3. BUS OPERATIONS

Bus operations in an urban environment are characterized mainly for sharing infrastructure with private vehicles. This circumstance causes certain effects on the operation parameters of the network, which will be explained in this chapter.

The urban bus service is characterized by the possibility of offering service along most of the city streets. This flexibility of route definition is only limited by special characteristics and regulations of the streets. However, using urban streets as the infrastructure for the service limits the commercial speed to the maximum allowable urban speed.

On the other hand, the city streets provide a low cost infrastructure which is able to support implementations, changes, and extensions of bus routes without an excessive amount of investment.

Regarding the passenger capacity, the urban environment does not allow a significant increase of the productivity since the measures that can be implemented are limited. For instance, the passenger capacity cannot be increased by enlarging or joining the vehicles.

Bus operations are subject to their evaluation by its users. An efficiently operated bus network will be profitable only if it fulfills the users’ needs and achieves the service quality required. Some indicating parameters for the users’ satisfaction are the vehicle frequency, the accessibility to the network, the travel time, the passenger capacity, and such.

For the network design it is therefore important to take under consideration the operator’s costs as well as the users’ interests, in terms of cost. Robusté suggests a simplified ground transportation network design, regardless of the infrastructure investment required, where the main variables would be vehicle frequency and accessibility to the network, as shown in the following formulation.

\[ TOTALCOST = C_{OPERATOR} + C_{USERS} = \left( \frac{a \cdot f}{w} \right) + \left( bw + \frac{c}{f} + \frac{d}{w} \right) \]

Access time \quad in-vehicle time

Waiting time
\[
\frac{\partial TC}{\partial v} = 0 \rightarrow w = \sqrt{\frac{af + d}{b}}
\]
\[
\frac{\partial TC}{\partial f} = 0 \rightarrow f = \sqrt{\frac{cw}{a}}
\]
\[
\text{optimal } w^*, f^*
\]

Where \(a, b, c, \) and \(d\) are factors for the network.

Another important factor for the network design is the fleet size required to provide the service expected. Determining the fleet size involves analyzing the cycle time of the vehicles, in which the time spent on bus stops is of great importance, as seen in the next formulation.

\[
T_c = \sum_{i=1}^{n} \frac{L_i}{v_i} + \sum_{i=1}^{n} t_i + T_0
\]

Where

\[
\sum_{i=1}^{n} \frac{L_i}{v_i} \text{ in vehicle time}
\]

\(T_0 = \) Lay over

\(t_i = \) time lost at stop \(i\). This time is composed by the dwell time (time needed to open and close the doors, acceleration and deceleration time, time spent to allow elderly to take a seat) and the maximum value between the time used by boarding passengers and alighting passengers.

Consequently, the time spent on bus stops within a route has a direct effect on the operator’s efficiency as well as on the user’s cost for traveling, since it increases the overall time spent in the vehicle.

There are different approaches to reduce the time used to complete a cycle. One of the approaches focuses on reducing the time lost at stops in order to improve the service quality of a route. The implementation of Bus Rapid Transit routes is the result of employing the mentioned approach.

Bus Rapid Transit can be defined as a flexible, rubber-tired form of rapid transit that combines stations, vehicles, services, and running ways into an integrated system with a strong identity. The applications are designed to be appropriate to the market they serve and their physical surroundings, and they can be incrementally implemented in a variety of environments.
Bus rapid transit routes are mainly implemented in countries such as the United States of America, Australia, Brazil, or Chile. The main purpose is to implement a bus route that includes lesser stops, so that the key attributes of speed, reliability, and identity of the service can be improved in that specific route. The objective for these routes is to offer a competitive public transportation alternative towards private vehicle at a level of service that is comparable to rail systems, which imply a much higher cost of investment.

Other approaches to the problem of reducing the bus cycle time by means of increasing the overall commercial speed results in the development and implementation of bus preferential treatments. Bus preferential treatments can be generally defined as a range of techniques designed to speed up transit vehicles and improve overall system efficiency. They include physical improvements, operating changes, and regulatory changes. Bus preferential treatments may reduce travel time variability and improve schedule adherence, depending on the application. When considering implementing these treatments, the total change in person-delay (including both passengers in buses and in private vehicles) should be taken into account.

Bus preferential treatments can provide a cost-effective way of improving transit service based on focused, one-time capital investments as opposed to increased service that requires annual operating funding. They offer the potential for reducing or postponing the need for added service to respond to congestion and can attract new riders to transit, if the treatments provide a noticeable improvement in travel time and/or service reliability.

For instance, separating buses from other traffic reduces the potential for conflicts that result in delays. In some cases, operating speeds may increase significantly with the use of busways and freeway HOV lane facilities.

Many freeway-related bus preferential treatments have produced important passenger benefits. Some have achieved time savings of 5 to 30 minutes savings that compare favorably with those resulting from rail transit extensions or new systems. The contraflow bus lane leading to the Lincoln Tunnel in New Jersey, for example, provides a 20-minute time saving for bus passengers.

