High Speed Tram : An Appropriate Public Transport System for Metropolitan Cities - A Case Study of Delhi

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The growing population and consequently the travel demand has been increasing at geometric progression in urban areas. In many of the cities, the vehicle population has reached alarming proportions in relation to the road network available. Given the high density of population and the scarcity of land, it is almost impossible in many cities to increase the road capacity substantially. Though the quality and the width of roads, can be improved/expanded, that alone would not be enough to accommodate the growing vehicle population and the travel demand. This prompts to work out some alternative ways of meeting the increasing transport demand given the constraints of land, capital, and the need to control the energy consumption, the pollution and the accidents.

URBANISATION

The trend towards urbanisation in India is inevitable and irreversible, eventhough India is predominantly rural. As per the 1991 census the urban population accounts for 25.72 percent of the total population in the Country. It was only 10.84 percent at the beginning of the century and 17.29 percent in 1951. The growth of urbanisation in India is presented in Table-1

Table-1: Growth of Urbanisation in India

Census Year	Number of UAs/Towns	Urban population	Urban population as % of total population	Decennial Growth rate of urban population (%)
1901	1827	25851873	10.84	—
1911	1815	25941633	10.29	0.35
1921	1949	28086167	11.18	8.27
1931	2072	33455989	11.99	19.12
1941	2250	44153297	13.86	31.97
1951	2843	62443709	17.29	41.42
1961	2365	78936603	17.97	26.41
1971	2590	109113977	19.91	38.23
1981	3378	159462547	23.34	46.14
1991	3768	217177625	25.72	36.19

The decadal growth rate of urban population in the country during 1980s at 36% was nearly 50% more than that of the growth of the total population in the country at 23.5%.

The growth of urban population in the country is not only explosive but also highly skewed. The bigger towns having a population of more than one lakh dominate the urban scenario today. In 1901, such towns accounted for 26% of the urban population, which increased to 65.2% in 1991, although the number of towns in this category increased from 24 to 296 during the same period. And number, as well as the share of population in smaller towns (below 10,000 population) have decreased over the years.

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There are 23 metropolitan cities in the country with a population of more than one million each. These cities account for roughly one third of the country's urban population and one-twelth of the country's total population. The population in these cities have been increasing at an annual average compound growth rate of 3.37 percent, a faster rate than that of smaller cities. The highest growth of population during 1981-91 is recorded by Visakhapatnam (74.27 percent) followed by Hyderabad (67.04 percent). The lowest growth is recorded in Calcutta (18.73 percent) preceded by Patna (19.55 percent). If the growth rate during 1981-91 is assumed to prevail the total urban population would be 402 million. by 2011 and by the time quite a number of cities would become metropolitan. The existing 23 metropolitan cities would have a population of 100 million by 2001 and 143 million by 2011.

There are four mega cities in the country with a population of more than 5 million. These are Bombay, Calcutta, Delhi and Madras. Of the 70.66 million population in the 23 metropolitan cities, 37.22 million or 52.68 percent reside in these four large metropolitan cities. The explosive growth of urbanisation, as discussed above, is not a cause for concern. It is inevitable and desirable as it contributes to growth process. In many Western countries, about 3/4 of the total population live in urban areas. What is, therefore, important is that the planners have to accept this reality and make adequate provisions to meet the increasing requirement of infrastructural facilities.

URBAN TRANSPORTATION

While urbanisation is rapid and the population in urban areas double in a period of about two decades, the travel demand within the urban areas increase by around 4 to 8 times. Three factors are responsible for this. First is the increase in population which needs more people to be moved. The second factor is the mobility, expressed in terms of Per Capita Trip Rate (PCTR) which increases because of the change in the social economic characteristics of the trip maker and the increase in the wide variety of opportunities offered by the city. The third factor is the average trip length (ATL) which is increasing due to continuous physical expansion of the city and distribution of the activities over a wide spatial frame.

DISTINGUISHING CHARACTERISTICS

The provision of transport service and the decision making therein are unique in more than one way. For example, like any other service once the service is provided, it cannot be stored. Either it has to be used or wasted. But unlike other businesses, the operator cannot adjust the capacity, viz. carrying capacity in a bus every now and then to conform to the fluctuations in demand. This peculiar feature of transport operation is responsible for the low load factor and hence decisions regarding the pricing have to make allowance for this. Further the operator does not know exactly the unit of output. While the cost is related to the bus kilometre, and the revenue to the passenger kilometres performed, the commuters demand is a trip from a particular origin to a particular destination. The above problems get aggravated in the urban context. The basic characteristics of urban passenger market are :

- The demand for public transport is highly peaked at the time of journey to and from work, education and business. If service capacity is to be planned to meet the peak requirement, the facilities and resources have to remain under-utilised during the peak hours. This will affect the unit cost adversely

- The average trip length in urban areas is relatively low and therefore the vehicle utilisation also becomes less

- The use of local public transport is relatively high, because of the high density of population, which makes the operation of public transport economical.

