



Seamless Transport System for Feasible Mobility: Case Study

KEYWORDS

Seamless transport, urban transport, sustainable transport system, Multi modal transit System

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ABSTRACT Urban transport is dominated by people making many short trips, multiple times per day; public transport is a sub set of it. Public transport is a network of passenger vehicles, for use by the public, running on set routes, usually at set times and charging set fares. At present these short trips made by different modes are inconvenient for commuter in terms of time and money. Passenger has to pay for each trip/mode for that they need to stand in a long queue, leads to wastage of time. At the same time the transport modes are not synchronized, it further adds to waiting time of commuter. Seamless transport comprises passenger transportation services which are available for use by the general public, as opposed to private and personalized modes or vehicles for hire, to make the travel hassle free. Generally, the fleet of vehicles and services are provided by a company, corporation or authority and the same is regulated and if necessary subsidized by them. The infrastructure used may be exclusive or shared with private and other vehicles. Delhi, India having population- 16,753,235 (2011 census of India) and daily average trip rate is 1.55 (all modes) has been studied for further understanding.

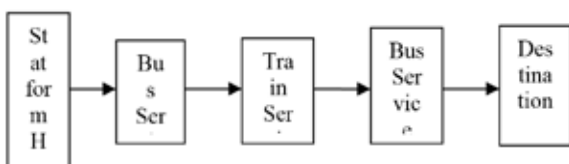
Introduction (Heading 1)

Urban areas require various modes of public transport for their existence and sustainability as per population, area density, socio economic characteristics etc. When two or more modes of transport are integrated for a single trip and used for convenient and efficient movement of passengers, it is defined as the Multi Modal Transport System (MMTS). Public transport is an important constituent of such a system. In metropolitan cities, transportation resources consist of roads, rails, rapid transit systems, automobiles, para transit systems, bicycles, pedestrian, shared and hired vehicles, private and personalized modes, parking facilities, traffic management, development a long and around the transit corridor etc. These resources provide a wide range of travel patterns for the residents for different purposes. Furthermore, transport resources and modal choices are interdependent components of the total urban transport system.

CONCEPT OF SEAMLESS TRANSPORTATION SYSTEM (STS)

Seamless Transport System (STS) relates to single trip consisting of combination of modes i.e. vehicle modes (bus, metro, car, tram, etc.) or service modes (private / public) between which the traveler has to make a transfer. Transfer is an essential part of seamless trip and traveler has to changes modes at transfer points, Fig 1 shows different transfer modes and arrow indicates to reach the next transit point we need to use either walking or sometimes non motorized transport medium. Hence, seamless travel is an important characteristic of the transport system.

Figure 1. Multi Modal Transfer Trip



In other words, STS is an integrated approach to incorporate all components of urban transport into a single coordinated planning and operation system for efficient use of available transport resources and infrastructure to ensure better urban mobility within a wide range of modal options for the commuters. In urban areas, multiple agencies, multiple jurisdictions, multiple modes and multiple disciplines are responsible for planning, designing, construction, operations, administration and maintenance of transport. They are independent but, are highly interdependent. Hence, a well designed and coordinated MMTS is required which has the following advantages:

- Smooth and comfortable transfer;
 - Combined planning, design and operations;
 - Better utilization of resources;
 - Better distribution of area wide transit system;
 - Extended availability of services ;
 - Single fare and single pass;
 - Elimination wasteful duplication in the same areas and corridors
 - Efficient and better interchange nodes ;
- Need of Seamless Transport System in Delhi, India

According to "Rail India Technical and Economic Services" (RITES)-2005, public transport in Delhi carries only about 60 % of total vehicular person trips but the same should be 80 % as per population size of the city. The population of Delhi is estimated to grow from 16.75 million (2011) to 23 million (2021). In the same period, the intra city vehicular trips per day are estimated to grow from 19.4 million to 24.7 million [22]. If about 15 % intercity trips are added the total trips to be catered to by 2021 will be about 28.7 million per day. Thus 80 % of these trips, i.e. about 24 mil-

lion, should be carried by the public transport by 2021. The present bus services, metro rail and Integrated Rail Bus Transit (IRBT), if implemented as planned together are estimated to carry about 15 million trips per day by 2021. Thus 9 million trips per day must be additionally catered to by other public transport. Hence it is necessary to take appropriate step for optimum use of carrying capacity of public modes and their proper integration with other modes such as monorail Light Rail Transit (LRT) etc.

