Planning for Safety in High Capacity Bus Systems

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INTRODUCTION

Most of the megacities in the world are already located in less motorised countries (LMC) and many more cities in these countries will grow to populations of ten million or more in the next few decades (World Health Organisation, 1998). All these cities are faced with serious problems of inadequate mobility and access, vehicular pollution and road traffic crashes and crime on their streets. Increasing use of cars and motorised two-wheelers (MTW) add to these problems and this trend does not seem to be abating anywhere. Many recent reports suggest that improvements in public transport and promotion of non-motorised modes of transport can help substantially in alleviating some of these problems (Mohan et al., 1996; Wu Yong and Li Xiaojiang, 1999; OECD, 2000; Commission of the European Communities, 2001). In recent years, high capacity bus systems (HCBS) with dedicated busways have been shown to be economically feasible and capable of transporting large numbers of people efficiently in many South American and European cities (Hans Örn, 1998; World Bank, 2000). A recent report prepared for the World Business Council for Sustainable Development (2001) states that "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 kilometer, 50 to 100 times cheaper than subways."

In view of these experiences it appears that use of HCBS will become more common in megacities in this decade. However, introduction of better technologies alone in public transport is not likely to shift adequate numbers of people from using cars and motorcycles. Some of the standard counter measures suggested to promote public transport include the following:

(a) Promote mixed land use.
(b) Move toward a greater diversity in modal splits with more importance to non-motorised modes.
(c) Lower commuting distances
(d) Increase costs of personal modes of motorised travel and raise fuel prices and introduce road fuel taxation.
(e) Increase frequency of buses.
(f) Bus stops should be within easy walking distance of home and work places.
(g) Buses should be made more accessible and comfortable for children, women, elderly, and the disabled.
(h) Make public transit affordable for the lowest quintile income.

(i) Improve quality of pedestrian and bicycle environment.
(k) Access to the bus must be made safe for all bus users.

Of all the measures listed above, (a) to (d) already exist in some form in Delhi and many LMC cities. Delhi has a very mixed land use pattern, a large proportion (~39%) of all trips are walk or bicycle trips (Operations Research Group, 1994); of the motorised trips more than 50% are by public transport or shared para-transit modes; compared to cities in highly motorised countries (HMC), trips per capita per day in LMCs are lower and more than forty percent trips are less than 5 km in length; and costs of motorised travel are high compared to average incomes. In spite of these structural advantages, public transport systems in Delhi and other LMC cities are not adequate.

Introduction of HCBS with modern low floor buses are likely to take care of the measures (e) to (g) listed above. However, what these cities do not have are safe and convenient walkways and bicycle lanes and streets that ensure safety of all commuters from accidents and crime.

