



## An Appropriate Bus Rapid Transit System

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### ABSTRACT

Bus Rapid Transit (BRT) has been adopted as an improvement on regular bus services through the combination of features like infrastructure changes that resulted in better operation speeds and service reliability. In this regards, it does pose a problem in selecting a BRT that is most suitable for a particular area/region. Hence, this study suggests an appropriate BRT system during in-depth literature review. To be able to select the appropriate vehicle option for a BRT system for a particular area/corridor, the transport demand, coverage/distance to be covered and length of public transport delay due to general traffic condition must be put into proper consideration. In terms of cost implication, median BRT system and kerbside BRT system should be selected over segregated BRT system.

**Keywords:** *Bus Rapid Transit system, Corridor, Transport demand, Speed*

### 1. INTRODUCTION

Today, both the public and private transports are facing problems due to increase in vehicle ownership and the suburbanization of both firms and residences in the world. In the past, public transport focused mainly on the central areas of the cities where high population and employment densities enabled frequent services, high occupancy rates and many routes. As growth is reaching suburban from the metropolitan area, imperative challenge crops up in the public transport to increase its service in order to serve the commuters better, and also to integrate suburban service with metropolitan service (Pucker and Hurth, 1996). The main aim of this study is to check the most appropriate BRT system through in-depth literature review. Hence, public transport has to be made more attractive and user friendly in relation to improved service, travel information, reliability, safety and upgrading of infrastructure like waiting stations. Cost is an imperative element that influences the demand for public transport in relation to the time spent waiting, boarding and alighting from vehicles coupled with the risks and inconveniences involved in those actions. The report (Conquest Research, 1997) also suggested that commuters and business users board the fastest and most direct routes.

#### What is BRT?

Bus Rapid Transit can simply be defined as a rapid mode of transportation that can coalesce the quality of rail transit and flexibility of a bus (Thomas, 2001). Transport Research Board (2001 cited in (Levinson et al. 2002) defined Bus Rapid Transit in a more simplified and understandable way as a flexible and rubber-tired rapid transit mode that combines running way, intelligent transportation system (ITS) elements, stations, vehicles and services into an integrated system with a strong positive image and identity. Bus Rapid Transit is a project embarked in phases as fund and opportunity permit because of the service flexibility. Bus Rapid Transit application is planned to be appropriate to the place/destination it serves and its

physical surrounding. Provided its performance in the implemented areas is successful, the service would be extended to other environments. Effective and cheap public transport provision will aid the growth of the nation in terms of the economy, social and environmental wellbeing leading to the urbanization of cities.

#### Historical development of BRT

The large-scale development of the BRTs started in Curitiba (Brazil) in 1974, and before then, there were several smaller-scale projects earlier to its development. After the success of effective BRT in Curitiba, Curitiba's experience inspired other cities to develop similar systems (Matsumoto, 2004). In the 1970s, development of BRT systems was limited to the North and South American continent. In the late 1990s, the replication of the BRT concept gained momentum and BRT systems were opened in Quito, Ecuador (1996), Los Angeles, USA (1999) and Bogotá, Columbia (2000) (Ernst, 2005:11). Especially, the TransMilenio project in Bogotá started operation in 2000 and its success drew attention from the world community as an example of the state of the art in BRT systems. As of 2005, there may be up to 70 systems around the world, depending on one's definition of BRT (Levinson et al. 2003; Wright, 2005)

#### System Performance

The system performance of Bus Rapid Transit (BRT) is based on the following five attributes.

#### Travel Time

One of the main advantages of Bus Rapid Transit is its higher operating speed. The overall travel time consists of four components, which are-

\* Running Time-Time spent in the vehicle moving from stop to stop.

\* Dwelling Time-Time spent when vehicle stopped at a station.

\*Waiting Time-Time spent by the passengers initially waiting to board a transit service.

\*Transfer Time-Time spent by the passengers to transfer from one vehicle to another vehicle in order to complete his/her trip (Federal Transit Administration, 2006b).

