AN OVERVIEW ON BUS RAPID TRANSIT SYSTEM
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ABSTRACT
Bus Rapid Transit System (BRTS) is an innovative, high capacity, lower cost public transport solution that can significantly improve urban mobility. Public Transport System in most Indian cities is rapidly deteriorating because of the increasing travel demand and inefficient transportation system. There are various problems related with public transport such that tremendous increase in number of accidents, Environmental degradation, Congestion, Overcrowding due to inadequate system, Frequency of service and schedule is not strictly adhered. The problem of pollution, safety and inefficiency have reached at alarming level in most of the major cities in India due to unabated growth of its population -both of people and motor vehicles, combined with inefficient public transport system and poor enforcement of environmental laws etc. Thus, there is a great need to ensure clean, efficient, affordable, effective and safe public transportation system and for this Bus Rapid Transit System could become an appropriate solution. Bus Rapid Transit (BRT) Systems have emerged as one of the important mode of public transport. They are Motorized Transport comparatively flexible, easily accessible, and efficient and also cost effective in terms of being able to transport a large number of people (rather than vehicles). BRT systems can easily be customized to community needs and incorporate state-of-the-art, low-cost technologies that result in more passengers and less congestion. This paper presents an overview of BRTS and the salient features of BRTS.

KEY WORDS: BRTS, CBDs, HOV

INTRODUCTION
Bus Rapid Transit System (BRTS) takes part of its name from "Rapid Transit", which describes a high-capacity transport system with its own right-of-way, implemented using buses through infrastructural and scheduling improvements, to provide a high level of service. Complicated as it sounds, this is nothing but high-capacity articulated buses operating in lanes reserved for their exclusive use. The Bus Rapid Transit system is expected to revolutionize public transport with new buses, special lanes and new routes, all at a low cost. Bus Rapid Transit System, or 'High Capacity Bus System’ as it is commonly referred to, is a flexible mass-transit mode that has the advantage of being the most economical amongst the mass-transit options. BRTS flexibility is both in terms of routes and areas of coverage as well as in terms of its amenability to features-up-gradation over time. BRTS, as a system, includes a number of broad elements such as running way, stations (or stops), vehicles, service and operating plans, fare collection, ITS (intelligent transportation system) etc., under which the different features of BRT are subsumed. In
India, roads are often designed to take a particular number of users, say 30,000 persons per hour per direction. But the demand for use of any one road tells us only part of the story; looking at corridor volumes using a travel demand model is a flawed approach. A service which delivers passengers from their desired origins to their desired destinations should be conceived while designing roadways. A single dedicated lane BRTS is known to carry 20,000 passengers per hour per direction. The Bus Rapid Transit System (BRTS) system project is intended to reduce traffic on roads while improving service - at no extra cost to commuters. The new 160-seater buses will be operated by metro bus and other contracted operators. The system helped to reduce traffic, air and noise pollution and lengthy commuting times. Segregation by vehicle type or travel mode is the key to improving traffic flow. In a BRTS system the median and the inner most lane or the left most lane can be dedicated to the bus. In case of median lanes bus stops or stations can be built in the median to further improve the flow. Passengers are allowed to cross at the nearest signal or intersections. A well implemented efficiently-run BRTS will also cause citizens to switch travel modes from car to bus, which will further alleviate the traffic situation.

BRT has gained considerable respect around the world as a practical and affordable choice for mass urban transport. It is similar to a mass bus network on the road surface on the lines of a local rail network, where pre-ticketing, wider and lower floors, high frequency and efficiency cut precious commuting time and give breathing space to the roads and parking areas which become bereft of private vehicular congestion. It is also a comprehensive system wherein cycling and pedestrian paths make the roads more people-oriented. As many as 35 cities in the world have successful BRTS, including five in China, besides North and Latin America and Europe.

NEEDS
There are many reasons for developing Bus Rapid Transit system:

- Central business districts (CBDs) have continued to prosper and grow in ways that require more transport capacity and improved access. Given the cost and environmental impacts associated with parking and road construction and the traditional urban form of most CBDs, improved and expanded public transport emerges as an important alternative for providing that capacity. In addition, many suburban cities exceed the aggregate employment base of many urban city CBDs but do not currently have the focus and density to make rail-based rapid transit a cost effective investment.
- BRTS systems can often be implemented quickly and incrementally.
- For a given distance of dedicated running way, BRTS is generally less costly to
build than rail transit. Moreover, where BRTS vehicles can reliably operate at high speeds on high-occupancy vehicle (HOV) lanes or general-purpose highways and streets over significant proportions of a given route, running way capital costs will be even lower compared to those for rail modes, which must be purpose-built over the entire distance covered.

