Multimodal LOS For Urban Streets

Richard Dowling – Dowling Associates
NCHRP 3-70 Research Project

- Objective: To develop a scientific basis for evaluating multimodal LOS on urban streets

- 4-year, $1.1 million project

- U.S. modal experts
  - Dr. Aimee Flannery, George Mason University
  - Dr. Nagui Rouphail, North Carolina State University
  - Bruce Landis, Sprinkle Consulting
  - Theo Petritsch, Sprinkle Consulting
  - Paul Ryus, Kittelson Associates
Data Collection

- Selected and shot video clips of 90 typical street cross sections from point of view of auto driver, bicycle rider, and pedestrian.

- Showed the clips to 120 people in video labs in four cities.
  - College Station, Texas
  - New Haven, Connecticut
  - San Francisco, California
  - Chicago, Illinois

- Asked to rate each clip’s trip experience from “best” to “worst.”
What about Transit?

- Did on-board surveys in Miami, Baltimore, Portland, and San Francisco
- No matter how bad the service, everybody on board the bus liked it.
- Used mode choice survey results and know patronage elasticities to construct transit LOS model
Introduction to MMLOS

- Multimodal Level of Service (MMLOS) Analysis for Urban Streets

- Each urban street right-of-way is shared by 4 major types of users:
  - Automobile Drivers
  - Transit Passengers
  - Bicyclists
  - Pedestrians

- The urban street should serve all users
Definition of MMLOS

- MMLOS is the degree to which the urban street design and operations meets the traveling needs of each user type.

- Four level of service grades for each street:
  - Auto LOS
  - Transit LOS
  - Bicycle LOS
  - Pedestrian LOS

<table>
<thead>
<tr>
<th>Bancroft Avenue Level of Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>User Type</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>Auto</td>
</tr>
<tr>
<td>Transit</td>
</tr>
<tr>
<td>Bicycle</td>
</tr>
<tr>
<td>Pedestrian</td>
</tr>
</tbody>
</table>
Factors Affecting Auto LOS

- Number of Stops per Mile
  - Average speed almost equally as important.
- Stops and speeds are in turn influenced by:
  - Demand, capacity, posted speed limit, number of lanes, signal timing, coordination, interference from other users (bus, bike, pedestrian)
Auto LOS – HCM 2000 Model

- LOS by Arterial Class and Speed Threshold

<table>
<thead>
<tr>
<th>Urban Street Class</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range of FFS</td>
<td>45-55 mph</td>
<td>35-45 mph</td>
<td>30-35 mph</td>
<td>25-35 mph</td>
</tr>
<tr>
<td>Typical FFS</td>
<td>50 mph</td>
<td>40 mph</td>
<td>35 mph</td>
<td>30 mph</td>
</tr>
<tr>
<td>LOS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>&gt;42 mph</td>
<td>&gt;35 mph</td>
<td>&gt;30 mph</td>
<td>&gt;25 mph</td>
</tr>
<tr>
<td>B</td>
<td>&gt;34-42</td>
<td>&gt;28-35</td>
<td>&gt;24-30</td>
<td>&gt;19-25</td>
</tr>
<tr>
<td>C</td>
<td>&gt;27-34</td>
<td>&gt;22-28</td>
<td>&gt;18-24</td>
<td>&gt;13-19</td>
</tr>
<tr>
<td>D</td>
<td>&gt;21-27</td>
<td>&gt;17-22</td>
<td>&gt;14-18</td>
<td>&gt;9-13</td>
</tr>
<tr>
<td>E</td>
<td>&gt;16-21</td>
<td>&gt;13-17</td>
<td>&gt;10-14</td>
<td>&gt;7-9</td>
</tr>
<tr>
<td>F</td>
<td>&lt;=16</td>
<td>&lt;=13</td>
<td>&lt;=10</td>
<td>&lt;=7</td>
</tr>
</tbody>
</table>

FFS = Free-Flow Speed
NCHRP 3-70 Auto LOS Model

- Probability that driver will perceive LOS “C” or worse

\[ Pr(LOS \geq C) = \frac{1}{1 + \exp(-\alpha - \sum_k \beta_k x_k)} \]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha =</td>
<td>-0.623</td>
</tr>
<tr>
<td>Beta (1) =</td>
<td>+0.253</td>
</tr>
<tr>
<td>X(1) =</td>
<td>Number of Stops/mile</td>
</tr>
<tr>
<td>Beta (2) =</td>
<td>-0.3434</td>
</tr>
<tr>
<td>X(2) =</td>
<td>Proportion of Intersections with Left Turn Lanes</td>
</tr>
</tbody>
</table>
NCHRP 3-70 Auto LOS Model