### Reliability

Reliability in the service rendered is the ability of the transit operators to offer a dependable level of service and maintain operations as planned. Customers may consider the service undependable when bus arrival times are unpredictable. Operating a dependable service increases the customer satisfaction as well as the perception of high-quality service that may increase ridership for the transit operator (Federal Transit Administration, 2006b).

### Service Adherence

Service adherence can be defined as the measure of reliability. In other words, it is the ability of the transit service to wait on schedule at the designated time point, which is designed to be within 0 to 5 minutes of the schedule. The Bus Rapid Transit (BRT) features that help to improve the travel times could also help in enhancing the schedule adherence by reducing the variability in wait times and in-vehicle travel times.

However, schedule adherence is expected to measure the logical occurrence of divergences from the schedule, for instance probability of the buses consistently arriving late at the stop. Service adherence is very pertinent to customer view, who may want to use the schedule information to determine promptly the time to arrive at a station to catch up with a particular vehicle trip in order to arrive at his destination at the exact time. Considering the operator perspective, service adherence is used to ensure the efficient running of the buses according to the schedule (Federal Transit Administration, 2006b).

### Service Interruption

Service interruption is overseen by the Department of Transportation Services (DTS) to tackle any maintenance related problems like where there is need for road repair, change of vehicle and return buses to its base. Unpredictable delays and likely increase in travel times affect the service reliability (Federal Transit Administration, 2006b).

### Image and Identity

Image and identity mean how the public views the service relative to other transit and transport options available. In this case, the public refers both the commuters and non-commuters of the service. The main aim of Bus Rapid Transit (BRT) is to introduce an identity and image that is different from the local bus services to ensure maximum potential of attracting extra commuters (Federal Transit Administration, 2006b).

### Safety and Security

Accident is an unexpected and unplanned event, often with lack of intention. It is usually a negative outcome, which may have been prevented, had the circumstances leading to the accident been recognized and acted upon earlier to its occurrence (Free encyclopedia, 2012). Safety and security of

Bus Rapid System (BRT) is a measure of the accident rate in the community.

### System Capacity

Each bus has a capacity of 160 passengers, transporting 1,596 passengers per day on the average, which is five times more than the average for the local buses (Federal Transit Administration, 2006a). Dario Hidalgo (2002 cited Federal Transit Administration 2006:18) suggested the daily km travel per bus has been growing from 216 to 370 (134 to 230 daily miles per bus), which was because of the extended hours of service, a higher number of express services and system expansion.

### Customer Satisfaction

The extent to which an organization is able to satisfy its customer is an indication of the general wellbeing and prospect of the future (Fornell, 1992). In addition, customer satisfaction can be described as a broad hypothesis that includes perceived evaluation of product and service. Customer satisfactory is based on the maximum utilization of the customer's opinion and information. Failure to implement the customer satisfactory idea can be termed as inexperience of the customer, which may lead to slow result of the business firm. All organizations had come to realize the importance of customer satisfaction. It is less costly and stresses less to keep existing customers than to look for new ones. Customer satisfaction is one of the criteria used to assess the success of many organizations in the public sector (Leem and Yoon, 2004).

### Service Quality

Yang, (2001) defined service quality as one of the determinants of a business's failure or success. In addition, service quality is a result of the comparison between the customer's expectation about a service and the perception in which the service is carried out. Fundamentally, service quality constituents are-

\*Tangibles: this refers to the appearance of the personnel, equipment and physical facilities.

\*Reliability: is the ability to execute the delegated task accurately and dependably.

\*Responsiveness: is the willingness to assist customer with the needed and prompt service.

\*Assurance: is the knowledge and politeness of the employee coupled with the ability to motivate trust and confidence unto the customers.

\*Empathy: is the individualized attention the company renders its customers (Budiono, 2009).

