Bus Rapid Transit in Malaysia, a Review on Recent Developments  

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Abstract: The first BRT system in Malaysia was implemented in the south eastern suburbs of Petaling Jaya, Selangor and has been launched to public since June 2015. The objective of this study is to evaluate the potential of BRT implementation in Malaysia. The document summarizes into literature review of current BRT systems in other cities, safety performance of public vehicles in Malaysia, field visit and data collection followed by suggestions for improvement in the BRT system in Malaysia. The results show that 84 percent of road accidents in Malaysia involved private vehicles and among public vehicles, taxi recorded the highest number of accidents. From the observation, it can be seen that the travel time of BRT is reliable and consistent, male-female ratio of BRT users is 1.06, 90 percent of the users are aged between 15 to 64 years old, 0.2 percent of disabled persons used the system during observation and the highest average passengers are detected during afternoon peak period. During the period of the study, the system is still struggling to achieve predicted ridership. Nevertheless, continuous efforts are essential in order to encourage public acceptance on the system and future attempts on the extension should be carry forward to generate sustainable public transport system.

Key words: BRT · Sunway · Sustainable transportation · Public vehicle

INTRODUCTION

An excellent public transport system contributes positive impacts to the country, community and most importantly individual. The system boosts healthy benefits in terms of social, economic and sustainable environment [1]. In accordance with eleventh Malaysia plan, public transport system will be transformed towards energy efficient vehicles, with the purpose of providing better services to the residents and improving accessibility. The improvement of public vehicle has become one of the country priorities in order to reduce number of private vehicles on the road, improve traffic conditions and providing sustainable transport service.

Economic growth and rapid urbanization in Malaysia over the past decades has risen the needs of travel by individual. However, the inefficiency of public transport services has led Malaysians to choose private vehicle over public transport. Factors found to be influencing mode of travel includes travel time and travel cost [2]. Studies have found that bus passengers are not satisfied with current service quality [3-4]. In another study, Lin [5] discusses that while urban growth encourages high CO₂ emissions from transport sector, the problems can be tackled through technological improvements in transportation.

The concept of cost-effective transit solution to cater high population growth in Bus Rapid Transit (BRT) has make the system popular around the world [6]. The features of BRT are mimicking rail system and with lower investment costs, the system is targeted to become more reliable and convenient compare to regular bus services. The system is upgraded through the provision of segregated right-of-way infrastructure and off-board fare collections, in addition to rapid and frequent operations. BRT is increasingly recognized as a sustainable solution of mobility issues, since the system desired low air and noise emission vehicles [7].

The BRT system in Malaysia has grown in importance in light of recent development of BRT Sunway line located in Petaling Jaya where operation starts on 2015. It is part of government efforts to improve urban public transport. Most studies of public transport in Malaysia have only been carried out on bus generally, without much detain in the BRT system. This study systematically reviews the existence research on BRT
implementation worldwide, aiming to understand the existence and future implementation of BRT in Malaysia. Recent developments in BRT have heightened the need for understanding BRT concepts. As Malaysia is keen to adapt BRT system as part of public transport system, this report is important in order to understand the performance of existance BRT and as a reference for the future planning on expansion of the corridor. Other than a study done by Azizan et al. [8], to the author best knowledge, there is no in depth study provided on the implementation of BRT in Malaysia. The study will help decision makers and practitioners to understand the issues and challenges related to the development of BRT, issues that are rarely addressed in Malaysia.

**Literature Review:** BRT is popular as a solution for relieving traffic problems and reducing transportation emissions. Over the past decade most research in BRT has emphasized on the cost benefits of BRT compare to other rail systems. Low cost investment of BRT can be perceived through the development of infrastructure, equipment, operational improvement and technology. In 2001, a report by U.S. Government Accountability Office (GAO) found that the average cost per mile of BRT is less than half of the average cost per mile for LRT [9]. Wright [10] found that the costs of high quality BRT in seven countries in developing countries range from US$4 million to US$7 million per kilometer, while the LRT system in three countries range between US$ 15 million to US$40 million. The cost of Lagos BRT system is recorded as US$ 1.7 million per km and listed as one of the cheapest compare to other BRT system [11].

