However, they do require strong political commitment and effective public sector planning in overcoming impediments to finance, in ensuring priority treatment in traffic management and infrastructure design, and in service procurement and supervision. Systems in Curitiba and Bogotá have shown that this can be done, but it requires effective forward planning, strong local political leadership, and a degree of stability and nonpartisanship in policy that is not found everywhere.

### ***Light rail transit (LRT)***

LRT ranges from the conventional on-street tramways of Eastern Europe and the Arab Republic of Egypt to the sophisticated elevated and completely segregated systems of Singapore. LRT is expanding rapidly in industrialized countries in cities with low corridor volumes, as a secure and high-quality alternative to the private car, and sometimes serving as a feeder to heavy rail systems. In developing Asian countries, LRT systems have been introduced in only the wealthier cities, such as Hong Kong, Shanghai, Kuala Lumpur, and some Japanese cities including Okayama and Sapporo (GTZ, 2002).

**Cost:** Construction cost of tramways is about the same or a little less than that of at-grade metros and much higher than busways. Rehabilitation of on-street tramways can be achieved at a low cost and may be worth considering in the cities with once used tramways.

**Table 2 Performance and cost of some typical MRT systems**

Example	Caracas (line 4)	Bangkok (BTS)	Mexico City (line B)	Kuala Lumpur (PUTRA)	Tunis (SMLT)	Recife (Linha Sul)	Quito Busway	Bogota (TransMilenio phase 1)	Porto Alegre Busways
Category	Rail metro	Rail metro	Rail metro	Light rail	Light rail	Suburban rail conversion	Busway	Busway	Busway
Technology	Electric, steel rail	Electric, steel rail	Electric, rubber tire	Electric, driverless	Electric, steel rail	Electric, steel rail	AC electric duo-trolleybus	Articulated diesel buses	Diesel buses
Length (kilometers)	12.3	23.1	23.7	29	29.7	14.3	11.2 (+ ext 5.0)	41	25
Vertical segregation	100% tunnel	100% elevated	20% elevated 55% at grade 25% tunnel	100% elevated	At grade	95% at grade 5% elevated	At grade, partial signal priority	At grade, mainly segregated	At grade, no signal priority
Stop spacing (kilometers)	1.5	1.0	1.1	1.3	0.9	1.2	0.4	0.7	0.4
Capital cost (millions of dollars)	1110	1700	970	1450	435	166	110.3	213 (inf only)	25
Comprising:									
Infrastructure/TA/ equipment (millions of dollars)	833	670	560	—	268	149	20.0	322	25
Vehicles (millions of dollars)	277	1030	410	—	167	18	80 (113 vehs)	Not included (private operation)	Not included (private operation)
Capital cost/route kilometers (millions of dollars)	90.25	73.59	40.92	50.0	13.3	11.6	10.3	5.2	1.0
Initial (ultimate) vehicles or trains/ hour/direction	20 (30)	20 (30)	13 (26)	30	—	8	40 (convoy operation planned)	160	—
Initial maximum passenger capacity	21 600	25 000	19 500	10 000	12 000	9600	9000		20 000
Maximum passenger capacity	32 400	50 000	39 300	30 000	12 000	36 000	15 000	35 000	20 000
Average operating speed (km/h)	50	45	45	50	13/20	39	20	20+ (stopping) 30+ (express)	20
Rev/operating cost ratio	—	100	20	> 100	115% in 1998	—	100	100	100
Ownership	Public	Private (BOT)	Public	Private (BOT)	Public	Public	Public (BOT) under consideration	Public infrastructure, private vehicles	Public infrastructure, private vehicles
Year completed	2004	1999	2000	1998	1998	2002	1995 (ext 2000)	2000 (1998 prices)	Mostly 1990s

— Not available.

Note: BOT = Buy-own-transfer. Tunis, Tunisia; Recife, Brazil.

(source: World Bank, 2002)

**Operational capacity:** Where LRT operates at grade, without priority or protection from obstruction by other traffic, it can transport from 10,000 to 20,000 pphpd. Compared to busways, it has little advantage in terms of operational capacity.

**Environmental impact:** The main advantages of LRT systems are that they have less local air pollution impact, signal a more permanent commitment to public transport, and have an image that triggers support for complementary measures, which buses have great difficulty achieving.