### Intelligent Transport System (ITS) in Public Transport

The use of technology within the transport environment is referred to as the Intelligent Transport System (ITS). ITS can be seen in all modes of transport and incorporates all the elements of the transportation system like the driver, commuters, vehicle and infrastructure interacting with dynamism. The main purpose of ITS is to enhance the operation of the entire transport system. However, ITS is a broad array electronic control and information systems that are engaged to enhance operation of a transport network.

Internationally, these systems are categorized into electronic fee collection, traffic management and operations, public transport management, incident management, transportation data management, disaster management and coordination, freight operations management and others for easy understanding of the extensive application environment.

ITS systems are pertinent in public transport for providing the management and control function with the support of IRPTN to ensure a well-organized communications network and operations center. Public transport can further be made satisfactory through ITS systems by integrated fare collection as well as apply user subsidies, providing real time passenger at stops and stations, giving priority to public transport vehicles to reduce journey times and improve reliability (Department of Transport, 2007)

### **Element of ITS Implement in Support of IRPTN**

The typical elements of an ITS implement based IRPTN requirements developed through a regional concept of operation are: (Department of Transport, 2007)-

#### **(1) Public Transport Operations Centre**

The management/operation centre forms the backbone of any efficient running of a system. This is the centre where the entire IRPTN system is operated on a real time basis and the interfaces between the various elements are controlled through a system integrator contract. Software is used for scheduling, routing, tracking, management and dispatching in public transport operations.

#### **(2) Passenger Information Signs**

Passengers' information shows at stops and key intermodal stations are pertinent elements of guaranteed acceptable user experience in the system.

#### **(3) Communications Backbone**

A widespread communications network is required to support the spread/roll out of the system. The type of communications infrastructure can be known through the dependent on the bandwidth requirements. It is worthwhile to establish a fibre core network that supports wireless systems. Provision should also be made for already established linkages between associated control and operational centers.

#### **(4) Electronic Fare Payment System**

An incorporated electronic fare payment system should be put in place not to only ensure the passenger's satisfaction but also to provide a platform of information needed to operate and plan these services. The elements needed are the smartcards, fare readers, associated software as well as the distribution network. Greater efficiencies and significant savings can be attained through a national roll-out of such a system and through appropriate utilization of banking payment methods when costing the elements needed for electronic fare payment system.

#### **(5) Traffic Detector**

Provision of traffic detectors and the associated infrastructure is necessary to ensure that the public transport priority can be implemented at intersections.

#### **(6) Surveillance**

Satisfied coverage of the main public transport corridors ought to be provided to ascertain commuters' safety and enhance operational aspects through closed-circuit television (CCTV) with digital video recorders. Surveillance should be operated either from the operations room or from a contracted surveillance operator.

#### **(7) Vehicle Tracking**

The provision of automatic vehicle location units, cameras and information signs on board of all vehicles for security reasons. This will enable the smooth running of the system from the operation centre through the availability of the necessary information.

The operational and maintenance aspects should also be put into consideration to ensure the effectual implementation of the above elements. An operational plan should be developed and the human resource requirement known to enable that the necessary skill is in plan to operate the public transport centre. Maintenance is the key to longevity; a thorough maintenance plan must be put in place to ascertain the reliability of the system upon operation.

#### **Branding**

The ability to abort branding in transport service is an important effort to encourage and maintain a reliable ridership. A perception survey was referenced in a 2004 report by FTA to measure public perception of BRT systems. The outcome of the survey indicated that most booming BRT systems were able to pull off a marked identity and position in their region amidst other transit services (Diaz and Schneck, 2000).

#### **Road configuration**

A road is an access way or route on the land between two places which has been paved or not to allow travel by motor vehicle, cart and horse. A road can be either one or two carriage ways, each consisting of one or more lanes coupled with pedestrian sidewalks and at times, with road verges. The road accessible by the public can be referred to as public roads or highways. Road is used by vehicles running on wheels on the bridge, tunnel, supporting structure, crossing, junction, toll road and interchanges. Road are normally paved to allow easy travel (Wikipedia, 2012).

