INTEGRATION OF PUBLIC TRANSPORTATION SYSTEMS

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Abstract: The recent scenario of public transportation in most of the Indian cities shows only 20% to 30% of the total passengers utilizing any public transit as their model of travel. With the ever increasing population and gradual increase in per capita income, dependence on private modes is increasing and same trend is expected to be continued in the coming years. With more private vehicles on roads, pollution as well as congestion levels in the cities are also expected to increase. Hence, there is a need to make the public transit a favorable mode of transport for the passengers. The objective of the study is to highlight the deficiencies of current transportation system in various metropolitan cities in India and suggest the best integration practice for each selected city. The paper deals with the current scenario of public transportation in major metropolitan cities of India viz. Delhi, Mumbai, Chennai and Kolkata and analyzing it with the norms provided by the MOUD, GOI to find out the deficiencies in the transit systems of the selected cities, after which the recommendations regarding public transport integration given by authors, authorities and organizations are provided. The paper then provides the case studies of various public transit integration measures practiced overseas and relating them to the situation of the selected Indian cities, in order to suggest the best integration strategies.

Keywords: Public Transportation, Deficiencies Integration, Strategy

1. INTRODUCTION

Public transportation plays a significant role in finding solutions to the numerous challenges of today's world. As per the American Public Transportation Association (APTA), public transportation helps conserving energy, reduces oil dependence, relieves congestion, protects the environment, improves air quality and health, provides mobility for small urban and rural areas and builds a strong economy as investments in public transportation generates significant economic benefits. FHWA extended the importance by stating that public transportation is critical to safe and efficient evacuation in times of emergency. The National Association for State Community Services Program (NASCSP) also stated public transportation can reduce social and economic inequalities by enhancing mobility for residents. Hence, the role of public transport is very crucial not only in the context of traffic management but also in terms of economic growth of a city. One of the emerging aspects to enhance the use of public transport in the developing nations like India is the concept of public transport integration. The concept of public transport integration appeared as early as in 1933 in London (a form of institutional integration) followed by Hamburg (1965) and Munich (1971). There were many definitions given by several authors "integration is a multi-faceted concept that includes a number of factors and a multiplicity of definitions[4][9]. Others have referred it to the rungs of an integration ladder[5]. "Public transport integration includes the comprehensive planning of services within an urban market for the purposes of facilitating seamless, multi-operator journey. It entails the organization of modes and services into a rational system of operational features in terms of routes, frequencies, timetables, fares and ticketing, as well as policy aspects such as, planning,

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marketing and development"[13]. Some studies defined it as "the way parts of public transport network are embedded in total mobility chain". However, NEA defined integration by further and more comprehensive statement as: "the organization process through which elements of the passenger transport system (network and infrastructure, tariffs and ticketing, information and marketing, etc.) are, across modes and operators, brought into closer and more efficient interaction, resulting in an overall positive enhancement to the overall state and quality of the services linked to the individual travel components"[7]. This definition emphasizes that integration is a process rather than a state. Hence, the structure of the paper is as follows: presenting the MOUD, Government of India policies on various public transportation aspects. It will

i. Optimal modal share for different city sizes
ii. Capacity of different public transportation modes and
iii. Selection criteria of Mass Rapid Transit modes

2.1 Optimal modal share for different city sizes

As per National Transport Development Policy Committee (NTDPC), the transport mode to be used and modal mix will depend on the city population, the city form and size, availability of road surface and trip length. Table 1 shows desirable modal split for Indian cities as a percentage of total trips.

Table 1 : Desirable modal split for Indian cities

City Population (in millions)	Mass Transport	Bicycle	Other modes
0.1–0.5	30–40	30–40	25–35
0.5–1.0	40–50	25–35	20–30
1.0–2.0	50–60	20–30	15–25
2.0–5.0	60–70	15–25	10–20
5.0 +	70–85	15–20	10–15

Source: Traffic and Transportation Policies and Strategies in Urban Areas in India, 1998, MOUD, GOI

then go on to comparing the various metropolitan cities with the policy norms stated in previous section, identifying the deficiencies present and suggesting the appropriate solutions as per the norms and finally dealing with the integration strategies overseas which can be incorporated in Indian cities.

2. GOVERNMENT OF INDIA POLICIES ON PUBLIC TRANSPORTATION

The Ministry of Urban Development (MOUD), Government of India has provided policies and specifications on various standards of public transportation in India. The major policies considered in this paper are:

2.2 Capacity of different public transportation modes

The standard capacity of various public transit modes is presented in Table 2.