- **BRTS** can be the most cost-effective means of serving a broad variety of urban and suburban environments. BRTS vehicles, whether they are driver-steered or electronically guided, can operate on streets, in freeway medians, on railroad rights-of-way, on aerial structures, and underground. BRTS systems can also provide a broad array of express, limited-stop, and local all-stop services on a single facility without complex signal and guide-way switching systems.

- **BRTS** can provide quality performance with sufficient transport capacity. For example, the Ottawa transit way system’s link to the CBD carries more people in the peak hour than most LRT segments in North America. The Brisbane South East Bus way carries approximately the same number of maximum load point, peak-hour, and peak-direction passengers about 10,000 per hour (Translink, 2008). Many BRTS lines in South American cities carry peak-hour passenger flows that equal or exceed those on many U.S. and Canadian fully grade-separated rail rapid transit lines. For example, Bogota’s Trans Milenio system serves more than 25,000 peak-hour (Trans Milenio, 2008), peak-direction maximum load point riders. The efficiency of the system and high capacity of the passengers depends on the system as a whole and not necessarily on the size of buses, though when necessary articulated buses could be used with ease. However, BRTS in other countries can handle passenger flows in the range of 5,000 to 25,000 passengers per hour per direction. BRTS is designed and developed to tackle all the drawbacks of the existing bus system in an economical and efficient manner. It is a low-cost option for providing cities with a quality transit option.

### MAJOR ELEMENTS OF BUS RAPID TRANSIT SYSTEM

The major elements of bus rapid transit are described below.

- **Running ways**—running ways drive travel speeds, reliability and identity. Options range from general traffic lanes to fully-grade separated BRT transit ways.

- **Stations**—Stations, as the entry point to the system, are the single most important customer interface, affecting accessibility, reliability, comfort, safety and security, as well as dwell times, and system image. BRT station options vary from simple stops with basic shelter to complex intermodal terminals with many amenities.
• **Vehicle**-BRTS system can utilize a wide range of vehicles, from standard buses to specialized vehicles. Options vary in terms of size, propulsion system, design, internal configuration, and horizontal/longitudinal control, all of which impact system performance, capacity, and service quality. Aesthetics, both internal and external, are also important for establishing and reinforcing the brand identity of the system.

• **Off-bus fare collection**: Conventional on-board fare collection slows the boarding process, particularly when a variety of fares are collected for different destinations and/or classes of passengers. An alternative would be the collection of fares upon entering an enclosed bus station or shelter area prior to bus arrivals (similar to fare collection at a kiosk prior to entering a subway system). This system would allow passengers to board through all doors of a stopped bus. This also includes smart cards and payment through credit cards.
• **Intelligent transportation System (ITS):** A wide variety of ITS technologies can be integrated into BRT System to improve BRT System performances in terms of travel times, reliability, convenience, operational efficiency, safety and security. ITS options include vehicle priority, operations and maintenance management, operator communications, real time passenger’s information, and safety and security systems.

• **Service and operation plan:** designing a service plan that meets the needs of the population and employment centers in the area and matches the demand for service is a key step in defining a BRT system. How it is designed can impact system capacity, service reliability, and travels times, including wait and transfer times.

**BUS RAPID TRANSIT SYSTEM (BRTS) IN INDIA**

With the unprecedented and rapid pace of urbanization, The BRTS is successfully running in a number of cities the majority of the million plus cities in India are facing across the world like, Curitiba, Bogotá, Sao Paulo, Mexico serious problems of traffic congestion and pollution. The City, LA, Beijing, Taipei, Seoul, Beijing, Johannesburg and solution to these twin problems is being increasingly seen Lagos. In India the BRT System is being implemented in Delhi, Ahmedabad and Pune while, Jaipur, Bhopal, Hyderabad, Indore and few other cities will be following soon. Table 1 presents the details of various BRTS projects being implemented in India.
Table 1 Details of various BRTS projects being implemented in India