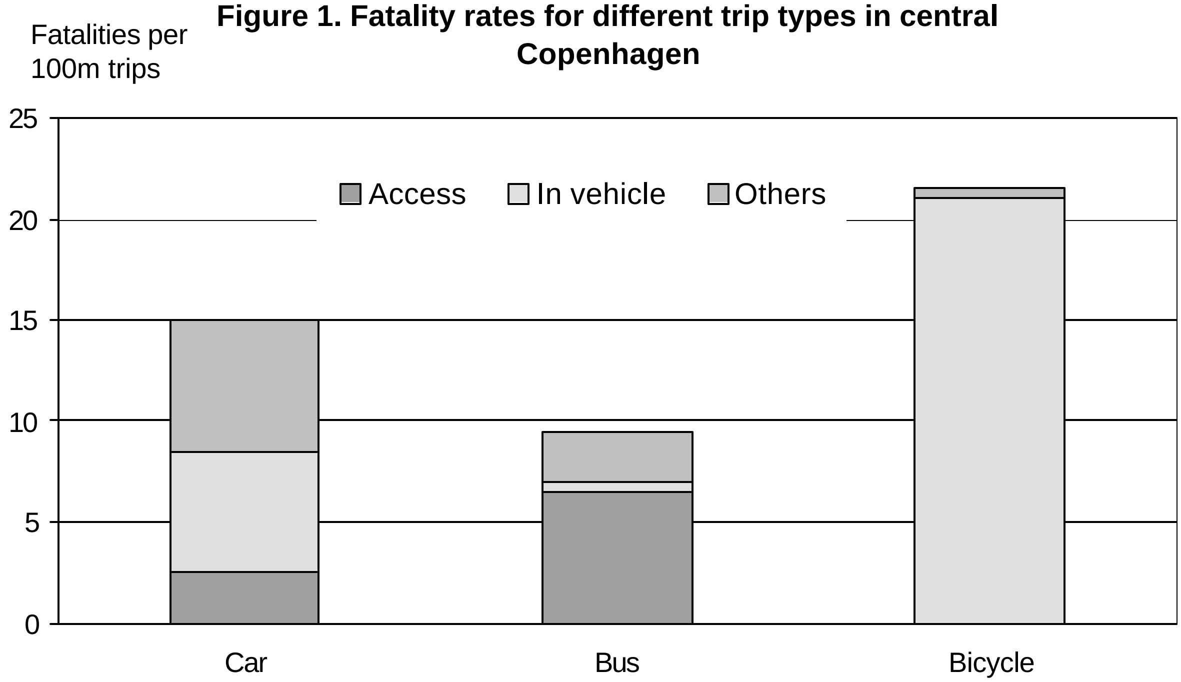
Deaths and injuries due to road traffic crashes are also a serious problem in LMCs (Asian Development Bank, 1998). According to one estimate the losses due to accidents in LMCs may be comparable to those due to pollution.(Vasconcellos, 1999). These problems become difficult to deal with because there are situations in which there are conflicts between safety strategies and those which aim to reduce pollution.(OECD, 1997) For example, large and heavy vehicles can be safer but they are consume more energy and pollute more; congestion reduces probability of serious injury due to crashes but increases pollution; increase in bicycling rates can decrease pollution but may increase crashes if appropriate facilities are not provided. However, unless access to public transportation systems is made much safer it would be difficult to ensure success of the proposed high capacity bus systems. In this paper we outline some of the issues and policy options connected with public transportation and safety.

PUBLIC TRANSPORT AND SAFETY

The safety record of bus transit operations has been reasonably good in most cities of the world as compared to other modes of transport but yet people still prefer to use their cars if they can afford it and when it convenient to do so. The main problem of safety is not as a bus passenger but as a pedestrian or bicyclist on the access trip. A study of risk of accidents by different travel modes in Copenhagen (Jorgensen, 1996) concluded, “There is no reason for a traveller to choose bus instead of car for the point of view of his own safety,” and that “From a social point of view there would be a safety benefit through a change of car driving into bus driving”. These conclusions were based on the fact that the risk of death per trip for a bus user was very high on access trips (see Figure 1).

The high risk of injuries and fatalities in urban areas to pedestrians, bicyclists and commuters in access trips have been documented from all over the world. The greatest risk to schoolchildren from bus related injuries was found to be as pedestrians after alighting from a bus in New South Wales, Australia (Cass, Ross and Lam, 1997); in Mexico City 57% of deaths from traffic crashes involve pedestrians (Hijar, Kraus, Tovar and Carrillo, 2001); injury to pedestrians was the most frequent cause of multiple trauma (54%) among children 0-16 years in a large Spanish urban area (Sala, Fernandez, Morant, Gasco, and Barrios, 2000); in California a motor vehicle versus pedestrian accident study reported that these accidents are common in a large urban trauma system and the high mortality rate among the elderly indicated the need for more aggressive and effective prevention efforts (Peng and Bongard, 1999); a study from Canada showed that children's exposure to traffic (number of

Figure 1. Fatality rates for different trip types in central Copenhagen



Source: Jorgenesen, 1996.

streets crossed) and injury rates were positively correlated (Macpherson, Roberts and Pless, 1998); in Kumasi, Ghana, the most common mechanisms of injury (40.0%) to children were pedestrian knockdowns (Abantanga, and Mock, 1998); A study of older people's lives in the inner city in Sydney, utralia, showed that the environmental hazards, such as pedestrian safety and traffic management, affect the whole population and require interventions at government level (Russell, Hilland Basser, 1998); a study from Seattle shows that 66% of the fatal injuries occurred on city or residential streets, and 29% occurred on major thoroughfares, and a single urban highway accounted for 12% of pedestrian fatalities and represented a particularly hazardous traffic environment (Harruff, Avery, and Alter-Pandya, 1998).

