Pre-Feasibility Study for Bus Rapid Transit Hyderabad, Andhra Pradesh

The Institute for Transportation and Development Policy

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1 Executive Summary

Hyderabad urgently needs to develop a mass transit system protected from its increasing traffic congestion. Mass transit is needed now on three central corridors, and will eventually be needed on at least nine corridors.

Bus rapid transit (BRT), metro, and monorail technologies could all provide a system with sufficient capacity and speed to improve mass transit ridership in those corridors. Metro and monorail would require large capital subsidies, and subsidies for the procurement of rolling stock. By contrast, BRT would not require subsidies for operation, construction or for the procurement of rolling stock.

The capital cost differences are significant. For the same amount of capital investments, ITDP estimates Hyderabad could build 294 km of BRT system, but only 37 km of elevated Metro or 31 km of monorail. The primary advantage of the monorail system is that it would minimize land acquisition. Metro's main advantage is its potentially higher capacity, but this level of capacity is unlikely to be required in Hyderabad.

While all 3 systems would save travel time and so help retain passengers on public transit, the metro and monorail system would require higher fare prices which would suppress demand. In addition, a larger system has much higher potential to shift passengers to mass transit. We project that if Rs.5000 crore were spent on each system, the BRT system would lead to a 21% increase in public transit mode share. By comparison, we estimate the same amount spent on metro would lead to a 1% increase in modal share, and for monorail would keep modal share constant (a 0% increase).

BRT can provide effective mass transit without requiring an increase in fare price. Thus, ***BRT has the highest potential to increase public transit mode share and relieve congestion*** in Hyderabad.

A 24 km BRT system in Hyderabad could be built using:

- Private build-operate-transfer (BOT) or government investment for infrastructure: Rs. 123 crore (Rs. 5.1 crore/km)
- Bus operator purchase of rolling stock: Rs. 80 crore

For an optimal mass transit system, the government needs to improve the right-of-way for both vehicles and pedestrians, at an estimated cost of Rs. 68 to 200 crore.

1.1 Overall Traffic Conditions in Hyderabad

The quality of life and economic vitality of the Municipality of Hyderabad are seriously threatened by the rapid growth in polluting two-wheelers, cars, and auto rickshaws, which have been growing at 10% per annum. Hyderabad's air pollution level is much higher than the recommended World Health Organization standard for suspended particulate matter, resulting in thousands of pre-mature deaths each year.

Traffic flow is nearing capacity, so that any minor incident can bring traffic to a standstill for extended periods of time. The rapid growth in the private vehicle fleet means that if nothing is done, Hyderabad's traffic condition will deteriorate further and result in severe congestion. Even if congestion causes only 5 minutes of additional travel time per trip in Hyderabad, this means Rs. 254 crore per year lost to congestion. Worldwide, cities that have not developed an effective mass transit system have been unable to reduce congestion despite massive expenditures on new roads.

Hyderabad's buses are currently overcrowded during peak hours. Good average bus speeds of 18-20 km/h during peak hours are achieved, but this is largely because bus stops are 800 meters apart on average (optimal distance is between 400 meters and 500 meters). This creates significant passenger inconvenience from increased walking times, and high safety risks to passengers who board between stops. In congested areas, bus speeds have dropped to 11 – 12 km/h.

As buses are caught in worsening congestion, they face increasing operating costs per kilometer. APSRTC, one of the better public operators in India, is today losing some Rs. 41 crore per year, and these loses are increasing. While APSRTC should be commended for providing reasonable bus service despite losses, the inconvenience and unattractiveness of Hyderabad's bus system encourages further shifts to private vehicles.

Traffic safety and the quality of public space are poor. In 2004, there were 419 people killed in Hyderabad city, most of them pedestrians. Thirty-three fatalities occurred along proposed Corridor I. These figures are exceptionally high by international standards. Sidewalks are non-existent or fully obstructed in most places, forcing pedestrians to walk in the road, compromising both traffic flow and safety.

1.2 Weighing Mass Transit Options: Basis of Analysis

Given these conditions, Hyderabad needs to explore immediately its options for improving access to the city center, and the public space and walking environment within the city center. The options available for addressing this problem are widely known. There are three main proposals being discussed for Hyderabad:

- Elevated metro
- Elevated monorail
- Bus Rapid Transit (BRT)

Whatever measures are taken to improve mass transit in Hyderabad, they should be accompanied by policies to:

- Restrain private vehicle use
- Improve conditions for cycling and walking.

ITDP recommends a combination of these two policies and BRT. ITDP encourages Hyderabad to seek more detailed analysis of the feasibility of the alternative options.

This report analyzes the feasibility of BRT on a major corridor in Hyderabad, providing a preliminary assessment of:

a. Whether BRT can accommodate the existing and projected future demand for public transit at a speed significantly higher than projected speeds for the existing bus system.

b. Whether BRT can operate at a profit in this corridor.

c. Whether BRT will also improve livability, reduce air pollution, and reduce traffic fatalities and injuries, and increase land values in the corridor.

BRT is a high quality, ultra-modern and passenger-oriented mass transit system that delivers fast, comfortable, economical and eco-friendly mobility to urban dwellers. The most important feature of the system is physically segregated lanes for buses, private motor vehicles and non-motorised traffic such as pedestrians and bicyclists. Segregated lanes help in increasing the average speed of all motor vehicles (including buses) and improving the overall traffic flow.

Some of the main characteristics of BRT are:

- Segregated busways
- Rapid boarding and alighting
- Priority at traffic signal points
- Clean, secure and comfortable stations and terminals
- Modal integration at stations and terminals
- Smart ticketing and efficient pre-boarding fare collection
- Effective licensing and regulatory regimes for bus operators
- Attractive, high capacity and customer-friendly buses
- Clear and prominent signage and real-time information display
- Sophisticated marketing identity

Some of the major cities where this system has been developed or is in the process of development include: Bogotá, Sao Paulo, Curitiba, Mexico City, Panama City, Quito, Boston, Eugene, Chicago, San Francisco, Vancouver, Leeds, Strasbourg, Bradford, Lyon, Jakarta, Beijing, Kunming, Taipei, Nagoya and Seoul.

1.3 Estimating Future Demand for BRT, Metro, and Monorail

ITDP concurs with the judgment of the Municipal Corporation of Hyderabad that the following three corridors have the highest potential demand for any mass transit option:

- Corridor I. Dilsukhnagar to Kukatpalli
- Corridor II. Secunderabad Station to Charminar
- Corridor III. Mehdipatnam to Lakdi ka Pul

We agree with the Municipal Corporation of Hyderabad (MCH) that Corridor I is a rational first priority both because of its high demand and the reasonable availability of existing right-of-way.

1.3.1 Existing transit demand in Corridor I

Any analysis of future demand must begin with an estimate of existing demand in the corridors. According to the Municipal Corporation of Hyderabad, Corridor I currently carries 40,000 to 50,000 peak period passengers per hour per direction (pphpd), of which 34% of the trips are carried by bus. Thus, the current number of bus passengers in the corridor is as high as 17,000 pphpd.

Our measurements agree with this estimate. The existing maximum load on the most critical link (static demand) is 11,600 pphpd. Adding the passenger rotation ratio (accounting for passengers getting on and off) of about 1.5, the total passenger trips one way is 17,400 pphpd. ***Daily demand on Corridor I is around 307,000 passengers per day.***

A system able to capture the entire existing demand on Corridors I, II, and III, would have a total daily demand of around 686,000 +/- 20%. We recommend a 300,000 On-Board Origin-Destination Survey of existing bus and paratransit passengers be carried out as a first step in project development, to allow more accurate estimation of demand.

1.3.2 Projecting Future Modal Shift

Future demand projections should start with historical trends. Bus trips have remained fairly steady at around 3 million trips per day since 1996, falling slightly in recent years to around 2.8 million trips per day (APSRTC, 2004). Therefore, if no new mass transit system is built, we can expect public transit ridership to remain constant or face modest declines. As population continues to grow, this means that transit would lose mode share if nothing is done.

How many passengers can be induced to switch from other modes to transit if a new mass transit system is built will depend on the characteristics of the system built. Projected future congestion levels for mixed traffic, and the level of restriction on private vehicle use will also affect modal shift.

Because metro and monorail systems are expensive, they generally can not be expanded fast enough to keep pace with urban dispersal and the growth of private motor vehicle fleets. ***No metro system in the world for which data is available has led to an aggregate modal shift in favor of public transit away from private motor vehicle use. Therefore, it would be wrong to assume that a metro or monorail in Hyderabad would have a significant modal shift impact.***

Public Transit Modal Split Before and After BRT and Metro Construction

City	% of Trips Before	% of Trips After
Metro Systems		
Mexico City	80	72
Buenos Aires	49	33
Bangkok	39	35
Kuala Lumpur	34	19
Santiago	56	33
Warsaw	80	53
Sao Paulo	46	33
Tokyo	65	48
Seoul	81	63
BRT Systems		
Bogotá	53	56
Curitiba	74	76
Quito	76	77

Sources: OTP (2003), Xu, K. (2004), Vasconcellos, E. (2001), SETRAVI (2003), Ciudad Viva (2003), WBCSD 2001, Barter 1999, Kuala Lumpur Draft Master Plan 2003, National Transport Secretariat of Argentina 2001, TransMilenio SA, Bogotá, 2002. URBS, Curitiba, 2004;

BRT, by contrast, has proven to bring about a modest modal shift in favor of public transit trips, primarily because fares can be held lower and the system can grow to reach a lot more people for the same investment and implementation period.

To project actual ridership for a new mass transit system in Hyderabad, ***it is not safe to assume that even all of the current transit passengers in the corridor will use the new system.*** The factors which determine the percentage of total transit trips that will actually be captured by a new public transit system serving this corridor are:

- The number of trips which both originate and end along the corridor.
- Whether or not normal bus routes are allowed to continue on the corridor
- The fare price of the new mass transit service relative to any competing mode choices available in the corridor
- The door to door travel time of trips utilizing the new mass transit service (inclusive of transfer time) relative to other modal choice options in the corridor.
- The feeder system provided and its cost.

Currently, only ***40% of the passengers currently using Corridor I are both beginning and ending their trip directly along that corridor.*** Many existing bus lines take Corridor I to other destinations. ***If all existing bus lines are allowed to continue to use Corridor I in competition with any new mass transit system, the maximum load on the critical link (static demand) will be only around 7000 pphpd on the new mass transit system.***

As the presence of the old buses in the mixed traffic lanes would not only undermine the profitability of the new system but also congest the mixed traffic lanes, ***it is recommended that whatever mass transit system is designed for the corridor, the following measures be taken:***

- ***80% of competing bus lines in Corridor I should be cut.***
- ***Free integration with mass transit service or bus services in trunk Corridor II and III should be provided.***
- ***Feeder buses should be provided at the terminals of Corridor I and at some intermediate points***

1.3.3 Projected Demand for Specific Mass Transit Options

Estimating the likely future demand of the monorail, elevated metro, and our BRT proposal, requires defining very carefully the characteristics of these systems. Unlike with the existing bus system, we can safely assume that because a metro, a monorail, or the BRT system would all have dedicated rights of way, increasing congestion of general traffic will improve the comparative advantages of traveling by mass transit. Therefore, ***we have assumed that if any of the three mass transit systems are built, transit ridership will increase slightly faster than population growth in the specific corridor it serves.***

However, the systems have different characteristics that will have a profound impact on the degree to which they can attract passengers. This report tests three specific scenarios: 1) the elevated metro proposal made by DMRC, 2) a theoretical monorail proposal based on a similar proposal made in Jakarta, and 3) a BRT system with three possible mechanisms for system integration with Corridors II and III.

Based on the system characteristics from the pre-feasibility studies, we estimate the following projected future demand for each system:

Comparative Demand for Monorail, Metro, and BRT

	BRT		Metro		Monorail	
	System Daily Pax	Corr I pphpd	System Daily Pax	Corr I pphpd	System Daily Pax	Corr I pphpd
2008	854,001	14,441	653,862	11,057	482,362	8,157
2011	905,221	15,307	693,093	11,720	511,303	8,646
2021	1,076,042	18,195	873,298	14,767	607,776	10,277

1.3.3.1 Characteristics of the DMRC Proposed Elevated Metro Rail System

The DMRC proposes a 38.3km elevated metro built on Corridor I (25.6 km connecting Miyapur and Chaitanya Puri) and Corridor II (12.7km connecting Secunderabad railway station and Falaknuma Railway Station).

The metro being proposed by the DMRC would be elevated. The proposal saves money and increases system speed by constructing fewer stations, but this will reduce convenience and potential modal shift to the system.

The elements of the DMRC proposal that are likely to affect demand in the corridor are:

- Transit vehicle speeds would increase from an existing average speed of 18 – 20 km/h to some 34 km/h.
- The average metro fare would be 50% higher than the projected bus fare.
- The 1 km distance between stops would be 25% farther than the existing 800m between bus stops.

1.3.3.2 Characteristics of the Metrail/Nash Proposed Monorail System

We understand that MetRail of Switzerland and Fraser Nash of Great Britain have both proposed monorail projects for Hyderabad. Having no detailed proposal, we consider a likely scenario:

- A 55 km monorail line would be built on Corridor I and II by private investors in a Build-Operate-Transfer (BOT) scheme.
- Based on Kuala Lumpur experience, the speed of monorail system could be as high as 30 km/h, depending on the distance between stations, attracting ridership.
- Fares are more than 50% higher than projected bus fares at time of completion.
- Stations are in roughly the same locations as proposed by the metro company.

1.3.3.3 Characteristics of ITDP's proposed BRT System

The system characteristics for BRT are detailed in the following section. However, for demand estimation purposes, our proposed BRT system will have the following basic characteristics:

- A 24km long system
- Average speeds of 26kph
- 450 meters between station stops.
- Fare prices equal to the projected future bus fares.

Four methods of capturing the majority of existing and future transit demand in Corridor I using BRT are presented, one of which was rejected.

The first three BRT options would all build a 'closed', Curitiba or Bogotá-style, BRT system down Corridor I. The first option would include two transfer stations to be built in the city center that would allow free transfer for passengers traveling from existing buses operating in mixed traffic on Corridor II and Corridor III onto the trunk mass transit line in Corridor I. This scenario would ensure the demand on Corridors II and III onto Corridor I would be captured.

The second option utilizes the 'closed' BRT system on Corridor I, and for Corridor II and III would procure buses that can operate both on the BRT system and also in mixed traffic. Operating both on and off the BRT system, these buses would be able to bring most of the demand onto the BRT system in Corridor I.

The third option provides passengers with free transfers between the normal bus system and the BRT system anywhere along the corridor through use of a smart card ticketing system. This option has the advantage that it would have the maximum impact on demand. The main disadvantage is that it requires the procurement and installment of a smart card ticketing system on all buses in Hyderabad.

Any one of these first three, 'closed' BRT, options will satisfy the stated project goals. The demand estimates for all three of these scenarios will be similar and, within the limits of our analysis, the costs similar.

A fourth BRT design option was considered and rejected. This option was to design an 'open' BRT system using the existing normal buses but giving them exclusive lanes in the center of the carriageway, as is being developed in Delhi. This option would reduce transfers and would ensure that all of the transit demand in the corridor could be captured. ***Because an open busway would either have very slow operating speeds or badly congest the mixed traffic lanes, or would require a lot more land acquisition, we do not recommend the option of designing a Delhi-style 'open' BRT system.***

1.3.4 Effect of Fare and Travel Time on Demand for Three Alternative Systems

The different systems being proposed will have different impacts on potential ridership. For comparison, we have assumed that all three systems will cut bus lines in Corridor I and capture demand from Corridors II and III through some sort of free transfers. Thus, the main factors varying demand between the three systems are differences in door-to-door travel time and door-to-door travel costs.

Door-to-Door Travel Time for Three Mass Transit Systems

	Metro			**Monorail**			**BRT**		
	Speed (km/h)	Dist-ance (km)	Minutes	Speed (km/h)	Dist-ance (km)	Minutes	Speed (km/h)	Dist-ance (km)	Minutes
Walking	4	0.5	7.5	4	0.5	7.5	4	0.25	3.8
Waiting	-	-	3	-	-	3	-	-	2
Riding	34	9.2	16	34	9.2	16	26	9.2	21
Walking	4	0.5	7.5	4	0.5	7.5	4	0.25	3.8
Total Time			**34**			**34**			**31**

An analysis of door-to-door travel time is presented in the figure above. The estimates for walking time for the metro and monorail are conservative; they include no factor for the increased time and inconvenience of having to climb the flights of stairs necessary to reach the elevated stations.

For comparison, a similar trip on Hyderabad's current bus system would have a door-to-door trip time of 51 minutes. Applying the value of time and cost elasticity assumptions used by DMRC (time valued at Rs.10/hour and cost elasticity =0.5) to all three scenarios, we can predict the effect of the travel time savings on the baseline demand.

Travel Time Effect on Demand for Three Mass Transit Systems

	Metro	**Monorail**	**BRT**
Time Savings (minutes)	17	17	21
Equivalent Value (rs)	2.8	2.8	3.4
Percentage savings	41%	41%	49%
Effect on Demand	+20%	+20%	+24%

Using the DMRC's assumptions for projected fares for regular buses and the metro, plus an estimate of fares based on the policies adopted by other BOT monorail projects in the region, we can estimate the effect of cost on demand.

Travel Cost Effect on Demand for Three Mass Transit Systems

	Metro	Monorail	BRT
Projected Fare	10.5	14	7
Percentage difference from bus	50%	100%	0%
Effect On Demand	-25%	-50%	0%

The net effect of the differences in system characteristics between the three mass transit systems analyzed on demand is -5% for metro, -30% for monorail, and a +24% for BRT.

1.4 System Design Recommendations

Metro, BRT, and monorail could all handle the projected passenger demand in the corridor.

The DMRC metro proposal would have an initial capacity of 20,000 pphpd on corridor I and 12,000 pphpd in Corridor II at the beginning of operations, increasing to 49,632 pphpd in Corridor I and 31,020 in Corridor II by 2021. Given a projected initial demand estimate of 11,000 pphpd, we believe this system will provide more capacity than needed.

A monorail system in Corridor I could carry about 18,000 pphpd if it were four cars long, requiring the elevated stations to accommodate four car trains. Metrail and Frazer Nash are claiming 36,000 pphpd, but this has not been achieved by an existing monorail. Given our projected demand estimates, we believe the monorail would be more profitable if it were designed to carry only around 10,000 pphpd. This is because the higher fares of monorail will suppress the demand to this level.

We recommend designing a BRT system to handle 18,000 pphpd upon opening in 2008 and increasing its capacity to 36,000 by 2021. While this is more than the projected demand in 2008, the additional cost of designing a system to handle this level of demand over projected demand is marginal.

The metro and the monorail systems can be designed with sufficient capacity to handle projected future demand. This report explains how these capacities can be achieved using BRT technology.

A BRT system can be built in Corridor I with the nearly the same capacity as the proposed metro system, with an average operating speed of 26 km/h, starting at 18,000 pphpd and increasing to 36,000 pphpd over time. TransMilenio in Bogotá is transporting 38,000 pphpd.

Reaching these levels of capacity in a BRT system requires careful design and engineering, utilizing the following characteristics:

- **The BRT system should occupy the central verge of the roadway**, rather than the curb lanes. This will avoid conflicts with turning traffic, pedestrians, stopping taxis and delivery vehicles, illegally parked vehicles, etc.
- **Passengers should pre-pay to enter each bus station, and each station platform should be elevated to the height of the bus floor.**
- The ***exclusive bus lanes must be physically separated from the rest of the traffic by a physical barrier,*** and enforcement of encroachment onto the busway must be maintained with ***additional police at the intersections*** during the initial months of operations. Fines for illegal encroachment on the busway must be strictly enforced.

- A**n overtaking lane at stations.** The busway needs two lanes in each direction at each station, and one lane in each direction at all other points. The overtaking lane is critical to relieve bus congestion.
- **Each station should have at least two platforms.**
- The **distance between bus stations should be brought down from the current average 800 meters to an optimal level of 450 meters.** This will slow down bus speeds somewhat (from 30 to 26 km/h) but it will reduce total trip time by reducing walking distances. **Forty stations with 80 pre-paid enclosed platforms should be built along Corridor I**.
- For Corridor I, use **109 articulated buses with 150-passenger capacity and four platform-level 1.1 meter wide doors on the right side** (Scenario I and III), or **the above buses plus 206 buses with two platform-level 1.1 meter wide doors on the right side and two standard curb-level left side doors on the left** (Scenario II).
- **Pedestrian access to the central verge should be at grade using improved crosswalks rather than using pedestrian overpasses.** As the maximum number of mixed traffic lanes the pedestrians would need to cross is two, this can generally be negotiated safely. (ITDP recommends pedestrian overpasses only when three or more mixed traffic lanes need to be crossed, with average vehicle operating speeds over 40 km/h.) Even in presence of overpasses, people generally prefer to negotiate the crossing at grade.
- Where possible, **restructure right turns along the corridor to** increase bus speeds and avoid worsening congestion in mixed traffic lanes.

The capacity of the system will be expanded from 18,000 pphpd to 36,000 pphpd as needed by adding an additional bus platform at each station, and by adding more express bus services which make fewer stops***. The addition of this extra BRT capacity costs very little money, in contrast to the cost of expanding the capacity of a metro or monorail system.*** An advantage of BRT systems over rail based systems is that headways between each vehicle can be reduced from around 3 minutes to less than 30 seconds. Because the obstacle to reducing headways is the capacity of the bus stations, additional capacity is added to a BRT system by adding additional bus platforms at each station. For this to work, however, an overtaking lane at the station is necessary.

1.5 Right-of-way

The right-of-way in Hyderabad's Corridor I is highly irregular, as is typical of many older cities, varying from over 60 meters in width to as little as 9 or 10 meters at specific bottlenecks. Any mass transit system proposed for this corridor will have to address the irregularity of this right-of-way.

This Corridor, most of which falls along National Highway 9 under the authority of the National Highway Authority of India (NHAI) is slated to be upgraded/widened from the existing 4 lanes to 6 and 8 lane roads. Efforts for BRT in Hyderabad therefore should be coordinated with the NHAI widening.

Throughout most of the right-of-way, walkways and cycle paths are either non-existent or highly inadequate. This compromises the quality of the urban environment in the city center, making this an unattractive and highly inconvenient destination for shoppers or employers. Regardless of the type of mass transit system selected for this corridor, ***the MCH needs to significantly improve the quality of the walking and cycling facilities in the corridor.***

We recommend a combination of approaches for dealing with the fact that the right-of-way is currently not an ideal width in all places:

- Where the buildings along the right-of-way are low rise and of low quality, or the land is vacant or underutilized, widen the right-of-way to as close to the ideal width as feasible.
- Where possible, restructure right turns to reduce traffic conflicts.
- In the city center, where there are one-way streets, explore two options: 1) splitting the BRT route into two one-way corridors, or 2) pushing part of the mixed vehicle traffic onto a parallel corridor.
- In bottlenecks where, because of an important graveyard or buildings of historical value, widening the right-of-way is difficult or impossible, we recommend first controlling any illegal vending activity and removing any parking, then compromising the capacity and speed of the BRT, mixed traffic lanes, and bike and pedestrian facilities in equal measure through signalization and channelization. (These are already compromised at such bottlenecks).

We recommend that Hyderabad do a detailed engineering plan for the corridor performed based on parameters set by the city administration regarding the relative difficulty and political sensitivity of site-specific land acquisition.

1.6 Estimated Costs and Financial Feasibility

The principal advantage of BRT over metro or monorail is cost. Based on our demand analysis and drawing from international experience, we provide a comparative analysis of cost and revenue to assist Hyderabad with its evaluation.

With a Rs 5000 crore capital investment, Hyderabad could build 294 km of BRT, about 37 km of metro, or about 31 km of monorail. Once built, the BRT system would also be able to fully finance its rolling stock (buses) out of the fare revenue, whereas the rolling stock in the metro and monorail system would have to be subsidized. A comparative profit / loss analysis shows the advantage of BRT in not having to cover high capital construction costs, and the increased revenue from higher ridership at lower fares.

Because of the high cost of construction, the monorail private investors are very likely to seek ***a government ridership guarantee, operating subsidies, and capital subsidies.*** Even after its official launching in June of 2004, the Jakarta monorail company is now seeking funding from the government before continuing construction, even though they had initially promised that now government funding would be required...