Engineering work and road construction engulf about 50% of the entire BRT system cost. Great cost saving will really affect the total financial burden of construction. Roadway design carries with it a good interaction with the current use patterns and existing geographical parameters of the road. The existing road width is also very pertinent which is used to determine the space requirement for the exclusive busways and their associated stations. The initial outlays and long term maintenance costs will be affected by the construction materials and techniques to be employed. A cement pavement is habitually preferred to an asphalt pavement due to durability particularly if the lane is being plied by heavy buses. Since

dedicated lane of a BRT system does not involve vehicle lane change and in order to save the cost of construction, some system developers leave the dedicated not to pave the centre of the lane as shown in the figure 4.0. The presence of the earth or grass at the centre of the lane will assist in absorbing the engine noise of up to 40 percent has been reported.

The mixture of coloured emulsion with asphalt or cement helps to give the dedicated lane a great sense of permanence to the system among the public. The motorists are most likely to know if they commit traffic infraction by crossing a visible bus lane when likened to the crossing of a lane that is undifferentiated from a normal mixed traffic lane. In a situation when the road does not permit lane conversion to busway, an expansion of the lane will be employed (Wright, 2003).

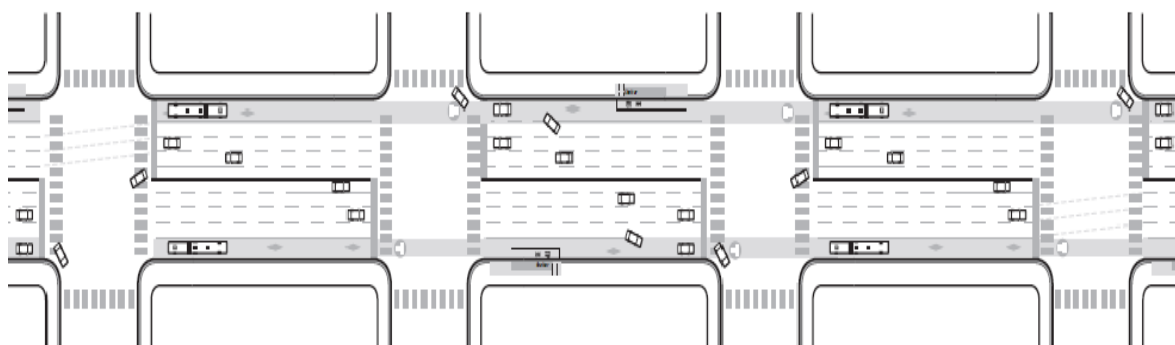
**Busways, bus lanes, grade separation**

The typical difference between busway and bus lane is the physical separation of the bus space from the traffic. Busway is separated from traffic with a raised block/pylon while bus lane is done with a painted line. At times, bus lane fails to due poor way of preventing traffic from entering the system which reduces the free flow of the system, hence the effect tells on the travel time of the bus. However, police vehicles and an ambulance may be granted access to the busway/ bus lane. There is different between grade-separated and at-grade busways. At-grade busway uses controlled signal intersection, which may reduce the overall ability of the system. Grade-separated busway are constructed through a tunnel like the cities of Seattle and Boston, overpasses and underpasses to avoid conflict with other lanes. However, such design of using tunnels, overpasses and underpasses is in contrary to the cost advantage a such BRT system has when compared to a rail system but the advantage it has is the avoidance of congestion, travel time saving, blurring the line between BRT and rail options and payback period maybe short (Wright, 2003).