**Application:** With the exception of the conventional tram systems of Eastern Europe and the former Soviet Union, LRT systems exist, or have been planned, only in relatively wealthy cities—such as Hong Kong, Singapore, Tunis and Kuala Lumpur—or for high-income developments—such as the Tren de la Costa of Buenos Aires. Some newer road-based light transit systems, such as the Fura Fila guided trolleybus in São Paulo, have lower infrastructure costs than similarly segregated LRTs. Although the capacity of LRTs is relatively low, if viewed as mixed systems—partly at grade and partly elevated or underground—and as interim steps to the creation of a full metro in larger and more dynamic cities, they may have some role to play, not least as a means of preserving the necessary right-of-way for a subsequent metro development.

### ***Metros***

**Cost:** Metros are usually the most expensive form of MRT per route kilometer. Total capital costs can be as low as \$15 million per kilometer where an at-grade right-of-way is available for conversion, and can rise to over \$180 million per kilometer for an underground railway in difficult terrain. To a large degree, the cost is attributed to differences in project management arrangements.

**Operation capacity:** Metros have the highest capacity and performance. With 10-car train sets and 2-minute headways, the first Hong Kong (China) line has carried as many as 80 000 pphpd. The Moscow metro has regularly achieved headways below 90 seconds. São Paulo's East line has consistently carried more than 60 000 pphpd. However, many metros are designed for capacities of around 30 000 to 40 000 pphpd, and few actually carry more than that.<sup>4</sup>

**Environmental impact:** Underground metros are regarded as the most environmentally beneficial because they are considered less intrusive in the urban fabric.

**Application:** The most important issue the policy makers need to consider when planning metros is financial viability. The financial performance of some of these systems is shown in Table 3. For a fully privately financed metro, operating costs account for only about 40% of the total cost, with capital charges accounting for the remainder. On that basis, only Hong Kong appears to come close to covering total costs; many do not cover operating costs. The table also indicates that, while costs do differ substantially between systems, the two main factors affecting financial viability are the corridor volumes and the revenue per passenger.

Although the existence of large external effects (about one-half of the benefits typically accrue to remaining road users) means that economic rates of return may be positive and acceptable even where the financial return is negative, the same factors that affect financial viability also affect the conventional measures of economic viability.

**Table 3 Financial performances of some metro systems**

City	System length (kilometers)	Population (millions)	Passengers per kilometer (millions)	Revenue per passenger (dollars)	Cost per passenger (dollars)	Operating cost per kilometer (millions of dollars)	Ratio of revenue to operating cost
Santiago	37.6	4.9	4.92	0.35	0.19	37.8	1.84
Singapore	83.0	4.0	4.67	0.57	0.34	71.9	1.67
Hong Kong, China	82.0	7.1	9.36	0.96	0.61	65.2	1.56
Buenos Aires	47.4	12.6	5.46	0.59	0.43	78.8	1.39
São Paulo	49.2	17.8	9.32	0.62	0.61	65.4	1.02
Seoul	286.9	12.5	6.56	0.38	0.44	64.6	0.87
Pusan	54.2	4.0	4.43	0.39	0.46	103.2	0.83
Mexico City	191.2	18.1	6.66	0.15	0.28	41.9	0.53
Kolkata	16.45	12.9	4.86	0.11	0.23	47.6	0.42

Note: Conversion to U.S. dollars at official exchange rates.

Source: Data from annual reports of companies for year 2000.

(Source: World Bank, 2002)

Capital costs, which may account for as much as two-thirds of total costs, are very largely determined by international prices for the metro technology. In contrast, it is typical for about three-quarters of conventionally measured economic benefits to be in the form of time savings for metro passengers and bus passengers; these savings are a function of local incomes. Hence, it is not only the financial but also the economic benefits of metros that depend critically on income levels.

### *Suburban railways*

Suburban railways are often well located for radial journeys. Cities such as Mumbai, Rio de Janeiro, Moscow, Buenos Aires, and Johannesburg are relatively well served by suburban railways.

**Operational capacity:** Although suburban railways account for fewer than 10% of trips, they can be very important in providing for longer commuting trips. However, suburban railways can have significant disadvantages. Sometimes, because they were developed before the growth of motorization, they have at-grade crossings that reduce their speed and capacity, and present serious safety hazards. Where the center of activity in the city has shifted, the central stations may not be well located, and in some cases underused rights-of-way become encumbered by poor people living illegally on publicly owned land (squatters), which makes redevelopment difficult. In some cases the sharing of tracks with freight or long-distance passenger services, as well as frequent grade crossings, also reduces their capacity.