- Probability that driver will perceive LOS “C” or worse

\[
\Pr(LOS \geq C) = \frac{1}{1 + \exp(-\alpha - \sum_k \beta_k x_k)}
\]

With LT lane
0 stops /mi \(\rightarrow\) 28% say LOS C or worse
5 stops /mi \(\rightarrow\) 57%
10 stops/mi \(\rightarrow\) 83%
Factors Affecting Transit LOS

- Frequency of Service
- Speed of Service
- Passenger Load
- Reliability
- Accessibility
- Bus Stop Amenities
Transit LOS Model

Transit LOS Score = 6.0 \(-1.50 \times \text{TransitWaitRideScore} + 0.15 \times \text{PedLOS}\)

\[
\text{TransitWaitRideScore} = f_h \times f_{\text{ptt}}
\]

| \(f_h\) | = headway factor  
|        | = the ratio of ridership expected on a route at a headway \(h\), relative to the ridership at 60-minute headways; |
| \(f_{\text{ptt}}\) | = perceived travel time factor  
|        | = the ratio of ridership expected at a perceived travel time rate \(PTTR\), relative to the ridership expected at a baseline travel time rate. |

The baseline travel time rate is 4 minutes/mile except for central business districts of metropolitan areas with over 5 million population, in which case it is 6 min/mile.
Converting Transit Scores to LOS

- For all modes:

<table>
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<tr>
<th>LOS Model Outputs</th>
<th>LOS Letter Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model &lt;=2.00</td>
<td>A</td>
</tr>
<tr>
<td>2.00 &lt; Model &lt;= 2.75</td>
<td>B</td>
</tr>
<tr>
<td>2.75 &lt; Model &lt;= 3.50</td>
<td>C</td>
</tr>
<tr>
<td>3.50 &lt; Model &lt;= 4.25</td>
<td>D</td>
</tr>
<tr>
<td>4.25 &lt; Model &lt;= 5.00</td>
<td>E</td>
</tr>
<tr>
<td>Model &gt; 5.00</td>
<td>F</td>
</tr>
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</table>
Factors Influencing Pedestrian LOS

- Auto Traffic and Speeds, Percent Trucks
- Lateral Separation between Vehicles and Pedestrians
  - Buffers
  - Barriers
- Crossing Difficulty
  - At intersections
  - Mid-block
- Pedestrian Density
Pedestrian LOS Model

- If there is pedestrian/bike path parallel to street:
  - Then go to existing shared use path procedures in Highway Capacity Manual to estimate LOS
  - Don’t use NCHRP 3-70 model

- If no separate ped/bike path, then Pedestrian LOS is the worse of:
  - Pedestrian Density LOS
    - New York City, San Francisco CBD LOS
  - Non-Density LOS
    - The NCHRP 3-70 MMLOS model
NCHRP 3-70 Pedestrian LOS Model

\[ \text{LOS} = (0.318 \text{ Segment} + 0.220 \text{ Intersection} + 1.606) \times (\text{RCDF}) \]

RCDF = Roadway Crossing Difficulty Factor

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Pedestrian Segment LOS

- Function of:
  - Lateral separation between vehicles and pedestrians
    - Barriers (trees, bushes, barricades)
    - On-Street parking
  - Presence of sidewalk
  - Width of sidewalk
  - Vehicle volumes
  - Vehicle speeds
Pedestrian Intersection LOS

- Function of:
  - Right turns on red
  - Left turns during “Walk” phase
  - Cross-street vehicle traffic
  - Cross-street vehicle speeds
  - Lanes on the cross-street
  - Vehicle volumes
  - Vehicle speeds
  - Delay waiting to cross at signal
Ped. Midblock Crossing Difficulty

- Can increase or decrease pedestrian LOS by up to 20%.
- Factor is related to the minimum of:
  - Delay waiting for gap in traffic
  - Delay walking to nearest signalized intersection
- If Jay-walking is Not legal then factor = 1.00
Factors Influencing Bicyclist LOS

- Auto Traffic
- Lateral Separation From Vehicles
- Vehicle Speeds
- Percent Trucks
- Pavement Quality
- Driveway Conflicts
Bicycle LOS Model

Bicycle LOS =
\[ 0.160 \times \text{(bicycle segment)} + 0.011 \times \exp(\text{signalized intersection crossing difficulty}) + 0.035 \times \text{(unsignalized and driveway conflicts)} + 2.85 \]

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</tr>
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</tr>
<tr>
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<td>C</td>
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<td>3.50 &lt; Model ( \leq 4.25 )</td>
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<td>Model &gt; 5.00</td>
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To Learn More

- Final Report: NCHRP Report #616

- User’s Guide: NCHRP Web document 128

- For more information contact:
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