Wilbur Smith Associates conducted surveys in 30 cities in 2007 and submitted the report to the Ministry of Urban Development (MoUD), Government of India. The report states about decline in the trend of public transport share particularly in metropolitan cities. Kolkata has the highest public transport share 54% and Delhi has 45 % only (Table 1). To enhance rider ship of public transport integration of various modes with Mass Rapid Transport System (MRTS) is required.

There has been a rise in the number of middle class population having desire to own personalized mode. Further, automobile companies are also coming up with new models of cars at reasonable cost. Thus personalized vehicles are increasing, which will further cause deterioration in traffic and environmental conditions. Hence, it is necessary to shift mode of travel from car to walk / cycle for short journey and to public transport for long journey. The main aim of STS is to reduce personalized modes and promote public transport.

Share of Public Transport and other Modes in Selected Metropolitan Cities in India in 2007 (Values in Percentage)

SNo	City	Walk	Cycle	Two wheelers	Public Transport	Car	Inter-mediate Para Transit	Total in %
1	Delhi	21	12	05	45	14	06	100
2	Mumbai	27	06	07	45	08	07	100
3	Kolkata	19	11	04	54	08	04	100
4	Chennai	22	09	20	31	10	08	100
5	Bangalore	26	07	17	35	08	07	100
6	Hyderabad	22	09	19	35	09	07	100

Source Wilbur Smith Associates and M/o Urban Development, Government of India New Delhi (2007)

GOVERNMENT INITIATIVES FOR SEAMLESS TRANSPORT SYSTEM FOR DELHI

Central Road Research Institute (CRRI)

Public transportation is gradually evolving in metropolitan cities in India. Operation of Delhi Metro has given a strong image to public transport. A study was carried out at CRRI, New Delhi (1989) on Planning of MRTS for Delhi. This formed the basis for implementation of Delhi Metro Project (Fig. 2).

Figure 2. Recommended MRTS, Source: Central Research Institute, New Delhi (1989)



MRTS was aligned on optimum corridors which cater to estimated demand projection. The database of this study was used for developing the transport sub models and projected transport demand for the years 2021. For transport analysis, database of household travel survey of Delhi urban area, carried out by Delhi Development Authority (DDA) in the years 1981, was used.

Rail India Technical and Economic Service (RITES)

RITES recommended their components of integrated multi modal mass rapid transport system in 1985. It comprised rail corridors, metro corridors and dedicated bus way for a total network of 184.5 Km. Later, MRTS network was extended to connect Vasant Kunj, an additional length of 14 km increasing the length to 198.5 km. In the first phase of the project, following sections of a total length 67.5 Km were to be constructed.

- (a) ISBT – Central Secretariat Metro Corridor
- (b) Patel Nagar – Tilak Nagar Metro Corridor
- (c) Shahdara –Nangloi Rail Corridor
- (d) Subzi Mandi – Naya Azadpur Rail Corridor
- (e) Patel Nagar – Najafgarh Bus Way

Multi modal transport integration was planned for pedestrian facilities, vehicle circulation, parking facilities, feeder buses to and from area to influence of each station and interchange facilities for passengers from National Capital Region and long distance intercity rail and bus modes. Details of Modal interchange facilities were planned for 44 MRTS stations which were proposed to be commissioned by the years 2005. It was estimated that a total of 115 feeder bus routes will be required for implementing the above multi modal transport system, interchange facilities for traffic between Delhi and National capital Region (NCR) were planned at some metro terminal stations which include Holambi Kalan ,Shahdara, Nangolai and Vishwa Vidyalaya as well as other stations ViZ New Delhi, Delhi, ISBT and Tri Nagar (Fig.3).

Figure 3: Recommended Integrated Multi Modal Rapid Transit System in Delhi



Source: RITES, New Delhi (1995)

National Capital Region Planning Board

The National Capital Region (NCR) consists of National Capital Territory (NCT) of Delhi (1483 km²), Haryana Sub region (13, 413 km²), Rajasthan Sub region (7,829 km²) and Uttar Pradesh Sub region (10853 km²). Thus total area of NCR is 33,578 km² the development of NCR is a milestone towards balanced and harmonious development of region by addressing large number of planning issues concerning urban and rural settlements.