**Application:** Existing, but less-well-used lines can be converted to effective local passenger services either in the form of a conventional rail service sharing facilities with other rail traffic or by replacement on the same right-of way by a light rail system.

Despite these problems, several systems could be converted into surface metros at a fraction of the cost of underground or elevated systems, even if there is a need to add an underground or elevated link to the central business district or any other populated area.

Several Asian cities (Mumbai, Delhi, Manila, Bangkok) and African cities (Abidjan, Côte d'Ivoire; Maputo, Mozambique; Cape Town, South Africa) are possible candidates for conversion of suburban railways into modern systems operated with multiple diesel units or multiple electric units.

### **3.2.3 Ownership and financing**

#### *Financing railways*

It is said that full-cost coverage would require a revenue-to-operating cost ratio of about two. As Table 3 shows, although some metros, such as those in Singapore and Hong Kong, are able to cover operating costs, most metros are likely to require substantial subsidies from the public sector unless the systems are very heavily utilized *and* fares are relatively high.

In recent years the mobilization of private finance has been seen as a way of escaping the fiscal burden. Examples of private financing are two systems in Kuala Lumpur and one each in Bangkok and Manila. In all cases the projects appear to have been constructed on time and to budget, but all have fallen short of estimated passenger demand. The revenue risk in the Manila project fell to the government under the build, lease, and transfer (BLT) structure adopted. The two Kuala Lumpur projects have had to be restructured, with the government effectively bailing them out. The viability of the Bangkok Transit System (BTS), the first to be purely privately financed, has not yet been proven. Furthermore, reliance on private finance has discouraged integration with other modes or other MRT lines, so that the contribution to the total urban system has been less productive than it might have been.

A different approach to private involvement has been employed in the concessioning of existing metro and suburban rail systems. This approach has been adopted in Buenos Aires, Rio de Janeiro, and other Brazilian cities, and is now being considered in Mexico City.

Experience suggests that private construction and management can yield substantial benefits, but that the benefit of private participation is likely to be greatest within a well considered and carefully planned overall strategy and where the public sector accepts the financial implications of such public policy objectives and builds in well constructed concession arrangements.

In some cases, it might not be advisable to take a purist view that all modes should be independently self-financing. Cross-modal financial transfers may be justifiable in situations where there are substantial external effects and interactions between modes, for example, where motorized road users do not meet the full costs of the infrastructure that they use. It is equally important, however, to avoid arrangements that effectively tax bus users to subsidize a minority of rail users.

Another possibility to finance MRT is to mobilize the “development gain”—the increase in value of land near stations due to introduction of MRT.

### ***Financing busways***

In the case of busways, it has proved difficult to structure private concessions for the provision of infrastructure and services, with failed attempts in São Paulo (1995) and Bogotá (1996). Despite their proven operational and financial performance, it appears that without active government participation in the implementation process, the risk may be too great to attract private finance. Bogotá's recent TransMilenio project thus concessioned only the provision and operation of its 470 buses, but the physical busway was financed and implemented by the municipal government. However, owing to the lower cost than for other MRT options, Bogotá was able to build the entire system of around 40 km without taking out loans (GTZ, 2002).

#### **3.2.4 Public transport integration**

The key to maximizing the operational capacity of public transport is effective modal integration, including the creation of appropriate interchange facilities and bus service restructuring.

Barriers to integration of public transport include fragmentation of operational responsibility between modes (and in the case of bus systems, within the mode), fragmentation of responsibility for rail-based modes and the bus sector, and resistance by bus operators to the reduction in their overall market share.

A second major problem is that, even if the institutional arrangements are conducive to an organized physical restructuring, it may not be seen as politically or socially feasible because of its effects on some disadvantaged groups. The key to effective modal integration is the existence of a strong regional coordination authority backed by the different levels of government.

#### **3.2.5 Pricing**

The primary objective of public transport pricing is to generate revenue that can ensure an efficient and adequate supply of public transport service. Public transport pricing may also be expected to contribute to reducing the congestion and environmental impact of road traffic, fostering efficient coordination between public transport modes, and reducing poverty.