A large and growing body of literature has investigated on the increasing ridership on public transport after the implementation of BRT. Currie & Delbosc [12] found that higher ridership occurred when the bus system has larger number of stations and high frequency, longer weekday service spans and high shares of segregated right of way. Metro Orange Line bus operation prospered in exceeding the number of ridership in Gold Line light rail by offering lower charge, high ridership through articulated bus and high frequency of trips [13]. Aplkokin [14] reported that a great number of ridership in Metrobus Istanbul is partly due to the removal of conventional buses and other intermediate forms of public transports from using Metrobus corridor. A survey conducted by Deng & Nelson [15] found that more than half of the respondents choose BRT over their own car because BRT was more convenient for their journey.

Another positive attributes on the implementation of BRT is the reduction on travel time. The MAX BRT system in Las Vegas produced significantly shorter travel times than previous travel mode throughout the day by reduction on number of stops and higher operation speeds [16]. In Los Angeles, the positive results can be seen in both corridors. Line 720 Wilshire/Whittier Blvd, travel times was reduced by 29 percent while in The Ventura Blvd. line, travel times were reduced by 23 percent [17]. The implementation of BRTS in Ahmedabad had saved 20-30 percent travel time over each corridor compare to the previous routes [18]. Joewono et al. [19] discusses the service quality of TransJakarta Busway, with 42.7 percent of respondents in first corridor use the busway due to faster trip. In another case, Vaz and Venter [20] found that the implementation of Rea Vaya BRT in Johannesburg, South Africa produce significant benefits through the reduction of travel time between 10 percent and 20 percent compare to previous travel modes.

Regarding the reliability, Huo et al. [21] found that mean headway and mean waiting time for Changzhou BRT are quite minimal, around 3.12-3.96 minutes and 2.17-2.82 minutes respectively. During morning and evening peak hours, mean waiting times are below 2.5 minutes and the best service reliability is found near a route’s origin terminal. In another study, Flynn et al. [22] found that the ratio of peak to non-peak travel time of Metro Orange Line in Los Angeles is approximately 1.008, which indicates insignificant variability between peak and non-peak periods. The consistency was shown in the on time schedule, with an average end-to-end deviation of only 32 seconds compare to time allocated in the schedule. Data shows that a small proportion of bus bunching (10%) occurred during weekday peak period. During peak hours, the frequencies of Istanbul Metrobus are as high as one bus per 45s for the Istanbul Strait crossing and 30 s for the European side section only [14]. The Metrobus corridor have no signaling stops or intersections (except on the Bridge section) for better travel time. The peak hour frequency at the maximum service point is between 15-to 20-seconds intervals while during off peak hour, the frequency is within 45-to 60-seconds intervals all day [23]. Similarly, Deng & Nelson [15] reported that Beijing BRT Line 1 has already achieved a very high frequency, with headway adherence of 1.5 min during peak and 2-3 min during off peak. Brisbane South East Busway have high service levels with peak headways of 24 seconds [24].

Additional advantages of BRT over rail services is the flexibility of the system to deal with shifting travel patterns. BRT routes can be altered based on the
feedback by users, such as in the case of MTA BRT in Los Angeles. In the case of implementation of BRT in Ahmedabad, the initial plan was to adopt curb-side stops, but the plan was altered to a central island bus stop with dual sided boarding in order to save costs and facilitating transfers [25]. Other improvements in Ahmedabad includes moving of bus stop locations from junctions to improve flow, relocating lighting from bus median to the curb and increasing the widths of pedestrians and cycle paths [25-26].

Furthermore, BRT can be operated by phase, rather than having to wait for an entire system to be built [26-27]. The construction of BRT in some cases are faster compare to the construction of LRT [28]. With the features of rubber-tired, BRT can operate in varied range of environments and wider geographic range than dedicated existence BRT guideways [29]. For Istanbul Metrobus BRT, bus operates in dedicated right-of-way except for the mixed traffic operations on the Bosphorus Bridge [23]. In addition, an open BRT system allows existing bus routes to be included in the system and allows conventional bus to enter the system [30]. Moreover, BRT can share the existence infrastructure sections place for Light Rail Transit in order to create smooth interconnection [27].

