HCM 2010

Urban Street Concepts:
Pedestrian, Bicycle, and Transit

Kittelston & Associates, Inc.
Transportation Engineering/Planning
Overview

- **What’s New for HCM 2010?**
- Brief history of HCM multimodal analysis
- Development of the HCM methodology
  - Pedestrian LOS model
  - Bicycle LOS model
  - Transit LOS model
- Complete Streets and General Plan Case Studies
- Traffic Impact and Sensitivity Case Studies
- Q&A
What’s New for HCM 2010?
(The 2010 Highway Capacity Manual)

- Volume 1 – Concepts
- Volume 2 – Uninterrupted Flow Facilities
  - Freeways, rural highways, rural roads
- Volume 3 – Interrupted Flow Facilities
  - Urban arterials, intersections, roundabouts
  - Signals at freeway interchanges,
  - Bicycle and Pedestrian paths
- Volume 4 – Supplemental Materials (Website)
What’s New for HCM 2010?

- Guidance on How to Apply the HCM
  - How and when to use microsimulation
  - Interpretation and presentation of results
  - Service volume tables
- New Freeway Weaving Method
- New Chapter on Active Traffic Management
- New Arterial Street Method
  - Multimodal Level of Service
  - New Roundabout Method
What’s New for HCM 2010?
(HCM 2010 Urban Street Analysis)

- Predict Stops, Speed, Queues
- Models signal coordination
  - force offs, yields
- Mixed street: signal, stops, roundabout
- Sensitive to access management
  - driveways, median breaks
- Service Volume Table
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Brief History of HCM Multimodal Analysis

- **1950 HCM**
  - Streetcars and buses impact motorized vehicle capacity at traffic signals
  - Pedestrian impacts on motorized vehicle capacity addressed indirectly

- **1965 HCM**
  - LOS concept introduced
  - Short (11-page) chapter on bus transit
Brief History of HCM Multimodal Analysis

- 1985 HCM
  - Greatly expanded transit chapter
    - LOS measures based on the probability of a queue of buses forming at a bus stop, passenger loads
  - New pedestrian chapter
    - LOS for sidewalks and street corners based on pedestrian space
  - New 4-page bicycle chapter
    - Focused mainly on bicycle impacts on motorized vehicle capacity
**Brief History of HCM Multimodal Analysis**

- **HCM 2000**
  - Transit chapter an abridgement of the then-new *Transit Capacity & Quality of Service Manual*
    - LOS measures for frequency, hours of service, passenger load, reliability
  - Expanded pedestrian chapter
    - Methods for additional facility types
    - LOS based on pedestrian space, speed, delay
  - Expanded bicycle chapter
    - LOS based on bicycle speed, delay, hindrance
**Brief History of HCM Multimodal Analysis**

- **HCM 2000 focus group findings**
  - Many jurisdictions didn’t require multimodal analyses
    - Therefore, they weren’t performed
  - Jurisdictions that did want to perform pedestrian & bicycle analyses didn’t find the HCM 2000 measures useful
    - For example, Maryland & Florida used measures of user comfort
  - Most pedestrian and bicycle facilities don’t have capacity or speed issues
    - No need to analyze them using HCM procedures
**Brief History of HCM Multimodal Analysis**

- **Issues with HCM 2000 alternative mode measures:**
  - Pedestrian and bicycle LOS measures reflected a traffic engineer’s perspective.
  - Transit measures reflected a traveler’s perspective, but 4 LOS measures created issues with results interpretation.

HCM 2000: Ped LOS A

HCM 2000: Ped LOS D
Multimodal Research Since HCM 2000

- Shared-use path LOS (FHWA, 2006)
- Florida Quality/Level of Service Handbook (FDOT, 2002 & 2009)
- Urban street multimodal LOS (NCHRP Report 616, 2008)
HCM 2010 Multimodal Philosophy

- Integrate multimodal analysis methods into the appropriate HCM methodological chapters wherever possible
  - Alternative mode material is presented side-by-side with auto mode material to encourage greater consideration of alternative modes by analysts
  - Encourage software developers to add multimodal analysis features
  - No separate bike, ped, transit chapters
HCM 2010 Multimodal Philosophy