Extension of multi modal transport network in a metropolitan region framework can encompass number of cities around the identified parent city. Future of Delhi depends on the sequential development of its metropolitan region. As per "Regional plan for NCR 2021" (RPNCR – 2021), the development zones of NCR comprise:

- National Capital Territory (NCT) Delhi ,
- Central NCR excluding NCT Delhi (earlier Delhi Metropolitan Area),
- Highway corridor Zone and
- Rest of NCR

Central NCR (DMA) comprise notified controlled area of Ghaziabad, Loni, Noida, Gurgaon Manesar, Faridabad, Ballabhgarh , Bahadurgarh and Sonapat & Kundli having 2000 km² area . Transport Plan 2021 of RPNCR 2021 has proposal for Regional Rapid Transit System (RRTS) Regional Rail Network and Orbital Rail Corridor. MRTS of Delhi has been extended to Central NCR. MRTS and RRTS has been planned with appropriate integrated feeder rail / road services.

The Proposed Integrated Multi Modal Transport Plan for NCR includes the following components.

- An extensive network of regional sub arterials (631 km.) which are the strengthened national highways and upgraded state highways;
- An extensive network of regional expressways (1,376 km.);
- An extensive network of regional arterials (1801 Km.), which are the strengthened national highways and upgraded state highways.
- An extensive network of sub-regional access roads which are the other district roads to be detailed in sub regional plans;
- An extensive network of regional collectors / distributors which are the strengthened major district roads and upgraded other district roads.

- An extensive bypass system around the regional urban centers;
- A large number interchanges on the road network system

Future expansions of the seamless systems are as follows:

- a network of regional rapid rail system (523 km) running on dedicated tracks and providing rail services for commuters.
- a new rail lines linking some of the regional centers (534 K.M)
- an extended network of metro rail system connecting the regional centre;
- an extensive fleet of bus system with supporting infrastructure (depots , workshops);
- a number of logistics hubs;
- a number of bus terminals and rail terminal enabling integration and smooth transfer amongst modes;
- a number of integrated freight complexes and truck terminals.
- a number of highway transport facility centers;

DELHI DEVELOPMENT AUTHORITY

The Master Plan for Delhi 2021 also advocates about multi modal transport system as future transport mode in the capital city.

Delhi Integrated Multi modal transit System Limited

The government of NCT Delhi has set up, in 2006; the Delhi Integrated Multi Modal Transit System (DIMMTS) Limited, for proposed multi modal network in NCT of Delhi

Ministry of Urban Development, Government of India (2006) formulated

National Urban Transport Policy, 2006 With the broad objective to ensure safe , affordable, quick, comfortable, reliable and sustainable access, for the growing number of city residents to jobs, education, recreation and such other needs within cities. One of the methods to achieve such objectives is enabling the establishment of quality focused Multi Modal Public Transport System that are well integrated, providing seamless travel across modes.

In metro cities the urbanization and migration pattern have direct impact on intra urban and inter urban mode of transport and vice versa. Hence, MRTS, sub urban rail, bus network etc. are required to be integrated with other modes. In multi modal transport system, the urban transit system should complement and not compete with other components of the systems. A coordinated integration of different modes brings about reduced congestion on the road, greater convenience for commuters efficiency and cost effectiveness.

LEVEL OF INTEGRATION AND SEAMLESS MOBILITY

Integrated public transport is defined as a system that provides door to door public transport services for passengers (Janic and Reggiani 2001). The term Inter Modal

Transport is commonly used for the transport of goods. There are as yet no standard definitions of these terms. The objective of integrated public transport is to achieve a high transit modal share with a seamless service using two or, more modes. In this context, various, levels of integration are required for seamless mobility which is presented in table 2.

Improved integration among various modes of mass transport helps people of move around easily and reduces the costs and inconveniences of travel. The information regarding parking facilities near interchange stations, unified tickets, coordinated time table and public awareness play an important role in achieving the coordination among various modes.