2.3 Selection criteria of Mass Rapid Transit modes

As per NTDPC, choice of mode depends mainly on demand level on a corridor, available ROW and capacity of the mode. Other considerations are land-use along the corridor, the location of building lines and the potential for increasing the ROW. The chosen mode should be adequate for the future demand level on a corridor, both in quantity and quality of service such as journey time. Other features such as speed, cost, safety, eco-

Table 2 : Standard capacity of Transit Modes

Public transport mode	Capacity
Standard Size Urban Bus	32-34 seating + standing (as per AIS 052)
Mini Urban Bus	13-22 seating + standing (as per AIS 052)
Midi Urban Bus	23-34 seating + standing (as per AIS 052)
Monorail	568 commuter for 4 car (852 for 6 car)
LRT	200-250 passengers per vehicle
Metro	1200-1500 passengers per train trip for 4 coach (1800 – 2100 for 6 coach)

Source : Urban Bus Specification, MOUD, GOI, Wikipedia, DMRC

friendliness, energy and land-conservation, aesthetics and local technology maturity for maintaining the system should be given due weightage. The selection criterion of mass rapid transit is given in Table 3.

respectively and it should be between 60 – 70% for Chennai and Kolkata while it is 31% and 54% respectively in these cities. Hence, one can infer that none of the major metropolitan cities in India is able to cater the desirable public

Table 3 : Selection criteria of Mass Rapid Transit modes

Mode choices	PHPDT in 2021	Population as per 2011 census (million)	Average trip length for motorized trips in km
Metro rail	≥ 15,000 for at least 5 km continuous length	≥ 2	> 7-8
LRT primarily at grade	≥ 10,000	> 1	> 7-8
Monorail	≤ 10,000	> 2	About 5-6
Bus Rapid Transit system	≥ 4,000 and up to 20,000	> 1	> 5
Organized City Bus Service		> 1 lakh hilly towns (50,000)	> 2 to 3

Source: Working Group on Urban Transport, NTDPC, Final Report, 2012

3. PUBLIC TRANSPORT SCENARIO OF METROPOLITAN CITIES

This section deals with comparing the public transport scenarios of various metropolitan cities with the norms of MOUD, GOI as stated in previous section. The selected cities include Delhi, Mumbai, Chennai and Kolkata. The various features of cities such as population, major PT modes available, PT mode share, passenger trips per day and average trip length for each of these cities have been summarized in Table 4.

Comparing the present public transport mode share with the desirable modal split values as shown in Table 1, The public transit modal share should be between 70 – 85% for Delhi and Mumbai while it is just 43% and 45%

transport modal share as suggested by MOUD.

The average trip length for all the selected metropolitan cities is greater than 8 kms and population of each of the selected cities is also more than 2 million. Hence, metro system is mandatory for all the selected cities. In fact, Delhi has a well connected metro system which is still expanding while Kolkata has the oldest metro systems in the country. Mumbai with the presence of suburban rails has also now started metro in few corridors while Chennai is yet to incorporate the metro system. This may also be the reason for lowest public transport share for Chennai.

3.1 Recommendations for Delhi

The following are some of the recommendations regarding integrated public

Table 4 : Various features of metropolitan cities in India

Feature \ City	Delhi	Mumbai	Chennai	Kolkata
Population (millions)	16.75	12.47	4.68	4.48
Major PT modes available	Buses, Metro, auto-rickshaws and taxis	Buses, Suburban rails, metro taxis, auto-rickshaws and ferry services	Buses, suburban rails, taxis and auto-rickshaws	Buses, Metro, trams, auto-rickshaws and ta...
PT mode share (%)	43	45	31	54
Passenger trips /day (lakhs)	1124.9	1124.9	469.8	469.8
Average Trip length (km)	10.2	1.9	8.6	10.0

Source: Study on Traffic and Transportation Policies and Strategies in Urban Areas in India, Final report (2008), Wilbur Smith Associates and MOUD

transport in 12th Five Year Plan:

i. Future transport shall consists of a mix of rail and road base system which include Metro Rail, Ring Rail, dedicated rail corridors for daily commuters, bus rapid transit systems and intermediate passenger transport on private modes on selected corridors.

ii. Establishment of a single authority is the need of the hour for planning of an integrated system, implementation and enforcement of the policies which may be framed in that context. This would help to avoid a wasteful expenditure and other problems that could arise from duplication, overlap and contradictory facilities.

iii. The integration of all public transport modes is essential to provide convenient public transport system to the commuter in the city. Bus transport need to be planned in the form of Feeder services to the Metro rail stations, ISBTs, Ring Railway system. Park and ride facilities will also have to be developed at important sites.

iv. The congested areas of the walled city Sadar Bazar, Karol Bagh etc. need medium capacity mass transit system comprising of BRTS and LRT.

v. In order to further increase the modal split in favor of public transport, some additional measures such as restriction on car ownership, increase in the fuel cost, congestion pricing etc. may be considered at a time when all the areas in Delhi are provided with an adequate and convenient integrated public transport.

vi. An integrated passenger information system covering all modes through publication of common route guides, time-table and information boards at all terminals for providing up-to-date information for the system users are also important. Introduction of common ticketing and their availability at convenient places will also be necessary.