In an analysis of emission by BRT and conventional bus systems, Chen et al. [31] found that BRT buses produce less emissions of nitrogen, hydrocarbons, carbon monoxide and particulate matter by 25.62% to 27.37% compare to conventional bus on the non-bus lane. The result is the same for bus lane scenario, where BRT emissions are lower around 12.76% to 14.00% compare to conventional bus. Chavez-Baeza & Sheinbaum-Pardo [32] model of transport emission in Mexico City Metropolitan Area shows that other than electric vehicle, modal shift from private car trips to BRT significantly reduce air pollutants and greenhouse gas emissions. Garcia [33] reported that in the first six years of operation (2004-2011), emission from Metrobus (gram/km per passenger) were reduced nine fold compared to buses and minibuses. Bel & Holst [34] compares the air polluting emissions before and after Metrobus implementation. The results show reduction emission of carbon monoxide by 16.6 to 20.4 percent, nitrogen oxides by 12.9 to 18.1 percent, particulate matter (PM_{10}) by 20.8-39.0 percent and (PM_{2.5}) by 9.6 to 24.4 percent according to city area. After the implementation of Transmilenio BRT in Bogota, there is a reduction of sulphur dioxide emissions by 43 percent, nitrogen oxide by 18 percent and particulate matter by 12 percent [35]. The reduction on pollution were also benefited by Lagos, where the BRT project reduced the CO\textsubscript{2} emissions by 13 percent and greenhouse gas emissions by 20 percent [36].

A number of researchers have reported on the decreased of automobile trip generation and vehicle motorized transportation (VMT) after the implementation of BRT [37-39;14]. As per capita traffic crash rates rise with per capita vehicle travel, implementing mobility management strategies have a positive outcome in reducing overall crash risk [40]. The operation of BRT which requires reduction of older public transport and bus oversupply, adopting better driving practices, segregating buses and organizing the boarding and alighting of passengers at stations help in improving road safety [41]. Previous studies have reported that some of BRT design features such as center lane configurations, kerb side lane, improved geometric road surfaces, sidewalks and road alignments, signalized mid-block pedestrian crossings with refuge islands and restrictions of right turn or left turns (depending on countries), can significantly improve road safety on the implemented corridors [41-44]. In addition, BRT system provides larger station spaces to reduce the interference between BRT and general traffic.

In a comparison study performed by Goh et al. [42] it was found that the presence of bus priority in Melbourne significantly reduces accident risks, specifically associated with 54 percent reduction in bus accident occurrence. In a similar study involving police reported data, Goh et al. [45] found that there is approximately 14 percent reduction of police-reported injury, serious injury and fatality accidents counted after implementation of bus priority lane in Melbourne.

After the implementation of Rea Vaya Phase 1A, the system reported to save roughly $249 million from avoiding road fatalities [46]. The implementation of Delhi BRT has resulted in a downward trend on the number of fatal accidents [47] along the corridor. Jaiswal et al. [18] compares the numbers of traffic crash occurred before and after the implementation of BRTS in five corridors of Ahmedabad. The results show the overall number of road crash dropped by 13.6 percent, with the number of fatal crash reduced by 18 percent. Rates of decline on the number of persons killed ranged from 11.1 percent to 44.4 percent, with the highest reduction were found in Corridor 1, from RTO to Chandkheda. Furthermore, the number of person injured also shows positive declining pattern, with an average of 12.1 percent reduction on the five corridors studied.
In 2012, a thorough study performed by Duduta et al. [48] found that geometry of the road plays an important role in road safety. A very large proportion (90%) of crashes on BRT corridors and busways occurred outside the dedicated bus lanes and did not involve buses. Among the busway design features, center-lane systems generally incline to be safer while conversely, counter flow lanes were the most dangerous possible configuration.

METHODS

The public transport vehicle accident data is analyzed in terms of frequency and pattern from 2011 to 2013 by crash type and location. The data comes from various sources, with the main sources come from Malaysian Royal Police Departments (RMP). Other sources include Malaysian Institute of Road Safety Research (MIROS), Road Transport Department (JPJ), Ministry of Works Malaysia (KKR), Department of Statistics Malaysia and World Health Organization (WHO) reports.

To carry out this study a weekday public transport commute sample is carried out in each BRT stations. At the time of the study, Sunway BRT is the only BRT implements and fully functional in Malaysia, operated with a length of 5.5 km, connected between Setia Jaya and USJ 7. To determine travel and waiting times, field measurements are carried out that make it possible to estimate these variables. The measurement consists of a representative sample of services for passenger car and BRT at first point to the last points of the route. Travel time by passenger cars was estimated using ‘Google Maps’ during peak and non-peak periods. The counts were used on the number of persons ascended and descended from the bus at each BRT Sunway bus stations, where the observer were seated within the bus. In overall, 620 data were collected during the observation.