<table>
<thead>
<tr>
<th>Cities</th>
<th>Length (in km)</th>
<th>Cost Sanctioned (in million USD)</th>
<th>Additional Central Assistance (in million USD)</th>
<th>System</th>
<th>Segregation</th>
<th>Bus Stop Location</th>
<th>Ticketing System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahmadabad</td>
<td>88.50</td>
<td>218.08</td>
<td>76.38</td>
<td>Closed</td>
<td>Yes</td>
<td>Middle</td>
<td>Off board</td>
</tr>
<tr>
<td>Rajkot</td>
<td>29.00</td>
<td>24.44</td>
<td>12.22</td>
<td>Closed</td>
<td>Yes</td>
<td>Middle</td>
<td>Off board</td>
</tr>
<tr>
<td>Surat</td>
<td>29.90</td>
<td>104.22</td>
<td>52.11</td>
<td>Closed</td>
<td>Yes</td>
<td>Middle</td>
<td>Off board</td>
</tr>
<tr>
<td>Bhopal</td>
<td>21.71</td>
<td>52.83</td>
<td>26.42</td>
<td>Open</td>
<td>Yes</td>
<td>Middle</td>
<td>Off board</td>
</tr>
<tr>
<td>Indore</td>
<td>11.45</td>
<td>21.88</td>
<td>10.94</td>
<td>Partially open</td>
<td>yes</td>
<td>Middle</td>
<td>Off board</td>
</tr>
<tr>
<td>Pune &amp;</td>
<td>124.77</td>
<td>302.92</td>
<td>151.46</td>
<td>Open</td>
<td>Partial</td>
<td>Middle</td>
<td>Off board</td>
</tr>
<tr>
<td>Pimpri Chinchwad</td>
<td>23.00</td>
<td>(69.36)</td>
<td>(34.68)</td>
<td>Open</td>
<td>Partial</td>
<td>Middle</td>
<td>Off board</td>
</tr>
<tr>
<td>Vijaywada</td>
<td>15.50</td>
<td>33.92</td>
<td>16.96</td>
<td>Open</td>
<td>Yes</td>
<td>Middle</td>
<td>Off board</td>
</tr>
<tr>
<td>Vizag</td>
<td>42.80</td>
<td>100.65</td>
<td>50.33</td>
<td>Closed</td>
<td>Yes</td>
<td>Middle</td>
<td>Off board</td>
</tr>
<tr>
<td>Jaipur</td>
<td>26.10</td>
<td>48.71</td>
<td>24.36</td>
<td>Open</td>
<td>Yes</td>
<td>Middle</td>
<td>Off board</td>
</tr>
<tr>
<td>Delhi</td>
<td>14.6 (implementing with own funds)</td>
<td></td>
<td></td>
<td>Open</td>
<td>Partial</td>
<td>Middle</td>
<td>Off board</td>
</tr>
</tbody>
</table>

**BENEFITS**

BRTS serves following benefits

**Saving in travel time** on the exclusive travel ways the person minutes saved is more than the person minutes lost by people in automobiles, which means significant saving in travel time. Exclusive travel ways reduce travel times in general about 1.5 to 2 minutes per mile (Hobert et al, 2004). Actual time savings are greatest when the previous speeds were the slowest.

**Reduced congestion**

Congestion has long been recognized as an environmental problem. Other than causing delay, it causes noise and fumes and increases
health risks to road users and residents. Cost estimates for HCBS are significantly less than the cost of grade separators, provided to reduce congestion.

**Increased safety**
By creating segregated bicycle lanes and re-designing intersections, conflicts between motorized traffic and bicyclists can be reduced leading to a sharp decrease in the number of accidents and fatalities for bicyclists and motorized two-wheelers.