ESTIMATION OF TRAVEL DEMAND

The travel demand in a city is a direct function of the level of population and is determined in the following manner :

D = P X PCTR X ATL

Where D = travel demand in passenger kms

P = N + F

Where N = Natural population

F = Floating population

PCTR = Per capita trip rate

ATL = Average trip length in kms.

PCTR and ATL are direct functions of population. The estimating equations for these are :

$$PCTR = 0.42 + 0.065 P$$

$$ATL = 16 - 16 e^{-0.18 p}$$

Where P = Population in million

Other factors like size and configuration of the city and level of socio-economic activity have a bearing on PCTR and ATL and consequently on the travel demand. These are, however, approximated by the population.

Since the population in big cities is increasing at a rapid rate, it has a magnified impact on the travel demand through increased ATR and PCTR. If we take two hypothetical cities having population of 5 million and 10 million respectively, the travel demand in these cities would work out :

D = P X PCTR X ATL

$5,000,000 \times (0.42 + 0.065 \times 5) \times$

$(16 - 16 e^{-0.18(5)})$

= 3.54 Cr. pass. kms. for city (1)

$10,000,000 \times (0.42 + 0.065 \times 10) \times$

$(16 - 16 e^{-0.18(10)})$

= 14.29 Cr. pass. kms. for city (2)

It is observed from the above calculations, that as the population doubles, the travel demand quadruples.

The travel demand is met by both private and public modes of transportation. It has been statistically found that the share of public transport in a city which depends on a number of factors, can be approximated by the size of population. The estimating equation is

$$PT = 0.80 - 0.80 e^{-0.33 P}$$

Where PT = Percentage share of public transport which comprises bus and rail.

P = Population in million.

A city with a higher population has a higher share of public transport. Taking the above example of two hypothetical cities, the shares would be

$0.80 - 0.80 e^{-33 (5)}$ = 64.6% for city (1)

$0.80 - 0.80 e^{-33 (10)}$ = 77% for city (2)

The share of these two cities would be as follows :

	Public (Lakh pass. Kms.)	Private (Lakh pass. Kms.)
City - 1	229	125
City - 2	1101	328

Depending upon the capacity of the railway infrastructure, the requirement of buses can be worked out for a city. The passenger kms performed by a bus in a year is derived as follows :

No. of Kms. operated by a bus per day X No. of days on the road in a year X Carrying capacity X Utilisation of carrying capacity

The No. of buses required could be found out by

Public Transport requirement - Requirement met by Railways

Passenger Kms performed by a bus in a year

In cities like Delhi, where public transport is synonymous with transport by bus, railways being negligible, the number of buses required works out quite high. If this high order is not met, people resort to personalised modes of conveyance.

URBAN ROADS

The length of urban roads in the year 1992 was only 1,89,400 kms which is about 8.7 percent of the total roads in the country as against the urban population of 25.72 percent. For the decade 81-91 while the urban population grew by 36.19 percent, the vehicle population grew by 263 percent; and the urban roads grew by 51 percent. As a result, urban roads are becoming congested day by day.

VEHICLE POPULATION

There were 23 million plus cities in the country in 1991. The passenger vehicle population in respect of these cities is presented in Annexure - 1. It is observed that these 23 cities have 8.2 percent of the total population of the country as against 36.8 percent of passenger vehicle population. As a result, the number of passenger vehicles per 1,00,000 population for these cities is 10468 as against the all India average of 2438. The percentage of two wheeler is 77 in these cities in comparison to the all India average of 79. The vehicle population during the decade 81-91 increased by 263 percent in these cities and by 296 percent in the country. The growth in passenger vehicle population and the share of personalised vehicles in urban areas is marginally less than that of the country despite the high density of population and relatively less road space.

The category-wise share of passenger vehicles to all India total is presented in Table-2.

Table-2 : Population of Passenger Vehicles in 23 Metropolitan Cities (1993)

Vehicle type	All India	Metro-politan Cities	% of metro politan cities to All India
All Passenger Vehicles	21467	7904	36.82
Two Wheelers	17026	5910	34.71
Three Wheelers	730	306	41.92
Cars, Jeeps & Taxis	3330	1572	47.21
Bus	381	113	29.66

It is observed from the above table that these 23 cities have nearly half of the country's Cars, Jeeps and Taxis as against 29.66% of buses.