The metro will not be able to cover the cost of the depreciation of the rolling stock nor the debt service on the capital investment. ***We believe the DMRC's demand estimates are 70% above realistic estimates and their construction costs 20% below realistic estimates.***

The financial estimates for both ***the metro and the monorail include no funds to improve the conditions for pedestrians in the corridor. These costs would be additional.***

Comparative First Year Profit / Loss for Hyderabad BRT, MRT, and Monorail (in Rs. Crore)

	Metro	Monorail	BRT
Capital Cost			
Company's Own Estimate	4204	2500	--
ITDP Estimate	5170	8910	408*
Capital Cost/Km			
Company's Capital Cost/Km estimate	110	45	--
ITDP Capital Cost/km estimate	135	162	17*
Annualized Capital Costs			

Annual Capital Subsidy (6 year financing)	862	1485	68
Annualized Capital Cost (20 year life)	**259**	**446**	**20**
Operating Costs – Annual	**108**	**80**	**42**
Revenue			
Projected Annual Passengers (Crore)	21	15	27
Average Fare	10	14	7
Projected Annual Farebox Revenue	206	213	188
Net Operating Profit / Loss	**+98**	**+133**	**+146**
Annualized Profit / Loss	**-161**	**-313**	**+126**

* BRT cost figures are inclusive of extensive pedestrian and urban space improvements that ITDP feels is vital for a successful mass transit system. Cost of BRT infrastructure is Rs. 123 crore (Rs. 5.1 crore/km).

To build a world class BRT system in Hyderabad that could handle 18,000 pphpd initially and increase to 36,000 pphpd, to reconstruct the corridor to make it a beautiful walking and cycling environment for transit passengers and shoppers, to build beautiful parks and public space along the BRT system, acquire all the land necessary, and acquire a fleet of modern high quality buses, Hyderabad would not spend more than Rs 408 crore for Corridor I, or Rs.17 crore/km. Without land acquisition costs, the BRT system would cost Rs. 203 crore, or Rs. 8.5 crore/km.

At an average fare of Rs. 7, the BRT system would be able to finance all of the bus procurement from the farebox revenue, and the debt service on the capital investment. **BRT in Hyderabad could operate without public subsidies and could earn enough profit to finance all new bus procurement.**

1.7 Environmental and Safety Benefits of BRT in Hyderabad

The two most important problems facing Hyderabad other than the growing traffic congestion are the escalating air pollution and pedestrian accidents. While any of the mass transit systems discussed in this paper can potentially draw some passengers out of private vehicles and into public transit, reducing emissions per person, because for the same money a much bigger BRT system can be built than any other system, **the air quality benefits of BRT are likely to be eight times greater than for any other option.** BRT emissions benefits result from the use of cleaner buses, the shifting of passengers from private vehicles to public transit, and finally the use of fewer buses per passenger trip (because the buses have more capacity and are not stuck in congestion).

Furthermore, the BRT system outlined here would be constructed with safe pedestrian infrastructure in the entire corridor. Traffic fatalities in the Bogotá BRT corridor dropped by 98% in the first year. The other mass transit systems proposals for Hyderabad would increase vehicle speeds in the corridor but do nothing for pedestrians or non-motorized vehicles. The net effect would actually increase traffic fatalities.

1.8 Conclusion: The Advantages of BRT over Other Mass Transit Options for Corridor I

Bus Rapid Transit offers the means to dramatically improve Hyderabad's transportation system while simultaneously making the city a nicer place to live, work, and shop at a price ***1/8 of the cost of the next cheapest alternative to meet this level of demand.***

If done well, ***the first BRT Corridor in Hyderabad could satisfy all of the public transit demand in Corridor I into perpetuity, while also decongesting the mixed traffic lanes***. The reduced capital costs will leave the city with funds for beautiful tree lined pedestrian promenades that could fundamentally transform the quality of the CBD from one that is not very desirable by international standards to one befitting a world class city. Real estate values along the much improved and much more accessible corridor would rise dramatically. The authority which develops the BRT system would be in a position to profit from the appreciation of this property.

The buses operating in the BRT system could be Indian buses, manufactured in India and eventually assembled in Hyderabad. Potentially these buses could be exported worldwide to other cities developing BRT systems. All the buses, spare parts, components, and maintenance and repair jobs would go to people in Hyderabad, adding to the local tax base, and creating a new vital export industry. The IT used in the BRT system could be done by local Indian experts.

ITDP recommends that Hyderabad seriously consider BRT coupled with improvements in pedestrian and other non-motorized travel conditions in Corridors I – III, and a tightened regulatory regime for parking. We believe these will be fastest, the most sustainable, and most cost effective means of addressing Hyderabad's growing traffic woes.

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2 Introduction to Transport in Hyderabad

The Institute for Transportation and Development Policy (ITDP) has conducted this preliminary assessment of transportation in Hyderabad City with the specific aim of assessing the feasibility of a bus rapid transit (BRT) system to improve the city's transportation system. This work is being conducted with the full cooperation of the Municipal Corporation of Hyderabad (MCH) as defined under a memorandum of agreement signed in July 2004. ITDP's work is being financed by a grant from the US Agency for International Development. The purpose of the grant was to improve the livability and reduce the air pollution in two Indian cities. Delhi and Hyderabad were selected based on our assessment of the level of preparedness of several municipalities to implement sensible measures. While the Municipal Corporation of Hyderabad cooperated in the preparation of this report, the conclusions represent are those of ITDP alone, and do not necessarily reflect the views of the Municipal Corporation of Hyderabad.

Though we do not have access to detailed technical information regarding the cost, technical capacity, or feasibility of alternative mass transit options that may or may not be appropriate for Hyderabad, we have tried to provide information on these alternatives to the degree that it is available.

The objective set for us by the Municipality was to study the feasibility of using BRT to reduce congestion in one major corridor in Hyderabad, providing sufficient mass transit capacity to handle both a substantial shift in trips from private vehicles to mass transit and also the projected growth of public transit trips in one corridor. We are confident that BRT can serve this purpose in Hyderabad if designed correctly.

Ultimately, it is the responsibility of the citizens of Hyderabad to decide on their future transportation system, and we hope than in a small way this report can assist in that decision-making process.

During the period from July to December, 2004, ITDP sent the following international experts to assess the feasibility of BRT in Hyderabad. These experts included the following: Former Mayor of Bogotá Dr. Enrique Penalosa, Paulo Custodio, (Project Manager, TransMilenio), Pedro Szasz (Senior Engineer, TransMilenio), Joao Carlos Scatena, (Consultant, Sao Paulo), and Remi Jeanneret (Consultant and Traffic Modeler, Rio de Janeiro and Paris). These experts are, in ITDP's judgment, the foremost experts in the world on BRT planning. They were directly responsible for the most successful BRT system yet implemented, Bogotá's TransMilenio BRT. These experts were assisted by ITDP's staff and management, including: ITDP Executive Director Dr. Walter Hook, ITDP Asia Regional Director John Ernst, Shreya Gadepalli, Technical Director of ITDP India, and Nalin Sinha, Managing Director, ITDP India.

This study done to date in Hyderabad by ITDP is of a preliminary nature. The purpose of the study, and this report, is to provide Hyderabad with a first assessment of the feasibility of BRT. All assessments of the transportation system and its performance in Hyderabad are based on limited sampling. While in general, experience shows that limited samples provide reasonable estimates for initial feasibility; planning, physical design and system operational planning requires more detailed analysis.

3 The Transportation Situation in Hyderabad

3.1 Introduction to Hyderabad's Traffic Conditions

Hyderabad is a fast growing city. The population of the greater metropolitan area increased from 1993 to 2002 from 4.67 million to 6.38 million. This represents a slowing of growth from the previous decade. Of this, 3.63 million live in the central core, governed by the Municipal Corporation of Hyderabad (MCH). The MCH area is only 172 Sq. Km (less than 10% of Hyderabad Urban Development Authority area of 1865 Sq. Km), but accommodates 60% of the population, more than half of the employment areas and almost all government offices.

Based on the most recent household survey taken by LT Ramboll (2004), the current modal split in Hyderabad is 37% walking trips, 9% cycle rickshaw, bicycle and other slow moving vehicles, 30% two-wheelers, 15% public transit, 7% auto-rickshaws, and 3% private cars and taxis. Together these modes generate 10,296,160 daily trips. Exclusive of walking, public transit constitutes 24% of total trips. If other modal split data exists, we have not seen it.

Modal Split, 2002, L T Ramboll Study

	Daily Trips	%	**Excl. walk**	**Work-only Trips**	%
Public Transit	1,529,328	15%	24%	269,392	11%
Auto Rickshaw	604,274	6%	10%	88,560	4%
Car	160,822	2%	3%	54,142	2%
2 - Wheelers	3,099,766	30%	49%	1,203,517	49%
Slow Vehicles	913,686	9%	14%	306,468	12%
Walk	3,988,284	39%		548,650	22%
	10,296,160	100%	100%	2,470,729	100%
Excl. walk	6,307,876				

Our data from APSRTC for 2002 (same year the survey was conducted) shows roughly 3 million public transit trips. MCH considers that there are about 7 million daily motorized trips, 40% of which are public transit. Because of the discrepancy in estimates of motorized trips in Hyderabad, our analysis uses our own surveys of public transit use in the corridor and focuses on changes in modal share – rather than absolute numbers of passengers – in estimating the effects of mass transit improvements on the whole system.

The fleet of registered auto-rickshaws, two-wheelers, and cars, has grown by over 150%, and the growth of unregistered vehicles may bring these levels even higher. Over the same decade, the bus fleet has dropped by 35%, though it increased in the last few years.

Vehicle Registrations, Hyderabad

	1993	2002	% Increase
Buses	3,836	2,512	-35%
Auto Ricks	23,874	71,069	198%
Cars & Jeeps	66,793	184,715	177%
Two Wheelers	467,225	1,124,508	141%
Goods Vehicles	16,473	48,292	193%
Taxis	5,333	5,531	4%
Pvt. Service Vehicles	2,110	1426	-32%
Population	4.67	6.38	37%

Given a population growth of 37% over the last decade, the decline in the bus fleet by 35%, and a decline in bus occupancy, it is certain that public transit mode share has dropped substantially over the last decade though the precise figures cannot be known without comparable household survey data from 1993. The vehicle fleet data also make clear that the mode share of two wheelers, cars, and motor rickshaws has risen sharply. ***Without interventions to alter this trend, it is safe to assume that the modal split of public transit will decline over the next decade.***

Currently, overall travel speeds are reasonable by international standards. Average bus speeds are around 18 km/h, and private motor vehicle speeds are higher. Traffic signal timing is generally well adjusted and traffic regulation (one way streets, turning movement restrictions on intersections, bus stops etc.) is adequate.

However, because traffic volumes are rapidly reaching capacity, any unusual occurrence such as a collision, illegally turning or parking vehicles, will rapidly lead to congestion. This congestion is becoming increasingly common. Because of the irregularity of current congestion patterns, estimating the time lost to congestion is not possible within the scope of this study. However, a simple calculation of the effects of congestion in Hyderabad shows that an average of only an additional 5-minutes per trip caused by congestion would cost Hyderabad Rs 254 Crore per year in lost time (based on 7 million motorized trips per year in Hyderabad, and using DMRC's valuation of time for bus and private vehicle passengers).

With two-wheeler, car, and auto-rickshaw fleets growing at over 10% per annum, and the expense related to expanding the existing road network a continuation of the deterioration in traffic speeds can be expected in the near future.

Traffic operation and administration are good, concentrating efforts where there are real problems, and there is effective on-street traffic policing in regards to traffic flow.

Lane-sharing behavior of two-wheelers increases road capacity but decreases safety.

The flow of both passengers and vehicles on Hyderabad streets is much higher than the theoretical capacity based on Western models, due to the prevalence of two-wheelers and three-wheelers and lane-sharing behavior. As a comparison, two-wheelers are considered to have a usual equivalent traffic weight of 0.7 to 0.5 PCU (passenger car units) in western manuals, but we estimate the real values in Hyderabad (similar to other oriental cities) are 0.18 PCU (+-0.04). This is roughly three times more capacity than western standards.

The cost of this extra fluidity is unsafe conditions, especially for pedestrians, as discussed below.

3.2 Public Transport

Operating Characteristics of City Bus System in Hyderabad

Year	Bus Fleet	Avg. Age of buses (years)	Pax/ day ('000)	Load Factor (%)	Daily Vehicle utilization	Cost/ Km (Rs.)	Revenue/ Km (Rs.)	Loss/ Km (Rs.)
1996-97	2122	NA	3177	75	238	11.19	10.55	0.64
1997-98	2217	NA	3054	69	242	12.19	11.49	0.7
1998-99	2328	NA	3253	70	248	12.65	11.58	1.07
1999-00	2425	6.97	3050	63	246	13.19	12.48	0.71
2000-01	2480	6.11	2872	58	243	14.62	13.47	1.15
2001-02	2605	6.89	3068	59	233	15.35	13.18	2.17
2002-03	2671		2800					

Source: APSRTC

Bus passenger trips have been fairly stable or slightly declining since the mid-1990s, averaging around 3 million trips per day. The procurement of some new buses recently has slightly reduced overcrowding on the buses. This has also meant that, coupled with increasing fuel prices, the system's operating costs have risen faster than passenger revenues. Annual operating losses have grown, reaching Rs. 2.17 per kilometer in 2001-2002.

No dependable figures for the total number of transfers per passenger were available. Estimates range from 12% to 30% according to the method used. This information is needed to determine total demand if the route system is reconfigured with a BRT system.

Competing with APSRTC buses are seven-seat three-wheeler auto-rickshaws and three-seat three-wheeler shared auto-rickshaws that also constitute a form of public transport. According to traffic police records, a total of 2800 of the seven-seat auto-rickshaws run in the city as of today. From our calculations, each vehicle must cater to approximately 100-125 passengers per day for their operations to be profitable. This translates into a total of 280,000 to 350,000 passengers per day carried by this mode. Counting the smaller auto-rickshaws which are used as shared taxis, the total number might be in the range of 450,000 to 500,000 passengers per day. This number does not include the trips made by small auto-rickshaws as regular taxis.

The three-wheeler shared transport is a relatively new phenomenon which has developed in the last 5 to 6 years. They ply on fixed routes on the outer edges of the city, or where bus operations are low but there is appreciable passenger demand. Formerly, these vehicles plied to the city center, but their entry into the center has been banned because of the congestion and pollution they create. Some of these routes act as feeders for passengers who get off buses, but a large percentage cater to areas where there is a low frequency of bus operation.

There also exists an urban rail system which has been recently renovated and renamed as the MMTS. This system is still being developed and presently carries around 34,000 passengers per day. The system uses the existing rail network. The services have not been streamlined yet and no feeder service exists, which gives it limited accessibility to a large part of the city's population. If integrated with a BRT system the demand on the MMTS system could be increased.

APSRTC operates three principal categories of buses:

- Ordinary (including suburban)
- Metro Express
- Vera and Vera-plus (initially started as metro liner)

A fourth type has been recently launched which is called High Tech.

Number of buses and passenger trips by APSRTC in Hyderabad

TYPE	Buses	Trips
Ordinary	1865	26,183
Metro	379	5138
Vera	92	864
Total	2336	32,185

Source: data from APSRTC route master for Aug 2004

The ordinary buses have a technical capacity of 44 seating and 16 standing. These are two-door buses where the front door is reserved for women for both entry and exit. 40% of bus seats are reserved for women.

Capacity of Metro Express buses is 40 seating with no technical standing capacity. Here again the front door is reserved for women and so are 40% of seats.

Vera buses have only one door, which is in the front. They have 39 seats with no technical standing capacity.

Buses carry a lot more than their technical capacity in the peak hours. Observed loads have been as high as 119 passengers in ordinary buses, which is nearly twice the capacity. Even Metro Express, as well as Vera buses, have occupancy levels of up to 75 passengers in peak hours, which again is twice their technical capacity. This is evidence of excess demand, or underpricing. Since the system is currently operating at a loss, an increase in the number of buses would require either increased fares or higher subsidies.

Bus operations are fairly efficient at present with a high average load of 40 passengers/bus and a good average speed of 18km/hour, which does not deteriorate much (down to about 11kph) in peak hours. Congestion at bus stops is not very common, even though it is observed that buses seem to arrive in convoys with the time gap between convoys creating some inefficiency. Bus stops are well defined and are split at high-demand locations to allow a large number of buses to stop at the location without congestion at the bus stop.

Average number of trips per bus is 14 with 270 km/bus/day and 1100 passengers/bus/day. These are very good figures which reflect on the efficient use of available resources by the bus company.

The high average speeds are partially caused by the large distance between bus stops. Stops are an average of 800m apart, and up to 1200m at places, even in central areas. The recommended distance optimum is 450m and even 400m in the CBD areas. The current system results in long walk trips at the start and end of most bus trips.

The following table provides information on average trip time for bus passengers. This information is from field observations on the Kukatpalli-Dilsukhnagar corridor. Waiting time seems to be excessive. A reduction from present average bus stop distance of 800m to the optimum of 450m would roughly reduces walking time by 2.7 minutes and increase traveling time by 1.8 minutes with a net passenger gain of 0.9 minutes (2.5% of total time):

Average Trip Time using Bus (including waiting time and walking)

	Distance	Speed	Time	
Activity	**Km**	**Km/h**	**Minutes**	**Percentage**
Walking	0.5	4	7.5	19%
Waiting	0	0	8.7	22%
Bus Travel	5.2	20	15.6	40%
Walking	0.5	4	7.5	19%
Total	**6.2**	**9.7**	**39**	**100%**

There is a common tendency to board and alight at non-designated stops, at places like intersections or even from and into moving buses when they slow down. This is because of the large distance between stops. While this practice aides the buses in achieving a good average speed, it is very unsafe for passengers.

3.2.1 Bus Fares

Bus fares on ordinary service start at 2 rupees and increase in steps of 2 rupees for every additional 4km. Metro Express fare is approximately 1.5 times that of Ordinary fare for the same distance and that of Vera is nearly twice that of ordinary service.

A system of bus passes is also common. Bus passes are available for both a day and a month. The rates are given in the table below.

APSRTC Bus Pass Rates (in Indian rupees)

Service	Day pass	Monthly pass
Ordinary	28	380
Metro Express	40	450
Vera	40	500

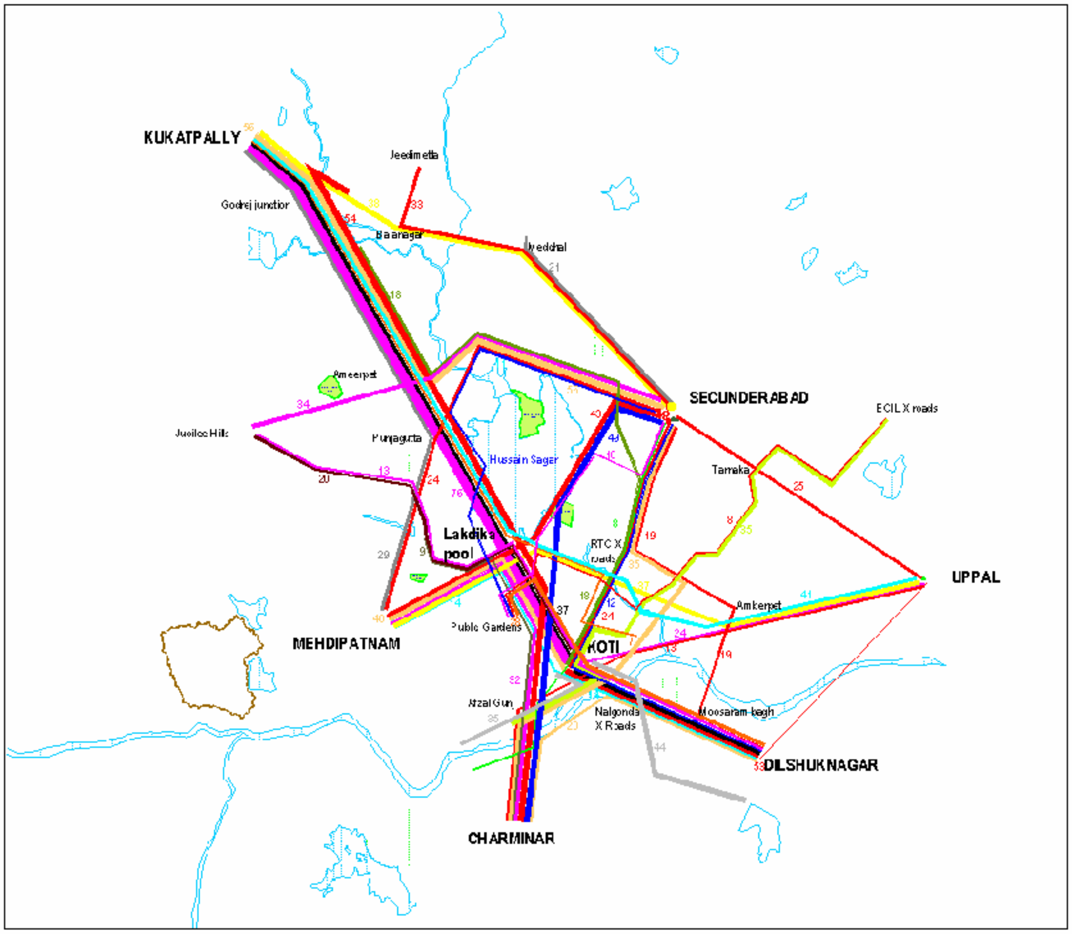
Other types of discount passes are also available for students and other categories for about 50% of the costs given above. One-third of the revenue of APSRTC comes from bus pass sales and two-thirds comes from daily sales of tickets.

We estimate that the bus system in Hyderabad makes annual losses of about Rs. 25 crore. Under a BRT system, if designed properly the system would become highly profitable, making it possible to raise investment for a modern bus fleet solely from passenger fares

3.2.2 Bus Routes

There are 850 official bus routes including all small variations. In practical terms, the number of routes could be considered to be around 250. Mean route length is 21 km. The following figure shows a simplified view of the bus network currently operating in the city of Hyderabad. (A more detailed bus network map has been prepared on a GIS based map using MapInfo software.)

The line thickness reflects the number of trips per hour on any particular route. This number is an approximation and includes all routes which ply on that corridor but have variation of route at either end or both ends.



Simplified Map of Current APSRTC Bus Network in Hyderabad

The figure gives us a fair idea about the principal bus route lines. Assuming that the current routes are fairly well rationalized, then these would be the desire lines of potential mass transit passengers. In the absence of clear data on bus passenger transfers, it is not easy to judge the actual desire lines. **To know the true desire lines for bus passengers, an onboard Bus Passenger Origin-Destination Survey needs to be conducted on a sample size of 10% of the total bus passengers /day.**

The main corridors which become evident from this map are

1) Kukatpalli to Dilsukhnagar (extendable up to LB Nagar)
2) Secunderabad to Charminar
3) Mehdipatnam to Lakdi ka Pul (up to Secunderabad via Tankbund)
4) Ameerpet to Secunderabad

One has to appreciate the fact that these are just sections of corridors which have high bus volumes and high bus passenger loads, but are not complete corridors by themselves. It is the network of all these sections which is more important than each section by itself.

3.2.3 Problems with Bus Services in Hyderabad

The buses used by APSRTC are in reasonable condition by Indian standards but are outmoded by international standards. They are made on a truck chassis and hence have a very high floor height of 1.15m from the ground. Even the first step is nearly 0.4m from ground, which makes access very difficult, particularly for women, children, and the elderly. It is impossible for physically challenged people to use the bus service.

The doors are narrow (approximately 0.5 m), also contributing the difficulty of boarding and alighting. Some new metro express buses have single wide central door (approximately 1.5 m) but these buses are very few in number.

Buses rarely stop at the bus stop because of the vendors, cyclists or from being in a hurry to reach their destination. Hence the passengers are forced to stand in front of the bus stop. Bus stops, where they exist, are in a dilapidated state. Many locations have no bus stops, just a signboard indicating a stop.

Current Hyderabad bus stops are in poor condition, and buses rarely stop there.

3.3 Other modes of motorized transport

3.3.1 Two-wheelers

This is the major motorized mode of transport in Hyderabad, carrying around 30% of trips (if pedestrian and NMV trips are included). The number of two-wheelers is growing very fast. It is interesting to note that there has been a role reversal of usage of bicycle with respect to two-wheelers in the last 10 years. This change is an indication that a bicycle user can shift very easily to a two-wheeler. So, having no incentive for bicycle usage can be indirectly seen as an incentive for two-wheeler usage.

Two-wheelers are very efficient not only in terms of transportation for the individual but also in road space utilization. They also have the advantage of point-to-point service, so that they can provide a total travel time of about half when compared to the current public transport system. They also require relatively limited space for parking.

Nonetheless, many people are not happy with two-wheeler travel due to the pollution and noise they create, the frequent severe accidents, exposure to weather, and operator discomfort over longer distances.

Three-wheeler auto-rickshaws frequently move about without passengers.

