Excerpts showing observed passenger volumes for bus systems and light rail systems in North America. This document created by John Niles of Public Interest Transportation Forum.

**Transit Capacity and Quality of Service Manual**

Conclusion: Many bus systems demonstrate higher peak passenger carrying capacities than light rail systems. For example, buses on 6th Avenue in Portland, Oregon deliver 8,500 passengers per hour in the peak period, while MAX light rail delivers 1,980 per hour.

 Prepared for
Transit Cooperative Research Program
Transportation Research Board
National Research Council

Complete manual available for Internet download at http://www4.national academies.org/trb/crp.nsf/All+Projects/TCRP+A-15
A copy of this web page is incorporated at the end of this document.

 Submitted by
Kittelton & Associates, Inc.

In association with
Texas Transportation Institute
Transport Consulting Limited

January 1999
Observed Bus and Passenger Flows

Streets and Highways

Observed bus volumes on urban freeways, city streets, and bus-only streets clearly show the reductive effects of bus stops on bus vehicle capacity. The highest bus volumes experienced in a transit corridor in North America, 735 buses per hour through the Lincoln Tunnel and on the Port Authority Midtown Bus Terminal access ramps, in the New York metropolitan area, are achieved on exclusive rights-of-way where buses make no stops (and where an 210-berth bus terminal is provided to receive these and other buses).\(^{(R13)}\) Where bus stops or layovers are involved, reported bus volumes are much lower. Exhibit 1-13 shows bus flow experience for a number of North American cities.

<table>
<thead>
<tr>
<th>Location</th>
<th>Facility</th>
<th>Peak Hour Peak Direction Buses</th>
<th>Peak Hour Peak Direction Passengers</th>
<th>Average Passengers per Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Jersey</td>
<td>Lincoln Tunnel</td>
<td>735*</td>
<td>32,600</td>
<td>44</td>
</tr>
<tr>
<td>Ottawa</td>
<td>West Transitway</td>
<td>225</td>
<td>11,100</td>
<td>49</td>
</tr>
<tr>
<td>New York City</td>
<td>Madison Avenue</td>
<td>180</td>
<td>10,000</td>
<td>55</td>
</tr>
<tr>
<td>Portland, OR</td>
<td>6th Avenue</td>
<td>175</td>
<td>8,500</td>
<td>50</td>
</tr>
<tr>
<td>New York City</td>
<td>Long Island Expwy.</td>
<td>165</td>
<td>7,840</td>
<td>48</td>
</tr>
<tr>
<td>New York City</td>
<td>Gowanus Expwy.</td>
<td>150</td>
<td>7,500</td>
<td>45</td>
</tr>
<tr>
<td>Newark</td>
<td>Broad Street</td>
<td>150</td>
<td>6,000</td>
<td>40</td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>East Busway</td>
<td>105</td>
<td>5,400</td>
<td>51</td>
</tr>
<tr>
<td>Northern Virginia</td>
<td>Shirley Highway</td>
<td>160</td>
<td>5,000</td>
<td>35</td>
</tr>
<tr>
<td>San Francisco</td>
<td>Bay Bridge</td>
<td>135</td>
<td>5,000</td>
<td>37</td>
</tr>
<tr>
<td>Denver</td>
<td>I-25</td>
<td>85</td>
<td>2,775</td>
<td>33</td>
</tr>
<tr>
<td>Denver</td>
<td>Broadway/Lincoln</td>
<td>89</td>
<td>2,325</td>
<td>26</td>
</tr>
<tr>
<td>Boston</td>
<td>South/High Streets</td>
<td>50</td>
<td>2,000</td>
<td>40</td>
</tr>
<tr>
<td>Vancouver, BC</td>
<td>Granville Mall</td>
<td>70</td>
<td>1,800</td>
<td>26</td>
</tr>
<tr>
<td>Vancouver, BC</td>
<td>Highway 99</td>
<td>29</td>
<td>1,450</td>
<td>50</td>
</tr>
</tbody>
</table>

*no stops

When intermediate stops are made, bus volumes rarely exceed 120 buses per hour. However, volumes of 180 to 200 buses per hour are feasible where buses may use two or more lanes to allow bus passing, especially where stops are short. An example is Hillside Avenue in New York City. Two parallel bus lanes in the same direction, such as along Madison Avenue in New York, and the 5th and 6th Avenue Transit Mall in Portland, Oregon, also achieve this flow rate. Up to 45 buses one-way in a single lane in 15 minutes (a flow rate of 180 buses per hour) were observed on Chicago’s former State Street Mall; however, this flow rate was achieved by advance marshaling of buses into 3-bus platoons and by auxiliary rear-door fare collection during the evening peak hours to expedite passenger loading.