Quite obviously, people’s fears regarding safety on the roads when using public transport are not unjustified. A large proportion of the decrease in road traffic injuries and deaths in HMCs is the result of the availability of cars which provide much greater safety to the occupants in crashes, and the result of a very significant reduction of the presence of pedestrians and bicylists on HMC streets and highways. Recent estimates from UK suggest that the number of trips per person on foot fell by 20% between 1985/86 and 1997/99 (House of Commons UK, 2001). Such trends suggest that reduction in pedestrian, bicycle and MTW fatalities in HMCs could be largely because of the reduction in exposure of these road users and less because the road environment has been made “safer” for them. In LMCs the exposure rates for pedestrians and bicyclists are much higher, and with the introduction of HCBS, it would become essential that road and vehicle designs ensure safety on access trips otherwise the system may operate at sub-optimal capacities.

PUBLIC TRANSPORT AND TRAFFIC CHARACTERISTICS OF INDIAN CITIES

Transport and land use patterns found in Indian cities are different from those existing in most HMC cities. These patterns reflect a new phenomenon and have not been seen in the West since its earlier days of motorization and urbanization. Intense mixed land use, short trip distances, and high share of walking and non-motorised transport characterize such urban centres (Newman Kenworthy, 1989). The rising cost of transport within the city and long working hours force the workers to live close to their places of work. Unlike the traffic in cities in HMCs, bicycles, pedestrians and other non-motorised modes are present in significant numbers on the arterial roads and intercity highways. Their presence persists despite the fact that engineers designed these highway facilities for fast moving uninterrupted flow of motorised vehicles.

In Delhi average speeds during peak hour range from 10 to 25 km/h in central areas and 25 to 60 km/h on arterial streets and Delhi's traffic fatalities in 2000 were more than double that of other mega cities in India. In 2000 there were 915 (46%) pedestrian and 255 (13%) bicyclist fatalities in Delhi (Tyagi, 2001). In a similar period (April 2000-March 2001) buses operated by the Delhi Transport Corporation were involved in 928 crashes of which 152 were fatal. A comparison of bus crash statistics of four major cities in India (Chennai, Delhi, Kolkata and Mumbai) is given in Table 1 (Performance…, 2001). These data show that fatalities per 100 million passenger km range between 0.40 and 1.04. These rates are unacceptably high compared to an average rate of 0.33 for the USA. (Federal Transit Administration, 1999). No data are available for injuries and fatalities on access trips by passengers. Clearly, criteria for recommending optimal speeds and congestion reduction do not include adequate policies for desired level of safety, pollution and land use patterns.

Table 1. Accident statistics of four metropolitan city bus corporations in India.

	Chennai CHI – I & II	*Delhi DTC*	*Kolkata, STC*	*Mumbai, BEST*
No.of buses	2,314	4,330	821	3,155
Number of accidents	1,797	928	306	806
Number.of fatal accidents	133	152	24	41
Fatalities per100 buses	5.7	3.5	2.9	1.3
Fatalities per 100 million passenger km	0.99	0.79	1.08	0.40

There is ample evidence to illustrate the mismatch between the careful planning and the growing transportation problems. Unless we understand the basic nature of problems faced by our mega cities, the adverse impact of growing mobility on the environment would continue to multiply in future.

Traffic Patterns and Planning Issues

A high share of non motorized vehicles (NMVs) and MTWs characterizes the transport system of Indian cities. In such cities nearly 45%-80% of the registered vehicles are MTWs. Cars account for 5% - 20% of the total vehicle fleet in most LMC large cities. The road network is used by at least seven categories of motorised vehicles and NMVs. Public transport and paratransit is the predominant mode of motorized travel in megacities and carry 20%-65% of the total trips excluding walk trips. Despite a significant share of work trips catered by public transport, presence and interaction of different types of vehicles create complex driving environment. The present design of vehicle technology does not take into consideration this environment where frequent braking and acceleration cannot be avoided.