3.3.2 Three-wheeler auto-rickshaws

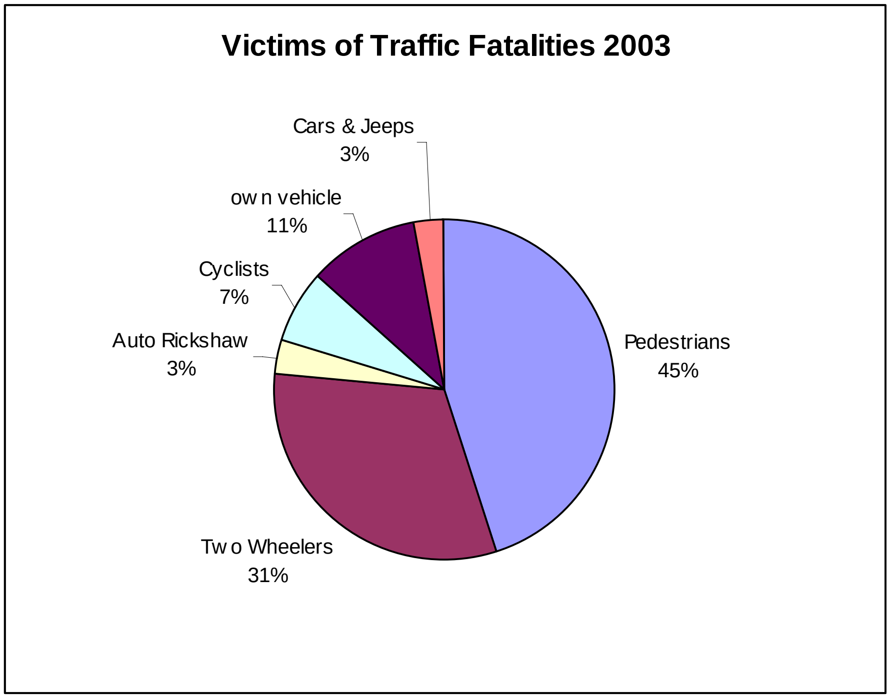
Over 70,000 auto-rickshaws exist in Hyderabad, making them omnipresent on the roads. They have a trip share of 10% in the city. They seem to have about the same efficiency as a western taxi because of the relatively low occupancy of 0.7 passengers/vehicle (not including the driver). A lot of them are seen moving around empty in search of passengers.

3.3.3 Cars

The number of cars in the city, around 185,000, is still not very high compared to other Indian and Asian cities. But the growth rate of cars, almost tripling over the last decade, is the highest in the country.

3.4 Non-Motorized Transport

The most important mode of travel in Hyderabad is walking. Nonetheless, pedestrians and other non-motorized vehicles face an extremely inhospitable walking and cycling environment. Very little attention has been paid to safe and comfortable facilities for pedestrians and other non-motorized vehicles. As a result, road safety is significantly compromised, as is traffic flow.



Traffic Fatality Victims in 2003 by Mode

Accidents and fatalities are extremely high by international standards. Unless careful attention is paid to the design of the walking environment in the BRT corridors, high levels of pedestrian accidents will continue.

Where BRT has been implemented with well designed pedestrian facilities, pedestrian accidents have fallen dramatically. In Bogotá, for example, where corridors with no sidewalks were given sidewalks with a minimum of 4 meters width, ***fatalities in the BRT corridor dropped by 98%.***

Obstructions on sidewalks force pedestrians onto the road.

3.4.1 Walking

This is still by far the largest transport component in the city with nearly 4 million trips a day. Lack of proper facilities for pedestrians is a serious contributor to traffic accidents. Sidewalks are non-existent or very inconvenient at most places, forcing pedestrians to walk in the road, reducing roadway capacity. High curbs, some of them as high as 50 cm, are a deterrent to illegal parking on the sidewalks but are inconvenient for pedestrians. Only 18cm is required to avoid vehicular parking. Where present, sidewalks are blocked by a variety of obstacles including electric transformers, electric and telephone poles, telephone junction boxes, building construction, signboards, trees, parked vehicles, vendors and public urinals.

Width of the side walk varies from under half a meter up to 3 meters at places. General condition is very bad with unpaved patches and large sections in disrepair. It is discontinuous and is frequently cut side-roads.

Sidewalks are mostly non-existent and where they exist it is not possible to use them. This is a very important issue that needs to be addressed for the implementation of a BRT system. Because of the obstructions on the sidewalks and the bad condition of the sidewalks where they exist, most of the pedestrians prefer to use the left most lane of the road. This lane now acts like a pedestrian path, of course, with a lot of conflict. To avoid conflict, motorized vehicular traffic tends to use the right lane (center of the road) for a given direction. **If a BRT system (with central lane) is implemented, the rest of the motorized traffic would be forced to use the left lane which is now used by the pedestrians.** This would cause a sudden increase in conflict, stress and discomfort for all road space users and will certainly cause a rise in accidents.

Obstructed sidewalks forcing pedestrians to consume a full lane of mixed traffic.

With relatively few signalized intersections and a lot of one-way movements (which increases the total throughput), crossing a road is both extremely difficult and dangerous for pedestrians. Often people have to wait nearly fifteen minutes to cross to the other side of the road. Zebra crossings are not respected, and at signalized intersections high-speed free left turns are allowed, so there is no time when pedestrians can cross safely.

Curbs over 18 cm are very inconvenient for pedestrians.

There are a few dedicated pedestrian signals, but they work very poorly and are frequently unsafe for pedestrians. The traffic keeps moving for up to 15 seconds after the signal turns red. The time left for the pedestrian to cross can be as little as 5 seconds before the traffic signal turns green, thus leaving the pedestrian stranded in the middle of the road.

Current efforts are underway to pedestrianize or partially pedestrianize the Charminar area in the historical city center.

3.4.2 Bicycling and Cycle Rickshaws

Cycle rickshaws are decreasing in Hyderabad, but provide non-polluting transport for short trips.

Over the last decade, the mode share of bicycles and cycle rickshaws dropped from 30% of total trips to 9%, while the mode share of two-wheelers increased to 30% of total trips. While two-wheelers and motorized rickshaws have some benefits (speed), they also generate a lot more pollution, are a greater danger to pedestrians and the driver/passenger, the vehicles cost more for the users, and the use of the vehicle does not confer any aerobic health benefit to the operator. Preserving and expanding the role of non-polluting non-motorized vehicles for short distance trips in Hyderabad should be considered. Including cycling facilities on any new right of way should be considered along with efforts to modernize the traditional cycle rickshaw.

Traditional Cycle Rickshaws continue to operate in Hyderabad's historical center but have been displaced elsewhere by motor rickshaws.

3.5 Parking

A system of prepaid annual parking fees in Hyderabad is severely underpriced.

There are numerous illegally and legally parked vehicles along the roadways. At parking lots, where they exist, enforcement is slightly better but still a major cause of concern. A parking fee is imposed in private parking lots and some run by the MCH, but it is not controlled at most places in the city.

The parking fee itself is highly under-priced. The annual fee for a prepaid parking card for all MCH parking is 220 rupees for a four-wheeler and 120 rupees for a two-wheeler. Single parking fee is 10 rupees for a four-wheeler and 5 rupees for a two-wheeler.

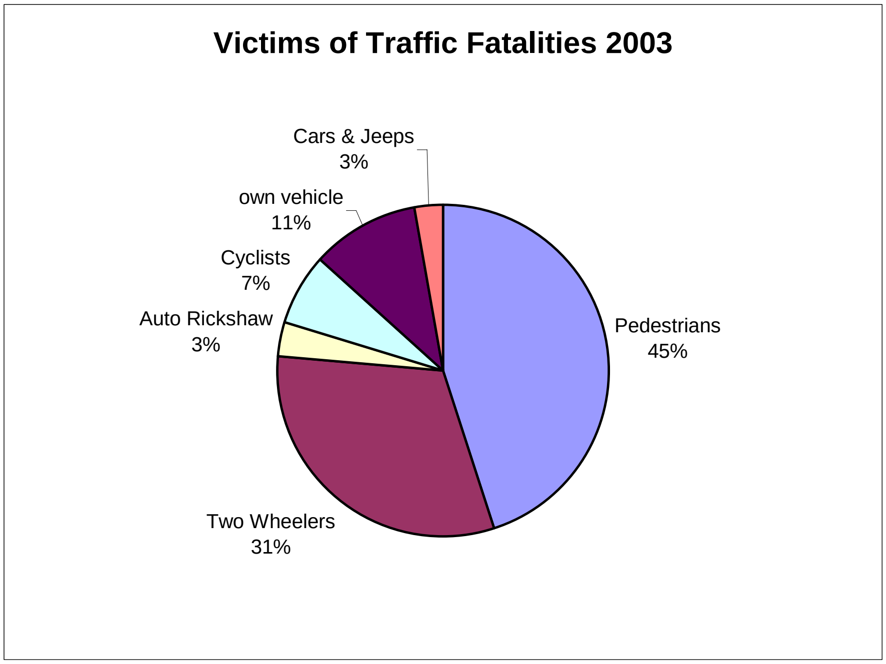
3.6 Safety and Traffic Enforcement

We gathered information on traffic collisions from Traffic Police for the years 2000 – 2004 and have completed our analysis to understand the trends for the last 3 years (2002-2004).

Traffic Collisions, Fatalities and Injuries in Hyderabad

YEAR	NO. OF COLLISIONS	NO. OF FATALITIES	NO. OF PERSONS INJURED
2004	3,525	419	3,741
2003	3,427	451	3,373
2002	3,039	411	3,115
2001	2,618	405	2,841
2000	2,492	425	2,422

For the last three years most of the accident victims (both fatal & injury) have been young people in the 20 – 30 years age group (approximately 30-35%).Almost 80% of all collision victims are male –generally the sole earning members of their families in a developing country like India.



Pedestrians and two-wheeler riders were the most vulnerable in all road deaths. The top three accident prone areas in Hyderabad, based on the occurrence during the last three years are:

1. Masab Tank - Road no. 12, Banjara Hills
2. KBR Park – Jubilee Hills Check Post
3. Punjagutta – Ameerpet area

If we talk about the Dilsukhnagar to Kukatpalli corridor (the 1st BRT corridor), it has the highest number of traffic accidents on any corridor in the city. The last three years data reveal that 1st BRT corridor accounts for around 20% of total traffic accidents and fatalities in Hyderabad city. In the year 2004 there were 573 accidents, 53 fatalities (35 pedestrians) and 612 injuries on this corridor. In 2003 the numbers were 650 accidents, 69 fatalities (34 pedestrians) and 634 injuries. In 2002 the corridor witnessed 551 accidents, 56 deaths and 580 injuries.

Near Charminar in the old city area there were 38 accidents, 3 deaths (2 pedestrians) and 39 injuries (21 pedestrians) in 2004. In 2003 the tally was 33 accidents, 5 fatalities (4 pedestrians) and 28 injuries (14 pedestrians).

The city does not have a mandatory helmet rule for two-wheeler riders. The helmet rule which was introduced by traffic police from November 3, 2004 was immediately withdrawn by the state Government under political pressure.

Lack of respect for rules and low enforcement are major issues of concern. Even though the traffic police are trying to improve conditions, they are understaffed. The traffic movement therefore is uncontrolled at most places with a very high rate of traffic infractions. A motorist is not punished unless caught breaking the rules on site. The license plate is for most practical purposes not useful for imposing fines though mail.

If lack of obedience continues with little or no enforcement, there is a high risk that any BRT lane implemented will be compromised by mixed traffic entering the lane. **Physical lane separators will be absolutely essential, but not sufficient. Police enforcement of the BRT right-of-way will be needed in addition to separators, especially at intersections, where physical separators are not possible.**

3.7 Transport and Air Quality

The prevalence of two- and three-wheelers in Hyderabad has led to a rapid increase in air pollution, particularly suspended particulate matter, or SPM. SPM is one of the leading causes of upper-respiratory disease. There is no healthy level of SPM, but an acceptable standard by the World Health Organization is 30 mgm/m^3. Hyderabad is more than 20 times above this standard, resulting in thousands of pre-mature deaths each year. Adopting Delhi-style CNG conversion for three-wheelers will help, but it will do little for the SPM being generated by two-wheelers. Attracting passenger trips away from two-wheelers and onto cleaner buses is therefore critical.

Suspended Particulate Matter in Hyderabad and other Asian cities (micrograms/m3)

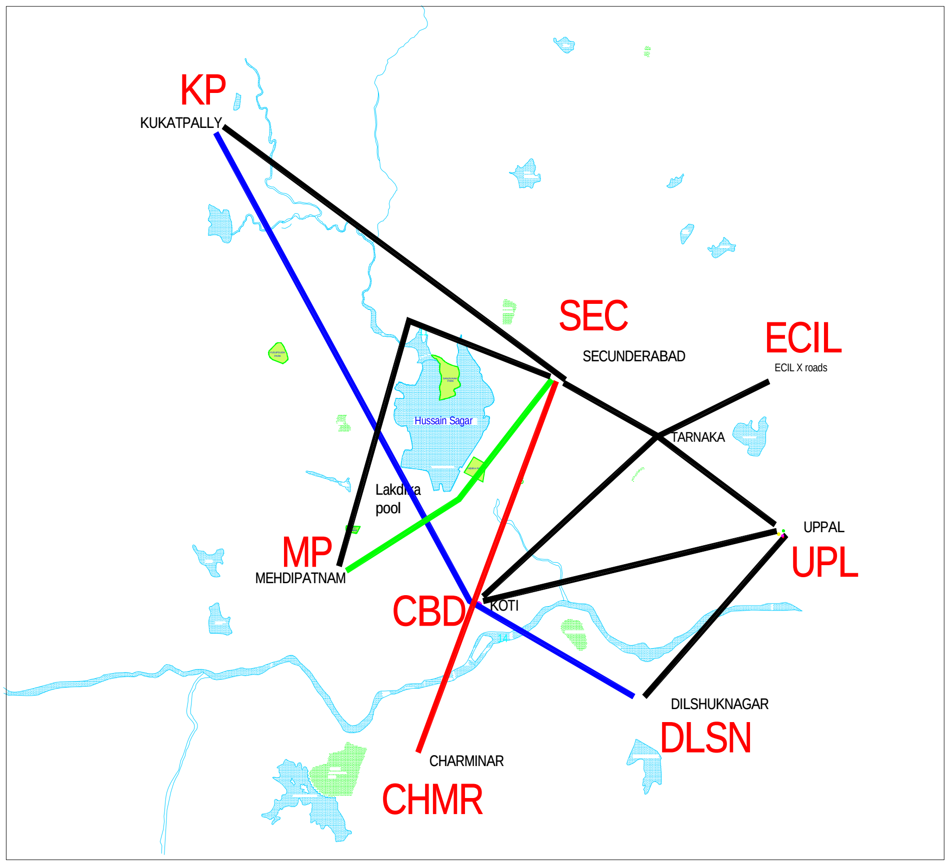
City	SPM (Micrograms / m3)
Hyderabad:	700
Delhi:	340
Chongqing:	250
Jakarta:	250
Kolkata:	230
Mumbai:	220
Shanghai:	170
Manila:	150
Tokyo:	40
Singapore:	30

One of the most important factors in long-term emission reduction from the transportation sector is the modal split. Road-based transport systems that attempt to reduce emissions by increasing vehicle speed – as have been developed in many U.S. cities, such as Los Angeles – create both incentives and necessity for use of private motorized vehicles. Even a very low emission motorized vehicle with 2 or fewer passengers has much higher emissions per passenger than a mass transit vehicle carrying 20-90 times as many passengers. For this reason, Los Angeles, which has the most stringent vehicle emission requirements in the world, continues to suffer from unhealthy pollution levels caused by private vehicle emissions. Los Angeles does not suffer from the particulates that currently plague Hyderabad, but from other emissions – primarily resulting in ground-level ozone – that are much harder to eliminate. For this reason, retaining and increasing public transit modal share is the most effective way for Hyderabad to improve its air quality in both the short and long term.

4 Public Transit Demand Analysis for Hyderabad

4.1 Analysis of Existing Public Transit Demand on the Network

Determining whether and what sort of a mass transit system is appropriate for Hyderabad should begin with a careful estimate of the projected demand on different possible mass transit corridors. This begins with an evaluation of existing public transit demand.



Mass transit demand analysis for Principal Origin-Destination (OD) nodes

For the purpose of preliminary mass transit demand analysis, the city has been simplified into 8 principal nodes. These nodes (see map, previous page) are:

- Kukatpalli (KP)
- Secunderabad Station (SEC)
- Taranka - ECIL X roads (ECIL)
- Uppal (UPL)
- Dilsukhnagar - L B Nagar (DLSN)
- Charminar (CHMR)

- o Mehdipatnam (MP)
- o Koti - Abids (CBD)

The following table shows the estimate of morning peak hour demand between different nodes. This in not the total demand for revenue projection purposes, but the load of passengers on bus trips between these points that should reflect present passenger movement. ***This estimate of demand is important for the physical design of the system's capacity.***

Matrix of estimated passenger demand for mass transit in Hyderabad

Location	Node description	Node	KP	SEC	ECIL	UPL	DLSN	CHMR	MP	CBD	Total
Northwest	Kukatpalli	**KP**		5.6		1.6	2.0	3.0	1.6	5.0	18.8
North	Secunderabad Stn.	**SEC**	5.6			1.3	2.2	4.0	1.5 +2.1	2.6	19.4
Northeast	Tarnaka (extending up to ECIL X roads)	**ECIL**							0.9	1.9	2.8
East	Uppal	**UPL**	1.6	1.3				0.7		1.3	4.9
Southeast	L B Nagar	**DLSN**	2.0	2.2				1.1	0.6	2.2	8.1
South	Charminar	**CHMR**	3.0	4.0		0.7	1.1				8.8
Southwest	Mehdipatnam (extending up to Tollichowki)	**MP**	1.6	1.5 +2.1	0.9		0.6			2.0	8.8
Center	Koti –Abids	**CBD**	5.0	2.6	1.9	1.3	2.2		2.0		15.1
Total			18.8	19.4	2.8	4.9	8.1	8.8	8.8	15.1	86.7

Note: Underlined values do not pass through the city center (Koti – Abids) and go through alternate routes. Values are in thousand passengers/hr/dir

The table excludes flows to and from some corridors, so it does not represent the total matrix of Hyderabad. It is a best estimate for a mass transit network from available data. With these values, we can estimate the corridor volumes for successive steps of implementation on the first 3 corridors. The principal corridors which have been chosen from this analysis are

1) BRT Corridor I - Kukatpalli to Dilsukhnagar
2) BRT Corridor II - Secunderabad Stn to Charminar
3) BRT Corridor III - Mehdipatnam to Lakdi ka Pul section joining the fist corridor at Lakdi ka Pul

Using available data supplemented with new traffic counts and bus occupancy surveys in Corridor I, we can get an estimate for existing mass transit demand in the corridor within a range of +/- 20%. Existing data includes a 5000 household Origin and Destination survey conducted by L & T Ramboll for their January 2004 report: "Development of Hyderabad Multi Modal Suburban Commuter Transportation System on Commercial Format"; and bus passenger ridership data from APSRTC. This was supplemented by traffic counts and bus occupancy surveys conducted by ITDP in Corridor I. To get a more exact estimate would require an on-board bus passenger origin destination survey (min. 150,000 surveys, max 300,000), and a fully calibrated traffic model.

This data indicates that only about 40% of the passengers using Corridor I have trips both originating and ending within the catchment area of Corridor I. The rest of the public transit passengers using Corridor I are just passing through the corridor on the way to some point not directly on the corridor.

This means that ***for any 'closed' mass transit system, like a metro, monorail, or closed BRT system, in order to service much of the public transit demand in the corridor a network of integrated buses feeding the corridor will be required.***

Contribution to total demand on Corridor I from integration with buses on Corridor II and III (in thousands of pphpd)

Phase	Corridor section > Corridors implemented	KP-CBD (C-I)	SEC-CBD (C-II)	DLSN-CBD (C-I)	CHMR –CBD (C-II)	MP-CBD (C-III)	Total System Demand (Pax/day)	Required Fleet (Articulated bus equivalents)
1	Corridor I w/out Integration w/ Corridor II & III	7.0		4.2			207 000	109
2	Corridor I integrated w/ Corridor II only	10.0	8.9	7.5	8.1		572 000	251
3	Corridor I w/ integration on Corridor II and III	11.6	10.4	8.1	8.1	5.8	686 000	313
4	Demand on Corr. I w/ full integration	11.6		8.1			307,000	

Note: C-I, C-II and C-III represent Corridors I, II, and III. Represents only BRT passengers and does not include all bus passengers. The fleet includes feeder services converted into articulated bus equivalent. Ratio of peak period one-way trips to full day trips = 1:13, rotation of passenger on and off buses in corridor 1.5. Adjustment to avoid double counting: 1: *.95, 2: *.85, 3 & 4: *.8.

Looking just at Corridor I, with feeder buses at the terminals ***but with no integrated bus services operating on Corridor II and Corridor III, the maximum load on the critical link would be about 7000 pphpd. This is 10,500 pphpd dynamic demand.*** The maximum critical load tells you how many passengers will be passing through the corridor on public transit at any given point during the peak period. The total passengers being served by the corridor, or dynamic demand, will be higher because passengers are getting on and off the buses all along the corridor. The remainder of the existing bus passengers (an additional 5000 pphpd or so) will prefer to continue using existing bus lines in the corridor, if they continue to operate.

As can be seen from the table above, the ***maximum load on the critical link*** (static demand) if all public transit passengers using Corridor I are counted would be around ***11,600 pphpd on the segment portion north of the CBD*** and around 8100 on the segment south of the CBD. We estimate that the passenger rotation ratio (accounts for passengers getting on and off) is about 1.5, so the projected maximum passenger trips is 17,400 pphpd, very close to the municipality's estimate.

Converting this maximum demand figure to a daily demand figure, to project the financial feasibility of the project, requires an assessment of the degree to which demand in Hyderabad is concentrated at the peak period or spread out evenly. In Hyderabad, ***the demand is spread out over a very long peak (three to four hours in both the morning and afternoon) and traffic flows are heavy in both directions. This is very good news as it indicates the system will be highly efficient.***

We estimate that ***daily demand on Corridor I should be around 307,000*** passengers, and a total system capturing all of the existing demand in Corridors I, II, and III should have a ***daily demand around 686,000*** (including integrated bus services on Corridors II and III). This figure was calculated by multiplying the maximum critical load pphpd times 13 (our calculation of the ratio of peak-period one-way trips to full-day two-way trips), then again by 1.5 (passengers getting on and off buses within the corridors), and then reducing this by a declining factor (.95%, .85%, .8%) to avoid double counting of passengers who are actually transferring when they are getting on and off. We believe this estimate to be accurate +/-20%.

According to the Municipal Corporation of Hyderabad, Corridor I currently carries some 40,000 to 50,000 peak period pphpd, of which some 34% of the trips are carried by bus. The Municipality therefore believes that current bus passengers in the corridor could be as high as 17,000 pphpd. If this represents dynamic demand on the buses, we believe this figure to be reasonably accurate.

Nevertheless, given the uncertainty***, our feasibility assessment will consider existing maximum load on the critical link to be anywhere between 10,000 pphpd and 15,000 pphpd in Corridor I. This figure will be used for the physical design process.***

The projected demand on the second corridor (SEC-CHMR) alone would be just a little weaker than the first (KP-DLSN) alone. The third corridor (MP-CBD) alone would have negligible demand.

Demand on Corridor II and III independent of Corridor I

Corridor	Corridor section > Corridors implemented	KP-CBD (C-I)	SEC-CBD (C-II)	EC-IL-CBD	UPL-CBD	DLSN-CBD (C-I)	CHMR-CBD (C-II)	MP-CBD
II alone	SEC-CHMR		6.1				4.0	
III alone	MP-CBD							2.0

Note: Corridor I is C-I and Corridor I is C-II. Figures are 1000 passengers/hr/dir. Represents only BRT passengers and does not include all bus passengers.

Other possible corridors could be:

- Kukatpalli to Charminar
- Kukatpalli to Mehdipatnam
- Secunderabad to Dilsukhnagar
- Secunderabad to Mehdipatnam
- Dilsukhnagar to Charminar
- Dilsukhnagar to Mehdipatnam

The demand on these alternative corridors is given in the following table.

Demand on additional alternative corridors

Corridor section > Corridors implemented	KP-CBD	SEC-CBD	EC-IL-CBD	UPL-CBD	DLSN-CBD	CHMR-CBD	MP-CBD
(KP-CHMR)	8.0					3.0	
(KP-MP)	6.6						3.6
(SEC-DLSN)		4.3			4.4		
(SEC-MP)		3.6					3.6
(DLSN-CHMR)					3.3	1.1	
(DLSN-MP)					2.9		2.7

Of these alternative corridors, the first three have potential based purely on preliminary demand estimates. We therefore concur with the decision of the Hyderabad Municipal Corporation to select the Kukatpalli -Dilsukhnagar corridor as Corridor I. The reasons for this have to do with the level of demand and the availability of right-of-way, as will be discussed in the next section.

4.2 Baseline Scenario for Future Public Transit Demand

Some prediction can be made regarding the likelihood that transit demand in general and in the corridor will grow over time, with and without the construction of a mass transit system. In all demand estimates, the prudent course is to use high demand projections for designing public transit system capacity, and low demand projections for estimating revenue obtainable from the system. This ensures the system can meet future demands, and reduces the risk the city will be forced to financially subsidize a system if ridership is below projections.