There have been a number of attempts to meet the latter objectives. These include passenger-targetted subsidies, such as the "vale-transporte" (a subsidy provided through employers to employees) in Brazil, integrated fare systems to eliminate the disadvantage of modal interchange, and flat fares to allow the peripherally located poor to have reasonable access to centrally located employment. Single-fare payment systems have been introduced in BRT systems in Curitiba, Bogotá, and Quito, allowing passengers to transfer to feeder buses using the same ticket.

It is also important to include the public in the process of price setting to reflect the views of the users in order to secure a high rate of ridership on public transport. In

Beijing, the public can join the price-setting processes for bus and subway fares, although the fare prices are basically decided on the basis of costs. Newspapers publicize the discussion, and public meetings are held when the new prices are set (Zhu, 2003).

### **3.3 Public road passenger transit**

#### **3.3.1 Bus systems**

As shown in Figure 1, buses are a crucial mode of public transport in Asia. Worldwide, buses travel 6.5 trillion passenger kilometers per year in 3 million vehicles, of which over 2 million operate in cities (World Bank, 2002). Although there are many types of bus transit system, they can be categorized into three basic types:

- Buses that operate in general traffic, with no priority,
- Buses that receive limited priority, such as bus lanes and at traffic signals, and
- Buses that operate on dedicated infrastructure such as busways, with minimal interaction with general road traffic (IEA, 2002).

The third category has already been discussed above as a part of MRT; the focus of this section is the first two categories.

Although buses play a crucial role in moving people in urban areas, their share of passenger travel has declined in many cities, even in those with quite low average incomes. Possible reasons are (1) poor performance of conventional bus systems in terms of average bus speeds, service frequency, passenger comfort, information on bus destinations and schedules, urban area coverage and transfer, and safety and aesthetics; and (2) people's preference to own private vehicles as their incomes grow.

#### ***Institutional issues***

One reason for poor performance in developing countries is institutional. In many cases governments have attempted to use the public transport industry as an instrument of social policy by simultaneously constraining fare levels and structures, and by guaranteeing favorable wages and working conditions to employees. As deficits mount, and in the absence of a secure fiscal basis for subsidy, first maintenance, then service reliability, and finally operating capacity disappear. In the process of decline, the public subsidy tends to be progressively captured by favored, but not necessarily very poor, groups (for example, unionized labor or middle-class students).

Overregulation also tends to discourage market responsiveness. Introduction of competition in the bus sector is one option. If a city takes the strategy of introducing competition, competitive pressures can be introduced in various forms, both within the traditional monopoly and between firms either "for the market" or "in the market."

#### ***Environmental impact***

The bus sector emits a significant amount of air pollutants and greenhouse gases. Strategies for cleaner bus systems include better maintenance of existing buses, better

diesel buses and improved fuel quality, alternative-fuel buses, and advanced propulsion systems.

Among the most cost-effective options are simply maintaining existing buses to a higher standard and making incremental improvements in diesel buses through improved engine design, emission control, and fuel quality. At the other extreme, new technologies, such as hybrid-electric and fuel-cell propulsion systems, offer very clean buses for the future; however, these are currently still under development and can be very expensive. Somewhere in-between lie alternative fuels such as CNG, LPG, and DME—clean, non-petroleum fuels that are neither inexpensive nor necessarily easy to establish, but that could provide an interim solution for some cities. Table 4 summarizes estimates by the IEA of costs associated with different options (IEA, 2002).

**Table 4 Bus technology cost estimates**

Category	Bus purchase cost (\$ thousands)	Other costs
Small, new or second-hand bus seating 20-40, often with truck chassis	10-40	
Large, modern style diesel bus that can carry up to 100 passengers, produced by indigenous companies or low-cost import	40-75	
Diesel bus meeting Euro II, produced for (or in) developing countries by international bus companies	100-150	Some retraining costs and possibly higher spare parts and equipment costs
Standard OECD Euro II diesel bus sold in Europe or US <sup>a</sup>	175-350	
Diesel with advanced emission controls meeting or exceeding Euro III	5-10 more than comparable diesel bus	If low sulfur diesel, up to \$0.05 per liter higher fuel cost (for small or imported batches)
CNG, LPG buses	25-50 more than comparable diesel bus (less in developing countries)	Refueling infrastructure costs could be up to several million dollars per city
Hybrid-electric buses (on a limited production basis)	75-150 more than comparable diesel bus	Potentially significant costs for retraining, maintenance and spare parts
Fuel-cell buses (on a limited production basis)	Up to one million dollars more than comparable diesel buses, even in LDCs at this time.	Possibly millions of dollars per city for hydrogen refueling infrastructure and other support system costs

a. Note that this range of prices includes transit buses in both Europe and North America. Buses in Europe are generally less expensive than in North America, with the prices in Europe for non-articulated buses generally below \$275 000.