Because bicyclists and pedestrians continue to share the road space in the absence of infrastructure specifically designed for NMVs, they are exposed to higher risks of being involved in road traffic accidents by sharing the road space with high-speed modes. Unlike cities in the West, pedestrians, bicyclists and MTWs constitute 75% of the total fatalities in road traffic crashes.(Tiwari, 1993). Buses and trucks are involved in more than 60% of the fatal crashes. Buses are often very crowded inside and significant proportion of passengers who die are those who fall from footboards of the buses.

Construction of a metro rail system and increase in number of buses would also increase the number of access trips by walking and bicycling. High-density metro corridors increase the presence of pedestrians on the surface. This can result in higher accident rates if special measures for traffic calming, speed reduction, and provision of better facilities for bicycles and pedestrians were not put in place in parallel.

The experience of designing and running a high capacity bus system in the city of Curitiba in Brazil gives us a very good example of what is possible in planning public transportation systems at a fraction of the cost (5%-10%) involved for metro lines.(Ceneviva, 1999). Special bus and bus stop designs have been developed in Curitiba to make access to buses easier, safer and faster. This is combined with provision of segregated bus lanes where necessary, traffic light priority for buses and moving buses in platoons. Many bus priority lanes around the world carry 15-20 passengers in one hour in each direction, and experiments show that modern specially designed bus systems up to 25,000 - 30,000 passengers in one hour in each direction.(Shen, et al, 1998; Smith, 1995). Since such systems can be put in place at a fraction of the cost of metro systems without digging or building elevated sections, they can be introduced on all major corridors of a city. Since the total number of lines so built would be many more than the high cost metro system, the total capacity of this system would also exceed that of a limited metro rail network. An intelligent mix of electric trolley buses and other buses running on diesel and alternate cleaner fuels could take care of pollution issues. The availability of modern computer networks, communication systems and intelligent transport technology hold great promise for making high capacity bus systems even more efficient and user friendly. Even the highly industrialised countries did not have these options available to them in the past decades and so very little serious research and development work has been done to optimise designs for megacities in low-income countries. Any investment in this direction should be highly profitable.

NEED FOR IMPROVING THE QUALITY OF PEDESTRIAN AND BICYCLE ENVIRONMENT

In light of the discussion above, an exclusive focus on bus and fuel technologies only may not be a sustainable option for cleaner air in cities like Delhi. In all LMC cities NMT modes constitute a high proportion of all traffic. Unless these modes are given importance and roads specifically designed for their needs they make the movement of motorised modes less efficient. In addition to bicycles, non-motorised carts and *rickshas* are used for delivery of goods like furniture, refrigerators, washing machines etc. Semi-skilled workers, carpenters, masons, plumbers, postmen, and courier services use bicycles or walk. Therefore, the demand for bicycles and other NMT nodes exists in large numbers at present and is likely to exist in the future also. This situation is not explicitly recognised in policy documents and very little attention is given to improving the facilities for non-motorised modes. Technological solutions based on improving fuels, engines and vehicles must be accompanied by improvements in road cross-sections and providing segregated facilities for non-motorised transport.

Mohan and Tiwari (2000) also show that in LMCs buses and trucks are involved in a much greater proportion of crashes than in HMCs, but relevant safety standards for these vehicles are lacking. In particular, a strong case can be made for evolution of pedestrian friendly fronts for buses and trucks, but such issues are not given any priority at present.
Better facilities for pedestrians and segregated bicycle lanes would also result in enhanced efficiency of the public transport buses that can be given the curbside lane or central two lanes for buses as per the site demand. Physically segregated lanes also improve safety of the vulnerable road users by reducing the conflicts between motorised and non-motorised modes. This would smoothen traffic flow and hence reduce pollution. Data clearly indicate that if public transport use has to be promoted in mega-cities like Delhi in LMCs much more attention has to be given to the improvement in safety levels of bus commuters and the non-motorised transport segment of the road users. This is particularly important because promotion of public transport use can also result in an increase in the number of pedestrians and bicycle users on city streets. This is because every public transport trip involves two access trips that are mostly walking or bicycle trips. Unless people actually perceive that they are not inconvenienced or exposed to greater risks as bicyclists, pedestrians and bus commuters it will be difficult to reduce private vehicle use. However, in LMC cities non-motorised modes of transport already constitute a significant proportion of all trips. It will be difficult to increase this share of public transport and non motorised modes unless these modes are made much more convenient and safer. It is clear that unless safety of pedestrians and bicyclists is ensured it will be very difficult to promote use of public transport as incomes of citizens increase in the next decade.