Several downtown streets carry bus volumes of 80 to 100 buses per hour, where there are two or three boarding positions per stop, and where passenger boarding is not concentrated at a single stop. (This frequency corresponds to about 5,000 to 7,500 passengers per hour, depending on passenger loads.)

These bus volumes provide initial capacity ranges that are suitable for general planning purposes. They compare with maximum streetcar volumes on city streets in the 1920s which approached 150 cars per track per hour, under conditions of extensive queuing and platoon loading at heavy stops.\(^{(R3)}\) However, the streetcars had two operators and large rear platforms where boarding passengers could assemble.
### Exhibit 1-23
Observed U.S. and Canadian LRT Passenger Volumes: Peak Hour at the Peak Point for Selected Lines (1993-96 Data)

<table>
<thead>
<tr>
<th>City</th>
<th>Location (may be trunk with several routes)</th>
<th>Trains/ h</th>
<th>Cars/ h</th>
<th>Avg. Headway (s)</th>
<th>Pass/Peak Hour Direction</th>
<th>Pass/m of Car Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calgary</td>
<td>South Line</td>
<td>11</td>
<td>33</td>
<td>320</td>
<td>4,950</td>
<td>6.8</td>
</tr>
<tr>
<td>Denver</td>
<td>Central</td>
<td>12</td>
<td>24</td>
<td>300</td>
<td>3,000</td>
<td>4.7</td>
</tr>
<tr>
<td>Edmonton</td>
<td>Northeast LRT</td>
<td>12</td>
<td>36</td>
<td>300</td>
<td>3,220</td>
<td>4.0</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>Blue Line</td>
<td>9</td>
<td>18</td>
<td>400</td>
<td>2,420</td>
<td>5.4</td>
</tr>
<tr>
<td>Boston</td>
<td>Green Line Subway*</td>
<td>45</td>
<td>90</td>
<td>80</td>
<td>9,600</td>
<td>5.3</td>
</tr>
<tr>
<td>Newark</td>
<td>City Subway</td>
<td>30</td>
<td>30</td>
<td>120</td>
<td>1,760</td>
<td>4.6</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>Norristown</td>
<td>8</td>
<td>8</td>
<td>450</td>
<td>480</td>
<td>3.3</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>Subway-Surface*</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>4,130</td>
<td>5.0</td>
</tr>
<tr>
<td>Sacramento</td>
<td>Sacramento LRT</td>
<td>4</td>
<td>12</td>
<td>900</td>
<td>1,310</td>
<td>4.9</td>
</tr>
<tr>
<td>Toronto</td>
<td>Queen at Broadway*</td>
<td>51</td>
<td>51</td>
<td>70</td>
<td>4,300</td>
<td>6.1</td>
</tr>
<tr>
<td>Portland</td>
<td>Eastside MAX</td>
<td>9</td>
<td>16</td>
<td>400</td>
<td>1,980</td>
<td>5.1</td>
</tr>
</tbody>
</table>

*Trunks with multiple-berth stations.

**NOTE:** In a single hour a route may have different lengths of trains and/or trains with cars of different lengths or seating configurations. Data represent the average car. In calculating the passengers per meter of car length, the car length is reduced by 9% to allow for space lost to driver cabs, stairwells, and other equipment. Data not available for the heavily used Muni Metro subway in San Francisco.

Exhibit 1-24 provides an indication of the maximum peak passenger volumes carried on a number of light rail systems for which data are available. The exhibit illustrates the peak passenger volumes carried over the busiest segment of the LRT system; in many cases, this represents passengers being carried on more than one route.

### Exhibit 1-24

<table>
<thead>
<tr>
<th>City</th>
<th>Average Weekday Riders</th>
<th>Peak 15 Minutes</th>
<th>Peak Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boston (Green Line Subway)</td>
<td>6,000</td>
<td>8,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Calgary (7th Avenue Mall)</td>
<td>5,000</td>
<td>7,000</td>
<td>9,000</td>
</tr>
<tr>
<td>Philadelphia (Subway)</td>
<td>4,000</td>
<td>6,000</td>
<td>8,000</td>
</tr>
<tr>
<td>Edmonton (Northeast Line)</td>
<td>3,000</td>
<td>5,000</td>
<td>7,000</td>
</tr>
<tr>
<td>Denver (Central)</td>
<td>2,000</td>
<td>3,000</td>
<td>4,000</td>
</tr>
<tr>
<td>Los Angeles (Blue Line)</td>
<td>1,500</td>
<td>2,500</td>
<td>3,500</td>
</tr>
<tr>
<td>Portland (Eastside MAX)</td>
<td>1,000</td>
<td>1,500</td>
<td>2,000</td>
</tr>
<tr>
<td>Newark (City Subway)</td>
<td>500</td>
<td>750</td>
<td>1,000</td>
</tr>
<tr>
<td>Sacramento (Central)</td>
<td>200</td>
<td>300</td>
<td>400</td>
</tr>
</tbody>
</table>