EXTERNALITIES

(i) Accidents : Cities are accident infested. About 50% of the total accidents occur on urban roads which form only about 8 percent of the total road network in the country. Twelve metropolitan cities (as per 1981 Census) for which data are available, have reported 45472 accidents involving 5371 casualties during the year 1992. This means that about 16.5% of the total accidents in the country have occurred in these cities.

It has been statistically found that the trips generated is directly and positively related to the number of accidents.

$$A = -1726.96 + 121.827\ T$$

Where A = Number of accidents in a city

T = Number of passenger trips generated in lakhs in the city.

Trips generated is a direct function of population and affects the traffic volume directly. While the population , trips, travel demand and consequently vehicle population in the urban areas are likely to increase at a fast rate in the coming years the number of accidents will also increase. This happens precisely because of constraints on road space which cannot be increased beyond a limit because of the high density of population. As the scope for increase of road space on the surface is limited, one has to think of increasing road capacity vertically, i.e. construction of roads above the surface or underground. The cost of construction of roads underground being prohibitive, it may be advisable to construct roads above the existing roads.

ENERGY

Road transport is highly fuel-intensive. Road transport consumes about 82% of the total energy consumed in the transport sector which account for one fourth of the total energy consumed in the country. The energy consumption by road transport for the year 1991-92 is given below :

	Energy consumption (million tonnes of coal replacement)	POL consumption (million tonnes)
Road Transport	159.75	18.42
Share of road transport to transport sector	81.78	84.42

The road transport mostly consumes liquid fuels like gasoline (motor spirit) and diesel oil (HSD). The consumption of diesel oil in the country is growing at the rate of 9 percent and that of gasoline at 7 percent annually. This leads to increased import of POL which coupled with the hike in international oil price, is becoming a serious drain on the scarce foreign exchange of the country.

The growth and composition of vehicle population has been quite unfavourable to fuel consumption. Not only the growth rate of vehicles is very high, but also the share of the personalised vehicles (low occupancy vehicles) in total is very high. For the 23 metropolitan cities, the low occupancy vehicles like two wheelers, three wheelers (passengers), cars, jeeps and taxis constitute about 98.5 percent while the high occupancy vehicles i.e. bus constitute only 1.43 percent. The lowest occupancy vehicle i.e. two wheelers alone constitutes 75 percent. The growth of the personalised vehicles has been quite high (two wheelers 6.8%). The special feature of these personalised vehicles is that although the fuel consumption per vehicle km is low, per passenger km it works out quite high. The following example illustrates the point :

Vehicle	Type of fuel	KMPL	Carrying capacity	Pass.Kms per KL.	Price (Rs.)	Cost/Pass km.(Paise)
Bus	HSD	4.5	66	297	7.00	2.35
Two Wheeler	MS	5.0	2	100	17.00	17.00

The fuel efficiency of various vehicles at optimum speed is as follows :

Vehicle	CC/Veh. Km.	CC/Pass. Km.
Scooter	18.7	15.1
Ambassador	75.8	9.45
Urban Bus	247.7	3.7

It is evident from the above workings that the fuel cost of one passenger km by two wheeler is about 7 times more than that of bus. This fact coupled with a high proportion of low occupancy vehicles is responsible for high POL consumption. The need of the hour, therefore, is to promote high occupancy vehicles, so that the per unit cost is minimum and to promote those types of transport which uses less or does not use POL products at all.

ENVIRONMENT

Road transport is considered as a major source of environmental pollution, since the vehicles are operated on petroleum-based fuels.

Table-3 indicates the level of various pollutants produced by four stroke engines :

Table-3 : Pollutants Produced by Four Stroke Engines

Pollutant	Emission Factor Kg/1000 gallons	
	Gasoline engine (Cars)	Diesel engine (Buses)
Carbon monoxide	1000	27
Hydrocarbons	90	60
Oxides of nitrogen	60	100
Oxides of Sulphur	4	18
Aldehydes	2	18
Particulates	5	50
Organic acids	2	14

The harmful pollutants like hydrocarbon and carbon monoxide are relatively less in case of diesel engines and to that extent it is advisable to discourage personalised vehicles like cars and promote public transport modes like buses.

Two wheelers normally have two stroke engines and run on gasoline. The studies indicate that emission of hydro carbon in two stroke engines exceed those of four stroke engines by factors that range between 10 and 17. Carbon monoxide emission is also substantially higher.