Future demand has two elements:

- **Baseline Scenario: change in public transit ridership that will result regardless of whether or not a new mass transit system is built.** This will largely be a factor of long-term economic and demographic changes in the corridor, and is normally estimated by reference to historical trends, and
- **Mass Transit Scenarios: changes in public transit ridership resulting from the implementation of new mass transit systems.**

If a new mass transit system is built, it will affect the generalized costs (travel time and out of pocket expenditures) of public transit vis-à-vis other travel modes, and as such can result in some shift between modes. Predicting the modal shift impacts of a new mass transit system requires developing a scenario for a new mass transit system in order to model the effects on a) total door-to-door travel time by mode, b) total door-to-door travel cost by mode, and c) comfort, convenience and safety of traveling by mode.

Future demand projections should start with historical trends. Bus trips have remained fairly steady at around 3 million trips per day since 1996, falling slightly in recent years to around 2.8 million trips per day (APSRTC, 2004). Therefore, if no new mass transit system is built, we can expect public transit ridership to remain constant or face modest declines. As population continues to grow, this means that transit would lose mode share if nothing is done.

During the 1990s, the population of Hyderabad increased by 36%. Thus, most of the growth in total trips has been captured by motorized 3-wheelers, 2-wheelers, and private cars. ***There is no current trend towards increasing public transit use, but a modest decline.***

Corridor I originates in Kukatpalli Municipality, passes through the center of the Municipal Corporation of Hyderabad (MCH), then approaches the boundary of LB Nagar Municipality. Corridor II begins in Secunderabad Cantonment Board Area, passes through the MCH, and terminates before it reaches the Rajendra Nagar Municipality. Corridor III begins in the city center and also terminates before it reaches Rajendra Nagar Municipality.

Historic Population and Density Levels in Hyderabad Urban Development Area

		1981		1991		2001		2003	
	Area	**Population**		**Population**		**Population**		**Population**	
Components	sq km	million	Per ha	Million	Per ha	million	Per ha	million	Per ha
MCH	172.6	2.15	124.6	3.04	176.4	3.63	210.5	3.77	218.4
Municipalities	418.6	0.39	9.2	1.00	23.8	1.72	41.0	2.10	50.2
SCB	40.2	0.14	33.9	0.17	42.8	0.20	50.8	0.20	48.5
Other Parts	1273.7	0.32	2.5	0.45	3.6	0.83	6.5	0.98	7.7
HUDA Total	1905.0	2.99	15.7	4.67	24.5	6.38	33.5	7.05	37.0

Historic Population Growth Rates in Hyderabad Urban Development Area

		Decadal Growth Rate	
		1981-1991	**1991-2001**
MCH	HUA 2001	42%	19%
10 municipalities	HUA 2001	158%	72%
SCB	HUA 2001	26%	19%
13 outgrowths	HUA 2001	44%	43%
5 Census Towns	HUA 2001	68%	27%
Medchal, Gandipet	Outside	33%	109%
Etc., panchayat areas & Ghatkesar CT	HUA 2001		
HUDA area (TOTAL)		**56%**	**37%**

Source: Draft Master Plan for Hyderabad Metropolitan Area – 2020

Population and employment in the Hyderabad metropolitan area remain highly concentrated in the MCH. Density in the city center is 219 people per hectare compared to 53 people per hectare in the surrounding municipalities. While some densification is still occurring in the city center, the population density in the MCH is already quite high by international standards, and the existing roads in this corridor are nearing their capacity. Meanwhile, densities are rising extremely rapidly in the surrounding municipalities.

The share of the total population of metropolitan Hyderabad concentrated in the MCH has fallen from 72% in 1981 to 65% in 1991 to only 57% in 2001. The population in the MCH and Secunderabad Cantonment grew by only 20% over the last decade, compared to 72% in the surrounding municipalities, most of which are not served by Corridor I.

Given the combined trends of increasing private motor vehicle use, the dispersal of population out of the city center, the lack of available road capacity in the city center, and the lack of land in the center available for development, we can expect these trends to continue or accelerate if no interventions are made. Corridor I primarily serves trips either originating or ending in the MCH; an escalation in population and employment increase in the corridor is unlikely. The effect of these factors on public transit ridership is being exacerbated by the rapid growth of private vehicle use in the corridor, particularly two-wheelers. We believe that from a design perspective ***a safe range for the projected 'do nothing' scenario for public transit ridership growth in Corridor I is a range from 0% to 30% over the next decade, with 30% over the next two decades a reasonable estimate. From a financial perspective a 0% baseline growth scenario is the safe assumption***

4.3 Modal Shift Impact of Mass Transit Systems

A new mass transit system will have different modal shift impacts in a specific corridor and for the city overall. A mass transit system that is most likely to shift modal share towards public transit citywide would have the following characteristics:

1. It would decrease door-to-door travel times for as many public transit passengers as possible in the shortest time frame.
2. It would reduce door-to-door travel costs for as many public transit passengers as possible in the shortest time frame.

As personal incomes increase, the shift toward private motorized vehicles can be seen in cities throughout the world, and also in Hyderabad. In these circumstances, even maintaining the total number of public transit trips is difficult. Given population growth, the total number of public transit trips must increase to maintain mode share. Increasing mode share is more difficult.

In the table below, we have compiled data on the modal share of public transit trips before and after either metro systems or BRT systems have been built. The data shows that system-wide, ***BRT systems have marginally increased public transit mode share***. By contrast, ***metro systems have not been able to reverse declining public transit mode share***, and in some cases have hastened the decline of public transit mode share. There are no monorails to our knowledge carrying a large enough number of passengers to have a significant influence on transit mode share.

Public Transit Modal Split Before and After BRT and Metro Construction

City	% of Trips Before	% of Trips After
Metro Systems		
Mexico City	80	72
Buenos Aires	49	33
Bangkok	39	35
Kuala Lumpur	34	19
Santiago	56	33
Warsaw	80	53
Sao Paulo	46	33
Tokyo	65	48
Seoul	81	63
BRT Systems		
Bogotá	53	56
Curitiba	74	76
Quito	76	77

Sources: OTP (2003), Xu, K. (2004), Vasconcellos, E. (2001), SETRAVI (2003), Ciudad Viva (2003), WBCSD 2001, Barter 1999, Kuala Lumpur Draft Master Plan 2003, National Transport Secretariat of Argentina 2001, TransMilenio SA, Bogotá, 2002. URBS, Curitiba, 2004;

Curitiba ***maintained*** a modal split over 70% of trips from 1974 until 1994, though now it has dropped to below 60%. Bogotá's TransMilenio increased public transit mode share from 53% to 56% between 2000 and 2004. (TransMilenio SA, 2003: URBS, 2003).

Within a specific corridor, under very high demand conditions, a metro or monorail system could increase modal share for public transit more than could be achieved by a BRT system. However, these corridor specific effects tend to be outweighed by system-wide effects.

The reasons for these system-wide effects are:

1. Metro systems take longer to build and cost more to build than BRT systems. All but two metro systems (Hong Kong and part of Sao Paulo) require ongoing operating subsidies. These ongoing budget constraints get more pronounced as the system expands. The cost and complexity of engineering have historically made it ***impossible to expand the catchment areas of metro systems faster than the rate of urban population dispersal***.
2. Metros must charge ***higher fares*** to cover their operating costs (especially substantial if depreciation is included). This in turn shifts some passengers to take competing modes. The relocation of transit traffic off the surface streets also increases mixed traffic vehicle speeds, which tends to attract people to private motor vehicles.
3. Metros often require the cutting of former bus lines that would compete with the new system. The result is that a lot of passengers will now have to ***transfer*** that before did not. Thus, particularly for short and new systems, ***metros actually increase rather than decrease door-to-door travel time*** for a large number of transit passengers, encouraging them to shift to other modes.

The problems with metro systems listed above also hold true for monorail systems and light rail systems.

Therefore, at the city wide level, ***metro systems and monorail systems usually have no net effect on aggregate trends in public transit modal split. BRT systems can stabilize and increase public transit mode share if their catchment area expands as rapidly as urban de-concentration, and their fares are competitive with existing luxury bus services.***

Neither the LT Ramboll study nor the DMRC study take heed of this cautious approach to future demand estimates. LT Ramboll used 'stated preference' surveys to estimate future public transit mode share. In this methodology, a thousand people were interviewed and asked whether they would be willing to switch to a modern light rail system if one existed. Stated preference surveys can yield useful information for demand projections and modal split. However, ***unless the stated preference survey asks people a question about a very specific mass transit proposal, complete with fare prices, precise location of the stations, and operating speeds, the information generated is not reliable.***

In the case of LT Ramboll (2004), the only information provided about the survey question is as follows:

> "The opinion survey data was analyzed with respect to the willingness to shift to mass transport with respect to the distance traveled. The shift from the present mode of travel to the proposed transit mode were found out as per stated preference."

Because 60% of those surveyed said under certain conditions they would be willing to switch to mass transit, ***LT Ramboll simply assumed that in 20 years mass transit demand would increase from the current 24% to 60%.*** As the actual mass transit system that might actually be in place in 20 years was not clearly specified, this conclusion is unfounded.

L & T Ramboll then simply inserted a future demand of 60% of total trips into its traffic model. ***In other words, the growth in transit mode share was simply assumed, and inserted into their traffic model: it was not the result of a detailed multi-modal demand model analysis.***

The DMRC (2004) study assumes that modal shift will occur if a metro is built, without providing justification. The DRMC study reads as follows:

"4.6 Modal Split

The observed modal split between public, private and IPT transport are 45:45:10. With introduction of Metro, the modal split in favor of public transport is assumed to be 65% by the year 2011 and 70% by 2021."

The DMRC simply assumed that mode share would increase to 70% if a metro system is built. They have provided no basis for this assumption, and world experience with metros does not support it.

Metro proposals worldwide have frequently predicted much higher demand levels and modal shift impacts than actually materialize. The proposals also frequently underestimate the cost of metro systems. According to the World Bank (Allport, 2000), the accuracy of Metro forecasts is extremely poor:

"Accuracy of Forecasts
The review of available research has highlighted unambiguously the poor record of forecasting the main financial parameters – capital cost, construction time, operating costs and ridership/revenues. It has also demonstrated that this is not confined to developing cities – the US experience mirrors that in developing experience, and is reinforced by much other developed country evidence."

Data from the US shows this trend to exaggerate the demand on metro systems. After completion, actual demand has been 28% to 85% lower than projections. Internationally, the level of exaggeration is higher.

Key Results of the USA UMTA Study

City / Project	Route-KMs	Weekday Ridership Forecast Vs. Actual	Annual Operating cost forecast Vs. actual	Capital cost forecast vs. actual
Metros				
Washington DC	97	-28%	+202%	+156%
Atlanta	43	Not known	+205%	+132%
Baltimore	12	-59%	Not known	+95%
Miami	34	-85%	+42%	+31%
Light Rail				
Buffalo	10	-68%	+12%	+59%
Pittsburgh	17	-66%	Not known	Not known
Portland	24	-54%	+45%	+28%
Sacramento	29	-71%	-10%	+17%

Source: UMTA, 1990

To develop more accurate estimates of modal shift and future total demand in Corridor I, the details of different scenarios need to be carefully specified. In order to provide some comparison, plausible scenarios for DMRC's metro proposal, a tentative monorail proposal, and BRT are reviewed.

4.4 Estimating Modal Shift and Demand for Mass Transit System Scenarios in Hyderabad

Regardless of the actual existing and projected aggregate transit trip demand in the corridor, it cannot be assumed that a new mass transit system will automatically capture all of this existing or future demand. A new mass transit system can depress total demand even within a specific corridor if it:

- Forces bus passengers to transfer. Causing passengers to wait twice increases door to door travel time
- Forces people to pay twice when transferring from their normal bus to the new mass transit system,
- Increases the distance between stations, increasing walking time and possibly door-to-door travel time
- Increases the fare price

These negative effects have to be considered when estimating modal shift impacts of a new mass transit system. The primary positive effects of new mass transit is faster vehicle speeds and, to a lesser extent, greater passenger comfort.

4.4.1 Network Effects in Hyderabad

Whether or not the positive modal shift impacts of faster on-board travel speeds outweigh the negative impacts on demand of higher fares, higher transfer costs, increased transfer times, and increased walking times, depends on the specific proposal.

In Corridor I in Hyderabad, ***only about 40% of the passengers are both beginning and ending their trip directly along Corridor I.*** The rest of the passengers are using the Corridor for only a part of their journey. Many existing bus lines take Corridor I to other destinations.

As a result, ***any 'closed' mass transit system built in the corridor will face stiff competition from existing bus lines unless these lines are cut***. If some existing bus lines are allowed to continue to operate in the corridor, most passengers with origins and destinations not immediately adjacent to Corridor I will refuse to switch from their existing buses onto the new BRT, metro, or monorail system. As a result, ***the actual demand on the new mass transit system may be much less than the total transit demand in the corridor***.

Below are demand estimates for three mass transit scenarios. All of the scenarios assume the following:

- There are feeder buses to the terminals and some intermediate points on Corridor I
- At least 60% of the competing bus lines in Corridor I are cut

Demand Variation by Corridor Integration

	pphpd	Corr I Daily	Tot. System Daily
Corridor I, Feeders at Terminals, No integration	7,000	207,000	207,000
Corridor I, Feeders at Terminals, Free Integration w/ Corr II	10,000	290,062	572,000
Corridor I, Feeders at Terminals, Free Int. w/Corr II and III	11,600	307,000	686,000

If some provision for free transfer is not made between Corridors II and III, and normal buses serving trips which use Corridor II and III for part of their journey are allowed to continue to operate on Corridor I, the demand on Corridor I will only be about 7000 pphpd, or 207,000 daily passengers.

If free transfer is made for buses feeding Corridor I from Corridor II, but not Corridor III, demand will rise to 10,000 pphpd and 290,000 daily. If free transfer is made for buses feeding Corridor II and Corridor III, demand will rise to some 11,600 pphpd or 307,000 daily passengers.

If free transfer is made for buses feeding Corridor I from Corridor II, but not Corridor III, demand will rise to 10000 pphpd and 290,000 daily. If free transfer is made for buses feeding Corridor II and Corridor III, demand will rise to some 11600 pphpd or 307000 daily passengers.

Therefore, if Hyderabad decides to build ***any 'closed' type of mass transit,*** whether light rail, monorail, metro, or 'closed' BRT (of the style of Bogotá, Quito, or Curitiba), it ***will have to provide a system of feeder buses with discounted or free transfer or else there is a significant risk that public transit mode share could actually decline as a result of the new system.***

This is no idle risk. According to a survey of Metro systems around the world (Allport, World Bank, 2000), ***out of 15 metro systems, 14 planned to cut competing bus routes, but only 3 actually cut competing bus routes.*** This frequently proves to be impossible due to public outcry about cutting existing low cost bus lines.

Similarly, with feeder buses, 14 planned to create a system of feeder buses, but only 6 actually set them up, and 3 were in the process of setting them up. This frequently proves difficult because private operators are unwilling to shift their operations from long distance line haul services to short distance feeder services. Another 7 planned to have integrated ticketing systems, but only 3 actually set up integrated ticketing systems, and another is in process.

Record of Implementation of Metro Integration Measures

	Number of Cities	
Form of Integration Measure	**Planned**	**Implemented**
Removal of competing bus routes	14 – 15	3
New feeder bus routes	14	6 – 9
Integrated fares	7	3 – 4

Source: Allport, World Bank, 2000

Therefore, ***there is a significant risk that it will prove to be politically impossible to cut bus lines and create feeder bus lines, and hence demand will be significantly lower than the above estimate.***

4.4.2 Travel Cost Effects

Another factor influencing demand in the corridor is the ***fare price.*** The elasticity of demand will be heavily affected by whether or not competing bus lines and para-transit services are cut in the corridor.

According to the DMRC, the elasticity of demand for public transit shows that for every 25% increase in the price of public transit, demand for public transit drops 12.5%. Demand will therefore vary by the fare price according to the table below. The chart assumes all directly competing mass transit services are removed (80% of the lines in Corridor I).

Demand Projections Varying by Fare Increase

Fare Increase:	0%	25%	50%	75%	100%
Daily	595,920	521,430	446,940	372,450	297,960
Corridor I	11,600	10,150	8,700	7,250	5,800
Corridor II	10,400	9,100	7,800	6,500	5,200
Corridor III	5,800	5,075	4,350	3,625	2,900

If competing mass transit services are not removed, the total demand for the new system would be lower but total mass transit ridership would be higher.

Therefore, it is critical that ***MCH avoid, to the extent possible, having a new mass transit system significantly increase the transit fares paid by existing transit passengers.***

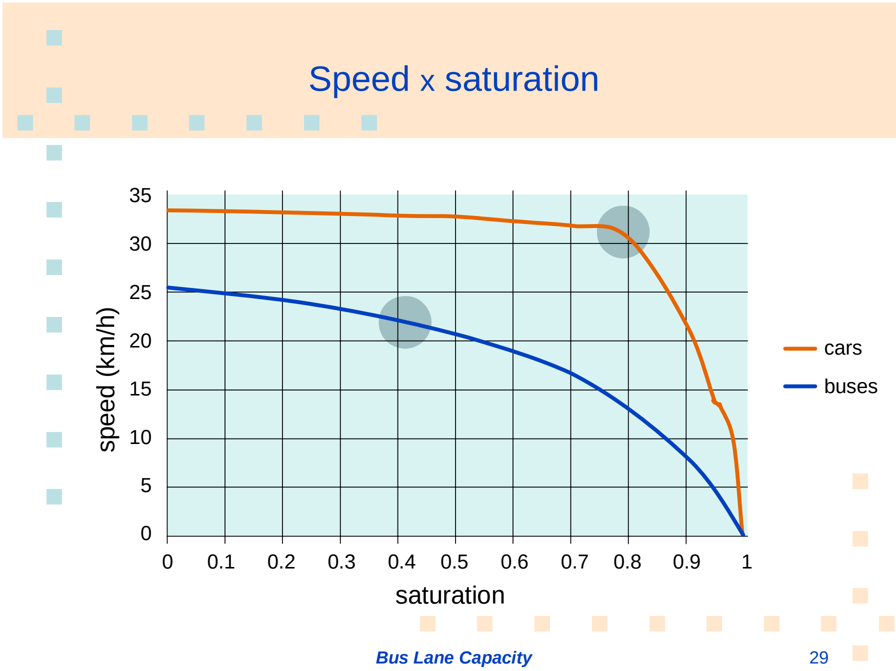
4.4.3 Travel time effects

Adverse impacts on demand from increased fare costs will be compensated to some degree by increased travel speeds and improved passenger comfort. The most critical factors for potential public transit users will be cost and door-to-door travel times. Door-to-door travel time is a function of:

- Distance from origin and destination to nearest station, a function of system coverage and distance between stations
- Headway (time between vehicles) of mass transit
- Potential new mass transit speeds in the corridor
- Transfer times

Current bus speeds in the corridor are reasonably high by international standards, at between 18 km/h and 20 km/h even during the peak hours. At some locations, however, they drop to around 12 km/h. As congestion worsens, therefore, existing bus operating speeds will decline significantly.

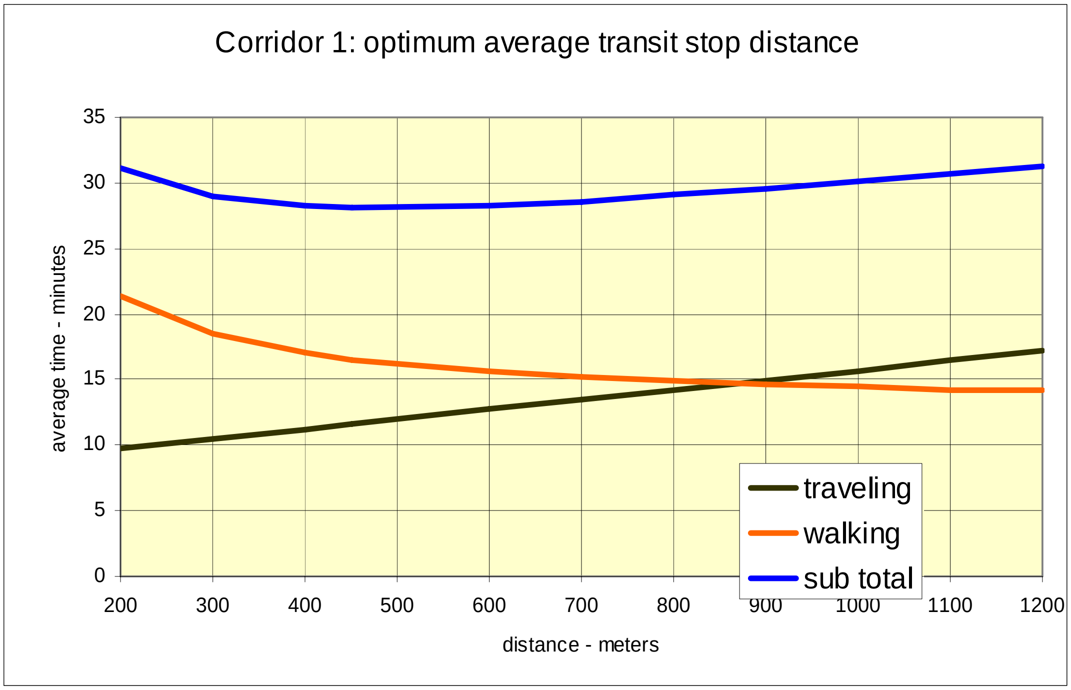
It cannot be assumed that any busway system will increase bus speeds in the corridor. With current bus flows in the corridor, simply restricting these existing buses to a physically segregated single lane bus lane would actually reduce bus speeds from current levels. The problem with an 'open busway' scenario in this corridor is that if demand rises to 17,400 as projected, this would be some 250 buses per hour or more. A single lane bus lane begins to congest at over 70 buses per hour. ***Because an open busway would either have very slow operating speeds and badly congest the mixed traffic lanes, or would require a lot more expensive land*** appropriation***, an 'open' BRT system of the Delhi or Taipei type is not advisable in this corridor.***



Bus vs. Car Systems Average Speed as Approaching Road / Lane Capacity

For any 'closed' trunk and feeder mass transit system, the travel time benefit resulting from the higher operating speed of the new system is reduced by additional time lost waiting, as passengers are now going to have to transfer. This transfer time will be a function of lead (or headway) times on the new system, the walking time between lines, and the time it takes to procure or process the ticketing.

Total travel time is heavily influenced by the distance between stations. There is generally a trade-off between the travel speed of the mass transit system, which decreases with more stations, and walking time to the system, which also decreases with more stations. The optimal from the point of view of door-to-door travel time tends to be around 450 meters between bus stations. Therefore, any mass transit system designed for Hyderabad will be less competitive with alternative modes as the distance between stations varies away from 450 m.



Optimal Distance between Transit Stops Considering Both Walking and Riding Time

4.5 Demand Estimates for Specific Mass Transit Scenarios

The potential for increasing mass transit speeds in the corridor depends on the type of system and its characteristics. This section reviews three proposals:

- The DMRC metro proposal for a two-corridor, 38.3 km elevated metro.
- A likely monorail scenario, proposed for 55km over 2 corridors
- A BRT proposal with three options for system integration.

4.5.1 Travel Time and Travel Cost Effects on Demand

To simplify comparison, we assume that all three systems – metro, monorail, and BRT – will include the removal of all directly competing bus services, and will utilize feeder systems with free transfers. This provides a common baseline demand from which to assess the travel cost and time effects on demand.

Total door-to-door travel time for each system is calculated using the assumptions of DMRC for an average trip length of 9.2km.

Door-to-Door Travel Time for Alternative Mass Transit Systems

	Metro			Monorail			BRT		
	Speed (km/h)	Distance (km)	Minutes	Speed (km/h)	Distance (km)	Minutes	Speed (km/h)	Distance (km)	Minutes
Walking	4	0.5	7.5	4	0.5	7.5	4	0.25	3.8
Waiting	-	-	3	-	-	3	-	-	2
Riding	34	9.2	16	34	9.2	16	26	9.2	21
Walking	4	0.5	7.5	4	0.5	7.5	4	0.25	3.8
Total Time			34			34			31

The time savings of each mode relative to the current bus system can be made by assuming that the current average bus trip distance of 5.2km also increases to 9.2km. This produces a theoretical current bus system trip time of 51 minutes.

Theoretical 9.2km trip on current bus system

Speed (km/h)	Distance (km)	Minutes
4	0.5	7.5
-	-	8.7
20	9.2	28
4	0.5	7.5
		51

Each mass transit system results in lower door-to-door travel times. Applying the value of time and cost elasticity assumptions used by DMRC to all three scenarios allows predicting the effect of the travel time savings on the baseline demand. The DMRC estimated the value of time for bus passengers at Rs. 10/hour, and 0.5 price elasticity. A projected basic bus fare of Rs.7 is used.

Travel Time Effect on Demand for Alternative Mass Transit Systems

	Metro	Monorail	BRT
Time Savings (minutes)	17	17	21
Value (rs)	2.8	2.8	3.4
Percentage savings	41%	41%	49%
Effect on Demand	+20%	+20%	+24%

All three mass transit systems result in increased demand due to time savings. BRT has a slightly larger effect because of the reduced time for walking due to stations being closer together.

