A Comparative Analysis between Bus Rapid Transit and Regular Bus Operation

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Abstract: A relative good public transportation bus line network should provide easy access and be cheaper in cost to the users. Buses are the most widely used in transit technology today because bus networks are easily accessible and cheaper than other kinds of public transportation. One way for improving operation time on bus network is operations in specific lane. Using the specific lane for bus operation can decrease delays in bus mission. In the meantime, Bus Rapid Transit (BRT) by operations in the limited lane could optimize standard deviation between actual and desired timetabling and vehicle scheduling. This high performance level can be shown by using statistical analysis. Hence, a case study based on an actual public bus operation is used to demonstrate the usefulness of devoting a specific lane for bus service.

Key words: Bus rapid transit, Regular bus operation, Passengers, Performance.

INTRODUCTION

A relative good public transportation bus line network should provide easy access and be cheaper in cost to the users. Operating cost and fixed cost are an important and noticeable issue for Transit companies. Also, travelling with minimum time and cost is significant for passengers.

Transit system characteristics include several components: First, system performance, second, level of service (L/S), third, impact of the transit service on the local environmental, social and economic situation, and fourth, costs (Grava 2002; Hafezi and Ismail 2011a).

The first transit system characteristic is system performance. It is measured based on unit departures per hour. It includes: service frequency (f), operating speed (V0), reliability, safety, line capacity (c), productive capacity (Pc), productivity and utilization. Service frequency is period motion transport, which means during their mission, throughout the day (Hafezi and Ismail 2011b). Operating speed usually is defined as average speed in total travelling time (Sun et al. 2008; Hafezi and Ismail 2011e). Reliability is expressed as a percentage of vehicle arrivals with less than a fixed time deviation from schedule. Safety is measured by number of fatalities injuries and accidents (Ismail et al. 2012). Line capacity is maximum number of spaces, which includes seats and standing space. Productive capacity is the product of operating speed and capacity of the line. Productivity is the quantity of output per unit of resource space-km. Utilization is the ratio of output to input person-km/space-km (Hafezi and Ismail 2011c). The second transit system characteristic is level of service. It is a basic element in attracting potential users to the system and includes: performance elements that affect users, service quality (SQ) and price. Performance elements that affect users include operating speed, reliability and safety. Service quality includes convenience, simplicity of using the system, riding comfort, aesthetics, and behaviour of passengers. Price is fare, which the passenger pays for using the service.

The third transit system characteristic is impact of the transit service on the local environmental, social and economic situation (Hwe et al. 2006). This issue is studied in two sections: short-run and long-run. The short-run includes potential reduction of street congestion, air pollution, noise and aesthetic impact along a new line. Long-run impact can include changes in land values, economic activities and the physical social environment of the city. The final transit system characteristic is costs. Two main issues are raised in costs: investment and operating costs. Investment costs include costs that are recovered over time. Operating costs are costs incurred through regular operation of the system (Armstrong-Wright and Thiriez 1987; Ortúzar and Willumsen 2001).

In this paper we studied statistical analysis of operations of Bus Rapid Transit in terms of trip-time reliability, slack time and operation speed. Hence, a case study based on an actual public bus operation in Tehran, Iran is used to demonstrate the usefulness of devoting a specific lane for bus service.
**Fundamental Scheduling For Bus Rapid Transit:**

A new system of inter-city bus rapid transit could reduce differences between actual and virtual planning (Sun et al. 2008). There are some parameters to achieve operations with minimum standard deviation of basic plane. These parameters are: average velocity, slack time and frequency (Hafezi and Ismail 2011d).

Operation speed is dependent on traffic flow and passenger crowding (Lieberman and Rathi 1997). In the peak-hours traffic operation speed is very poor due to traffic congestion and more demand of passengers for using the bus (Haghani et al. 2003). In addition, bus drivers must drive very carefully. Unilateral (dedicated) bus routes can reduce bus delays that result from congestion caused by other traffic. In this situation, buses can maintain their average speed in all parts of their routes. (Figure 1 and 2).