**Increased capacity**
An exclusive bus lane carries significantly more people than an adjoining general traffic lane during the peak travel periods. The number of bus riders in an exclusive bus lane exceeds the number of automobile occupants using adjacent lanes. Thus exclusive travel ways result in to increased capacity. If a separate segregated lane is constructed for BRTS and bicycles, the curbside lane, which is currently used by bicyclists, becomes available to motorized traffic and buses. This relatively small investment in bicycle lanes can increase the road space for motorized traffic by 50% on three lane roads. Bicycle lanes also result in better space utilization. Not only does extra space on the main carriageway become available to other modes, the dedicated bicycle track also provides a higher capacity for bicyclists. Provision of exclusive bicycle track also provides an opportunity to develop left lane as an exclusive bus lane. For instance a 3.5 m wide lane has a carrying capacity of 1800 cars per hour whereas it can carry 5400 bicycles per hour. Average occupancy of a car is 1.15 persons and bicycle carries one person. This implies that in order to move the same number of people we would need 2.6 times the roads that would be required for bicyclists. Give the fact that there is not much space available to expand existing road the future mobility needs and projected trips can only be met by increasing the capacity of the existing road network. This can be achieved by encouraging modes, which are more efficient in terms of space utilization. Motorized vehicles benefit because of improved capacity of road and improvement in speeds. Capacity estimates of a typical arterial road in Delhi show improvement in corridor capacity by 19-23 percent by providing an exclusive cycle track. If the full capacity of the corridor is utilized, i.e., provision of a high capacity improvement by 56-73 percent (present carrying capacity is 23,000 passengers/hour to 45,000 passengers/hour) (Tiwari G., 2004). BRT systems provide a dedicated corridor for quicker bus movements (coupled with bus priority signaling system) and give a segregated and safe corridor for pedestrians and non-motorized transport like cycles and cycle rickshaws. Salient Features of Bus Rapid Transit System can be summarized as follows:

- **Bus only, grade-separated (or at-grade exclusive) right-of-way**: The main feature of a BRT system is having dedicated bus lanes which operate separate from all other traffic modes.
• **Comprehensive coverage**: In addition to using dedicated bus lanes, BRTs can also take advantage of existing roadways in cities that already have a comprehensive road network for private automobiles. Service can be made more time efficient and reliable than a standard bus system by taking advantage of bus priority methods.

• **Bus priority at Intersections /Signals**: Preferential treatment of buses at intersections reduces delay to buses to a great extent. Intersection priority can be particularly helpful when implemented in conjunction with bus lanes or streets, because general-purpose traffic does not intervene between buses and traffic signals

**Positive Impacts**

From the socio-economic and safety perspective, post-project evaluation studies suggest that BRTS can bring a range of benefits for users as well as the community residing along the project corridors through different BRTS System elements, BRTS performance, and BRTS System benefits:

- **Increased Accessibility**: BRTS being a flexible system can run on the street across the street, over the street or on canal banks. Although it serves communities best when built on surface, BRTS can be run on elevated structures or in tunnels if necessary. Stations and right-of-way are compact and efficient.

- **Identity and Image**: Through articulated metro-like BRTS System elements viz. Running Ways, Stations, Vehicles, Fare Collection, ITS, Service and Operating Plans, BRTS will have a unique identity and public image.

- **Travel time savings**: With respect to total BRTS travel times, BRTS projects with more exclusive running ways generally experience the greatest travel time savings compared to the local bus route. Exclusive transit way projects abroad operate at an average speed of 35 kms per hour and Arterial BRT projects in mixed flow traffic or designated lanes at 20-25 kms per hour).
Reliability: One of the basic objectives of any transport infrastructure projects is saving in travel time. Systems with more exclusive transit ways would demonstrate the most reliability and the least schedule variability and bunching. Passenger surveys around the world indicate that reliability is important for attracting and retaining passengers. New automated vehicle location systems allow for the objective and conclusive measurement of reliability. Safety and Security: BRTS will be a safe mode of public transportation. Passengers traveling by BRTS are very safe and neighborhoods through which the system passes are also much safer. A single bus will remove about 50 cars from the road and scientific signal systems will make the neighborhoods safer for local traffic and pedestrians. Customer perceptions of “personal safety” or security reveal that customers perceive BRT systems to be safer than the rest of the transit system.

Increased Rider-ship: Attracting higher rider-ship is one of the main goals of any rapid transit investment. The ability to attract rider-ship reaffirms the attractiveness of the transit service and confers many benefits to a region, including reduced congestion, increased accessibility, and reduced pollution. The number of passengers is the surest indicator that a service is attractive and appropriately designed. The identity and passenger information advantages of BRTS are seen positively by potential BRTS customers when they make their travel decisions. When considering impacts on rider-ship, it is important to note that BRTS systems attract three types of trips:
   a) Existing transit trips that diverted to the new BRTS system from other systems/services
   b) Totally new or “induced” trips that were not made before by transit or any other mode
   c) Trips that were previously made by another, non-transit mode (drive alone, carpool, walk or bicycle) now opt for BRTS service.