Since the urban areas have a large number of vehicles with two stroke engines and four stroke gasoline powered engines, the pollution level in some cities have assumed alarming proportions. Therefore, maximum efforts should be made to control the growth of low occupancy personalised vehicles and promote transport which does not use petroleum based fuels.

COST OF OPERATION

The large proportion of personalised vehicles carrying a relatively small proportion of passengers is a matter of concern as it makes uneconomic use of resources. The economic costs of operation of personalised and public modes per unit of passenger transport (passenger km) vary significantly. An estimate by the Ministry of Surface Transport in 1991 indicates that the economic costs of passenger transport varies widely across vehicles as can be seen from Table-4.

Table-4 : Economic Costs of Operation of Vehicles on Single Lane Roads with RF = 30 and Roughness = 10,000

Vehicle	Cost (Rs./Veh. km)	Cost (Rs./Pass. km)
Two wheelers	2.19	1.09
New technology car	8.31	2.07
Old technology car	9.59	2.40
Bus	17.70	0.34

RF signifies rise and fall in m/km and roughness is in mm/km as measured by a standard towed fifth wheel bump intergrator

The problem becomes acute because many of the economic costs of transport like degradation of environment, depletion of natural resources, congestion, accidents etc. (negative externalities) are borne by non-users of transport. From the view point of energy, environment, efficiency etc., public transport is relatively more efficient. This calls for a strategy to reduce the growth of personalised vehicles and if possible, also its share in the total number of vehicles. In addition to regulate the growth of vehicle population, an adequate and efficient public transportation system would have to be provided.

A CASE STUDY OF DELHI

In the following paragraphs an attempt has been made to analyse the transport requirement of Delhi, which has the highest density of motor vehicles and is the most polluted city in India.

DEMOGRAPHIC CHARACTERISTICS

According to the 1991 Census, 94 lakh of people are inhabited in the Union territory of Delhi (DUT), of which 85 lakh persons comprise the Delhi Urban Aglomeration (DUA). The growth of population in Delhi is presented in Table-5.

Table-5 : Growth of Population in Delhi

Year	Total (DUT)	% variation	ACGR (%)	Urban DUA (%)	Rural (%)
1901	405819	—	—	52.76	47.24
1911	413851	+2	0.16	57.50	42.50
1921	488452	+18	1.67	62.32	37.68
1931	636246	+30	2.68	70.33	29.67
1941	917939	+44	3.73	75.58	24.42
1951	1744072	+90	6.63	82.40	17.60
1961	2658612	+52	4.30	88.75	11.25
1971	4065698	+53	4.34	89.70	10.30
1981	6220406	+53	4.34	92.73	7.27
1991	9420644	+51	4.23	89.93	10.07

DUT : Delhi Union Territory DUA : Delhi Urban Agglomeration
ACGR : Annual Compound Growth Rate during the decade.

The population of DUT which was 4.1 lakh in 1901 almost doubled during the next 40 years to 9.2 lakh. But during the next 50 years, the population increased ten times to 94.2 lakhs. The decennial growth rate during the last four decades in Delhi has been above 50 percent and the annual compound growth has been 4.3 percent, the highest among metropolises. The DUA component which was 52.76 percent in 1901 increased monotonically to 92.7 percent in 1981. It has declined thereafter marginally to 89.9 percent in 1991. It might be due to the shift of urban population to rural areas as city life in Delhi is becoming costlier. The population density in Delhi increased from 274 in 1901 to 6352 in 1991. The density in DUA is 12098 as against 1212 in rural areas.

The growth of population for DUT as well as DUA have been presented in graph No.1. The population growth is quite explosive. To make the situation deteriorate Delhi has quite a substantial of floating population whose demand for transport is very high. These people visit Delhi city for specific purposes like education, medical treatment, political rallies, business, trade, commerce, sight seeing etc. If the floating population is assumed to be 5 percent of the resident population, the effective population (resident plus floating) of DUT is about one crore.

TRAVEL CHARACTERISTICS

The demand for transport is positively related to the level of socio-economic activities. The per capita trip rate (PCTR) has been increasing continuously due to the change in the socio-economic characteristics of the trip maker and the wide variety of opportunities offered by the city. In Delhi the PCTR (Vehicular trips only) increased from 0.49 in 1970 to 0.72 in 1981 and is estimated to increase to 1.1 by 2001. The report of the study group appointed by the Planning Commission in 1982 on requirement of buses for DTC estimated the PCTR to be 0.92 for 1981 and projected this at 1.34 by 2001. These estimates, however, did not consider the impact of the floating population. If the floating population is taken into account, the PCTR will be still higher. Hence these estimates are not realistic.