VENDORS, HAWKERS, MOBILITY AND SAFETY

The measures mentioned above are necessary, but not sufficient, steps toward sensible policy making. This is because dealing with technology and health in the public space is much more complex than we think. If your stress test shows that your heart muscles have become weak, you can panic and demand a single magic pill to solve all your problems. However, your doctor will only laugh at your demand. Instead, he will tell you to change your diet, do a set of prescribed exercises every day, alter your life style, *and* take a set of medicines every day. In addition, he will also ask you to monitor your health status periodically and change your drugs accordingly. Tackling traffic flow, vehicular pollution and road accidents is no less complex. These problems require the same level of scientific expertise, interdisciplinary cooperation, and long term attention as any other public health problem.

To solve problems of safety and vehicular pollution in an integrated manner we need to work from first principles. Quite obviously, the most long lasting solution would be if people travelled less. This depends mostly on how your city is organised. Mixed land use helps. Homes, businesses, hospitals, schools, entertainment areas, all need to be intermixed in localities. This is happening more by default than policy in our cities. *Thelawalas* going house-to-house selling things reduce trips; vegetable shops, *dhobis*, *mochis*, *paan* shops, and *tandoor* stands in neighbourhoods eliminate thousands of scooter and car trips.

Even the existence of poor neighbourhoods cheek by jowl with rich ones may be reducing motorised trips and increasing employment. When you shift low-income people to the periphery of a city you have to provide bus transport to the formally employed. But the others become unemployed and may take to crime.

It is easy to list the above principles but not so easy to make and implement effective policy. All policies, like drugs, have side effects. Before prescribing a drug you have to be certain that the side effects are not worse than the disease! For example, our simple calculations show that all the effects of reducing pollution from buses would be *nullified* if only 10-15 percent of bus users shift to using two-wheelers or cars (Sanghi, Kale, and Mohan, 2001). This may also result in an increase in road traffic crashes and injuries. Greater use of two-wheelers would also increase injuries due to accidents. Therefore, before we make new laws that might increase the cost of buses, we have to make arrangements for cross-subsidy of public transport. This follows from the Apolluter and user pay@ principle based on free market economics. Since car users pollute the most, use the most road space and injure more people per person transported, they must pay for their comfort that harms others. Two wheeler users come next and bus users a low third. A pollution and road tax paid by private vehicle users could help pay for better buses so that we avoid a migration from buses to two-wheelers and cars. It is quite clear that safety and cleaner air will come at a price, and only if we have well thought out long term policies. The future committees which deal with these issues would be well advised to consider all the complex issues, consider the Aside effects@ and perform cost effectiveness studies before issuing edicts. If we don=t do this, the air will not be cleaner and a lot of people will be angry.

DEVELOPMENT OF A BUS COMMUTER SAFETY POLICY

Safety of bus commuters can only be ensured if a scientific policy is put in place and implemented by a proactive system. A recent report on the subject commissioned by the U.S. Department of Transportation (1999) lists the following conditions for such a system:

- Address all departments within the transit system (safety, operations, maintenance, etc.).
- Include both patrons and employees in the plan development.
- Address all of the safety issues associated with the transit system.
- Provide for and maintain top management and board of directors approval in the form of a signed policy and the allocation of adequate resources.
- Ensure that the safety director/officer has direct access to top management.
- Designate one individual as the responsible safety authority for the system.
- Clearly identify the roles and responsibilities of the safety director/officer and the safety department.