![Fig. 1: BRT operation in bilateral street.](image1)

![Fig. 2: BRT operation in unilateral street.](image2)

Slack time includes time for boarding and alighting passengers. This process includes paying travel fare and the additional slack time is spent for fare collection. Regular frequency of buses can help to maintain proper scheduling (Hafezi et al. 2012). This can be achieved by on-time arrival of buses at bus stops and finally in depots.

The equation of round-trip time consists of the journey time on the inbound path and journey time on the outbound path. Journey time on the inbound path is given by (Ismail and Hafezi 2011)

\[ T = \frac{D}{v} + tS + RC + \sum_{n=1}^{j} D_n \]  

where \( D \) is the distance of bus route, \( v \) is average speed, \( tS \) is the spent time in the terminals, which is obtained experimentally, \( RC \) is the recovery time and \( D_n \) is slack time, given by

\[ D_n = \max \{ \alpha \cdot B_n, \beta \cdot A_n \} \]

\( B_n \) and \( A_n \) are the number of boarding and alighting passengers, respectively, \( \alpha \) and \( \beta \) represent the coefficient of time for boarding and alighting respectively, per passenger. This is dependent on the fare collection system and number of channels in the bus.
Statistical Analysis of Bus Rapid Transit Operation:

Statistical analysis for BRT operation is studied for several factors: journey time, slack time and operation speed. The bus line to be studied in this paper is about 8,400 m from west to east where the transfer of passengers from suburban areas to the city centre takes place. It has 12 bus stops and two terminals where the origin and destination line terminals are used only for parking buses and crews’ rest breaks, and not for boarding and alighting passengers. The total number of buses is 8 and all of them are of one make.

Journey time is measured by start and end node of mission time. Also, it is measured at each bus stop. Figure 3 represents the actual measurement of journey time for Bus Rapid Transit, analysed for 8 buses during morning peak-hours traffic.

![Figure 3: Measurement of journey time for BRT.](image)

Maintaining constant values of operation can reduce delay in bus operation. Delay of buses at each bus stop results from delays of buses at previous stations. Average operation time of buses along the bus route is summarized in Table 1.

**Table 1: Average operation time of buses along the bus route**

<table>
<thead>
<tr>
<th>Stop number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average operation time</td>
<td>2.71</td>
<td>2.43</td>
<td>3.12</td>
<td>5.01</td>
<td>3.73</td>
<td>2.40</td>
<td>3.09</td>
<td>2.28</td>
<td>2.61</td>
<td>3.48</td>
<td>2.99</td>
<td>2.68</td>
</tr>
</tbody>
</table>

In the bus rapid transit system, for reduction of slack time at the bus stops, places are designated for fare collection where passengers can pay their fare before arrival of the bus, either by cash or using the touch-n-go card. And, for longer routes where the fare is calculated by distance, passengers can use the touch-n-go card again in the destination station. Slack time of 3 buses in the bus stops is shown in Figure 4.

![Figure 4: Slack time on the bus stops for BRT.](image)

Average velocity of buses is obtained by dividing distance of route by operation time. Furthermore, it’s value is different depending on the time during the operational day. In the peak-hours traffic operation speed is lower than at other times, due to increased number of buses, greater passenger demand, and crowding of buses. Figure 5 plots the measurement of average velocity of buses.
Concluding Observations:
In this paper, a statistical analysis of bus rapid transit operation has been presented. We studied different effective parameters in BRT, including operation time, slack time and average velocity. It has been highlighted that operation in a specific lane for inter-city bus operation, can maintain high reliability as well (Wirasinghe and Vandebona 2011). According to Figure 3 and Table 1, buses were able to maintain travel time between bus stops at an average of 3.04 minutes. Average slack time of buses for boarding or alighting was 2.87 seconds for each passenger at bus stops (see Figure 4). Fare payment outside the buses could reduce boarding and alighting time by around 3 seconds per passenger (Pelletier et al. 2011; Vuchic 1981). According to Figure 5 average velocities of buses are around 19.11 km/h. Regular running of bus operation can help to limit fleet size and to prevent increased operation cost.

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REFERENCES