The effect of travel cost is a direct function of the fare to be charged. DMRC projects the average bus fare to be Rs. 7 in 2008 when a mass transit system might open. They state their fare would be 1.5 times this amount, or Rs.10.5. Without detailed knowledge of the proposal, we estimate the monorail fare will have to be higher as it is proposed without central government financing. We estimate this at 2 times the bus fare, or Rs. 14. BRT would be able to operate at the same average fare as the regular buses, or Rs.7. This is because the cost of new equipment is offset by the reduced running costs of the buses.

Travel Cost Effect on Demand for Three Mass Transit Systems

	Metro	Monorail	BRT
Projected Fare	10.5	14	7
Percentage difference from bus	50%	100%	0%
Effect On Demand	-25%	-50%	0%

Combining the travel time and travel cost effects on the baseline demand, the net effect for metro and monorail systems on baseline demand is negative, while for BRT it is positive. This is primarily due to the lower fare cost possible with a BRT system.

Net Effect of Travel Cost and Travel Time on Demand for Three Mass Transit Systems

	Metro	Monorail	BRT
Projected Fare	**-5%**	**-30%**	**+24%**

4.5.2 Projected Future Demand for Mass Transit in Hyderabad

Estimating the likely future demand of the monorail, elevated metro, and our BRT proposal, requires defining very carefully the characteristics of these systems. Unlike with the existing bus system, we can safely assume that because a metro, a monorail, or the BRT system would all have dedicated rights of way, increasing congestion will improve the comparative advantages of traveling by mass transit. Therefore, ***we have assumed that if any of the three mass transit systems are built, transit ridership will increase slightly faster than population growth in the specific corridor it serves.***

However, the systems have different characteristics that will have a profound impact on the degree to which they can attract passengers. This report tests three specific scenarios: 1) the elevated metro proposal made by DMRC, 2) a theoretical monorail proposal based on a similar proposal made in Jakarta, and 3) a BRT system with three possible mechanisms for system integration with Corridors II and III.

Based on the system characteristics from the pre-feasibility studies, we estimate the following projected future demand for each system:

Comparative Demand for Monorail, Metro, and BRT Systems

	BRT		Metro		Monorail	
	System Daily Pax	Corr I pphpd	System Daily Pax	Corr I Pphpd	System Daily Pax	Corr I pphpd
2008	854,001	14,441	653,862	11,057	482,362	8,157
2011	905,221	15,307	693,093	11,720	511,303	8,646
2021	1,076,042	18,195	873,298	14,767	607,776	10,277

The reason for these demand estimates are explained below.

Scenario I: The DMRC Metro Proposal

Scenario I, based on the DMRC's Metro proposal for Hyderabad, makes the following assumptions:

- An elevated 'medium capacity' metro is built on Corridor I (25.6 km connecting

Miyapur and Chaitanya Puri) and Corridor II (12.7km connecting Secunderabad railway station, bypassing the Charminar area which is slated for pedestrianization, passing down Purani Haveli Rd, on to Falaknuma).

- There would be 39 stations along this total of 38.3km system, averaging 1 km apart.
- The system would be operational five years after project commencement.
- The fare would be 1.5 times the executive bus fare at the time of opening.
- Line I would have a capacity of 20,000 pphpd on Corridor I and 12,000 pphpd on Corridor II at the beginning of operations, increasing to 49,632 pphpd in Corridor I and 31,020 in Corridor II by 2021.
- Trains would have 3 minute headways during the peak.
- Average operating speed will be 34 km/h.
- All bus lines fully overlapping with Corridor I and II would be cut, as would some paratransit services in these corridors.
- Free feeder bus services would be provided to the terminals at both ends of the system.

The elements of the DMRC scenario that are likely to affect demand in the corridor are as follows:

- Transit vehicle speeds would increase from an existing average speed of 18 – 20 km/h to some 34 km/h. (a 50% increase in travel speed)
- Headway times compared to current bus services reduce from 9 to 3 minutes, reducing trip time by 6 minutes
- The metro fare is 50% higher than the future bus fare for all passengers, leading to a 25% reduction in demand levels, according to the DMRC's own elasticity estimates.
- 60% of passengers will face increased transfer times of between 5 and 10 minutes.
- The metro stations will be 25% farther apart than existing bus stops, so walking times will be farther – compared to the current bus stops – for about 25% of the passengers.

The DMRC estimates the demand when the system begins to operate as the following:

Demand Forecast, Hyderabad Metro (DMRC)

Year	Pax/Day	Avg Trip (Km)	pphpd Corr I
2008	1,111,000	9.17	36,010
2011	1,221,000	9.26	39,680
2021	1,881,000	9.9	58,860

Source: Hyderabad Metro DPR, DMRC, June 2003, Chapter V.

Using our own demand estimates in the corridor, we project future baseline demand at 20% decadal growth rates and modify this to include the effects of reduced travel time and increased travel cost.

Hyderabad Metro Demand Projections by ITDP

	Total System	Avg Trip (Km)	Corr I pphpd
2008	653,862	9.17	11,057
2011	693,093	9.26	11,720
2021	873,298	9.9	14,767

Percentage increase of DMRC Demand Estimate compared to ITDP Estimate

	Pax/Day	PPHPD
2008	70%	226%
2011	76%	239%
2021	115%	299%

We could not find sufficient information in the DMRC proposal for us to determine the basis of their demand estimates. In the case of the Delhi Metro, the estimated demand was high primarily because the model used an incorrect inflation factor, i.e., the ratio of the sample size in the OD survey to the total population. DMRC's demand projections ***difference is much greater for the pphpd estimate than for the daily passenger estimates.*** The most likely explanation is that the DMRC derived their pphpd figures by taking a standard share of daily trips. In many cities trips are very highly peaked and uni-directional. In Hyderabad, however, the peak is spread out over several hours almost evenly in both the morning and evening, and there is not much difference in the demand in each direction. This could have led to an over-estimation of the share of total daily trips represented by the peak hour in one direction.

Finally, note that DMRC's demand estimates assume that bus lines and paratransit in the corridor will all be cut. ***We have assumed an 80% cut of bus lines in the corridor (for all three scenarios). However, MCH should note that if none of the existing bus lines and paratransit lines are cut, the demand is going to be significantly lower, at around 7000 pphpd.***

Scenario II: The Monorail Option

Currently, no details have been worked out for a monorail proposal for Hyderabad. We understand that MetRail of Switzerland and Fraser Nash of Great Britain have both proposed monorail projects for Hyderabad. The most likely scenario is discussed, using the following assumptions:

- A 55km monorail line would be built on Corridor I and Corridor II by private investors using a Build-Operate-Transfer format.
- All bus lines paralleling the monorail system are cut
- The government guarantees a minimum ridership required to ensure the private investors realize a return on their investment, or operating subsidies, or capital subsidies.
- Fares are more than 50% higher than projected bus fares at time of completion (projected bus fares are 25% more than the current bus fare).
- Stations are in roughly the same locations as proposed by the metro company.

A monorail system in Corridor I could carry about 18,000 pphpd if it were four cars long. The current monorail in Kuala Lumpur has a capacity of only 5000 pphpd with two car trains. A capacity of 18,000 pphpd will add significant additional costs because the elevated stations have to be bigger to accommodate four car trains

Assuming the above, it is reasonable to estimate that ***demand on the monorail will be slightly lower than for the Metro system listed above, as the price is higher and the speed is slower. A closer estimate requires having more information about the proposal.***

Scenario III: A "Closed" Bogotá - Style BRT System

This Scenario assumes the following:

The system characteristics for BRT are detailed in the following section. However, for demand estimation purposes, our proposed BRT system will have the following basic characteristics:

- A 24km long system
- Average speeds of 26kph
- 500 meters between station stops.
- Fare prices equivalent to the projected future bus fares.

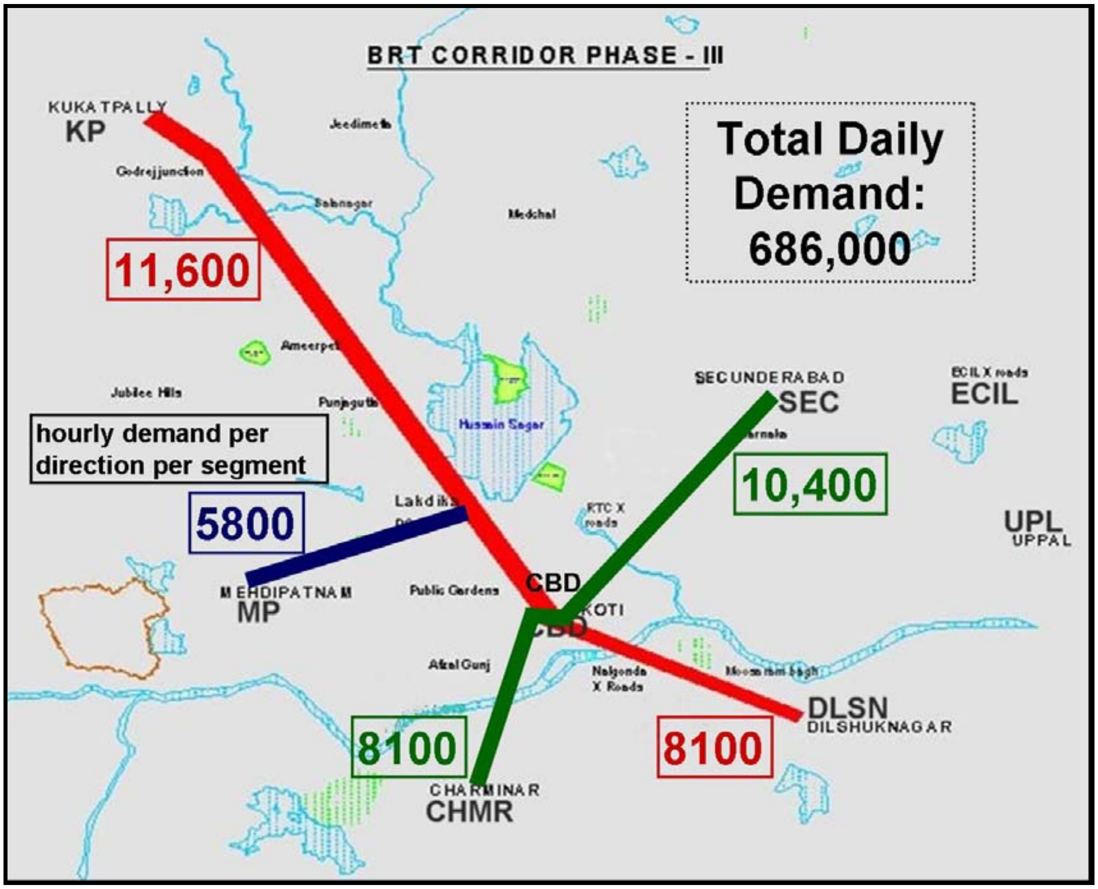
There are three possible ways of capturing most of the existing and future public transit demand in the corridor on the BRT system.

- Two stations would be built in the city center that would allow free transfer for passengers traveling from existing buses operating in mixed traffic on Corridor II and Corridor III onto the trunk mass transit line in Corridor I, or
- A smart card ticketing system would be installed on all buses in Hyderabad allowing for free or deeply discounted transfers onto the BRT system, or
- Buses would be procured for corridors II and III that allow the buses to operate both inside the BRT corridor with large platform-level doors on the right, and also in mixed traffic with curb-level doors on the left.

The main advantage of having free transfer terminals in the city center is that it does not require the procurement of special buses or a modern ticketing system. The main disadvantage is that if the BRT system is eventually expanded to corridor II and III, these free transfer terminals will be rendered obsolete.

The main advantage of the smart card ticketing system is that it could be used for free or discounted transfers at all points on the BRT corridor, but it requires installing the system on the existing bus system.

The main advantage of procuring buses that operate both on and off the corridor is that it minimizes transfer times and consumes the least land in the city center. The main disadvantage is that it requires the procurement of a lot of additional specially designed buses.



The BRT vehicle operating speeds are lower than the metro system, but door-to-door travel times would be slightly better because bus stations will be half as far apart, significantly reducing walking times. Furthermore, demand would be higher than for the metro because the fare price will be roughly the same as the bus fare rather than 50% more.

For all three system integration options the projected future demand is shown in the following table:

BRT Demand Projections

	Total System (Daily)	Corr I pphpd	Corr II pphpd	Corr III pphpd
2008	686,000	11,600	10,400	5,800
2015	857,000	14,500	13,000	7,250
2021	1,029,240	17,400	15,600	8,700

4.6 Conclusions

ITDP projects that with a Rs.5000 crore capital investment, by 2021 a BRT system in Hyderabad would lead to an increase of mass transit's mode share from a current 15% (including walking trips) to 36%, while with the proposed metro system, transit mode share would increase nominally to 16%, and with a monorail it would not increase at all.

Transit Mode Share Estimates for Alternative Mass Transit Scenarios

(excludes walking trips)

	2008	2021
Metro	15%	16%
Monorail	15%	15%
BRT	15%	36%

The BRT system has the advantage of attracting more passengers than metro and monorail proposals mainly because the fare price would be lower and the stations would be closer to people's destinations, which more than offsets the higher average operating speed of the rail alternatives.

Designing a mass transit system in the corridor with the capacity to handle 18,000 pphpd would provide MCH with sufficient mass transit capacity for the foreseeable future. The critical load -- the peak hour peak demand on the critical link on Corridor I in Hyderabad -- is not currently carrying more than 12,000 pphpd, and by 2021 is unlikely to be carrying more than 17,400 pphpd, regardless of whether a BRT, a metro, or a monorail system is built in the corridor.

Were MCH to consider providing ridership guarantees to investors into mass transit systems in the corridor, we would strongly advise that the MCH guarantee no more than 9,000 pphpd in Corridor I, or 240,000 daily passengers.

Furthermore, we recommend that ***whatever system is built, it should be a system where additional capacity can be added as needed without massive additional costs.***

Given the difference between our projected transit demand in the corridor and that identified by the DMRC is so large, a more detailed analysis is called for. For this reason, ***as a first step we recommend a 300,000 On-Board Origin-Destination Survey*** of existing bus and paratransit passengers be carried out before major financial commitments are made.

5 System Design Recommendations

Metro, BRT, and monorail could all handle the projected passenger demand in the corridor.

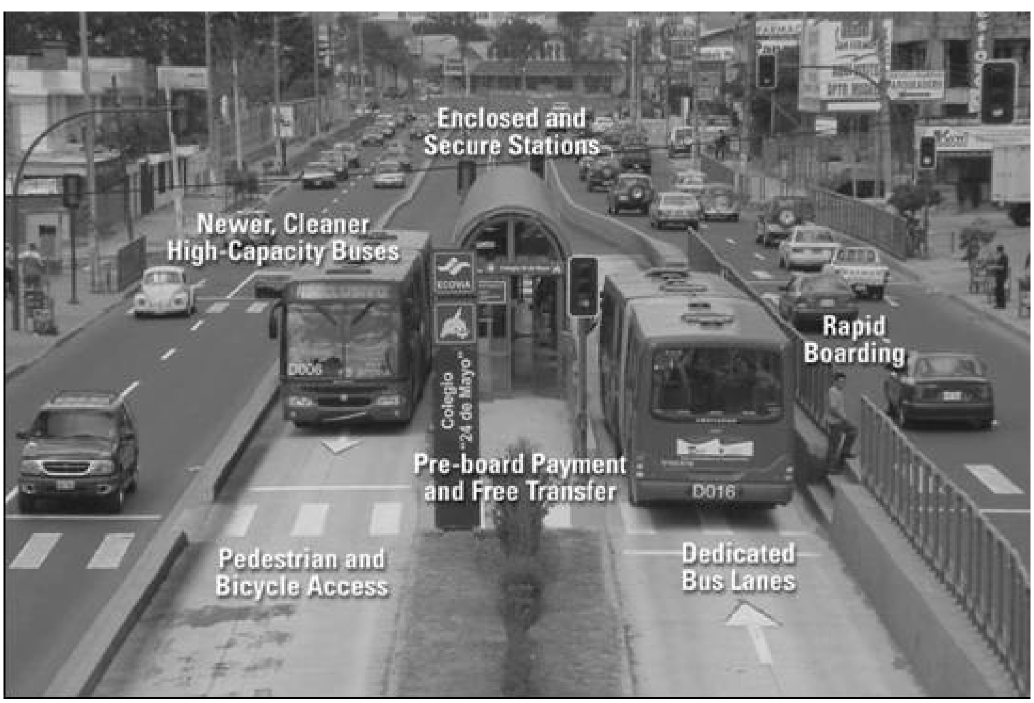
The DMRC metro proposal would have an initial capacity of 20,000 pphpd on corridor I and 12,000 pphpd in Corridor II at the beginning of operations, increasing to 49,632 pphpd in Corridor I and 31,020 in Corridor II by 2021. Given a projected initial demand estimate of 11,000 pphpd, we believe this system will provide more capacity than is needed, which causes higher than necessary construction and operations costs.

A monorail system in Corridor I could carry about 18,000 pphpd if it were four cars long, requiring the elevated stations to accommodate four car trains. Metrail and Frazer Nash are claiming 36,000 pphpd, but this has not been achieved by an existing monorail. Given our projected demand estimates, we believe the monorail would be more profitable if it were designed to carry only around 10,000 pphpd. This is because the higher fares of monorail will suppress the demand to this level.

We recommend designing a BRT system to handle 18,000 pphpd upon opening in 2008 and increasing its capacity to 36,000 by 2021. While this is more than the projected demand in 2008, the additional cost of designing a system to handle this level of demand over projected demand is marginal.

We are not questioning the ability of the metro and the monorail systems to be designed with sufficient capacity to handle their projected future demand. However as fewer people are familiar with how these capacities can be achieved using bus technology, we provide a detailed explanation of how such a BRT system can be designed.

5.1 Principles of BRT Design: Obtaining Metro Performance Levels from Buses



Some Characteristics of BRT Systems.

Bus Rapid Transit, or BRT, refers to a group of bus systems that have many of the characteristics of metro systems. As a result, they can provide a similar level of service to metro systems, often at a fraction of the price.

While not all BRT systems have all of the characteristics of BRT, the following are typical:

- Physical separation of the bus lane from mixed traffic lanes (to give buses a congestion free right-of-way)
- Bus station platforms are level with the bus floor (to speed and ease bus boarding)
- Busway alignment in the center of the carriageway (to avoid conflicts with turning traffic, unloading trucks, bicycles, pedestrians, and stopping taxis.)
- Payment occurs when entering a physically enclosed bus station rather than on board the bus. (to speed bus boarding and alighting and to give passengers greater security)
- A clear identity for the system (for marketing purposes)
- Trunk and feeder routing system with free transfer terminals (to avoid bus congestion and make the system more profitable)
- Large, articulated buses with multiple wide doors (to increase the capacity of the busway and the speed of boarding).
- Quality control of bus operation, cleanliness, maintenance and service
- Traffic signal priority (typical only in Europe at low bus volumes)
- Information technologies to provide real-time information to passengers
- Clean bus technologies to reduce emissions

Some of the major cities where this system has been developed or is in the process of development include: Bogotá, Sao Paulo, Curitiba, Mexico City, Panama City, Quito, Boston, Eugene, Chicago, San Francisco, Vancouver, Leeds, Strasbourg, Bradford, Lyon, Jakarta, Beijing, Kunming, Taipei, Nagoya and Seoul.

Using these methods, the most famous BRT systems in the world have achieved operating speeds, capacities, and service quality standards at the level of many metro systems, but at a fraction of the cost.

BRT and METRO Systems Cost and Capacity Comparisons

	Line	Capital Cost/Km ($ million)	Actual capacity (passengers / hour / direction)
Metro	Hong Kong Metro	$220	81,000
	Bangkok Skytrain	$74	25,000 – 50,000
	Caracas Metro	$90	21,600-32,000
	Mexico City Metro	$41	19,500 - 39,300
	Kuala Lumpur LRT Putra	$50	10,000 – 30,000
BRT	Bogotá TransMilenio	$8	35,000 - 45,000
	Sao Paulo Busways	$3	27,000 -35,000
	Porto Alegre Busway	$2	28,000
	Curitiba Busway	$2	15,000
	Quito Bus Rapid Transit	$2	9,000-15,000
	TransJakarta	$2	8,000

While there are now over 100 BRT systems worldwide, the most famous systems are in Curitiba (1974), Quito (1997), and Bogotá (2000). The first BRT systems in Asia opened in Kunming and Taipei in the mid 1990s, Jakarta (January 2004) and Beijing (December, 2004). Bogotá's TransMilenio is currently the best system in the world in terms of average operating speed, capacity, and the quality of service.

BRT systems are able to reach capacities and speeds equivalent to rail-based systems despite having smaller vehicles largely because they are able to reduce headways to much lower levels than rail-based systems. Once boarded, a near constant stream of buses can pass through an intersection during the green phase with only a matter of seconds between vehicles.

In systems with very low volumes, the bottlenecks tend to occur at the intersections, and signal priority becomes important. That is why signal priority is an important factor in busway and tramway capacity and speed improvements in developed countries.

In systems with very high volumes, as is the case in India and many other developing countries, the bottlenecks occur at the bus stations. Bus priority measures are no longer effective because the traffic light would have to be in a constant state of green to give priority to the busway. Therefore, many of the measures that constitute a BRT system are primarily aimed at reducing dwell time at bus stations.

System capacity is a function of:

a. The capacity of the vehicle
b. The load factor (how many passengers are actually using each bus at any given link)
c. The frequency of the vehicles
d. Average speed of the vehicle, determined by operating speeds, intersection delays, and time required for boarding and alighting

5.1.1 Increasing Bus Capacity

Standard TransMilenio Bus, Bogotá

Increasing the capacity of the bus is easy to understand. Bus capacity is basically a function of the length of the bus, with 3 meters for the engine and driver, and 1 meter for every ten persons for the balance. The articulated bus used in TransMilenio (above) has become the BRT standard because as the buses get any longer (bi-articulated) they become much more expensive and have difficulties on turns.

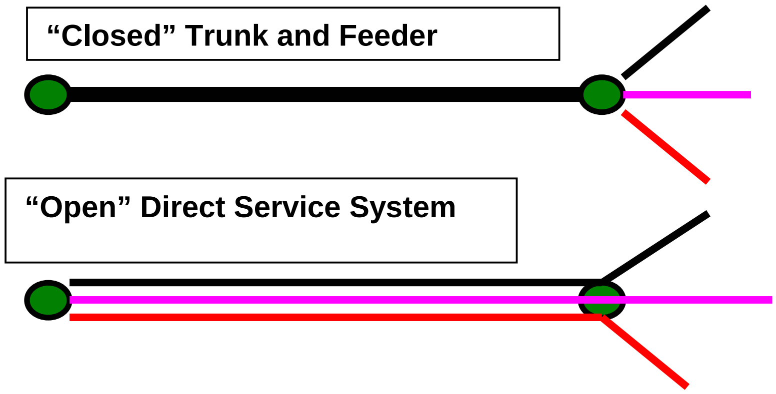
5.1.2 Increasing the Load Factor

Another way to increase the actual capacity of the system is to increase the number of passengers per bus, or the 'load factor.' To change the load factor generally requires re-routing the other bus lines serving a particular corridor.

In some BRT systems – which we call 'open' BRT systems – normal buses operate on normal bus routes; the only element of BRT is that a physically separated exclusive bus lane has been constructed, usually in the central verge of the carriageway. These 'open' BRT systems have the advantage over 'closed' BRT systems that bus routes do not need to be changed, and there is no problem ensuring that all bus passengers use the new busway.

However, frequently buses in an 'open' busway are not full to capacity. If bus volumes are less than 70 per hour, this does not present any problems. However, above 70 buses per hour, the busway will begin to congest, and reducing the number of buses in the bus lane becomes very important to maintaining bus speeds. ***The normal way to do this is to shift from a 'direct' routing structure to a 'trunk and feeder' system***.

Shifting the bus routing system to a 'trunk and feeder' system will increase the load factor of each bus.



Schematic diagrams of Open and Closed BRT Systems.

The BRT systems in the US, Taipei, Kunming, Sao Paulo, Porto Alegre, Brisbane, and the planned HCBS in Delhi are open BRT systems.

An 'open' system in Bogotá, built before TransMilenio, with two lanes per direction was able to move over 30,000 passengers per direction at the peak hour, but it moved them slowly, at about 12 km/h. The new Passa-Rapido system in Sao Paulo moves passengers also only at about 12 km/h, due to bus congestion at the bus station.

"Open" Direct Service BRT Systems in Sao Paulo

Design drawing of planned Delhi High Capacity Bus System (Indian Institute of Technology-TRIPP)

The system that is being built in Delhi (construction is to begin in January 2005) is an 'open' BRT system. It will move over 200 buses per direction per hour. No bus route re-organization was possible in phase I. In order to avoid the problem of busway congestion, two full boarding platforms have been provided. This should be sufficient to avoid congestion within the busway. This design, however, consumes a very large amount of right-of-way.