Levels Of Integration And Seamless Mobility

SN	Integration	Facilities for Seamless Mobility
1	Information Integration	Traveler Information Services (TIS) to provide complete real time information on public transport system at MRT stations, major bus stops interchanges nodes etc. Information on routes, schedules, fares and transfer points for all transit modes by the centralized source.
2	Network Integration	Integration of bus network with MRT, LRT and other modes; Feeder service routes ; Pedestrian facilities.
3	Space Integration	Spatial integration between terminals stations & various levels such as underground, ground and elevated. Desirable space connectors : lifts, ramps, stairs and escalators Reduced gap between platforms and trains / vehicles and tactile floors; Provision of concourse.
4	Institutional Integration	Integration among different agencies operators etc; One Controlling Authority above all; Single Tariff Association (joint tariff and distribution of jointly collected revenues). Transit Federation (with certain power to execute planning and construction works as well as facilitate coordination for routes and schedules);
5	Operational Integration	Operational performance and co-ordination of various modes of public transport; Eliminate wasteful duplication of services; Reduce headways on existing routes and extend services into new areas; Synchronization of time tables of various modes for both peak and non peak hours ; Matching modes to service requirement (high capacity and long haul modes i.e. commuter rail, rapid rail express bus etc. must run on major high density travel corridors while demand responsive services, park & ride facilities are provided in low density areas); Reserved bus lanes and streets. Changes of work schedules (spread peak demand by staggering work hours)
6	Physical Integration	Provision of transfer facilities such as covered link ways, Overhead bridges , under pass subway, bus shelters, taxi stands etc; Multi modal transport terminal Use of standardization identification symbols for various modes and services.
7	Service Integration	Provision for mobility of disabled persons; Provision of for children, women and people carrying luggage Good lit facilities at evening, night etc; Provision of toilets, phones and first aid.

8	Movement Integration	Integration of vehicle movement and commuter movement through organized space Provision for formal and informal space for commuters Sufficient space for maximum accumulation, turn over etc.
9	Fare Integration	Integration ticketing system to allow passengers to travel on MRT, LRT and buses. Unification of fare structure; Graduated fare structure (so that each passenger pays according to length of his total trip); Fare Discount (encourage off peak use of transit through discounts for travel before or after commuter hours. Simplify fare purchasing procedures for regular transit users through weekly or monthly passes, discounted fare for disabled/s senior citizens etc. Single fare systems for all transit modes so that passengers can move freely between the different services without being stopped by barriers turnstiles; Automatic ticket vending machines
10	Financial Integration	Sharing of budget allocation and cost sharing among various agencies : Share of revenues.

CASE STUDIES

Singapore

Multi –modal Public Transport System: Singapore integrated Public Transport Service includes bus mass rapid transit (MRT), light rail transit (LRT) and taxi. The amalgamation MRT of Singapore in the overall transportation system is a good example of multi modal transportation system introduced during 1992. On 01 November 2001, Singapore Bus Service (SBS) Transit came into existence which reflects the multi modal status, a move from being just a bus operator to provider of both bus and train service. Many initiatives, as discussed in the following sections, have been introduced to make traveling via bus MRT, LRT and taxi more attractive and comfortable.

Physical Integration : New transit station is now designed to integrate with commercial development and at least one other transport mode (Tong 2002). The North East Line, which was opened in June 2003, has all its stations well integrated with adjacent activity centers. This policy is a departure of the earlier MRT station design – often separated from the nearby neighborhoods and shopping area by a good 10 minutes walk on average. The Senkang LRT and the Punggol LRT act as feeder services to the North – East Line and are integrated with local neighborhoods.

Existing MRT stations are upgraded to achieve better integration. These include:

- (a) Woodland MRT upgraded to have bus interchange;
- (b) Novena MRT station integrated with nearby commercial development;
- (c) Dover MRT station integrated with roadside bus stop ;
- (d) Toa Payoh MRT station integrated with a relocated bus interchange;

More attention is given to the architectural design of new MRT station from both the aesthetic and accessibility points of view. Safe and easy walk paths and elevators are now provided for all users, especially for the ageing population and those on wheel chairs.