3.2 Recommendations for Mumbai

Proposed integration for Mumbai city given by S.L.Dhingra in "First Indo-US Symposium on Advances in Mass transit and Travel behavior research, 2008" is as follows:

i. Integration on the proposed Versova-Andheri-Ghatkoper LRT Metro with other existing and proposed public modes of transport.

ii. Influence area of each railway station shall be free from presence of any other railway station, and then feeder routes should be developed so that duplication of travel by train and bus will be avoided.

iii. The battery-powered emission free mini

buses are proposed to be used, to bring the passengers from their homes to the nearest metro or suburban railway stations within the influence area of the station.

iv. Every railway station should have a bus depot in its vicinity so that buses can start from railway stations to the selected destinations and are not interfered by autos will lead to easily transfer of passengers and reduction in environmental pollution.

Recommendations on Fare Policy by Vijayshree Pednekar are as follows:

i. Single journey ticket: distance based or transfer rebates based on mutual agreement between the operators and to avoid misuse of the system following transfer rules shall be applied:

   a. Only one entry and exit to railways/BRTS.

   b. Same route number of BEST cannot be taken twice.

   c. The trips shall be unidirectional.

   d. Maximum 4 transfers within 120 minutes.

ii. Multimodal Passes (limited/unlimited): multimodal pass for Railway and BEST based on km or fixed route with/without discount.

iii. Fare integration technology: it should be open system (except BRTS), contactless smart card for store values and passes and cards are personalized to avail discounts for specific patron categories.

3.3 Recommendations for Chennai

Institute of Transportation and Development Policy (ITDP) is providing technical assistance to the Corporation of Chennai (COC) to plan and implement a public cycle sharing system covering 19 sq. kilometers in central Chennai. The system will have 200 stations and 3000 cycles. Cycle sharing will improve last mile connectivity from Chennai's MRTS system and provide a new mobility option for short trips. It is working with the Chennai Metro Rail Corporation to develop plans for intermodal integration and improved pedestrian access to metro stations.

The Corporation of Chennai recognizes walking and cycling as major modes of transport. With assistance from ITDP, COC has initiated the process of creating a non-motorized transport policy. The policy aims to strengthen the city's commitment to non-motorized projects in the design and management of city streets. ITDP also is advising the city on policies for on-street and off-street parking. Improved parking management will support and encourage modal shift from private vehicles to public transport, cycling and walking.

3.4 Recommendations for Kolkata

The Infrastructure Development Finance Company Ltd. and Superior Global Infrastructure Consulting Pvt. Ltd. has recommended following measures in their Comprehensive Mobility Plan:

I. To increase the efficiency of transportation system, time-bound synchronization between different modes of travel should be planned such that more and more people are lured into using public transport.

ii. The coordination between transportation modes should be complemented by availability of multiple affordable travel options at each interchange.

iii. Synchronizing operational timing: n order to provide the commuter with a single travel experience, the timing of each mode would be synchronized at the point of interchange. This would also facilitate effective passenger dispersal at the transportation modes.

iv. Higher frequency schedule at peak hours: the frequency of the public transit modes would be higher during the peak hours.

v. Allocating movement corridors for each mode according to the traffic

volume on different routes: routes would be categorized according to their congestion level depending on the V/C ratio of each route. The modes of public transport operating on each route would be according to the volume of traffic on each route and the need for congestion mitigation. This would ensure that each mode is optimally utilized and its operations are financially sustainable.

vi. Unified ticketing system: a provision of purchasing a single ticket for using all modes of public transport will be a success because the transport network is so complex that a single element on its own cannot facilitate complete journeys and each journey requires one or more changes. There shall be a discount component involved in using unified ticket over single mode tickets.

vii. All bus terminals shall have access to the mass transit, be facilitated with infrastructure like information bureau, eateries, toilets etc.