The very high-capacity, very high-speed BRT system in Bogotá, Colombia, is what is known as a "Closed" Trunk-and-Feeder type BRT system. Such systems are used where there are very high bus volumes and where there is not enough right-of-way to handle the projected passenger demand at a reasonable speed using lower cost 'open' systems. Shifting the bus routing system from direct service to a trunk-and-feeder makes it possible to move the same number of passengers through the same corridor using less road space by reducing the number of buses needed and increasing their size.

Bogotá and Quito's BRT systems reduced by 2/3 the number of buses passing through the BRT corridor. Because a trunk-and-feeder routing structure will increase the load factor, (passengers per bus), the profitability of bus operations is increased.

Quito's Avenida 10 de Agosto, Before and After the BRT System was Implemented.

5.1.3 Increasing Bus Frequency and Reducing Headways

The remaining measures aimed at increasing busway capacity and bus speeds focus on increasing the number of buses per hour that can pass through a corridor before the bus station congests.

In a standard busway with normal stations, at levels above 40 buses per hour, bus speeds begin to slow, and over 70 buses they slow sharply. Above this amount, adding more buses will not add additional capacity. This is largely because it is difficult to reduce 'dwell time' at the bus stations. The bus stations are therefore the main bottleneck.

Dwell times have a variable element: passenger boarding and alighting time – a function of the number of passengers getting on and off the bus at any given station, and how long it takes them to get on and off per passenger. There is also a fixed element – a function of how long it takes the vehicle to slow down, speed up, and open and close its doors. Together, these elements will determine the total dwell time.

Below, the capacity of a simple busway on Oxford St, England is compared to the Sao Paulo Metro. The dwell time on the busway is longer than on the metro only because of the time it takes passengers to board and alight. The capacity of the busway is much lower than for the rail system partly because the vehicles are smaller, but partly because of this longer dwell time per vehicle.

Capacity and Dwell-Time Details on a London Busway Compared to the Sao Paulo Metro

		Bus London	**Metro Sao Paulo**
Arrive	Seconds	5	10
Open Doors	Seconds	2	2
Boarding and alighting	Seconds	48	25
Close Doors	Seconds	2	5
Exit Station	Seconds	2	10
Total Time	Seconds	59	52
Frequency	Veh/hr	24	33
Passengers/vehicle	Pass/veh	70	1700
Capacity	Pass/hr	1708	56100

A standard bus station can only handle about 3000 passengers per hour per direction (pphpd). If the passengers do not have to pay the driver, but can board the bus and then have a conductor collect their payment, capacity can be increased to some 4000 pphpd. If the passengers do not have to climb up steps but can board the bus at the same level as a boarding platform, capacities can increase further to over 5000 pphpd. If passengers can pay before they enter the bus, then the buses do not have to worry about passenger payment control, and can have four very large doors. Passengers entering simultaneously through two 1.1-meter wide doors, and exiting simultaneously through 2 other 1.1 meter wide doors will allow a capacity of 9,400 pphpd.

Bus System Capacity Increases Possible with Various Improvements

Improvement	Capacity	Boarding Time (sec)	Multiple stops per station	Express Lines %	Lanes at Bus Station
Original	3,000	2	1	0	1
At level Boarding	5,000	1	1	0	1
External Fare collection	9,400	0.33	1	0	1
Bus Convoy	16,000	0.33	4	0	1
Multiple Stops per Station	28,200	0.33	3	0	2
Express Lines	36,700	0.33	3	40%	2
Express Lines	43,000	0.33	3	60%	2
Express Lines	52,000	0.33	3	80%	2

TransMilenio buses have four 1.1 meter wide doors. Two doors are used by boarding passengers and two are used by alighting passengers.

Getting a BRT system to handle more than 9,400 pphpd, requires the buses to enter and leave stations and intersections in groups of three or more, or what is called a 'convoy.' Through convoying, you can increase capacities to 16,000 pphpd.

To have convoying requires increasing the number of bus platforms at each bus station. In order to increase capacity further, there needs to be an additional lane in each direction at the bus station where the buses can go around other buses that are stopped to load passengers.

One of two sets of two 1.1 m-wide doors allowing rapid boarding and alighting on Bogotá's BRT

Bogotá's TransMilenio Split-Station Design with Passing Lane is a Secret to Achieving Metro-Level Capacities

With two bus platforms per station and a passing lane, headways can be reduced to about 30 seconds, and capacities increased to over 18,000 pphpd. With three bus platforms per station, you can get the headways down to 16 seconds, and capacities over 36,000 can be achieved. Also note that TransMilenio forbids left turns (what would be right turns in India) at all but the major intersections. This keeps traffic signal delay to a minimum, giving at least 50% of green phase to the BRT.

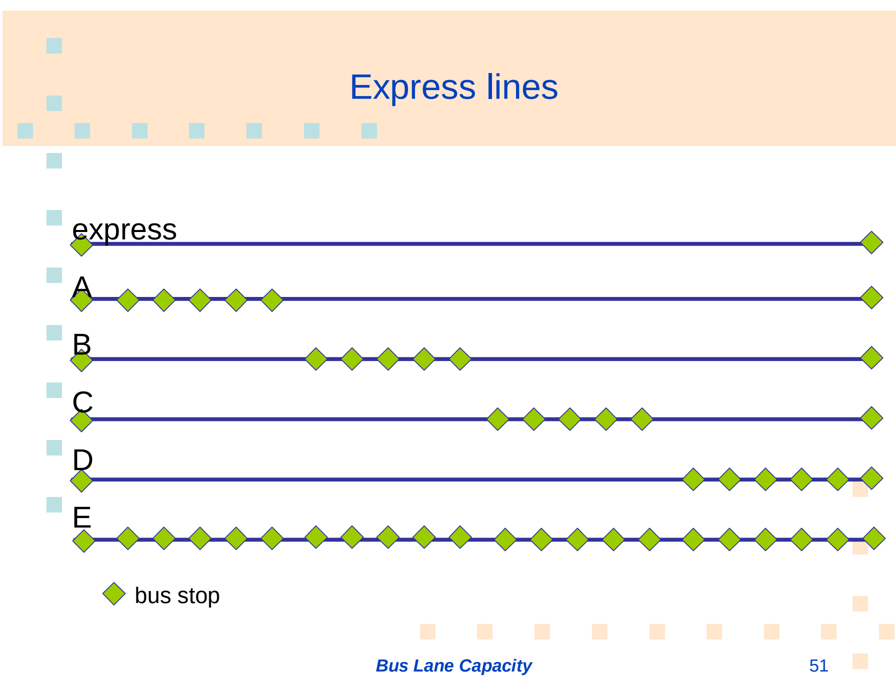


Diagram of Possible Ordinary and Express Line Configurations Allowing Express Buses to Skip Some Stops, Increasing System Capacity

Finally, BRT system capacity can be further increased by splitting the bus services into local and various express services. Express buses do not stop at all stations, and therefore increase dramatically both bus speeds and bus capacity.
When all these measures are implemented simultaneously, BRT systems can reach capacities over 45,000 pphpd.

5.2 BRT System Design Recommendations

Based on the analysis in the previous chapter, the BRT system is projected to have 18,000 peak-period passengers per hour per direction (pphpd) by 2021. However, predicting the number of future passengers is more an art than a science. For engineering purposes it is much safer to err on the side of designing for more passengers than you get.

A BRT system can be built in Corridor I with the nearly the same capacity as the proposed metro system, with an average operating speed of 26 km/h, starting at 18,000 pphpd and increasing to 36,000 pphpd over time. TransMilenio in Bogotá is transporting 38,000 pphpd.

Reaching these levels of capacity in a BRT system requires careful design and engineering. To reach these levels, the Hyderabad BRT system would need to have the following characteristics:

- **The BRT system should occupy the central verge of the roadway**, rather than the curb lanes. This will avoid conflicts with turning traffic, pedestrians, stopping taxis and delivery vehicles, illegally parked vehicles, etc.
- **Passengers should pre-pay to enter each bus station, and each station platform should be elevated to the height of the bus floor.**
- The ***exclusive bus lanes must be physically separated from the rest of the traffic by a physical barrier,*** and enforcement of encroachment onto the busway must be maintained with ***additional police at the intersections*** during the initial months of operations. Fines for illegal encroachment on the busway must be strictly enforced.
- A**n overtaking lane at stations should be included in the BRT design.** In other words, the busway needs two lanes in each direction at each station, and one lane in each direction at all other points. The overtaking lane is critical to relieve bus congestion.
- **Each station should have at least two platforms.**
- The **distance between bus stations should be brought down from the current average 800 meters to an optimal level of 450 meters.** This will slow down bus speeds somewhat (30 to 25km/h) but it will reduce total trip time by reducing walking distances. **Forty stations with 80 pre-paid enclosed platforms should be built along Corridor I**.
- For Corridor I, **109 articulated buses (150-passenger capacity) with four platform-level 1.1 meter wide doors on the right side** (Scenario I and III) *or* **109 of the above buses and 206 buses with two platform-level 1.1 meter wide doors on the right side and two standard curb-level left side doors on the left** (Scenario II) should be used.
- **Pedestrian access to the central verge should be at grade using improved crosswalks rather than using pedestrian overpasses.** As the maximum number of mixed traffic lanes the pedestrians would need to cross is two, this can generally be negotiated safely. We recommend pedestrian overpasses only when three or more mixed traffic lanes need to be crossed, with average vehicle operating speeds over 40 km/h.

- Where possible, we suggest **restructuring right turns along the corridor to** increase bus speeds and avoid worsening congestion in mixed traffic lanes.

The main advantage of BRT systems over rail based systems is that headways between each vehicle can be reduced from around 3 minutes to less than 30 seconds. Because the obstacle to reducing headways is the capacity of the bus stations, additional capacity is added to a BRT system by adding additional bus platforms at each station. For this to work, however, an overtaking lane is necessary at each station.

The capacity of the system will be expanded from 18,000 pphpd to 36,000 pphpd as needed by adding an additional bus platform at each station, and by adding more express bus services which make fewer stops***. The addition of this extra BRT capacity costs very little money in contrast to the cost of expanding the capacity of a metro or monorail system.***

6 Analysis of the Feasibility for BRT on the Existing Corridor I Right-of-Way

The BRT system on Corridor I in Hyderabad should be designed to travel at 26 km/h and initially handle a volume of 18,000 passengers per direction at the peak hour at any given segment. Ideally, the level of service for mixed traffic should be retained at current levels or improved. The environment for cyclists and pedestrians should also be made safe and attractive, both to promote these non-polluting modes that give vitality to the city center and also in recognition that all public transit trips have a walking component.

This ideal scenario cannot be achieved in Corridor I or II in Hyderabad without land acquisition and resettlement. The National Highway Authority of India (NHAI) which owns and maintains much of the right of way, has also been working on a proposal to widen some of the road segments from the existing 4 lane to 6 or 8 lane on NH9. Therefore, we urge the MCH to communicate with the NHAI and ensure that any road widening plans for the Corridor incorporate the right-of-way needs that will be identified below.

After clarifying which roads may or may not be widened by NHAI, the Municipality of Hyderabad will need to make some careful decisions about where to widen the right-of-way, where to compromise the level of service of the BRT system, where to compromise the level of service for mixed traffic, and where to compromise the safety and level of service for non-motorized travel.

In the city center, our general recommendation is to minimize road widening and land acquisition, and focus on improving pedestrian and bicycle facilities. Adverse impact on the level of service for the BRT system, the pedestrian and cycling environment, and on mixed traffic, can be minimized by splitting the BRT route into two one-way routes on parallel roads, or by having both BRT lines on one route and relocate mixed traffic onto parallel roads.

Outside the city center, where the density of development is lower, we generally recommend widening the road where possible. Where not possible, we recommend a compromise between the level of service for the BRT system, mixed traffic, and cyclists and pedestrians.

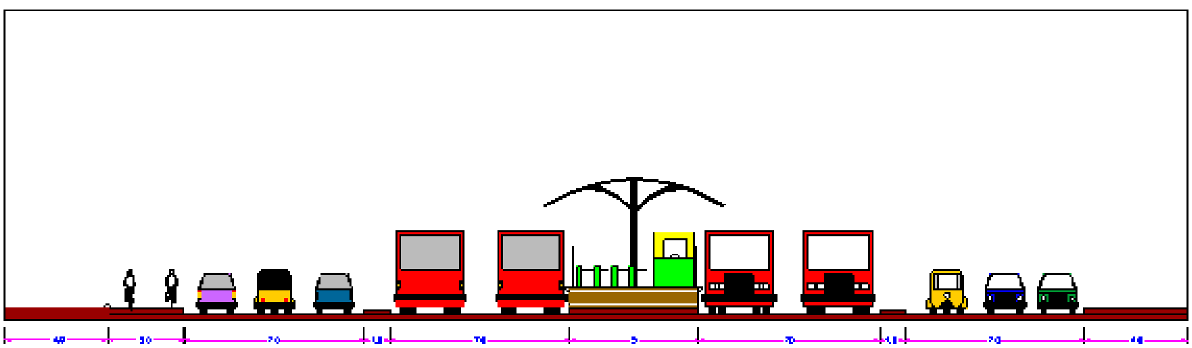
6.1 Right-of-way Requirements for Hyderabad BRT System: Best Case

Given below are the right-of-way requirements for a standard high capacity BRT configuration: 1) at a normal section, 2) at a bus station, and 3) an interim design where bus bays are retained to accommodate buses not using the BRT system.

Right of way for BRT system (Segment wise break-up)

Segment	Normal section		At BRT bus station		Normal section (retaining curb side bus bays for remaining bus routes)	
	minimum	good	minimum	Good	Minimum	Good
Sidewalk	4	4.5	4	4.5	6	6.5
Mixed traffic	6.5	10	6.5	10	10	13.5
Bus lane	3.5	3.5	7	7	3.5	3.5
Island	1	1	5	6	1	1
Bus lane	3.5	3.5	7	7	3.5	3.5
Mixed traffic	6.5	10	6.5	10	6.5	10
Sidewalk	4	4.5	4	4.5	4	4.5
Bicycle lane	0	3	3	3	3	3
TOTAL	**29**	**40**	**40**	**52**	**34.5**	**45.5**

Note: all figures given in meters

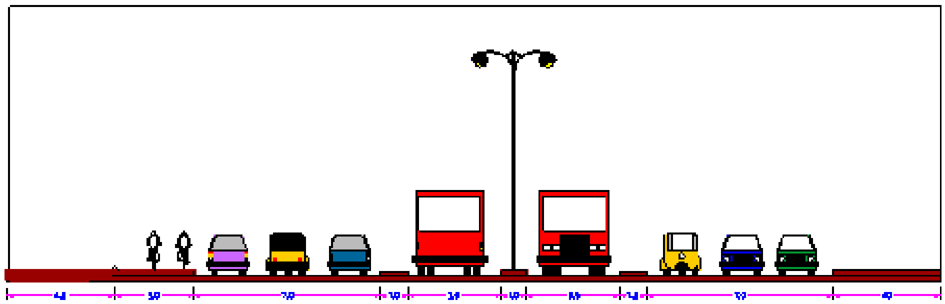


Best BRT System Cross-section at Bus Station (total 52 m)

The figures above and below show what the ideal standard cross section would look like both at a bus station and without the bus station, if 1) the level of service for the BRT is to be high enough to reach our recommended 26 km/h, 2) the capacity is to be above 18,000 pphpd, and 3) the level of service for all other modes is to be maintained or improved.

The overtaking lane at bus stations is an important feature for the efficiency of the system that will be necessary to reach the level of demand of 18,000 pphpd. Without the overtaking lane, it is impossible to include express services that do not stop at every station. The express services can also be staggered. This is to say that each express service would have predefined stations which could be different from other express services, as illustrated in Chapter 4 above. The regular services stop at most stations but they too can be staggered. A detailed schedule plan would be developed in the detailed design phase of this project.

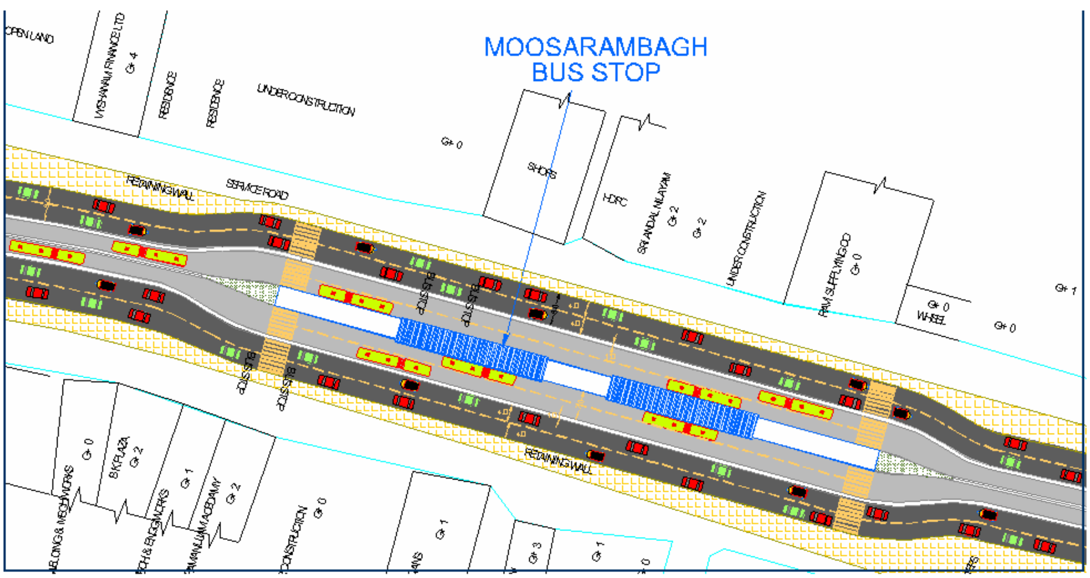
At 12,000 pphpd, the initial projected demand level, an overtaking lane is not entirely necessary. If taking right of way is a major concern, therefore, the passing lane can be added later as demand increases. In either case, the system would occupy a single lane at all non-station sections of the roadway.



BRT System General Cross-section (Total 40 m)

As a general rule, the central lane (right side in India) should be used as a bus lane. This is the general practice in BRT systems and is considered as a standard. Curb side bus lanes are too frequently impacted by side-road and stopping traffic to be effective.

Bus stations can have more than one loading platform depending upon the demand at a given location. Places which have very high demand would have 3 platforms per station whereas others could have two platforms or one platform. The figure below shows a typical two platform bus station. The basic look of this station design can be seen in the photo of Bogotá's TransMilenio at the end of Section 4.



Overhead View Diagram of BRT Station with 2 Boarding Platforms

Wide doors in the center of the bus and elevated platforms with at-level boarding and alighting is a widely accepted BRT feature. On the first corridor these platforms can be implemented. On others corridors the platforms will require road improvements or road widening in some cases.

The distance between bus stations should be brought to an average distance of 450m, as was discussed above. This would reduce the total travel time for the majority of passengers. Bus passenger demand is directly proportional to the accessibility of a bus station

The system requires a single-lane, physically-separated busway. Bus stations located at least 120 meters from an intersection will improve traffic flow. The busway would widen to 2 lanes per direction at the bus stations. The number of platforms per bus station would vary from one to three depending on the level of passengers boarding and alighting at a given station.

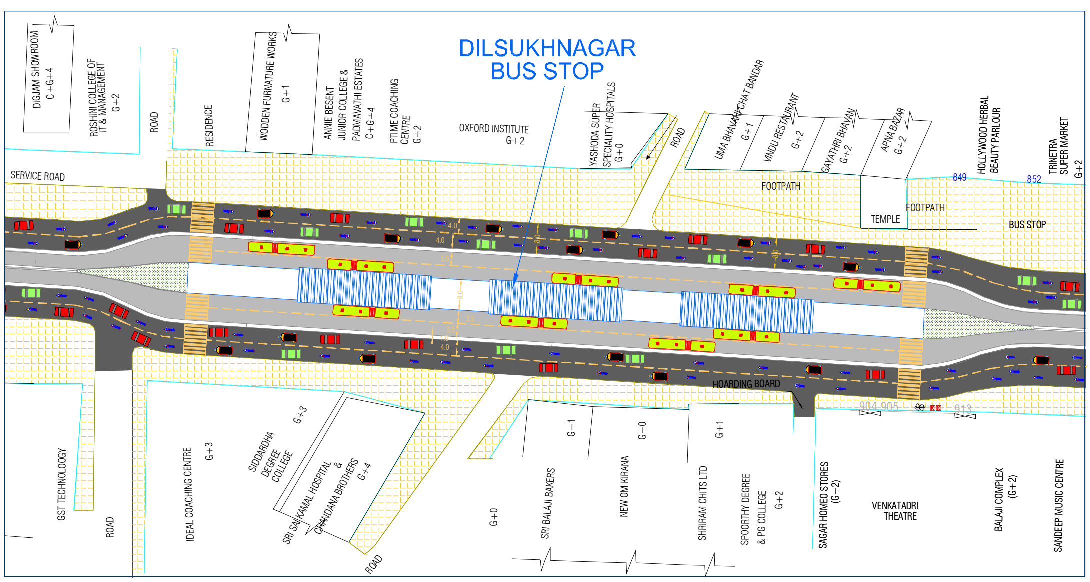
On normal sections (not at bus stations), considering future demand (flow) up to 18,000 passengers/hour/direction, the equivalent volume of articulated buses would be 133 buses/hour/direction (with 150 passengers per bus).

Taking 6 seconds as the average time to clear a bus at a signalized intersection, 800 seconds of green time would be needed per hour at every intersection. This converts to 22% (800/3600) of green phase required in a signal cycle. At most intersections on corridor, 50% of cycle time is green phase (with right turn restriction). So, the saturation level is just 44% (22/50). At this level of saturation, one lane is sufficient at the intersection to clear the buses without considerable delay. As an example, consider a signal with a cycle of 90 second with 45 seconds of green time. With a flow of 120 articulated buses, the difference in average delay is just 1.5 seconds when comparing a design with one bus lane at the intersection vs. two bus lanes at the intersection. Hence, one lane is sufficient.

At bus stations, this is quite different, because even with all BRT capabilities, buses stop for an average of 25 seconds at each station. If there is just one lane without an overtaking lane, usually all buses would use the same bus platform and the additional time (compared with two bus lanes and two bus platforms) would be around 75 seconds. Therefore, an overtaking bus lane becomes necessary.

The figure below is an AutoCAD rendering of how a typical median BRT station with three bus platforms would work in Hyderabad. Even at high demand stations, this station configuration should be sufficient to handle the level of passengers. The bicycle lane is not currently shown.

If the demand for the system rises above 18,000 pphpd, the BRT system can be reconfigured. An additional platform at stations with high passenger flows allows expansion of the capacity beyond 18,000 pphpd.

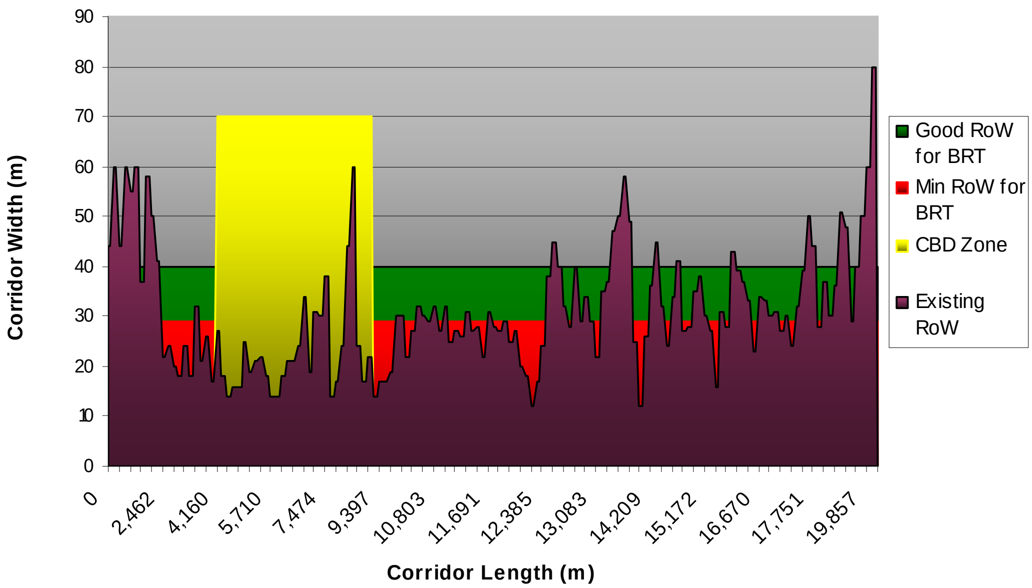


Overhead View Diagram of BRT Station with 3 Loading Platforms

6.2 Right-of-way Overview on Dilsukhnagar - Kukatpalli corridor

Currently, many sections of Corridor I have enough existing right-of-way for the standard recommended BRT configuration as described above. In other sections, however, there is not enough existing right-of-way for this standard BRT configuration. This can be dealt with in two basic ways: changing the standard BRT configuration or acquiring land and widening the right-of-way. While acquiring additional land is expensive and involves complex social issues, changing the standard BRT configuration will compromise the level of service for either the BRT system, or the mixed traffic, or both. We recommend that the standard BRT configuration be altered in the city center, and that the right-of-way be widened outside the city center.