Network Integration: Bus and rail networks are properly integrated. It is suggested to use bus (or LRT) network so that only as a feeder service to MRT so that there is less surface road congestion on arterial roads, the MRT network is to provide the major share of the long haul travel. In changing the role of the bus network, it is important to ensure that current bus users are not penalized with a walking distance substantially longer than the current 300 m in order to catch a train, the issue of network integration becomes even more important if bus trunk routes are no longer provided.

Fare Integration: A single fare card usable on all public transport modes greatly facilitates integrated transport. Singapore introduced a magnetic stripe, stored value Transit Link fare card in 1990 for bus rail travel. A contact less smart card, called the EZ Card, was introduced in 2002 as a common fare card for all bus MRT and LRT services.

The impacts of such a system are efficiency gain and operating cost reduction. In a train study on the use of the EZ Card, the boarding time of a bus was found to decrease by 62 % compared with cash payment, and 34 % compared with magnetic transit cards. With a single fare card, it is also easy to encourage using public transport by introducing rebates for inter modal transfer. Using the EZ card and the earlier Transit link Card, a rebate of up to Singapore \$ 0.25 is given to an individual passenger who transfers from an MRT station to a bus within 30 minutes. Fare integration and rebates are powerful tools to achieve a high transit modal share.

Information Integration: A service company, Transit Link, was formed in 1989 to produce a transit travel guide and coordinate transit travel information such as routes, timetables and multi modal data at interchanges. The Transit Link Guide provides coordinated and comprehensive information on all aspects of traveling on bus, MRT and LRT in a single book. It is updated every year and remains in use today. An electronic version of the Transit Link Guide is also available through the internet.

In future, real time information could be provided through an I – Transport platform, this is an IT platform that integrates traffic information from road based ITS measures (signal) system, freeway monitoring system roads pricing system and transit based measurers (GPS equipped taxis and buses, MRT/ LRT locations). A traveler would be able to use this real time information to make decisions on modal choices, trip start times and route planning.

Institutional Integration: The formation of a service company such as Transit Link in 1989 was a first step towards institutional integration. In 1995 the Land Transport Authority was formed which combined the function of a planning agency and regulatory body for both public and private transport.

The latest institutional integration takes the form of two key operators. (a) SBS Transit operating the north East Line, the Senkang and Punggol LRT (also in the north east sector of the island) and the majority of island wide bus services. (b) the SMRT Group, which has most of the MRT lines :North South Line, East West Line, the Circle Line that is under construction and the Bukit Panjang LRT Line in the north west sector, Another bus company, TIBS operating on the north side of the island, is now part of the SMRT Group.

There is some overlap of the bus network of SBS Transit and TIBS and hence some competition. The rail networks are quite well segregated geographically. Each operator is thus in a good position to provide integrated services within its designated territory.

Multi modal Transport System –Hyderabad, India

Multi Modal Transport System (MMTS) is local train service in the city of Hyderabad. It is operational since 2003, an associate the South Central Railway (SCR) and is presently running 84 service a day, covering 27 stations. The first phase covers a distance of 43 km of Secunderabad-Falaknuma (15km) at a cost of Rs 173 Cr. Transport in Hyderabad is classified into two categories namely (a) MMTS Stations in Hyderabad (b) Railways stations in Hyderabad. The Falaknuma – Hyderabad (FH) is a rapid transit service of the MMTS of Hyderabad. It covers 17 stations and runs between Falaknuma and Nampally (Hyderabad). It is operated by South Central Railway. There is a combined pass issued by the state owned APSRTC and MMTS. Hence buying a single pass helps in traveling by bus as well as the train.

CONCLUSION

Singapore Public Transport System is one the best examples of multi modal transportation system and integrated planning. All LRT stations are located on arterial roads and integrated with feeder bus routes and covered walkways from station to adjacent HDB blocks similarly. MRT station and LRT stations are vertically integrated, within the station, vertical transportation between LRT / MRT platforms is through escalators and lifts without having to exit the paid area of the station, using the same fare card. It is seamless transfer at its best. The same is linked with bus interchange via bridges and covered link ways. Similarly planning of LRT stations has blended with surroundings commercial and residential development. In fact, integration of various modes and proper planning give faster and more comfortable transportation services to the commuters.

MMTS in Hyderabad lacks various integrations like bus-rail integration and information integration. It also needs restructuring of Bus routes to enhance MMS rider ship, development of new link ways from station entrance to bus shelters as well as interchange design.