**Figure 4.0 Unpaved centers of a BRT lane**  
Source: Wright, 2003

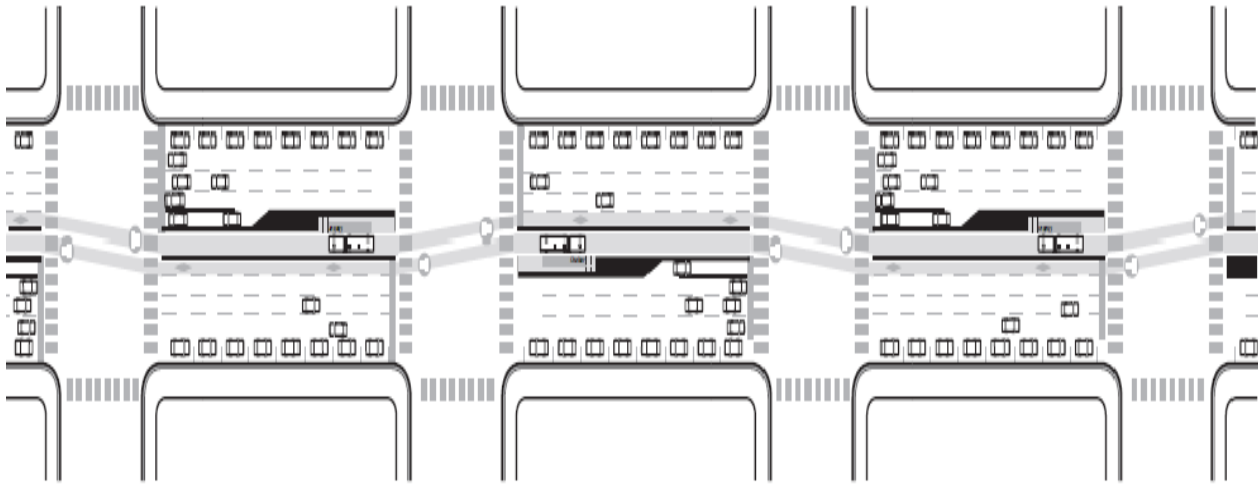
These forms of BRT system- kerbside lane, Median lane and segregation lane differ in benefits. Moreover, as the investment in BRT system increases across the globe, there is also improvement on the travel speed and high quality stations. Bus lanes, indented bus stops, signal priority and regulatory signs are the simplest form of improvement of the BRT system in the world. In Canberra, Australia, kerb side lane BRT system is provided with a dedicated and continuous lane for buses to travel against the kerb edge of the road. The bus stops are fairly designed in such a way that it guarantees easy access to the surrounding streets. The main problem is when other vehicles need to cross the dedicated lane into driveways and side streets. (VTA Transit Sustainability Policy, 2007).



**Figure 1 Kerbside BRT concept – typical lane configuration**  
Source VTA Transit Sustainability Policy, 2007

Median lane BRT system is when the lane is situated alongside the median, for instance Adelaide Avenue in Australia, the median is protected possibly with some physical barriers to keep the vehicles off the lane. Bus stations are developed at key locations, which are usually adjacent to the major side street. Passengers are assisted with pedestrian crossway

through the traffic signal or overhead walkways. However, improvement over kerbside and median lane BRT still suffers delays at the intersections; these can be reduced through signal priority measure (VTA Transit Sustainability Policy, 2007).



**Figure 2: Median BRT system – typical lane configuration**

Source: VTA Transit Sustainability Policy, 2007

Segregated lane BRT is fully separated from other traffic either via elevated structures/tunnel. Brisbane and Adelaide in Australia operate this kind of BRT system, which offers a fast operating speed when compared with other types of BRT systems and bus services. The main challenge in this kind of BRT system is that it requires a huge financial investment (ACT Government, 2012: 1).

#### **Factors that determine the type of BRT system to be adopted**

In determining the type of BRT to be adopted anywhere in the world, there are some factors that need to be put into proper consideration including the number of passengers to be carried, available road space/land, funding available for the implementation of the BRT system and the time travel benefits that need to be achieved. The implementation of BRT system is simply considered flexible in sense that one method of it can be adopted and then transition to another seamlessly, just like in Belconnen, which operates the different types of BRT system in one corridor. Secondly, BRT system can be built gradually if needed without interrupting the operation of the existing bus in such corridor (ACT Government, 2012: 1).