- **Transit Supportive Land Development:** BRTS will enhance property value along the corridor. In some cases, the development will take place adjacent to transit to the transit facility, while in other places the development would be integrated with the transit stations. Generally, it is being recommended to link transit and land development around the world and even in Indian cities where BRTS is being implemented including Ahmadabad wherein increase in FAR is being proposed along BRTS corridor on ring road. Hence, transit oriented development is envisaged for Bhopal also.

- **BRTS reduces pollution:** When discussing urban transportation systems, the primary way to improve the environment is through
reduction of vehicular emissions to improve air quality. The BRT System will take large number of individualized vehicles off the road, thereby reducing air and noise pollution.

• **Other Benefits**: Like all successful transit modes, bus rapid transit may also result in other system benefits. These benefits can include:

  ➢ **Increased Revenue** – Ability to generate revenue from new riders, new ways of collecting fares, or new auxiliary revenue sources (e.g., advertising opportunities on passenger information).

  ➢ **Reduced Congestion** – The ability to attract riders from the automobile can help reduce or limit the growth in congestion.

  ➢ **Economic productivity** – Improvements to BRTS system design can save time for existing BRT passengers, improve mobility for new BRTS passengers, and reduce congestion on the road network, saving time for automobile users and freight carriers.

  ➢ **Quality of Life** – Providing mobility alternatives and improving transit supportive development can improve the quality of life of a region. Transit also supports community preservation.

  ➢ **Improved Economic Opportunities** – Providing additional mobility choices can enhance the pool of employment opportunities a regional population can pursue and reduce costs associated with more expensive modes. Retail establishments and other businesses benefit from increased sales and labor force availability.

  ➢ **Job Creation** – Transit investment has direct positive impacts on employment for the construction, planning, and design of the facilities.

**Negative Impacts**
On locations where the existing carriageway is too narrow, due to many reasons including encroachments to allow construction of new corridor and consequent widening, construction of stations and depots, additional land acquisition is unavoidable. There are few stretches along identified corridors where existing carriageway is just insufficient for the system to be built, thereby, necessitating clearance of structures.

**CONCLUSIONS AND RECOMMENDATIONS**

• An important advantage of BRTS is its flexibility. This approach lends itself to incremental learning of the problem, and eliminating mistakes as the development proceeds. The relatively low
implementation costs also don't leave taxpayers tied to one particular technology or solution.

- Proper attention needs to be given to pedestrian approach, crossing and circulation in bus stations. Continued planning of BRT stations and configurations should minimize difficulties of pedestrian circulation and passenger transfer. This implies that stations should be as close to intersections as possible. Transit stations should be located in the heart of their target service areas.

- The commuters prefer to board/alight at intersections, Thus creating informal bus stops which cause hazardous Traffic conditions, it is advisable to plan the facilities as per the commuters’ requirements

- A dedicated lane for the buses should not be subjected to repeated punctures into the facilities existing on the sides, such as offices and colonies the design provides for adequate pedestrian safety for crossing the roads

- The signal system should be resorted to at the junctions to minimize the merging/ weaving of the traffic

- Kerbs dividing the lanes may lead to accidents without physical kerbs but the lane segregation will not be possible without the kerb stones these can be suitably redesigned to take care of safety aspect.

REFERENCES

- Bhopal City Development Plan under JNNURM, A Report, Bhopal Municipal Corporation, Bhopal, (downloaded from Internet, Nov., 2009)
- Case study:-Social Cost and Benefit Analysis for BRT, Road Research in India, 2008-2009, IRC Highway Research Board.
- Tiwari Geetam, Bus Priority Lanes for Delhi, Transportation Research and Injury Prevention Programme, Indian Institute of Technology, Delhi, India 110016
- Workshop, Bus Rapid Transit System, Department of Transport, Government of the National Capital Territory of Delhi, 12-13, Dec., 2005, Delhi. (downloaded from Internet, Nov., 2009)