**NOTE:** Data not available for the heavily used Muni Metro subway in San Francisco.

Some streetcar and light rail lines carried substantially higher passenger flows in the peak years of 1946-1960. Post-World War II streetcars operated at as close as 30-second headways both on-street (Pittsburgh) and in tunnels (Philadelphia). Peak-hour passenger flows approximated 9,000 persons per hour. San Francisco’s Market Street surface routes carried 4,900 peak-hour one-way passengers per hour before they were placed underground. Now, the observed number of peak-hour passengers at the maximum load point usually reflects demand rather than capacity. Peak 15- to 20-minute volumes expressed as hourly flow rates are about 15 percent higher.
The transportation profession lacks a consolidated and generally accepted set of transit-capacity and quality-of-service definitions, principles, practices, and procedures for planning, designing, and operating vehicles and facilities. This is in contrast to the *Highway Capacity Manual* that defines quality of service and presents fundamental information and computational techniques related to quality of service and capacity of highway facilities. In the absence of a comparable, authoritative document, the case for transit service in a multimodal decision environment is weakened. Therefore, there is a need for a Transit Capacity and Quality of Service Manual.

Transit capacity is arguably more complex than highway capacity: it deals with the movement of both people and vehicles; depends on the size of the transit vehicles and how often they operate; and reflects the interaction between passenger traffic concentrations and vehicle flow. It also depends on the operating policy of the transit agency, which normally specifies service frequencies and allowable passenger loadings. Accordingly, the traditional concepts applied to highway capacity must be adapted and broadened. For this project, "capacity" is defined as "person capacity" as stated in the 1985 edition of the *Highway Capacity Manual*: "Person capacity is defined as the maximum number of people that can be carried past a given location during a given time period under specified operating conditions."

"Quality of service" reflects the transit-user perspective and should be measured by a quantitative measurement or prediction of how a transit route, facility, or system is operating under specified demand, supply, and control.
conditions. The concept of quality of service for transit includes some of the same factors that affect capacity, such as vehicle size, load factor, service frequency and travel time. Travel time is influenced by factors such as stop frequency, dwell times, road and rail traffic interference, and right-of-way design. In addition to the factors that affect both quality of service and capacity, quality of service also includes such items as accessibility, comfort, area coverage, and reliability.

Considerable work has already been done on transit capacity and quality of service, but it needs to be consolidated and updated. There are also gaps in knowledge that require additional research. This project is intended to lay the groundwork for a comprehensive Transit Capacity and Quality of Service Manual and to produce an interim version. It will also contribute to the transit chapter of the year 2000 update of the *Highway Capacity Manual* and conduct new research to address the highest priority gaps in knowledge about transit capacity and quality of service.

The objectives of this research are to (1) define the content of a comprehensive Transit Capacity and Quality of Service Manual, (2) provide transit input to the *Highway Capacity Manual 2000*, (3) develop a prioritized research agenda for completing the Transit Capacity and Quality of Service Manual, (4) complete those portions of a Transit Capacity and Quality of Service Manual for which information is available and produce an interim document, and (5) conduct research on one or more high-priority research topics growing out of the research agenda.

**Status:** The project was completed on January 31, 1999. The project also prepared draft materials for transit-related Chapters 12 and 27 of the *Year 2000 Highway Capacity Manual (HCM)*. These materials are being reviewed and finalized by the Transit Subcommittee of the TRB Committee on Highway Capacity and Quality of Service. TRB has formed a Transit Capacity and Quality of Service Task Force, which will eventually be responsible for the contents of the *Transit Capacity and Quality of Service Manual* just as the Highway Capacity Committee has long been responsible for the contents of the HCM. Highlights of the manual were published as *TCRP Research Results Digest 35*, which is available in portable document format (PDF). Double-click on the files below to access the report. (A free copy of the Adobe Acrobat Reader is available at [http://www.adobe.com](http://www.adobe.com).)

**TCRP Research Results Digest 35**

Comments are welcome.

The *Transit Capacity and Quality of Service Manual, First Edition*, is available in portable document format (PDF). Double-click on the files below to access the report. (A free copy of the Adobe Acrobat Reader is available at www.adobe.com.) **PLEASE NOTE:** Due to the very large size...
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**TCRP Web Document 6**

**Front matter, Table of Contents, Foreword, Part 1: Introduction and Concepts**

**Part 2: Bus Transit Capacity**

**Part 3: Rail Transit Capacity**

**Part 4: Terminal Capacity**

**Part 5: Quality of Service, Part 6: Glossary**

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