Then again, it must be reminded that the main purpose of the implementation of these measures is to improve the role of public transit in accommodating a community’s travel needs. These measures should therefore be cost-effective and should consider both long-term changes to mode split and the potential for attracting new riders.

Bus preferential treatments include a wide range of different possibilities, among which only a few options have been mentioned in this chapter. Table 1 summarizes the advantages and disadvantages of the implementation of several bus preferential treatments, as can be found in the TCRP – Report 100 (2003).
Table 1. Advantages and disadvantages of Bus Preferential Treatments.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exclusive Bus Lanes</td>
<td>• Increases bus speed by reducing sources of delay&lt;br&gt;• Improves reliability&lt;br&gt;• Increases transit visibility</td>
<td>• Traffic/parking effects of eliminating an existing travel or parking lane must be carefully considered&lt;br&gt;• Requires on-going enforcement</td>
</tr>
<tr>
<td>Signal Priority</td>
<td>• Reduces traffic signal delay&lt;br&gt;• Improves reliability</td>
<td>• Risks interrupting coordinated traffic signal operation&lt;br&gt;• Risks lowering intersection LOS, if intersection is close to capacity&lt;br&gt;• Requires inter-jurisdiction coordination&lt;br&gt;• Cross-street buses may experience more delay than time saved by the favored routes</td>
</tr>
<tr>
<td>Queue Bypass</td>
<td>• Reduces delay from queues at ramp meters or other locations</td>
<td>• Bus lane must be available and longer than the basic of queue</td>
</tr>
<tr>
<td>Queue Jump</td>
<td>• Reduces delay from queues at signals&lt;br&gt;• Buses can leap-frog stopped traffic</td>
<td>• Right lane must be available and longer than the back of queue&lt;br&gt;• Special transit signal required&lt;br&gt;• Reduces green time available to other traffic&lt;br&gt;• Bus drivers must be alert for the short period of priority green time</td>
</tr>
<tr>
<td>Curb Extensions</td>
<td>• Eliminates re-entry delay&lt;br&gt;• Riding comfort increased when buses don't pull in and out of stops&lt;br&gt;• Increases on-street parking by eliminating need for taper associated with bus pullouts&lt;br&gt;• More room for bus stop amenities&lt;br&gt;• Reduces pedestrian crossing distance</td>
<td>• Requires at least two travel lanes in bus's direction of travel to avoid blocking traffic while passengers board and alight&lt;br&gt;• Bicycle lanes require special consideration</td>
</tr>
<tr>
<td>Boarding Islands</td>
<td>• Increases bus speed by allowing buses to use faster-moving left lane</td>
<td>• Requires at least two travel lanes in bus's direction of travel and a significant speed difference between the two lanes&lt;br&gt;• Uses more right-of-way than other measures&lt;br&gt;• Pedestrian/ADA accessibility, comfort, and safety issues must be carefully considered</td>
</tr>
<tr>
<td>Parking Restrictions</td>
<td>• Increases bus speed by removing delays caused by automobile parking maneuvers&lt;br&gt;• Increases street capacity and reduces traffic delays</td>
<td>• May significantly impact adjacent land uses (both business and residential)&lt;br&gt;• Requires on-going enforcement</td>
</tr>
<tr>
<td>Turn Restriction Exemption</td>
<td>• Reduces travel time by eliminating detours to avoid turn restrictions</td>
<td>• Potentially lowers intersection level of service&lt;br&gt;• Safety issues must be carefully considered</td>
</tr>
</tbody>
</table>

**ROADWAY AND TRAFFIC SIGNAL TREATMENTS**

**BUS OPERATIONS TREATMENTS**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus Stop Relocation</td>
<td>• Uses existing signal progression to bus's advantage</td>
<td>• May increase walking distance for passengers transferring to a cross-street bus</td>
</tr>
<tr>
<td>Bus Stop Consolidation</td>
<td>• Reduces number of stops, thereby improving average bus speeds</td>
<td>• Increases walking distances for some riders&lt;br&gt;• Pedestrian environment may not support walking to the next closest stop</td>
</tr>
<tr>
<td>Skip-stops</td>
<td>• Substantially improves bus speed and capacity</td>
<td>• Unfamiliar riders may be unsure about where to board their bus&lt;br&gt;• Requires available adjacent lane</td>
</tr>
<tr>
<td>Platoonizing</td>
<td>• Reduces bus passing activity</td>
<td>• May be difficult to implement</td>
</tr>
<tr>
<td>Design Standards</td>
<td>• Service changes to improve operations more easily justified&lt;br&gt;• Supports consistent transit planning and design</td>
<td>• Too rigid an application of standards can be just as bad as not having standards</td>
</tr>
</tbody>
</table>

*Source: TCRP – Report 100 (2003).*