3.5 Rolling Program

The rolling program is based on the 'Service Level Bench Marks' issued by MOUD SLBMs provide four levels of service. assumed that all cities are at the starting point and will move up one notch every five years up to 2030. Different cities require different infrastructure. A strategy for action in cities of various size and type has been developed in Final Report on Working Group on Urban Transport, NTDPC. Table 5 shows the strategies to be adopted for the selected 4 cities.

4. INTEGRATION STRATEGIES OVERSEAS

This section deals with the integration practices adopted by other developed countries. The cities involve Singapore, Queensland and Hong Kong. Various aspects of integrated services for each of these cities have been presented.

4.1 Singapore

Singapore with a population of 5.07 million has paid particular attention on the integrated public transport in order to improve the connectivity of transport modes so that public transport becomes a practicable alternative to

Table 5 : Strategies to be adopted for selected cities

City Size	Strategies		Actions Required	
Population (in lakhs)	Short Term	Medium & long term	Short Term	Medium & long term
10 – 80 (Chennai & Kolkata)	NMV, Motorized IPT, PT (buses)	NMV, Motorized IPT (feeder trips), BRT, PT (buses), rationalize private vehicle parking	NMV, Motorized IPT (feeder trips), BRT, PT (buses), rationalize private vehicle parking	NMV, BRT expansion and integration with rail based system
> 80 (Delhi & Mumbai)	NMZ, Motorized IPT (feeder trips), and taxi systems, BRT, PT (buses), rationalize private vehicle parking	NMV, taxi system with IT support, BRT expansion and integration with rail based system serving intercity trips with satellite towns, congestion pricing.	NMV audit mandatory for all infrastructure, SPC for preparing master plans and priority implementation for BRT, PT (buses).	Urban transport authority for integrating land-use with transport plans, planning taxi system with IT support, BRTS expansion and integration with rail based system, congestion pricing.

Source: Working Group on Urban Transport, NTDPC, Final Report, 2012

cars and reduces road congestion and environmental emissions[6]. The following are some of the measures adopted by the city:

i. **Institutional integration:** the establishment of TransitLink in 1989 was the first step in this respect. In 1995, Land Transport Authority (LTA) was formed which undertook both functions of planning and regulatory for public and private transport. The SBS Transit provided nearly all bus services in Singapore until Trans-Island Bus services (TIBS) began operation in 1983. The Singapore Mass Rapid Transit (SMRT Group) became in charge of operating all heavy and light rail services. In 2002, TIBS was merged with SMRT Group in order to integrate the institutional framework of public transport.

ii. **Physical integration:** the North-East Line, which opened in June 2003, has all its stations well-integrated with the adjacent activity centres. Moreover, LRT lines act as feeder services to this line and are integrated with local neighborhood and adjacent buildings[6]. In addition, more attention is paid on the architectural design of new MRT stations, especially in terms of accessibility to other modes (e.g. linkways from station entrances to bus shelters). Safe and easy walk paths and elevators have been provided for aging population and disables.

iii. **Network integration:** the government put efforts to use the bus/LRT network only as a feeder service to MRT to reduce congestion on arterial roads. Therefore, it reduces unnecessary duplication of services and improves the utilization of the system. In changing the role of bus network, it has been assumed that the current bus users are not penalized with a walking distance by longer than current 300 m to catch a train[6].

iv. **Fare integration:** a magnetic strip, stored-value Transit Link fare card was introduced in Singapore in 1990 for bus and rail as a fare integration measure. Also a contactless smart card, called the EZ smart card, was introduced in 2002 as a unified fare card for all MRT, LRT and bus services. This card has been developed so that it can be used for other transport purposes (e.g. park-and-ride facilities) and small retail purchases. This system has had a significant effect on the efficiency and operating cost of the public transport system as it provides seamless travel commuters travelling with different public transport modes. A trail study revealed that the boarding time of a bus has been decreased by 62% in comparison to cash payment[6]. Moreover, rebates have been assigned to the intermodal transfer as a functional incentive for the public transport passengers. A rebate of $0.25 is given to an individual passenger from an MRT station to a bus within 30 minutes.

v. **Information integration:** in 1989, Transit Link produced travel guide and coordinated public transport information (e.g. routes, timetables and multi-modal data) at interchanges. The authority provides coordinated and comprehensive information about travelling on different modes of public transport in a single book which is updated every year. In addition to annual Transit Link guides, the LTA has implemented Traveler Information Services (TIS) to provide real-time information on public transport system. All MRT stations and major bus stops are being equipped with information panels which give the passengers essential real-time information, such as arrival and departure times of different modes.