The number of trips coupled with the trip length determines the transport requirement of a city and the trip length in turn primarily depends on the land use structure. As a city expands physically in size, the Average Trip Length (ATL) also increases. The ATL in Delhi increased from 5.4 kms in 1970 to about 8 kms in 1980. A recent study has indicated that the ATL in Delhi for work trips to be as high as 13 kms. The ATL on DTC has increased from 6.2 kms in 1971-72 to 14 kms in 1988-89. With the dispersal of population and socio-economic activities from city to outside regions and NCR areas, the ATL will still be higher since people commute daily for their work or business and come back to Delhi without shifting their residences to outskirts for various reasons.

TRAFFIC CHARACTERISTICS

According to a study by CRRI in 1989 buses constituted 8.4 percent of the total vehicles in Delhi, moving on a particular stretch of road during a given interval,and they carried 63 percent of the total passengers carried by all vehicles. Other fast moving vehicles (excluding trucks) like cars, mopeds, scooters, taxis and auto-rickshaws comprising of 74 percent of the vehicles, carried only 33.6 percent of the passengers. Slow moving vehicles formed 13.3 percent of the total vehicles on Delhi roads and carried only 3.4 percent of the passengers. Therefore, all personalised vehicles and hired modes including slow moving vehicles which form 87 percent impose huge social costs in the form of congestion, pollution etc., but carry only 37 percent of the total passengers carried.

The traffic in Delhi is characterised by large number of vehicles of varied description moving together on available limited road space. The total number of vehicles in Delhi is higher than the total in rest of the three metropolises taken together. A large number of vehicles (nearly 1.5 lakh) enter the system every year to service the ever increasing travel demand. The number of vehicles has been growing at the rate of about 13 percent per annum during the decade 1981-91. It increased from 5.4 lakh in 1981 to 18.1 lakh in 1991. The growth has, however, slowed down to 8.28 percent in 1992, to 6.83 percent in 1993 and further to 6.76 percent in 1994. The buses constitute only 1.11 percent of the total vehicles in Delhi while the personalised vehicles constitute 93.7 percent and goods vehicles 5.20 percent. The two wheelers alone constitute 67 percent. It appears that the ownership pattern of vehicles has stabilised. During the period 1981-91, two wheelers constituted about 66-69 percent, three wheelers 3-4 percent, four wheelers 21-24 percent of the total vehicle population. The growth and composition of vehicles are presented in Graph 2 and 3 respectively.

If the growth of vehicle population is juxtaposed to the growth of human population and road network, the situation appears to be alarming. If the growth rate of vehicles, population and road network during 1971-91 prevails in the future years, the traffic density by 2011 would be as indicated in Table-6.

Table-6 : Population, Road Network and Vehicle Population

Year	Popu lation (in lakh)	Road Network (Kms.)	Veh. Pop. popn	Vehicle/ lakh of of road (in lakh)	Vehicles/ 100 km of road length
1971	40.7	7327	180434	4433	2463
1981	62.2	13904	536011	8618	3855
1991	94.2	20330	1812967	19246	8918
2011(E)	218.0	56409	18216352	83561	32293

(E) - Estimate

It is observed from Table-6 that while the population doubled in a period of about two decades, the vehicle population increased ten fold during the same period. The decennial growth rate of population during 1981-91 was recorded to be 51 percent while the growth of vehicles during the same period was recorded to be 238 percent with the result, the number of vehicles per lakh of population increased from 8618 in 1951 to 19246 in 1991. Similarly the growth of road length in Delhi has been very negligible while the vehicles grew by leaps and bounds. There is hardly any correlation between the number of vehicles registered in Delhi and the road infrastructure available. What traffic can bear is not in any reckoning at the licensing level, the result of which is unprecedented congestion on Delhi roads. The number of vehicles per 100 km of road length increased to an alarming 8918 in 1991. Since there is a limit in improving the road capacities, the only solution to the problem of congestion is to encourage a mode which can carry more people and occupy relatively less road space. A comparison with other million plus cities, as given in Annexure - 1 indicates that Delhi has the highest density of registered motor vehicles per lakh of population as well as the share of personalised vehicles was one of the highest for the year 1991. Delhi has 1.11 percent of India's population but 8.51 percent of the vehicle population.