The following graph depicts width of the existing right-of-way along the 20.4 km of the proposed first corridor from Dilsukhnagar (south east) terminal to Kukatpalli (north west) terminal. (Right-of-way width is based on available AutoCAD maps. Field measurements would be needed to confirm the exact measurements.)

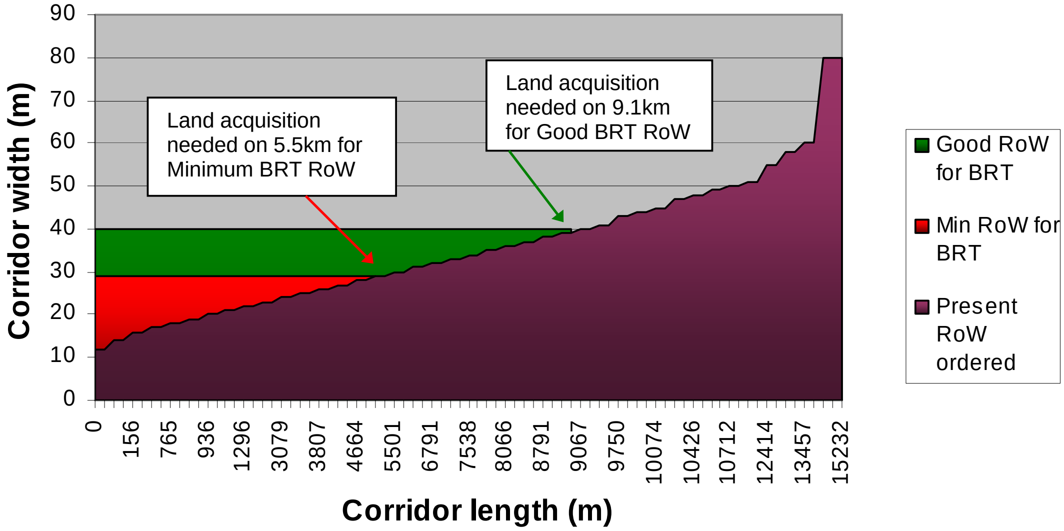


Dilsukhnagar – Kukatpalli Corridor Right-of-way width

The central section marked as CBD zone starts from Chaderghat and ends at Lakdi ka Pul. The central section can be considered separately from the analysis given below since it has a good network of roads. A system of one ways for both BRT and mixed traffic, or an alternative design, is feasible for this section.

The red line represents the minimum requirement of a 29 m standard BRT configuration. The red zone highlights the locations where this minimum standard is not met. The area highlighted in yellow is the city center, and will be discussed separately. The dark green line represents the "good" measure of 40 meters, and for this the red zones as well as the green zones in the graph need to be expropriated. Bus stations requirements (100 meters each 550 meters as an average) are not includes in this graph. The graph reveals more than a dozen stretches much under the required minimum of 29 meters.

Excluding the central section where other solutions are possible, and the bridges, (where acquisition is not possible) we obtain a reduced graph.



Dilsukhnagar – Kukatpalli Corridor Right-of-way (road width sorted, excluding CBD zone)

Land acquisition would be needed on a minimum of 5.5 km for the basic configuration or 9.1 km for a "good" configuration. The additional land needed to add a 3 meter bicycle lane is only marginally more, so if the city goes to all the trouble to appropriate land, it might as well include land for bike lanes. A poor solution with 2 meters of sidewalks, no bike lanes, and only 5.5 meters for mixed traffic will reduce the minimum width from 29 to 23 meters and acquisition will be needed only on 2.3 km length. The result, in terms of comfort and appearance, would be less desirable as it would not create the high quality pedestrian environment required for project success. With the remaining buses which are not part of the BRT system, thousands of two-wheelers, and appropriation of sidewalk space by parked vehicles, vendors, utilities, etc, the result is likely to be poor. Therefore, while 29m of right-of-way is the minimum recommended, 40m is advised.

In addition to this 5.5 km where land acquisition is needed, we should include another 1.3 km for bus stations putting the total at 6.8 km. Taking 10 m as an average width for the land to be expropriated, 68,000 square meters of land acquisition would be required. At 10,000 rupees/sq. m. (suggested average market value of land) the cost will reach 68 crore rupees for acquisition, possibly around the same cost as that of constructing the corridor. For the 40 meters width, it is estimated that less additional land will be needed for stations, and land acquisition would be needed on 10.3 km with an average of 20m additional width required, totaling to about 200,000 sq. m. at a value of 200 crore rupees.

Estimated Land Acquisition cost (as per present market value) for Hyderabad BRT – Phase I

Option	Length of corridor	Average width Acquired	Total area	Unit cost	Total cost
	Km	M	(Sq. m.)	Rs./Sq. m.	Rs. crores
Minimum	6.8	10	68,000	10,000	68
Good	10.3	20	205,000	10,000	205

While our recommendation is that Hyderabad go ahead with this land acquisition, it is also possible that some of the solutions being used for the narrower roads in the city center could be extended beyond the city center. This, however, will come at the expense of the level of service for the BRT system, mixed traffic, or the non-motorized traffic.

Acquisition should be done with the involvement and support of the local communities and affected businesses, and full compensation for those relocated incorporated into project costs. If communities understand the entire plan they will be more ready to make sacrifices and see potential opportunities.

Business can also be integrated with the design process. Special construction rights can be given to business owners on the corridor who give their land for the system. Options like building shopping arcades on top of BRT stations hold high commercial potential, and those losing land might have priority access to such development rights.

6.3 General Corridor Design Recommendations

For the portion of the corridor not in the City Center, we recommend using the "Best" configurations listed above. Solutions for the city center will be discussed in the next section. The physical design for Hyderabad's BRT system should take into account all three phases of the Hyderabad BRT program at once, so that integration of corridors I, II, and III is planned into roadway, bus terminal, bus station, and ticketing system design from the inception. These phases are:

- **Phase I:** Kukatpalli – Amirpet – Lakdi ka Pul – Police Control Room – Gunfoundry – Abids - Koti – Chaderghat – Nalgonda X roads – Malakpet - Dilsukhnagar
- **Phase II:** Secunderabad Station – Koti – Charminar
- **Phase III:** Mehdipatnam – Lakdi ka Pul

We recommend physically closed stations with an average distance between them of 450m. We recommend physically separated lanes for the BRT system.

One option is for Corridor I to have three interchange terminals for the initial phase located at

1) Kukatpalli: Land is available near KPHB colony with the Kukatpalli Municipality
2) Dilsukhnagar: Land is available with APSRTC at the existing bus depot.
3) Koti. Perhaps at the Govt. College for Women. This land belongs to the Govt. College for Women in the front of Andhra Bank head office.

Transfer terminal between trunk and feeder lines, Quito

This would give the system flexibility for present operations as well as allow for seamless integration with Corridor II and III when second and third phases are implemented.

The Koti terminal would allow some routes coming from Kukatpalli in the north to return back to north from center and ones coming from Dilsukhnagar in south to shuttle between south and the center. There would also be routes which go all the way through from Kukatpalli to Dilsukhnagar.

In additional, big interchange stations might be required at more than these locations to integrate with the second and the third phase. One possible location could be the Police Control Room area.

All the three terminals would have feeder services. Buses running on the second corridor would function as feeder services to the first corridor in Phase I.

Alternatively, special buses could be used on Corridor II and III that could operate both on the BRT corridor and on a normal road. A third alternative is to install electronic fare card equipment on all Hyderabad buses that would allow free, or reduced cost, transfers to and from the BRT.

Land acquisition would be recommended mainly in the north section at more than a dozen locations. In the south section of the corridor, land acquisition is required on a single stretch from Chaderghat until Malakpet.

6.4 Options for the City Center

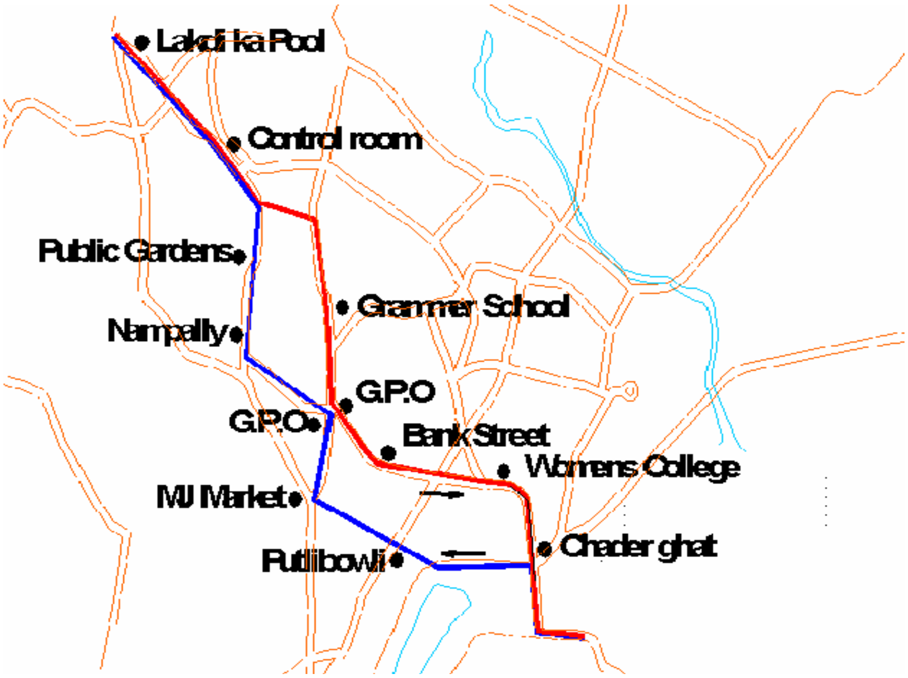
Hyderabad's city center has space enough to solve right-of-way problems, with only a modest decrease in the level of service for BRT or mixed traffic, by changing the standard BRT configuration. The access roads to the central area are narrow but severe congestion is uncommon.

Therefore, it is recommended to give preference to pedestrian access and create the BRT system to reach the principal origin and destination points. The two main options are:

- Option 1: Make streets available for one-way flows and allow general traffic also to enter the streets.
- Option 2: Divert general traffic to other streets and convert the street into an exclusive bus way street, with buses running in both directions

The first option for the central section would be to retain the existing system of one way streets and separate the two directions of the BRT system. The routes in such case would be:

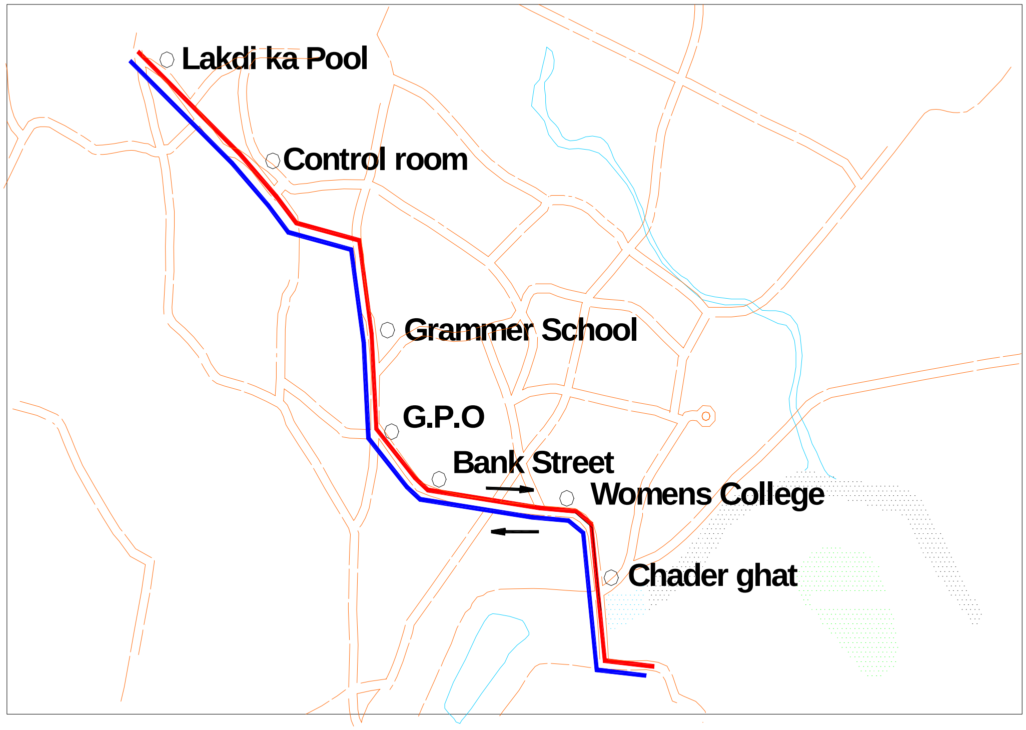
- **North to South:** Lakdi ka Pul – Police control room – Gunfoundry – Abids GPO – Bank Street – Women's college – Chaderghat
- **South to North:** Chaderghat – Gandhi medical college (Putlibowli) – MJ Market – Abids GPO – Public gardens – Lakdi ka Pul



BRT design for CBS – One-way for BRT and Mixed Traffic

The second option would be to segregate BRT from the rest of the traffic. In this design one route would be used exclusively by BRT, allowing one lane of mixed traffic in some places, while the rest of the traffic would be diverted to the network of roads available. The BRT route would then be:

> Lakdi ka Pul – Police control room – Gunfoundry – Abids GPO – Bank Street – Women's college – Chaderghat



BRT Design for CBD – Exclusive BRT-street

Both options – and combinations of the two options – need to be studied carefully. Examples of both types of systems exist. Some possible configurations are shown below in the photos below.

A variation on the second option is to retain one lane of mixed traffic. Because of the irregularity of the road network, it should be possible to integrate better managed parking, significantly improved and expanded pedestrian space, and more formalized and organized vending activity into many places along the corridor. With no mixed traffic access, the commercial districts may lose some customers from trips not well served by the BRT system.

Configuration I: BRT with Best Ped. Amenities. Example: Bogota, Colombia

Configuration 2: BRT and Minimum Sidewalk Only. Example, Quito, Ecuador

Configuration 3: Median Two-Way BRT and One Mixed Traffic Lane Per direction. Example: Rouen, France

Configuration4. Curb-side bus lane on One-Way Street. Example: Quito, Ecuador

Configuration 5: Median One-Way BRT with Two Lane, two-way mixed traffic street. Example: Quito, Ecuador

Configuration 6. Side-Aligned Two-Way BRT Adjacent to Two Lane, one-way street. Example: Curitiba, Brazil.

Alternate Configurations for BRT in Hyderabad's Central Area

6.5 Hyderabad BRT Fare Collection System considerations

External fare collection is one of the distinct features of BRT systems around the world. Selecting an appropriate ticketing system is complex and relates not only to the speed and capacity of the BRT system but also to the institutional structure of the BRT system. External fare collection is not a technical necessity except at very high passenger volumes, but there may be other institutional or marketing reasons for adopting external fare collection. This report does not cover the institutional elements of a proposed BRT system in Hyderabad.

Smart card ticketing systems may be adopted in order to: 1) allow easy discounted transfer to other systems or lines, 2) allow other commercial uses of the smart cards, 3) improve control over the revenue stream, 4) separate the revenue stream from the bus operator, and for other reasons.

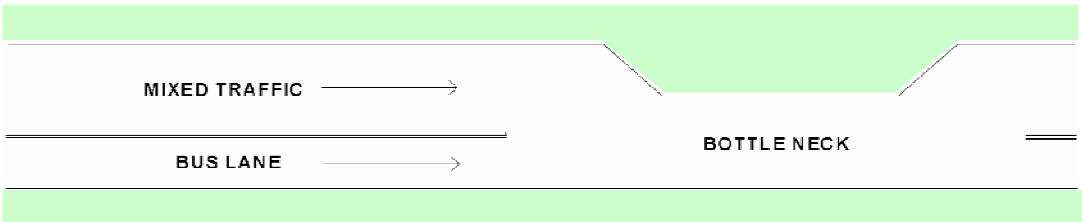
From the point of view of the speed and capacity of the BRT system alone, the current manual collection method with an independent collector inside the bus is old fashioned but very efficient. Passengers board fast from all doors without the restrictions of turnstiles (which is a standard feature in bus systems in Latin America). There are a variety of methods of getting reasonably high-speed fare collection without external fare collection, but platform-level boarding is critical to reducing boarding and alighting time.

At critical points where many passengers board at the same time, like at terminals, the external collection would accelerate the boarding process. It is easier to control flow and passenger numbers with an external turnstile than the internal manual collection. MCH should consider various alternatives and select an appropriate ticketing system only after the basic design of the system and the basic institutional structure of the BRT system is clearly established.

6.6 Dealing with Bottlenecks that Cannot be Moved

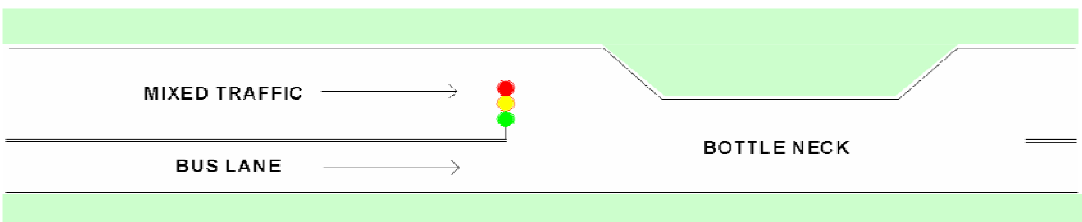
Some bottlenecks along the corridor may be politically impossible to move, whether they are graveyards, temples or other significant areas. While every effort should be made to achieve sufficient right-of-way where possible, there are design options for dealing with remaining bottlenecks.

In these cases the lowest cost recommendation is to end the bus lane just behind the bottleneck and let the BRT buses move with mixed traffic at the bottleneck.



Bus lane ends before bottle neck

In cases where the bottleneck is long and the delays are considerable inside the bottleneck, a traffic signal should be installed to control congestion with separate cycles for BRT buses and other traffic.



Bus lane ends before bottle neck with signal prioritization

Another possibility is traffic diversion. Traffic volume is not a fixed variable, but can be redirected to other alternative routes on the network where capacity exists. This has to be analyzed locally, but in general, in Hyderabad, there are not many alternative routes in either the north or the south sections of the corridor outside the CBD area of Lakdi ka Pul to Chaderghat.

The construction of an overpass or underpass can be explored if the bottleneck is of limited length, and land is available before and after the bottleneck. Some photos of recent bus-only underpasses from Quito are shown below.

BRT transfer facility under grade-separated roundabout in Quito, Ecuador

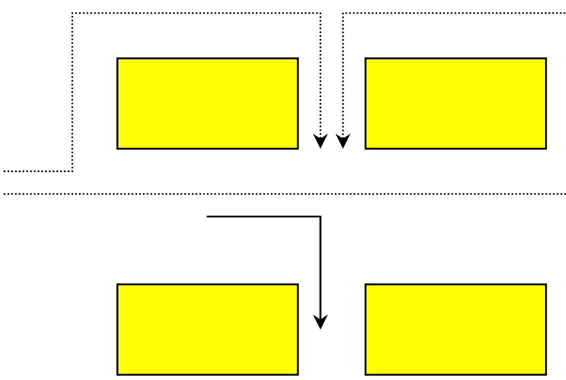
BRT-only underpass in Quito, Ecuador

6.7 Right turning movement at intersections

Even without the bus lane, right turns are a problem to the corridor because:

- It is usually an extra phase introduced to the signalized intersection reducing overall capacity
- Build-up of motorized vehicles waiting for the right turn phase reduces lanes available for the straight traffic.

With the central bus lane there is even less space, and the problem would become more acute. As a principle, attempts should be made to eliminate the right turn. The usual solution is for vehicles to turn left and take a detour on a parallel road and return back to the intersection as part of straight moving traffic perpendicular to the corridor. This solution is very efficient and is a standard for instance in São Paulo, where left turns (equivalent to right here) are an exception at traffic signals and the same is clearly indicated before the signals.



Right-turn Alternatives

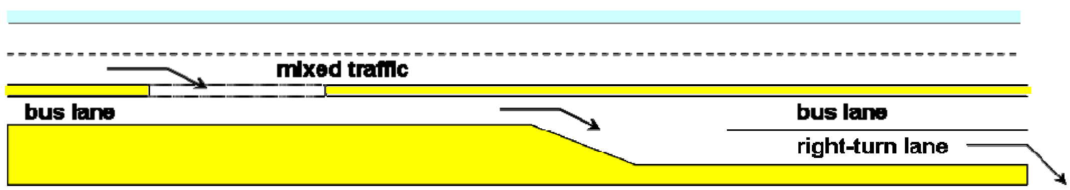
But, with the typical Hyderabad network, due to the lack of alternative routes for the detour, other solutions should be explored at many places, such as:

- transfer the right turn to another point, where more space is available

- expropriate land to accommodate the right turn
- maintain the right turn
- interrupt the bus lane
- combination of the previous alternatives

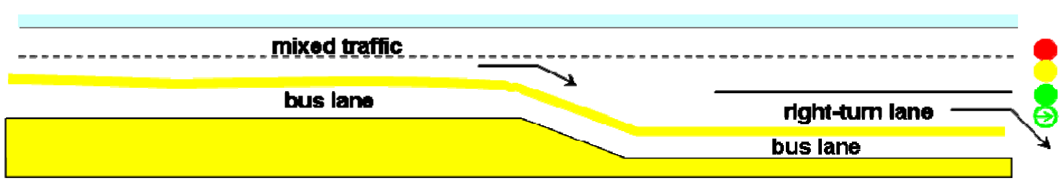
Bus lanes can support right turns and there are different configurations, the two main being:

- permission to enter the bus lane before the signal and a special space to accommodate these vehicles:
- standard traffic signal solution:



Cut in Bus lane before intersection

The configuration allowing mixed traffic to enter and cross the bus lane before the intersection has the advantage of avoiding a special phase for merging buses and right flow, so this practically results in no extra delay for the BRT buses. This configuration is typically used for low flows on right turning traffic (up to 500 PCU/hour), but in Jakarta, for a U-turn, the system accommodates up to 1500 PCU/hour, using a solution similar to this one.



Standard traffic signal solution for right turn

Buses stop to accommodate the right turn phase and vice versa. The other movements and phases remain the same as before. This solution uses the same space as the previous configuration, but increases the delay for buses. This is more commonly used for heavy right turning traffic.

7 Financial Feasibility of Three Transit Alternatives

Comparative Annual Profit/Loss for Hyderabad BRT, MRT, and Monorail (in Rs. Crore)

	Metro	Monorail	BRT
Capital Cost			
Company's Own Estimate	4204	2500	--
ITDP Estimate	5170	8910	408
Capital Cost/Km			
Company's Capital Cost/Km estimate	110	45	--
ITDP Capital Cost/km estimate	135	162	17
Annualized Capital Costs			
Annual Capital Subsidy (6 year financing)	862	1485	68
Annualized Capital Cost (20 year life)	**259**	**446**	**20**
Operating Costs (Annual)	**108**	**80**	**42**
Revenue			
Projected Annual Passengers (Crore)	21	15	27
Average Fare	10	14	7
Projected Annual Farebox Revenue	206	213	188
Net Operating Profit (Loss)	**+98**	**+133**	**+146**
Annualized Profit (Loss)	**-161**	**-313**	**+126**

The principal advantage of BRT over metro or monorail is cost. By our calculations, ***with a Rs5000 crore capital investment, Hyderabad could build 294 km of BRT, about 37 km of metro, and about 31 km of monorail.*** Once built, the BRT system would also be able to fully finance its rolling stock (buses) out of the fare revenue, whereas the rolling stock in the metro and monorail system would have to be subsidized.

The revenue figures in the table above are based on the demand projections, discussed in detail in the Demand Analysis above, and the stated or estimated fare cost for each system. The cost figures for each system are explained in detail in this section.

7.1 Assessment of the DMRC Metro Proposal

The DMRC proposal for Hyderabad estimates that the system will cost roughly Rs. 4204 crore if debt service is included (DMRC, Ch. 13, p.2) for a 38.3 km system. This is roughly Rs.110 crore/kilometer. According to the World Bank (Allport, 2000):

> "Based on the available evidence of outturn costs, and including often ' hidden' public sector costs, we have estimated that the all-in cost of metros in Asia today is about:
> - At-grade US$ 15-30mn/km
> - Elevated US$ 30-75mn/km
> - Underground US$ 60-180mn/km"

Using the lowest figure for elevated metro, we believe that Rs. 135 crore/km is a more reasonable estimate for Hyderabad.