4.2 Queensland

With a population of 1.1 million people and area in excess of 6300 sq. km, the major public

transport vehicles include rail, bus and ferry services. The following integration measures were adopted:

i. In June 2002, Queensland Government established a new authority 'TransLink' to lead and deliver an integrated urban transit system

ii. TransLink was given authority to deliver integration over four key areas:

    a. One ticket – by integrating the tickets and standardizing the fares

    b. One network – by centrally planning and coordinating all major public transport route, services, connections and infrastructure

    c. One system – by marketing the system through consistent branding and passenger information

iii. Fare integration: it was implemented by TransLink in July 2004 which included introduction of new zonal fare structure and a range of fully integrated fare products delivered by existing fare collection equipment. A new smart card, go card, was introduced in 2008 by TransLink for use on the TransLink network. This card is currently used by passengers instead of tickets so that this card is used in more than 60% of public transport trips.

iv. Network integration: a plan was released by TransLink in March 2005 in order to integrate and improve public transport services and infrastructure in the city. This plan was focused on the re-structuring of the network to improve services to growing suburbs, the connectivity of services and make public transport more frequent and reliable[16].

4.3 Hong Kong

Hong Kong has different modes of public transport which include Kowloon-Canton railway, Mass transit railway, franchised bus, public light bus, taxi, tram, light rail transit and ferry to cater the transportation needs of 7.17 million population. The following measures are taken to integrate the services:

i. Integrated ticket: a common fare card, Octopus, is being used on major public transport modes which include Kowloon-Canton Railway (KCR), Mass Transit Railway (MTR), bus and some minibuses and ferries.

ii. Integrated fare: although there is no integrated fare but there is an alternative way to passengers such as public transport operators are encouraged to give discounts to passengers who are offered different levels of transfer discounts on trips through interchange schemes between rail and other participating transport modes with the use of Octopus card.

iii. Physical integration: most public transport interchanges are located at key locations such as railway stations and main shopping mall. Better public transport interchange facilities have been taken as a measure to encourage people to use public transport. Through public transport interchange, passengers can easily make transfer between rail and bus or minibus.

iv. Coordinated services: coordination has been proposed between railways and other public transport modes which should operate as feeders. Bus arrivals as well as departures are not highly reliable due to unpredicted situation; it may then be difficult to co-ordinate services between buses. The government intends to provide more choices of route. Public transport operators are encouraged to promote interchange schemes so as to attract more passengers. These include Bus-rail Interchange Schemes, Green Minibus-rail Interchange Schemes, Taxi-rail Interchange Schemes and Bus-Bus Interchange Schemes.

5. BEST INTEGRATION STRATEGY FOR SELECTED INDIAN CITIES

This section deals with the integration strategies that can be adopted for the selected

Indian cities as compared with the integration strategies adopted overseas given in the previous section. The following are the best integration strategies which can be adopted for selected cities:

i. For Delhi, the best integration practice can be establishing an authority which can undertake the operations of Metro and Buses and provide a common smart card for both the transit modes so that waiting and transfer times are reduced and passengers can easily switch from buses to metro and vice-versa during travel.

ii. For Mumbai and Kolkata, provision of feeder services synchronized with the existing suburban railway system can be the best integration practice. With limited capacity of roads, enormous increase in private and intermediate transport services and uncoordinated use of public transport services has resulted in commuter dissatisfaction due to delay, longer journey time, poor level of service and environmental pollution. Hence, feeder route services can overcome these shortcomings.

iii. For Chennai, the provision of dedicated bus lanes and discouraging parking are the solutions to increase mobility and reduce traffic congestions. The reserved bus lanes serve dual purpose in promoting transit ridership. First, it inhibits automobile travel along freeways and in CBD by limiting the amount roadway private vehicles are permitted to use and secondly, the reliability and speed of bus transit is significantly improved along separate right-of-ways, making public transit a relatively more attractive mode of urban travel.

6. CONCLUSIONS

The concept of public transport integration is emerging in developing countries like India where the share of public transit commuters is very less in comparison to actual standards. None of the metropolitan cities in India is meeting the desired public transit modal share as specified by MOUD due to which the cities are facing problems of congestion as well as pollution. Hence, there is a need to make public transit a more dependable mode of transit for passengers by providing them better comfort, convenience and door-to-door service with fairly less travel cost and travel time compared to that of private modes, which can happen only when the services are integrated to provide seamless travel. The various recommendations on integrated services for each of the selected city provided by authors, authorities and organizations can be implemented as all these have been provided taking into account all the prevailing conditions of the respective cities. The examples of successful integrated public transport measures in overseas countries have also been provided with the city population and facilities to compare with the selected cities in India and the best integration technique has been provided which can be adopted in each of the selected city.

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