RESULTS AND DISCUSSIONS

With a high number of fatality involving motorcycles and private vehicle in Malaysia (Figure 1), there are lots of road safety measures that have been introduced and aimed to reduce accidents involving death and serious injury. It has been conclusively shown that with little protection and exposed body region, motorcycles have higher relative risk of fatal crashes compare to passenger cars [49-51]. Under Road Safety Plan of Malaysia 2014-2020, one of the initiatives of risk reduction for motorcyclist is by improvement in public transport safety.

Figure 2 shows a comparison between type of public vehicles from 2011 to 2013. Taxi recorded the highest number of injuries and deaths due to road accidents and injuries, followed by express bus and stage buses. In 2013, municipal roads recorded as the third highest number of fatal accidents, after federal and state roads [51]. However, fatality accidents involving public vehicles are higher in municipal roads for 2012 and 2013 compare to state roads. As BRT is part of stage bus, further comparison was analysed between taxi and existence stage bus before the introduction of BRT. From 2011 to 2013, the number of road fatality accidents involved taxi increased significantly and except in 2011, taxi has highest fatality and injuries accidents compare to stage bus, including accidents occurred in municipality roads.

An understanding of the attitudes and behaviours of riders is an essential condition for the development of an effective transportation system intended to encourage a more efficient use of the city’s public transportation system. The results from the observation on Sunway BRT shows that the mean travel time from first to last station is approximately 14 minutes and average travel time from station to station take around 2 to 3 minutes. It provides faster option during congestion periods. However, passengers need to spare around 20 to 65 percent of their total trip time to wait for bus arrival at the station. A study by Wan et al. [52] found that frequency, on-time performance and speed plays an important role in gradually increase overall satisfaction of BRT passengers.

Currie & Delbosc [12] identify that segregated right of way has a positive impact on ridership. In another study, Chakrabarti [53] highlighted that transit’s speed in comparison to private vehicle plays a significant role in determining the transit mode choice. The study further noted that although congestion level and non-reliability are not the major factor for people to shift to transit, continuous improvement on transit service can attract higher travel demand. This situation can be seen when RapidKL opened the Kelana Jaya LRT station, which connected directly with BRT station USJ 7 and boost up the number of passengers up to nearly 20 percent [54].

Fig. 1: Number of road death by road user category (Source: RMP 2013)
The male-female ratio of respondents (1.06) is approximately close to male-female ratio of Malaysia population (1.07) between 2016 to 2017 [55]. The result shows that female passengers are comfortable with the services. Morton et al. [56] reported that female passengers tend to hold more negative attitudes concerning the quality of bus transit cabin environment. Previous studies have reported that safety and comfort plays an important role in people’s decision to ride public transport [57-59]. Delbosc [60] found that gender have indirect effects on the feelings of safety on public transport. Another possible explanation for this might be that the observation only conducted during day time.

The majority of the passengers observed are within 15 to 64 years old. This result may be explained by the fact that majority of the riders are travelling with the purpose of work and education. Out of 2279 passengers, 0.2 percent of individual disabled person users ride the system. The boarding patterns for Sunway BRT passengers on working days show a high number of passengers during afternoon, followed by evening peak hours (Figure 3). The analysis shows that traditional morning and evening peak hours are not necessarily the most congested periods. Referring Figure 4, Thursday listed as the day with the greatest amount of passengers recorded. In contrast, Friday has the highest passengers recorded per hour during peak and non-peak period.

Through an examination of passengers ascended and descended counts, we found that USJ7 station is the most popular station for both activities (Table 1). The nearby area consists of residential suburbs, shopping centres, college, hotel and direct transfer to LRT USJ7. Sunmed has the lowest people ascended and Mentari has the lowest people descended from. While there is a direct ticket integration between BRT USJ7 with USJ7 LRT line, the case is not the same with KTM Setia Jaya and BRT Setia Jaya. Passengers need to buy different ticket if they want to transfer by KTM, which in results adding travel time.

In term of weather, the highest riderships were observed during overcast, whereas the rain has the lowest ridership. These results of the current study are consistent with those of Arana et al. [61], who stated that wind and rain could result in decrease trips. A high number of ridership during overcast may be due to reduced temperature compare to sunny day for walking activity. Since Malaysia is a tropical country, it was exposed to uniform temperature, high humidity and copious rainfall. Adverse weather conditions may cause people to shift transportation modes or avoid traveling at all [62]. The reasons include reduced bus operating speed thus delay the travel time and as transit is associated with walking behaviour, it hinders the potential user to arrive to the station without getting wet.