- Clearly identify the safety roles and responsibilities of all other transit system departments.
- Establish a proactive safety program with the process and procedures necessary to identify and resolve hazards prior to their resulting in accidents.
- Include a mechanism for ensuring that all employees are accountable for safety. This must include a disciplinary process.
- Provide a mechanism for cooperation (including the resolution of differences) between the individual transit system departments and external agencies that support the transit system.
- Include the establishment and review of data bases to assist in the continuous monitoring of the system safety program to ensure that it is providing the results expected.
- Prepare a fully documented system safety program plan.

Such a system must include the following elements (Federal Transit Administration, 2001):

Safety Process-Centric Elements

- Safety Data Acquisition/Analysis
- Accident/Incident Reporting & Investigation
- Hazard Identification/Resolution Process
- Emergency Response Planning, Coordination and Training
- Internal Safety Audit Process

Human-Centric Elements

- Driver Selection (Basic safety element)
- Driver Training (Basic safety element)
- Drug & Alcohol Programs(Basic safety element)
- Employee Safety Program
- Fitness for Duty (additional requirements beyond the drug and alcohol requirements)
- Rules/Procedures Review
- Contractor Safety Coordination

Infrastructure & Equipment-Centric Elements

- Vehicle Maintenance (Basic safety element)
- Facilities Inspections
- Maintenance Audits/Inspections
- Hazardous Materials Program
- Alternative Fuels and Safety
- System Modification Review/Approval Process
- Interdepartmental/Interagency Coordination
- Configuration Management
- Procurement
- Security
- Operating Environment and Passenger Facility Management
- Dedicated Busway or Roadway Inspection and Maintenance

In addition, special attention has to be paid to safety of women (METRAC, 2000) and children (see for example a report prepared by the National Association of State Directors of Pupil Transportation Services, 1998). Such policies should ensure that women and children are free from violence and the threat or fear of violence in buses, bus stops and on their access trips.

CONCLUSIONS

Buses and non-motorised modes of transport will remain the backbone of mobility in LMC mega-cities. To control accidents and pollution in an integrated manner, both bus use and non-motorised forms of transport have to be given importance without increasing pollution or the rate of road accidents. This would be possible only if the following conditions are met:

Public Transport

- Design and development of modern and sophisticated high capacity bus systems be given priority in megacities of Asia.
- The increase in fares because of more expensive buses is likely to shift bus passengers to cars and two wheelers and thus increase total pollution and accidents. The benefits of better technologies will be defeated if bus passengers shift to personal modes of travel due to fare increases. Therefore, the government must put in place a comprehensive policy of financing of public transport including cross subsidies. This could be done by invoking the "polluter pay principle". Owners of cars and two-wheelers must be made to pay a pollution tax, the proceeds from which could be used for financing more efficient bus transport.
- The problem of shift to 2-wheelers and cars from public transport has to be addressed irrespective of the fuel used by buses. Therefore, public transport has to be made more convenient, safe and efficient. The safety and efficiency of bus transport, and its attractiveness for users could be increased substantially if modern low floor buses are inducted in the Delhi fleet.

Facilities for Non-Motorised Transport and Safety

- Every round trip by public transport involves four non-motorised trips and at least two street crossings. Therefore, greater use of public transport cannot be ensured unless use of roads is made much safer for pedestrians and bicyclists.
- All arterial roads must have segregated lanes for non-motorised transport and safer pedestrian facilities.
- Urban and road design characteristics must ensure the safety of pedestrians and bicyclists by wider use of traffic calming techniques, keeping peak vehicle speeds below 50 km/h on arterial roads and 30 km/h on residential streets and shopping areas and by providing convenient street crossing facilities for pedestrians.

The above recommendations have to be considered in an overall context where safety and environmental research efforts are not conducted in complete isolation. We have to move toward adoption and implementation of schemes that remain at a human scale and improve all aspects of human health. The authors of a report on integration of strategies for safety and environment published by the OECD (1997) suggest the following guidelines for policy makers:

- Ask leading questions about safety and environmental goals at the conceptual stage of the project and look beyond the immediate boundaries of the scheme.

- The safety and environmental consequences of changes in transport and land use should be made more explicit in technical and public assessments.
- There should be simultaneous consideration of safety and environmental issues by involving all concerned agencies.
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