No metro system in the world covers the costs of operations, rolling stock depreciation, and the debt service on the infrastructure. Only the Hong Kong metro and parts of the Sao Paulo metro cover both their operating costs and also the full costs of depreciation of rolling stock. Some systems with very high demand cover their operating costs, such as Buenos Aires, Singapore, and Santiago. Virtually all the other metro systems world wide cannot cover their operating costs or the depreciation of rolling stock, and hence constitute an ongoing financial burden on the municipality in which they are located. The Calcutta metro for example covers only 42% of its operating costs out of farebox revenues (World Bank, 2000).

Therefore, we believe it is more reasonable to assume that the price of this metro system would be any less than Rs. 135 crore/km or Rs.5170 crore for the whole system. Thus, we consider that DMRC's estimated ***construction costs are roughly 20% below a realistic projection***.

The estimated operating and maintenance costs of the Hyderabad metro, (excluding depreciation of the rolling stock) according to the DMRC***, is Rs. 108 crore ($23.5 million) in the first year of operation.*** We did not analyze the feasibility of this operating cost estimate.

The DMRC claims that the system will earn Rs 267 crore per year, and hence that the system will be able to cover part of the cost of the depreciation on the rolling stock and part of the debt service. In our own estimate, ***a revenue of Rs. 206 crore can be expected if at least 80% of bus lines in the corridor are cut***. This Rs.98 crore 'profit' per year is not sufficient to cover the depreciation of the rolling stock or the debt service. According to the DMRC, debt service will be in the range of Rs.200 crore annually for the first three years of operation. They are assuming the availability of capital subsidies from the state and national government of Rs.1682 crore. As such, ***the municipality could be inheriting an ongoing debt service burden of at least Rs.123 crore annually for at least six years.***

A double tracked metro system has higher peak capacity than BRT. However, ***we believe the DMRC's demand estimates are 70% higher than reasonable demand projections for this corridor.***

The financial estimates for the metro include no funds whatsoever to improve the conditions for pedestrians in the corridor under the metro. These costs would be additional.

7.2 Assessment of Monorail

The monorail companies are claiming they can build a 55 km system in Hyderabad with a capacity of 36,000 pphpd for Rs. 2500 crore, or Rs.45 crore/km. **We believe this is less than 1/3 of what it would actually cost**. The monorail in Kuala Lumpur (KL) has a capacity of only 5000 pphpd and cost Rs.162 crore per kilometer. The capital costs were not very high because they cut corners on safety, and designed a low capacity system. It was paid for by heavily subsidized government loans. Because the fare price is high, daily demand is only 45,000, around 4000 pphpd, so the system doesn't need more capacity now. While some capacity can be added by adding trains and reducing lead times, reaching 18,000 pphpd would require reconstructing station platforms and would significantly increase costs (based on recent World Bank review-classified).

The monorail in KL covers its operating expenses from passenger revenues, largely because it successfully connects several light rail lines. It does not make enough money to cover its debt service payments, and i**t is unclear what will happen when the first debt service payments become due.**

A monorail would not consume as much of the existing surface right-of-way. But this would come at a very high price. Currently, there are monorail companies from Japan and Malaysia promising to invest in monorails using only private money, but in practice they have initiated construction before providing transparent financial analysis, and in the end they always ask for some sort of government subsidy, either for capital investments, or in the form of demand or revenue guarantees, or loan guarantees. Because most of their profits are made in the sale of the rolling stock and the construction contracts, they are not that concerned about whether the Monorail operating company is solvent or not.

In Jakarta, construction on the monorail began, and then stopped when an agreement could not be reached on the financing. After initially stating they would build the monorail at their expense, the developer is now asking the Jakarta government for a $20 million annual operating subsidy for 7 years and a $60 million dollar initial equity investment. Even if DKI Jakarta agrees to provide this subsidy, they are still exposed to substantial risk. If the system still loses money, the company can threaten to bankrupt the system unless the subsidy is increased.

The Jakarta monorail agreement requires that all the bus lines in the corridor be cut, and are asking to charge a fare price of $1.50 per trip (Rs68), many times higher than the current bus fares. Thus, the transit passengers, many of them low income, will pay much higher transit fares, or shift to two-wheelers. Private companies have a strong incentive to exaggerate the projected demand figures and underestimate the system costs to make the project look low risk to the government. ***We recommend that our own demand estimates above be considered before any ridership guarantees are issued by the government, and that whoever certifies the demand estimate be made financially responsible for the outcome.***

Ten months after monorail construction was officially inaugurated in Jakarta in June 2004, the project has foundered due to the private developer's demands to the city for additional funding.

Furthermore, where will the monorails be manufactured, where will the spare parts come from, where will the construction jobs and maintenance jobs go? The rolling stock from monorails is proprietary, which means that you can not buy monorails from one company and use them on another company's monorail. You are locked into a single supplier. That is why Japan and Malaysia are willing to invest in these systems. In the long run, even if the monorail operator goes bankrupt and the city has to take over the system, they will still be dependent on the equipment supplier for repairs and spare parts. Hyderabad will be trapped using their suppliers into perpetuity. Should the Indian taxpayers be creating jobs in Malaysia and Japan rather than supporting Indian firms?

Safety and breakdowns are also a concern. Maintenance is a major problem in all countries, including India. When systems are new they break down, until 'teething problems' are resolved. Then as they age, they begin to break down frequently again and leak oil. When a monorail breaks down, the whole service has to be suspended as there is no way of getting around the stopped vehicle. On BRT you simply make the buses enter mixed traffic until the problem is fixed. Furthermore, the monorails built in Kuala Lumpur were built without catwalks, so when the monorail breaks down, the passengers are stuck up there. A recent tire explosion in Kuala Lumpur led to two serious injuries and it took hours for the service to return to normal. The old monorails also drip oil down on the street below. Construction standards in Malaysia are not so high, and safety regulations not so tight.

We estimate that a monorail in Hyderabad with a capacity of 18,000 pphpd would cost at least Rs.162 crore/km, and the whole system would cost around Rs. 8910 crore, or $1.98 billion. If we optimistically assume that this includes financing charges, the capital cost would be around Rs.1485 crore per annum for six years. If it has operating costs somewhat lower than for the metro (Rs.80 crore/annum), and had a system of feeder buses with free transfers like the metro and BRT systems, and charged an average fare of Rs.12, they might be able to clear Rs.100 crore annually. This would not be sufficient to cover the depreciation on the rolling stock, let alone the debt service on the construction. ***No investor is going to agree to this without a government ridership guarantee, operating subsidies, or capital subsidies.***

The financial estimates for the monorail include no funds whatsoever to improve the conditions for pedestrians in the corridor. These costs would be additional.

7.3 Assessment of BRT

BRT systems vary widely in quality. Bogotá's system cost the most because it included the full reconstruction of the entire roadway, including the mixed traffic lanes, new sidewalks, parks, public space, and other improvements and amenities in the corridor. A full breakdown of the costs in Bogotá is shown.

Detailed Cost Breakdown of Per Km Costs for Bogotá's TransMilenio BRT System

Component	Total Cost (US$ Million)	Cost/Km (US$ Million)
Studies and designs	4,01	0,09
Exclusive Ways	36,69	0,87
General traffic	36,13	0,85
Public space[1]	28,29	0,67
Stations[2]	25,51	0,6
Pedestrian	16,57	0,39
Terminals	15,72	0,37
Parking and	17,16	0,40
Properties	29,18	0,69
Network services	18,57	0,44
Maintenance	18,57	0,54
Roads for feeder	15,28	0,36
Control Center	3,33	0,08
Others[3]	22,85	0,54
TOTAL TRUNK LINES	**292.2**	**6,89**

Because construction costs in Hyderabad are lower than in Colombia, we believe that a similar high quality system with excellent public space can also be built in Hyderabad at a much lower cost.

Per Km Costs of Various BRT Systems Worldwide

City	Segregated Lines (km)	Cost per Km (US$ million)
Taipei	57	0.5
Porto Alegre	27	1.0
Quito (Eco-Via Line)	10	1.2
Las Vegas (Max)	11	1.7
Curitiba	57	2.5
Sao Paulo	114	3.0
Bogotá (Phase I)	40	6.8

MCH should avoid the temptation to save money by not properly planning any mass transit system. Building a transit system is like performing heart surgery on the city. If it is built and designed properly the first time, the MCH can save itself hundreds of crore rupees.

Bogotá spent some $5.3 million on the planning alone. The breakout for this cost is as below. They spent considerable funds working out the institutional and legal arrangements. Now that much of this has been worked out and the methodologies standardized, these costs can be reduced substantially. Still, for Hyderabad, at least $1 million (Rs.4.5 crore) would need to be spent to do a proper detailed design and engineering.

Bogotá Planning Costs, Phase I

Firm Contracted	US$	Paid By
McKinsey	3,569,231	UNDP
Investment Bank	192,308	Department of Transport
SDG	1,384,615	Department of Transport
Landscape Designs	115,385	Department of Transport
TOTAL	**5,261,538**	

To build a world class BRT system in Hyderabad that could handle 18,000 pphpd initially and increase to 36,000 pphpd, to reconstruct the corridor to make it a beautiful walking and cycling environment for transit passengers and shoppers, to build beautiful parks and public space along the BRT system, acquire all the land necessary, and acquire a fleet of modern high quality buses, Hyderabad would not spend more than Rp 407.5 crore ($90.6 million) for Corridor I, or Rs.17 crore per km ($3.8 million).

The infrastructure cost of constructing Corridor I would be around Rs. 123 crore (Rs. 5.1 crores/km), or roughly $27.4 million ($1.1 million/ km). Bus procurement should cost another Rs. 80 crore (200 buses x Rs.35 lakh/ bus), or $17.8 million. Land Acquisition will cost some Rs. 200 crore ($44.4 million) or less, depending on the design. Planning cost should be around $1 million in total (Rs.4.5 crore).

A 24 km BRT system in Hyderabad could be built using:

- Private build-operate-transfer (BOT) or government investment for infrastructure: Rs. 123 crore (Rs. 5.1 crore/km)
- Bus operator purchase of rolling stock: Rs. 80 crore

For an optimal mass transit system, the government needs to improve the right-of-way for both vehicles and pedestrians, at an estimated cost of Rs. 68 to 200 crore.

Estimated Capital Costs of 24km BRT Corridor in Hyderabad

Per Km Costs	**Lakh Rs/Km**	**# Per km**	**Total Crore Rs**
Footpaths & Pedestrian Amenities	15	2	7
Pavement Cost - Mixed Traffic lanes	25	4	24
Pavement Cost - BRT Lanes	19	2	91
Moving Poles	2.5	2	120
Moving Transformers	12	2	58
Bus Stations	80	2	38
Dividers & Medians	0.35	4	0.3
Overruns, miscellaneous	50	1	12
Sub-Total			**98**
Additional Costs	Lakh Rs Each	Quantity	
Terminal Stations	1250	2	25
Total Infrastructure			**123**
Bus Fleet Acquisition (averaged price of articulated and feeder buses)			**80**
Land Acquisition - per ha (estimated as per market value)	10,000	205	**205**

These capital costs amount to only some Rs.68 crore annually for a period of six years. Estimating operating costs at Rs.22.5 ($0.50) per bus kilometer, and 200 buses make 6 round trips per day for 300 days per year (adjustment for off peak and vacations), annual operating costs should be in the range of Rs. 42.12 crore/year, or $49.36 million/year on Corridor I.

In terms of revenue, the BRT system would have some 686,000 total passengers, of which 308,000 would be the demand primarily on the trunk system, and 378,000 would be demand on buses originating in mixed traffic conditions on Corridor II and Corridor III but controlled by the BRT system. At an average fare of Rs.7, this would yield annually some Rs.188 crore from the whole system, and roughly Rs.85 crore in Corridor I.

Revenue Estimates for BRT in Corridor I, Scenario III or IV

Assumptions:	**pax/day**	**Daily Revenue (Rs) at Rs. 7/pax**	**Annual Revenue (Rs crore) (300 days)**	**$ Annual Rev (million)**
Total system	686,000	5,488,000	164.6	$36.59
Corridor I	308,000	2,464,000	73.9	$16.43

This would yield an operating profit of Rs. 123 crore per year ($27 million). With a Rs. 123.crore annual profit, all bus procurement costs should be recovered in just one year, and part of the debt service on the infrastructure could also be financed out of the farebox. ***Another option would be to reduce the average fare to Rs.6, which would still allow the buses to be fully paid for within 6 years***.

For BRT, we recommend the following financing:

Government improvement of right-of-way (cost of Rs. 68 to 200 crore)

Rs. 123 crore: Private or Government investment for infrastructure

Rs. 80 crore: Private Investment or Public Bus Authority Financing

In other words, ***BRT in Hyderabad could operate without public operating subsidies, could earn enough profit to finance all new bus procurement, and at an initial capital investment of roughly 1/8 that of a metro***. Infrastructure for a BRT system could also be developed on a BOT basis.

Furthermore, because these funds would be sufficient to significantly improve the corridor, rather than blighting it with an elevated structure, the possibility of extensive profits from parallel real estate development is as likely as not more likely to materialize with BRT than with other mass transit options.

8 Projected Impacts of BRT in Hyderabad

8.1 Impact of BRT in Hyderabad on Mixed Traffic Congestion

While the precise impact of the proposed BRT system for Hyderabad on mixed traffic speeds would need to be modeled, it is certain that ***the BRT system could significantly improve current mixed traffic speeds.***

The reasons for this improvement are as follows:

- Some 80% of existing buses would be relocated out of the existing mixed traffic lanes.
- Buses would be forced to stop in an orderly fashion at each bus station, avoiding the current problem of buses stopping two abreast and blocking three lanes of traffic.
- Pedestrian and bicycle traffic currently occupying a full lane of mixed traffic would be relocated onto special segregated facilities.
- While existing mixed traffic lane capacity is highly irregular, the net impact of the project would be to increase mixed traffic lane width.

We anticipate that mixed traffic vehicle speeds will increase by at least 5kph on average, if not more.

8.2 Impact of BRT on Air Pollution in the Corridor

The BRT system would lead to a significant reduction in air pollution by roughly 20% - 40% in the corridor. The specific amounts of the improvement will depend on the bus technology selected and the modal shift impacts.

The air pollution reductions in a BRT corridor result from the following impacts:

a. The total number of buses being used in the corridor is reduced.
b. The BRT buses tend to be cleaner than traditional buses.
c. The BRT system will help prevent further mode shift away from buses to polluting vehicles like two wheelers.

Of these impacts, the modal shift impacts are by far the most important. In the case of Bogotá, the positive modal shift impacts were not the result solely of the introduction of BRT, but were also a result of complimentary measures to build 300km of bike lanes, and to restrain private motor vehicle travel by reducing total subsidized public parking.

The most important reductions are likely to be in particulates, SO2, and nitrogen oxides. Because the modal shift options are greater for BRT than for Monorail or Metro, the emission reduction benefits would also be greater.

8.3 Impact on Road Safety

Currently, road safety is one of the most urgent concerns faced by Hyderabad. A disproportionate number of pedestrians are killed as a result of conflicts between bus boarding and alighting and mixed traffic at bus stops. The lack of proper sidewalks and pedestrian crossings cause dangerous conditions on Hyderabad streets. Currently BRT Corridor I has an average of 60 fatalities a year, of which 35 are pedestrians. The BRT system is likely to reduce these fatalities to fewer than 5 per year.

By forcing buses to stop at pre-paid bus stations, the dangerous conditions at existing bus stops will be avoided. Further, the physical barrier between the bus lane and mixed traffic lane will also serve as a pedestrian refuge for pedestrians crossing the street.

8.4 Risks of a BRT System

It is often the case that politicians will become inspired to develop a BRT system in a fast way due to the time constraints facing all politicians. BRT systems can be designed and built extremely rapidly and well, but to design it both rapidly and well costs money. Bogotá spent over $6 million just on the planning for TransMilenio, and was able to plan, build, and complete the system in eighteen months. Because they were ready to spend the money, they were able to hire the best experts in the world and hire them immediately.

Even on TransMilenio mistakes were made due to this haste. Contractors building the road-bed were not of high quality, and the road bed has cracked prematurely in some locations. Other systems have made even more costly mistakes. Jakarta rushed forward with a system that reached capacity in less than 1-year by ignoring demand projections, and is having to repair the roadbed in piecemeal fashion because of neglecting to consider this at the beginning.

9 Conclusions and Next Steps

Bus Rapid Transit offers the lowest cost means of dramatically improving Hyderabad's transportation system while simultaneously making the city a nicer place to live, work, and shop at a price ***1/8 or less of the cost of the next cheapest alternative to meet this level of demand, and requires less land acquisition than a metro.***

If done well, ***the first BRT Corridor in Hyderabad could satisfy all of the public transit demand in Corridor I into perpetuity, while also decongesting the mixed traffic lanes***. These same funds will not only leave in place a top quality BRT system, they will also leave the city with beautiful tree lined pedestrian promenades that could fundamentally transform the quality of the CBD to one befitting a world class city. Real estate values along the much improved and much more accessible corridor would rise dramatically. The authority which develops the BRT system would be in a position to profit from the appreciation of this property, just as with a metro system.

Furthermore, the buses operating in the BRT system could be Indian buses, manufactured in India and eventually assembled in Hyderabad. Potentially these buses could be exported all over the world to other cities developing BRT systems. All the buses, spare parts, components, and maintenance and repair jobs would go to people in Hyderabad, adding to the local tax base, and creating a new vital export industry. The IT used in the BRT system could be done by local Indian experts.

ITDP recommends that Hyderabad seriously consider BRT coupled with improvements in pedestrian and other non-motorized travel conditions in Corridors I – III, and a tightened regulatory regime for parking. We believe these will be the fastest, most sustainable, and most cost effective means of addressing Hyderabad's growing traffic woes.

9.1 Next Steps

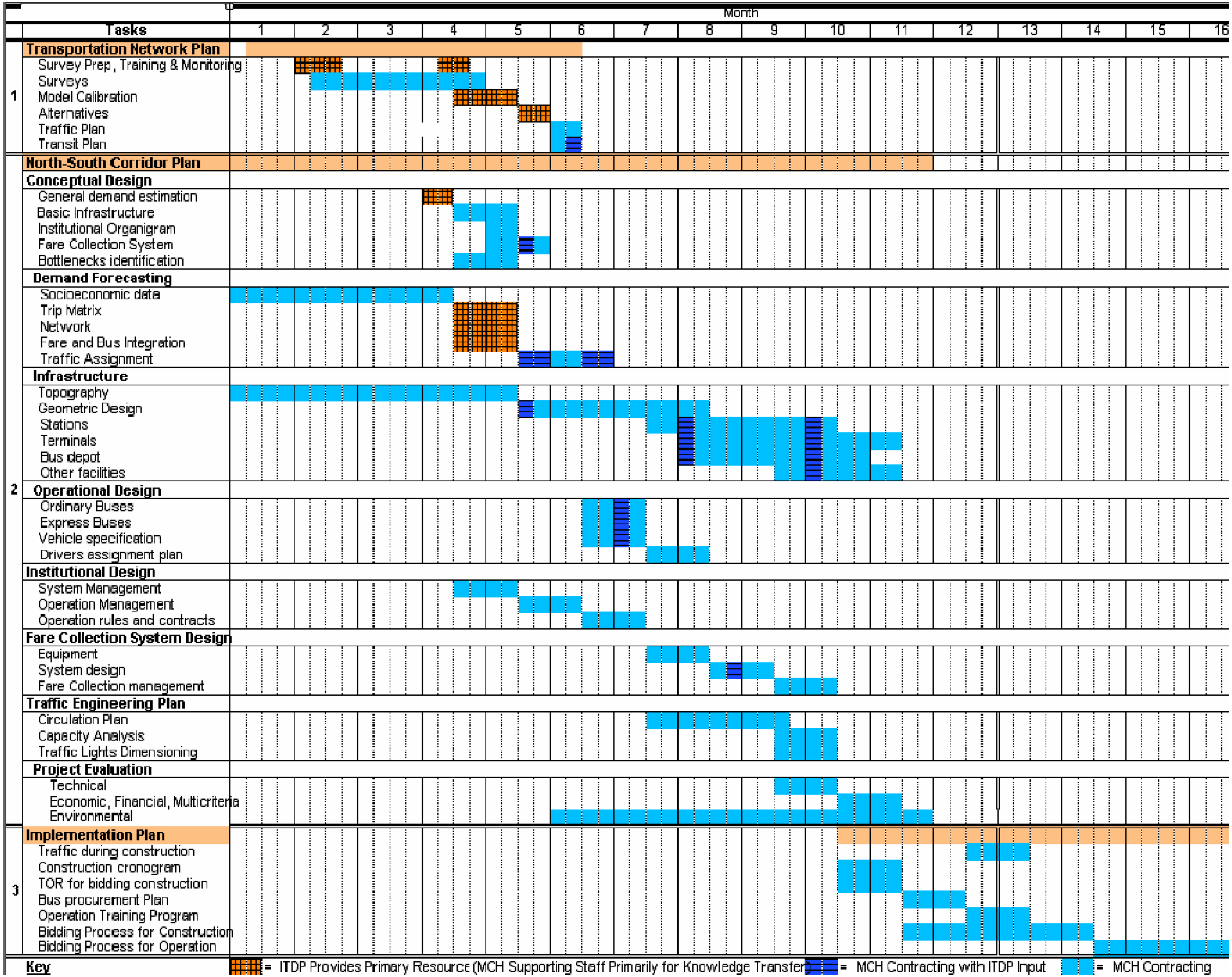
The Municipality needs to establish a permanent project management unit or special purpose vehicle to oversee the implementation of the project, and to appoint a director with significant powers to see the project through.

To plan the system, we urge that the best Indian and international experts be hired in consortiums through competitive bidding. Technical control is critical, and final designs should be signed off on by both the lead Indian expert and the lead international expert. Mistakes made in the planning stage can cost tens of millions of dollars to fix, problems that qualified experts can easily avoid.

The most important next step is to complete the on-board origin-destination survey of bus passengers, and plug this into a traffic model. This is needed to get more robust demand estimates for each corridor, to make critical decisions about the importance of route changes, to facilitate difficult decisions about design and land acquisition issues in the city center, and to determine if bus routes need to be converted to feeder routes, and how many and which ones.

In parallel, decisions about where land acquisition and road widening are possible and where they are not possible, and to what extent, needs to be made quickly. The system cannot be designed until this issue is thoroughly addressed. The issue is not purely technical and must be resolved through the political process. Engineers can design a BRT system no matter what decision is made, but it will look and operate differently depending on these decisions.

On the following page is a more outline of the next steps that need to be taken to ensure a successful BRT system is developed in Hyderabad. It also highlights those steps for which ITDP's grant from US AID can continue to support.


Month
Tasks
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1
Transportation Network Plan
Survey Prep, Training & Monitoring
Surveys
Model Calibration
Alternatives
Traffic Plan
Transit Plan
2
North-South Corridor Plan
Conceptual Design
General demand estimation
Basic Infrastructure
Institutional Organigram
Fare Collection System
Bottlenecks identification
Demand Forecasting
Socioeconomic data
Trip Matrix
Network
Fare and Bus Integration
Traffic Assignment
Infrastructure
Topography
Geometric Design
Stations
Terminals
Bus depot
Other facilities
Operational Design
Ordinary Buses
Express Buses
Vehicle specification
Drivers assignment plan
Institutional Design
System Management
Operation Management
Operation rules and contracts
Fare Collection System Design
Equipment
System design
Fare Collection management
Traffic Engineering Plan
Circulation Plan
Capacity Analysis
Traffic Lights Dimensioning
Project Evaluation
Technical
Economic, Financial, Multicriteria
Environmental
3
Implementation Plan
Traffic during construction
Construction cronogram
TOR for bidding construction
Bus procurement Plan
Operation Training Program
Bidding Process for Construction
Bidding Process for Operation
Key
= ITDP Provides Primary Resource (MCH Supporting Staff Primarily for Knowledge Transfer)
= MCH Contracting with ITDP Input
= MCH Contracting

10.2 Annex II: Sources and Previous Studies

Some of the previous studies which were done on transportation issues in Hyderabad are

- Hyderabad Area Transportation Study (HATS), 1986 by Regional Engineering College, Warangal
- Feasibility Study on Urban Mass Rail Transit System Construction Project in Andhra Pradesh State, Hyderabad City in India, 1988 by Japan External Trade Organisation (JETRO)
- Feasibility Study for Hyderabad Light Rail Transit, 1989 by RITES
- Report on Phase I of Hyderabad Multimodal Suburban Commuter Transportation System, 2003 by MCH, Hyderabad.
- Pre-feasibility Study of Hyderabad Light Rail Transit System, 1993 by IL&FS.
- DPR on Hyderabad Metro, 2003 by DMRC
- MMTS Phase-II study, 2004 by L & T Ramboll

This report also relied on:

- Allport, Roger. 2000. Mass Rapid Transit in Developing Countries. (World Bank: Washington DC.)