In Delhi MMTS has enhanced accessibility in NCR. Economic Growth, Public Health. Environmental protection security safety and social cohesion, there is multiplicity of authorities involved in transportation, Metro rail is operated by DMRC, sub urban rail services by Northern Railway, bus transport services by DTC, and taxi and auto rickshaw by the private operators it is desirable to set up Multi modal Transport Authority as coordinating agency. Having representatives from various stakeholders, to regulate and facilitate the planning and implementation of transport system that is seamlessly integrated across all modes.

As a conclusion, Multi modal transport system is an integrated approach which requires systematic implementation of various measures and services amongst transport authorities agencies operators etc for multi modal travel. The role of bus services and rail network must be as complement and supplement in nature to enhance rider ship.

There is need to integrate land use and mass transport planning to achieve physical integration. Public transport occupies comparatively less road space and causes less

pollution per passenger km than personal vehicles. It provides time cost saving, it generates patronage due to reduced travel time and improved accessibility for bus passengers and is considered as a more sustainable form of transport

The application of intelligent systems is also required to enhance the efficacy and sustainability of multi modal transport system for seamless mobility, Smart card tickets in Delhi metro, car taxi using wireless system in Delhi and Chennai vehicle tracking and monitoring system using GPS, GIS in Bangalore automatic vehicle tracking system using GPS technology by DTC in Delhi are some of the good examples of ITS application.

REFERENCE

- [1]Ministry of Urban Development, Study on Traffic and Transportation Policies and Strategies in Urban Areas in India, Final Report, May 2008, | [2]Central Road Research Institute, CRRRI New Delhi, Planning of Mass Rapid Transit System. For Delhi,1989 | [3]Ministry of Urban Development (Delhi Division). New Delhi, Delhi Development Authority (2007) Master Plan of Delhi for 2021 | [4]DIMMTS Ltd Integrated Multi modal Public Transport network for NCT of Delhi New Delhi., 2008 | [5]Friedrich M. 1998 A Multi modal Transport Modal for integrated Planning paper presented at the 8 world conference on Transport Research Antwerp. | [6]Government of India, 2001, Task force on integrated Transport Policy, Planning commission New Delhi. | [7]Government of India 2006, National Urban Transport Policy 2006, Ministry of Urban Development New Delhi. | [8]Ibrahim Muhammad Faishal, 2003 Improvements and integration of a Public Transport System. The case of Singapore Cities Vol. 20 No. pp 205-216. | [9]Janic M and Reggiani . A. 2001 Integrated Transport System in the European Union . An Overview of Some Recent Developments Transport Reviews,pp 469 497. | [10]Kumar Pawan Kulkarni, S.Y and Parida (2009). Multi modal Transport System in Urban India , Proceedings of National Conference on Developing Harmonious and Sustainable cities in India for a better Urban Future March 20-21 New Delhi India. | [11]Luk James and Olszewski Piotr. 2003, Integrated Public Transport in Singapore and Hong Kong Road and Transport Research .Dec.2003 | [12]National Capital Regional Planning Board, 2005. Regional plan for NCR 2021 NCRPB. Ministry of Urban Development Government of India New Delhi | [13]RITES, 2005, Integrated Multi Modal Public Transport Network for NCT of Delhi RITES New Delhi | [14]Singh S.K. 2005, Review of Urban Transportation in India, Journal of Public Transportation Vol. 8 No 1 pp 79 -87. | [15]Tong C.Y 2002, The integration of Commuter Facilities at Mass Rapid Transit Stations, Proceedings of National Conference on Seamless and Sustainable Transport. November Singapore. | [16]Wilbur Smith Associates & Ministry of Urban Development, 2008, Study on Traffic and Transportation Policies and Strategies in Urban Areas in India New Delhi. | [17]EPCA report no. 19 (March 2006) , Status report on implementation of the High capacity, bus system in the NCT of Delhi, In response to the Hon'ble court's order dated November 30, 2005, In the matter of W.P.(C) No.13029 of 1985; M.C. Mehta v/s UOI & others | [18]Gupta S K, Nathani Nishant, December 2013, Urban Transport Green: India, International Conference on Emerging Trends in Engineering and Technology (ICETET'2013), Phuket.