(source: IEA, 2002)

Asian countries are starting to introduce cleaner bus technologies. For example, Beijing and Shanghai have started projects to introduce CNG and LPG vehicles. Beijing started to introduce CNG buses in 1999 and by 2001 there were 1630 CNG bus vehicles and 3000 bi-fuel LPG buses. Shanghai converted its existing public buses into CNG or LPG vehicles by 2000.

### 3.3.2 Paratransit

One of the most notable features of the public transport sector in the developing and transitional economies in recent years has been the explosive growth of publicly available passenger transport services outside of the traditional public transport regulatory system, often referred to as paratransit. There are over 2 million paratransit vehicles operating in cities worldwide.



A number of characteristics are typical of paratransit services, although not necessarily applicable in all cases: (1) services are informal, unscheduled and demand-responsive and (2) vehicles are small, old, and cheap and include nonmotorized transport (NMT) vehicles (Table 5).

### *Environmental impact*

Paratransit services are usually provided by informal operators. On the one hand, the services provided by the informal sector may better respond to consumer demand than those of the formal sector, and employment in informal transport may be one of the few areas of gainful economic activity open to new rural-to-urban migrants.

On the other hand, informal transport brings with it adverse effects on congestion, environment, and the viability of the basic public transport network. A balance needs to be found. It may be generalized that paratransit is favorable in smaller cities, where excessive supply is not a problem, but not favorable in larger, congested, and polluted cities.

The critical question then becomes at what point does the growth of paratransit need to be controlled.

**Table 5 Informal (noncorporate) urban transport operations**

Vehicle type	Service features		Passenger capacity	Service niche	Market regime	Examples
	Routes	Schedules				
Large bus	Fixed	Fixed	25–60	Line-haul	Franchised	Buenos Aires; Rostov, Russian Federation
Minibus	Fixed	Fixed/semifixed	12–24	Line-haul	Franchised	São Paulo; Bangkok; Harare, Zimbabwe; Johannesburg, South Africa
Jeepney	Fixed	Semifixed	12–24	Line-haul	Franchised	Manila
Microbus and pick-up truck	Fixed	Semifixed	4–11	Feeder	Licensed	Caracas
Shared taxi	Variable	Variable	3–6	Short trips	Licensed	Casablanca, Morocco; Lima; Maracaibo, Rep. Bol. de Venezuela
Three-wheelers	Variable	Variable	2–4	Short trips, feeder	Unregulated	Phnom Penh, Cambodia; Delhi; Bangkok; Jakarta
Motorcycle	Variable	Variable	1–4	Feeder, some longer distances	Unregulated	Bangkok; Cotonou, Benin; Lomé, Togo; Douala, Cameroon
Pedicab and horse-drawn cart	Variable	Variable	1–6	Short trips, feeder	Unregulated	Dhaka; Vientiane, Lao People's Dem. Rep.; Mumbai

Notes: "Franchised" means holding official permission specifying task, area of operations, and so on. "Licensed" means holding unspecified permission to operate the vehicle.

(Source: World Bank, 2002)

## **4.0 Factors for Successful Introduction of Public Transport**

### **4.1 Integration of public transport with land-use planning**

To provide environmentally friendly public transport services, it is imperative to integrate them with appropriate land-use planning to ensure that the modes of public transport cover a substantial percentage of the transportation needs by efficiently connecting central business districts and residential areas.

The MRT system in the Tokyo Metropolitan Area was introduced on a large scale in the 1950s; however, lack of integration with housing development planning has brought about a sprawl of urban residential areas. Even if ‘restricted urbanization area’ was designated, it is not well designed enough to stop urbanization (Hayashi, 1996). The consequent urbanization has created a large demand that cannot be met by public transport. Automobiles or buses are highly used to travel to the closest train stations, leading to traffic jams and overloading of trains during commuting hours. This lack of integration between land transport planning and land-use planning is also seen in Bangkok and Manila. In Bangkok, the first statutory land-use plan was not issued until 1992, and the delay of land-use planning is thought to be a reason behind road-oriented dispersal and the sprawl of the city. In Manila, disorderly development with highly mixed land use prevails along major roads and in the suburbs owing to the lack of adequate development controls (PADECO, 2000).