This unhealthy growth and composition of vehicles in Delhi city is responsible for the increased consumption of motor spirit (MS) and

HSD. The consumption of MS and HSD have been increasing at an annual compound growth rate of 7.7 percent and 5.5 percent respectively during 1981-94. If the same trend is continued, the annual consumption of MS and HSD would be 7.39 lakh tonnes and 14.8 lakh tonnes respectively by 2011 as against 3.7 lakh tonnes of MS and 8.33 lakh tonnes of HSD in 1993-94. Studies indicate that in Delhi, traffic accounts for 40-50% of air pollution and the daily emission by road traffic is estimated at 1320 tonnes. The economic cost to the city and the community on this account is estimated at Rs. 15 million per day and Rs. 54 crore a year.

During 1992, the number of accidents in Delhi was 1391 which resulted in 252 fatalities. The economic cost of a fatal accident is estimated to be Rs. 0.2 million and thus the loss to the society on account of fatal accidents during the year 1992 is estimated at Rs. 5 crore.

ALTERNATIVES

In order to meet the growing transport demands in the cities, the following options are available :

(a) Strengthening the road transport system i.e. buses

(b) Introduction of high speed trams, and

(c) Construction of heavy mass rapid transport system (MRTS).

By adopting the first option i.e. strengthening the bus transport system, it is possible to meet the short duration transport needs i.e. for 5 years or so. Given the growth rates of the population in metropolitan cities, buses alone would not be adequate to cater to the transport needs in the next 10 years. In cities, the physical and geographical restrictions/limits on extension/expansion and construction of roads, makes the situation worse. The dooms day, no doubt, can be postponed by a few years by improving the surface of the roads, widening of roads and by constructing fly overs, but the roads have to give way for faster and high capacity modes. Further, with the increase in the number of vehicles, the menace of pollution and accidents would continue to increase in the same proportion. It is, therefore, quite evident that bus system alone would not be sufficient in cities to meet the travel demand. In fact, there is no city in the world with a population of 9.3 million which is served by bus transport alone.

The other mode of transport which has become imperative for metropolitan cities is the MRTS. This kind of system will be mostly underground and elevated. Wherever possible, this kind of transport system will be at grade also. For constructing such a kind of transport system, it is necessary for the Government to own or acquire land and make huge investment. The question of MRTS of Delhi is an example. The cost of construction of such a rapid transport system has been estimated at Rs. 8000 crore at 1992 prices. This is a kind of transport system for which neither adequate investment from the Government nor from the private sector can be expected because if one has to create a corridor of 12 kms, it will amount to an investment of Rs. 520 crore. If it is totally underground, the cost per km works out to Rs. 200 crore. In view of the resource constraints, it is not possible to either allocate or expect such a huge investment from any source for the metropolitan cities.

The MRTS which is proposed for Delhi by the RITES will take atleast 20 years for completion of both the phases. Presuming that a decision is taken during 1995, the project will get completed only in 2015 by the time the population of Delhi would have reached 25 million as against about 10 million today. The vehicle population is likely to reach a staggering figure of 2 crore by 2014 as against 22 lakh today. The biggest dilemma for the city authorities and the Government at the centre, is whether in a static situation it would be possible to manage a population and vehicle strength of the magnitude stated above. The answer is to be found now, failing which the city will plunge into chaos and mismanagement in the next few years.

The strategy should be to create a mass rapid transport system in the course of time, which may take from 20 to 50 years. It is imperative for metropolitan cities to create a medium capacity transport system which combines the plus points of the road based bus system and the rail based MRTS and yet feasible. The only system of this type can be the high-speed trams (HST).

FEATURES OF HST

The HST system may consist of elevated tracks supported on a single new pillars erected in the central verge of the road and spaced at about 25 to 30 metres apart. The thickness of the pillars may be 1 metre which can be easily accommodated in the existing verge of most of the roads of Delhi without encroaching upon the usable width of the road. The clear height below the track may be 4.5 metres to allow the plying of double decker buses easily.

The HST is not to replace the bus system as well as MRTS. While the low density traffic corridors could continue to be served by buses, and the corridors earmarked for MRTS by MRTS the HST could be introduced in those high density corridors which are not reserved for MRTS. Through studies such corridors could be selected and implemented as separate projects.

Each tram rake may consist of 3 coaches with a total carrying capacity of 856 persons and if the rake moves at an average speed of 30 km/hour at a frequency of 3 minutes, 24 rakes would be needed. In an hour, these rakes can transport about 20,000 passengers and in a day, about 2,00,000 passengers. If required, the frequency can be increased by adding additional rakes.

The capital expenditure for a stretch of 12 kms of rakes could be at Rs. 240 crore @ Rs. 20 crore per km. The working capital requirement would be about 16 crore. The operational expenses would amount at Rs. 8 crore per year. The revenue would work out to Rs. 40 crore per year on the assumption that (a) the load factor is 100 percent (as this capacity is flexible), (b) the fare structure is kept at Rs. 5 upto 8 kms and Rs. 7 beyond 8 kms, (c) 75 percent of passengers travel a distance upto 8 kms and (d) non-traffic income is ignored. Internal rate of return works out to 12 percent for its economic life of 20 years although the track would have a life of 70/80 years. The net present value works out to Rs. 30 crore for 20 years.