#### **Discussion/results**

##### **Cost implication**

Cost is an important factor to be put in place during construction or execution of a project. As there are common features attributed to any BRT lane configuration, there are also some forms of structure in one configuration that cannot be implemented in the others. The capital cost, which is the

cost of design, engineering, project management, construction of corridors, stations, purchasing of vehicles and installing of supporting system like security, ITS and fare collection with the exclusion of the maintenance cost and replacement of facilities cost. Curb side and median lane configuration are less expensive when compared to a segregated BRT system because of its aerial or underground busway. Curb side BRT system does not need a pedestrian bridge while a median needs a pedestrian bridge which is safer than a grade pedestrian crossway.

##### **Pedestrian Crossing**

Among the key component of BRT design and planning is the pedestrian safety, convenient and secure access to the facility. If these are not put into proper consideration, commuters will be utterly discouraged about the system. Pedestrian crossing should be controlled traffic light which enables both the abled and physically challenged passengers to be less at risk when going to the station.

In all the BRT lane configuration discussed in this study, there is also a provision for pedestrian to cross to where the station is situated. It is better to have a pedestrian bridge which seems to be safer than a crosswalk and a crosswalk controlled by traffic light is preferable to the one that is not controlled by traffic light. It is good for a curb side and median BRT configuration to have a pedestrian bridge for access compare to a crosswalk.

Also for physically challenged commuter, curbside and segregated BRT systems would be good for them because of the access to the station.

## Vehicle maneuver

In terms of the three mode of BRT system in respect to the lane discussed in this study, vehicle maneuver would pose a delay for a curbside BRT system but the other lane configurations would be OK. If curbside would be adopted, a shoulder lane-where automobiles can park and make U-turn to their destination, should be implemented which would improve the system.

## CONCLUSION

To be able to select the appropriate vehicle option for a BRT system for a particular area/corridor, the transport demand, coverage/distance to be covered and length of public transport delay due to general traffic condition must be put into proper consideration.

If the transport demand and coverage are low, a standard bus could be selected over other modes of bus option and in order to enhance rebranding and marketing strategies a stylised bus could be picked over others provided the condition is the same as above.

However, if the length of public transport delay experience at a particular suggested corridor or area is low, a standard could be appropriate over the modes of bus option and to enhance marketing and branding or rebranding, a stylised bus could be the best to be selected. Conclusively, they offer cost effective when compare to light rail transit.

Using this mode of BRT systems across the nation, there are an improved travel times, more reliable, safer and faster is achieved when compared to buses and automobiles travelling in mixed flow traffic lanes because they operate on a dedicated bus lane. A separate lane enables the system to have lower headways and accommodate higher peak period loads. When further combined with signal priority, delay would be greatly minimized at intersection.

## RECOMMENDATION

Any form of BRT system should be implemented in a place of none because it offers increased level of mobility, fewer stops and accessibility than the traditional public transportation. It used also serve as an attractive means to get drivers or car owner to the system.

BRT system should not be operated in a mixed traffic because it poses delay but the introduction of a bus lane would increase reliability and transit speed of such system and has positive effect on the commuters of increased visibility and identity of the system. Level of service of a segregated BRT system is more better than that of curbside and median BRT system. The level of service of a curbside could be improved by the provision of a shoulder lane where vehicle can hover or park to execute their task.

It is only when there is no space for expansion should a BRT system be operated in a mixed traffic because implemented of any mode of BRT system depends on the availability of space in such area and different mode could be practiced based on a

single corridor based on available space. For the abled and physically challenged pedestrians, segregated BRT system could be given priority over the rest. Relative to the capital cost, a curbside and median mode could be given plea consideration over segregated mode. Segregated and Median BRT system should be picked over Curbside germane to vehicle maneuver. Segregated is far better of the exclusive right of way. A curbside BRT system could be improved by providing a shoulder lane for parking and maneuver.

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