Curitiba is an example of the integration of land-use and transport planning. The Master Plan for Curitiba, developed in 1965, has the objective of adapting the zoning and land-use requirements to the socio-economic and territorial development of the city (Nieri, 2000). On the basis of the plan, the city has been developed along a structural axis, the physical form around which the development of the city and its BRT network is organized. Curitiba introduced this strategy when automobile ownership was still low and public transportation needs were substantial, and prior to the traffic congestion that was anticipated with an exponential growth in population (Krutchmeyer, 2000).

Another successful example is “Urban Growth Management Functional Plan” of Portland. It introduced region-wide growth management strategy seeking to limit new urban land development and to focus all new growth in existing areas, especially around the light rail system (Newman and Kenworthy).

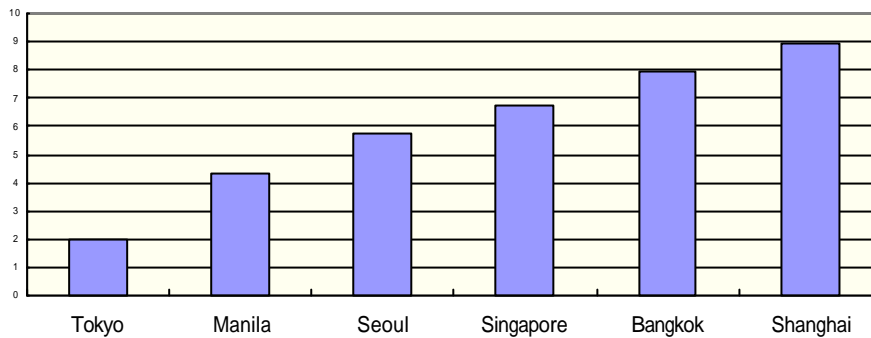
Therefore, it is advisable to introduce land use planning which can effectively control urban sprawl and provide spacial structures allowing the substantial amount of transportation needs covered by public transport, especially for cities that are in the early stages of development and motorization and anticipate high population growth,.

## **4.2 Coupling public transport with traffic demand management**

Public transport development is best approached by a strategy that includes rigorous traffic demand management measures as an integral part (PADECO, 2000). MRT infrastructure projects have limited impact on car ownership and use. Car ownership is generally more influenced by parking space availability and ownership costs rather than by MRT supply (PADECO, 2000). In fact, even in Paris, where the city center is served by an excellent public transport system, car use has been increasing and population densities falling, because there is no policy of strongly restricting car use (GTZ, 2002).

Singapore and Seoul started to limit the growth of private vehicle ownership at an early stage, before levels reached 70 cars per 1000 people (PADECO, 2000). Shanghai also started to limit the number of vehicle licenses from early 1990 (Liu, 2003). Singapore has highlighted the importance of integrating and balancing public transport with

private car constraint measures. Disincentives of car ownership include the Vehicle Quota System and fiscal measures such as import duty, a goods and services tax, and registration fees. In addition, road-pricing mechanisms have been in place since 1975 to reduce congestion in the CBD. The ratio of average user cost of a car trip to average user cost of a trip by public transport in Singapore is more than 3 times higher than that in Tokyo (Figure 2).



(source: author, based on the data by Kenworthy and Laube, 2001)

**Figure 2 Ratio of user cost of a car trip to user cost of a public transport trip**

## 5.0 Items for Further Discussions/Activities

Public transport plays a key role in improving the environmental quality and meeting the mobility needs of people in the cities of Asia. Asian cities vary in their structures and socio-economic conditions, and there is no one-for-all solution to developing sustainable transportation. Each city is faced with challenges to identify its long-term strategic objectives, and to then develop its own public transport plans. In developing plans for sustainable transport, common concerns may include:

- Selection of appropriate modes or an appropriate mix of modes, taking into consideration the costs, performance, and environmental impacts of each mode as well as the size and population distribution of the city;
- Development of effective networks among the various modes in terms of infrastructure and fares;
- Improvement of the paratransit and bus sectors and their integration with the public transport system;
- Development of sustainable funding plans to avoid indebtedness;
- Integration with long-term land-use planning to avoid uncontrolled sprawl;
- Integration with traffic demand management, such as congestion pricing and restriction of vehicle ownership.

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