ARGUMENTS IN FAVOUR OF HST

(1) *Land Acquisition* : As the tracks for HST will be constructed in the air space, it would not occupy any ground space unlike road based or rail- based transport systems. The HST hence takes care of the scarcity of land in the urban areas.

(2) *HST is a Capacity Flexible Mode* : It can carry 1 to 4 lakh passengers per day on a stretch of about 10-15 kms by suitably adjusting the frequency and the number of coaches.

(3) *The Project Completion Schedule is Quite Less in Comparison to MRTS* : The construction of any one corridor of 10 to 15 kms may be completed within 2 to 3 years. Work can be started simultaneously on a number of corridors and at different patches in the same corridor.

(4) *This Mode is Less Capital Intensive* : The total cost of having 15 HST corridors of 12 kms each, would be around Rs. 3200 crore in comparison to Rs. 8000 crore at 1992 prices for MRTS of 184 kms.

(5) *Commercially Viable* : The cost estimates indicate the external rate of return at 12 percent. There is no need of any subsidy. People would not hesitate to pay Rs. 5 for a distance upto 8 kms and Rs. 7 for a distance beyond 8 kms, given the comforts associated with this travel.

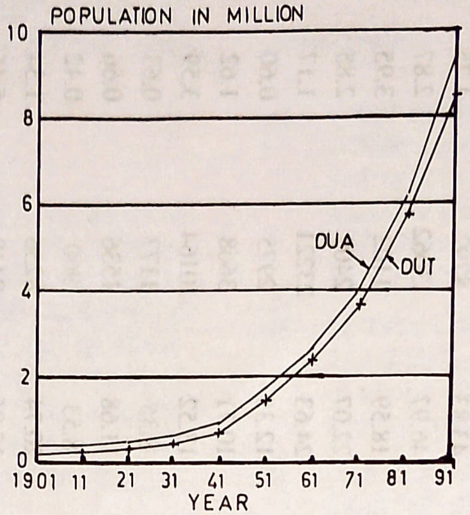
OTHER SOCIO-ECONOMIC BENEFITS

In addition to the financial viability from the view point of the entrepreneur, it would confer a number of social benefits which if quantified, would increase the internal rate of return substantially :

(1) HST is environment-friendly as it would operate on electricity and not petroleum-based fuels, which emit harmful pollutants. There will be no emission of smoke or gas. It would rather reduce air pollution by diverting traffic from and reducing growth of road transport.

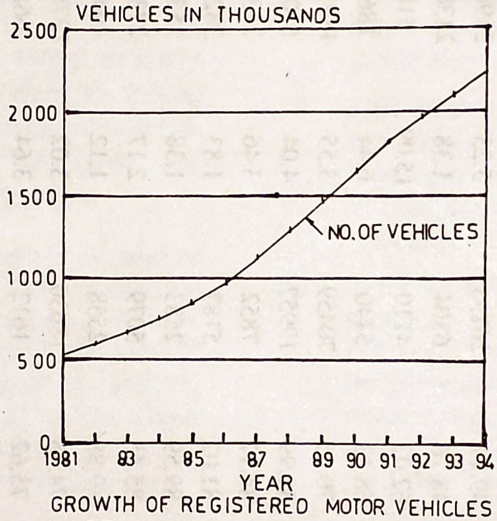
PERCENTAGE COMPOSITION OF PASSENGER VEHICLES IN METROPOLITAN CITIES AS ON 31.03.93