During observations, there are several aspects that can be highlighted for continuous improvements on the system. First is the acceptance of public on the system. The number of passengers has been dramatically dropped after the fare was introduced. This highlighted lower willingness of the passengers to pay more for bus services. Bian & Ding [63] discussed that low price of tickets resulted in a serious operating loss but expensive tickets will hinder people to ride. Wright [10] discusses that the most common errors in BRT planning includes designing system around technology instead of customer. It is important to note that the BRT services should be targeted lower and medium households, because they are the main user of public services. With a huge investment, the authorities and operators need to introduce new strategies in order to attract new users and retain existence customers.

![Fig. 2: Injuries and deaths by type of public vehicles from 2011 to 2013](Source: RMP 2013)
Continuous promotional campaign on BRT is essential in order to promote the services to the public. Wright & Hook [64] discusses the important of creating public awareness about the new BRT system and its purposes through information campaigns to gain public buy in of the project. In the case of TransJakarta, local television station was not interested to promote BRT as it introduces new concept. However, through the employment of nonprofit organizations specialize in corporate communications have given publicity of BRT to the public [65]. Redmann et al. [66] discusses that the improvement of public transport is usually measured through the increase of public transport ridership or through the shift of private motor vehicles users to public transport.

Secondly, the features of BRT Sunway include closed system and elevated guideway. Hook [67] discussed that a closed busway is unsuitable if the busway constitutes only a small part of most of the bus routes in the corridor, as it will impose transfer costs on the majority of the users while offering limited benefit. Wang et al. [68] discussed that traveler’s attraction to BRT increasing when the distance increase. This is because with the distance less than 5km, normal bus service and non-motorized travel via walking modes may still work well. By taking the advantage of flexibility in BRT, the corridor should be expanding for other destinations. Further study needs to be done for future expansion in order to align the BRT routes with the travel demands of low and medium households. Aragao et al. [69] suggested that a participative network reconstruction procedure, beginning with the reform of the main trunk lines and then extending to the other mains and secondary lines should be preferred.

Another important notes to be highlighted is, BRT implementation successfulness varied within city and region. In a study done by Rizvi & Sclar [26], the author compares between the implementation of BRT in Delhi and Ahmedabad. While there were some difficulties on Delhi implementation, Ahmedabad is successful due to key strategies of outreach, knowledge sharing, technology showcasing and branding. Future planning on the implementation of BRT in Malaysia should involve extensive research from all of the agencies involved in order to ensure the successfulness of the system.

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<tr>
<th>Station</th>
<th>Ascending (%)</th>
<th>Descending (%)</th>
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<tbody>
<tr>
<td>S. Setia</td>
<td>19.06</td>
<td>20.97</td>
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<tr>
<td>Mentari</td>
<td>7.34</td>
<td>4.73</td>
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<tr>
<td>Lagoon</td>
<td>9.81</td>
<td>15.96</td>
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<tr>
<td>Sunmed</td>
<td>6.84</td>
<td>5.39</td>
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<tr>
<td>Monash</td>
<td>11.27</td>
<td>11.56</td>
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<tr>
<td>S. Quay</td>
<td>8.50</td>
<td>10.35</td>
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<tr>
<td>Usj7</td>
<td>37.17</td>
<td>31.04</td>
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CONCLUSION

As the number of accidents involving private vehicle in Malaysia is high, enhancement of public vehicle is important in order to encourage mode shifting. Even though taxi recorded the highest number involved in
accidents, stage bus also prone to involved in accidents after taxi and stage bus. The introduction of BRT system can help in reducing the number of accidents involving stage bus in municipality roads. With a huge investment involving project cost of approximately US$30 million per km, BRT Sunway still struggling to achieve expected ridership. Observations on the system shows consistent travel time, good reliability and the system is equipped with intelligent transportation system for passenger to plan their travel time. However, several medias have highlighted the cost as the barrier for locals to fully utilize the system. This study has found that generally the implementation of BRT in Malaysia seems to give full attention to the segregated BRT transit ways, complex ITS applications and sophisticated station. It is important to note that the market and the services are the most critical parts in planning and designing the criteria, in order to achieve successful implementation. Looking back to the purpose of investment in BRT, it is an attempt to provide efficient and effective public transport services. However, the objective is not fully achieved if the people did not used the services.

As a new public transport system, BRT has a big potential public transit medium that can reform the city’s urban transportation system. The study on the pattern of current BRT users and through a comparison with leading BRT cases in the world may help in improving current public transport in Malaysia and those encouraging the mode shifting of private vehicles towards public vehicles.

REFERENCES