Metropolitan Cities	All Vehicles (No.)	Two Wheelers (No.)	% of Two Wheelers to total	Three Wheelers passengers (No.)	% of Three Wheelers to total	Cars, Jeeps Taxis (No.)	% of Four Wheelers to total	Buses (No.)	% of Buses To Total
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Ahmedabad	435470	341943	78.52	32593	7.48	49103	11.28	11734	2.69
Bangalore	627478	498272	79.41	25165	4.01	95833	15.27	8109	1.29
Bhopal	139273	118731	85.25	5751	4.13	12870	9.24	1822	1.31
Bombay	501096	246404	49.17	26195	5.23	219607	43.83	8792	1.75
Calcutta	455422	222069	48.76	6304	1.38	213890	46.97	13062	2.87
Cochin	27904	17310	62.03	4210	15.09	5186	18.59	1102	3.95
Coimbatore	84524	57927	68.53	5440	6.44	18652	22.07	2408	2.85
Delhi	1985977	1403050	70.65	70459	3.55	489148	24.63	23221	1.17
Hyderabad	494238	410173	82.99	19957	4.04	61034	12.35	2975	0.60
Indore	227112	191163	84.17	7852	3.46	24331	10.71	3668	1.62
Jaipur	282794	229125	81.02	5187	1.83	38222	13.52	10164	3.59
Kanpur	186830	167375	89.59	2583	1.38	15596	8.35	1177	0.63
Lucknow	234319	200230	85.45	5079	2.17	27375	11.68	1536	0.66
Ludhiana	228257	205163	89.88	2558	1.12	19476	8.53	960	0.42
Madras	616471	461638	74.88	18630	3.02	127848	20.74	8256	1.34
Madurai	44336	33526	75.62	1612	3.64	6685	15.06	2419	5.46
Nagpur	164549	142080	86.34	6200	3.77	15415	9.37	755	0.46
Patna	177196	133775	76.06	8021	4.53	31761	17.92	2540	1.43
Pune	290448	235735	81.16	19569	6.74	31329	10.79	3716	1.28
Surat	238473	208256	87.33	9953	4.17	19780	8.29	384	0.16
Vadodara	183521	142784	77.80	13684	7.46	25476	13.88	1478	0.81
Varanasi	120976	101800	84.15	5236	4.33	12048	9.96	1794	1.48
Visakhapatnam	157108	140471	89.41	3789	2.41	11486	7.31	1263	0.80
Total	7903773	5910000	74.77	306027	3.87	1572151	19.89	113335	1.43



POPULATION TREND IN DELHI

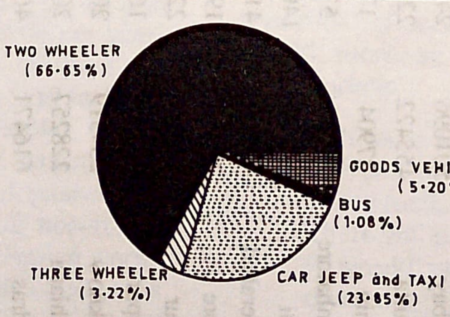
GRAPH-1



GROWTH OF REGISTERED MOTOR VEHICLES IN DELHI DURING 1981-94

GRAPH-2

COMPOSITION OF MOTOR VEHICLES IN DELHI IN 1994



GRAPH NO.3

(2) HST is fuel efficient. If it is assumed that with the introduction of HST, vehicle population remains stagnant at 1993 level, by 2011 Delhi city alone would be saving 3.7 lakh tonnes of MS and 6.5 lakh tonnes of HSD, which if valued at 1994 prices amount to Rs. 1047 crore per annum. This would entail a saving of corresponding amount in foreign exchange.

(3) If road transport is allowed to grow at the current rate, by 2010 AD, flyovers have to be constructed on every road at a distance of about 3/4 kms. This means along a corridor of 12 kms at least two flyovers have to be constructed. This would involve an expenditure of Rs. 60 crore @ Rs. 30 crore/flyover.

(4) Since the HST would operate on dedicated track, the number of accidents and fatalities would come down drastically. If the number of fatalities reduce by 200, the saving to the society would be Rs. 4 crore per year.

(5) There would be enormous saving in time that would follow from higher speed of passenger movement and less congestion on roads. Even waiting time at the terminal would be reduced as the maximum waiting time would be five minutes. If it is assumed that 1,00,000 passengers save 5 minutes in the waiting time and 5 minutes in the journey time, there would be a saving of 17,000 man hours per day and 61 lakh hours in a year. If hourly earning is taken at Rs. 3 assuming the minimum wage rate at Rs. 25 for 8 hours, the society would save Rs. 183 lakh in a year from a corridor of 12 kms. Assuming 10 such corridors in Delhi, the saving would be Rs. 18 crore.

CONCLUSION

Integrated transport planning for urban areas have to make allowance for immediate, medium term and long run travel demand. The immediate plan should be to strengthen the existing bus transport, while the long run should be MRTS. The medium term is HST which may be introduced on high density corridors in all the 23 metropolitan cities in the country. State Governments could select the suitable corridors by survey. In the four major cities like Bombay, Calcutta, Delhi and Madras and perhaps in Ahmedabad, Bangalore and Hyderabad, HST could be constructed on stilt basis, i.e. elevated. A two way dedicated up and down HST can be created at a capital cost of Rs. 20 crore per km. In other cities HST can be introduced on grade.

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