- Refer readers to the *Transit Capacity & Quality of Service Manual (TCQSM)* for most transit operational analysis methods
  - Difficult to keep the HCM & TCQSM in synch
  - HCM still presents transit material used for a multimodal analysis of an urban street
Allow trade-offs in the use of the right-of-way by different modes to be evaluated

<table>
<thead>
<tr>
<th>Mode Affected</th>
<th>Auto</th>
<th>Ped</th>
<th>Bike</th>
<th>Transit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto</td>
<td>Auto &amp; HV volumes, Turning patterns, Lane configurations</td>
<td>Minimum green time, Turn conflicts, Mid-block xings</td>
<td>Turn conflicts, Passing delay</td>
<td>Heavy vehicle, Blocking delay: stops, Signal priority</td>
</tr>
<tr>
<td>Ped</td>
<td>Auto &amp; HV volumes, Signal cycle length, Driver yielding, Turn conflicts, Traffic separation</td>
<td>Sidewalk crowding, Crosswalk crowding, Cross-flows</td>
<td>Shared-path conflicts, Bicyclist yielding</td>
<td>Heavy vehicle, Transit stop queues, Bus stop cross-flows, Vehicle yielding</td>
</tr>
<tr>
<td>Bike</td>
<td>Auto &amp; HV volumes, Auto &amp; HV speed, On-street parking, Turn conflicts, Traffic separation</td>
<td>Shared-path conflicts, Min. green time, Turn conflicts, Mid-block xings</td>
<td>Bike volumes</td>
<td>Heavy vehicle, Blocking delay: stops, Tracks</td>
</tr>
<tr>
<td>Transit</td>
<td>Auto volumes, Signal timing</td>
<td>Ped. env. quality, Minimum green time, Turn conflicts, Mid-block xings</td>
<td>Bike environment quality, Bike volumes</td>
<td>Bus volumes</td>
</tr>
</tbody>
</table>
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Methodology Selection

- NCHRP Report 616 method used in HCM 2010
  - Designed specifically for the HCM
  - LOS measures based on traveler perceptions
  - Modal LOS scores can be directly compared to each other and reflect average traveler satisfaction by mode
  - Model developed and tested based on national conditions
Methodology Development

- Pedestrian, bicycle, auto modes:
  - 90 typical street segments recorded
  - Video labs in four cities around the U.S.
  - 120 Participants rated conditions on a 1–6 scale,
Transit mode:

- Video lab not a feasible

- On-board surveys conducted in 4 cities
  - However, results showed too wide a range to fit a model to

- Final model was based on national traveler response data to changes in transit service quality
  - For example, when service frequency or travel time is improved, ridership increases
- Methodology Characteristics -

- All models generate an perception score that is generally in the range of 1–6
- All models have multiple service quality factors as inputs
  - Traditional HCM service measures are based on a single factor (e.g., delay)
- LOS thresholds are the same across models
### LOS Score Interpretation

<table>
<thead>
<tr>
<th>LOS</th>
<th>LOS Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>≤2.00</td>
</tr>
<tr>
<td>B</td>
<td>&gt;2.00 – 2.75</td>
</tr>
<tr>
<td>C</td>
<td>&gt;2.75 – 3.50</td>
</tr>
<tr>
<td>D</td>
<td>&gt;3.50 – 4.25</td>
</tr>
<tr>
<td>E</td>
<td>&gt;4.25 – 5.00</td>
</tr>
<tr>
<td>F</td>
<td>&gt;5.00</td>
</tr>
</tbody>
</table>

- Auto LOS is based on *travel speed as a percentage of base free-flow speed* instead of on the auto perception score.
LOS Score Interpretation

- LOS is reported individually by mode and direction
- No combined LOS for the street
  - Auto volumes would typically dominate an LOS weighted by number of travelers
  - Combined LOS would potentially mask important deficiencies for a given mode
- Measures the degree to which urban streets meet the need of all users

HCM 2010 Overview & Multimodal Level of Service
Treatment of Safety in Multimodal LOS

- HCM 2010 does not explicitly include safety in LOS calculations.
  - Crash history does not affect LOS
- However, HCM 2010 does include safety implicitly.
  - Traveler Perceived Safety
    - Speed of traffic, percent heavy vehicles, barriers between sidewalk and street, lateral separation between vehicle stream and bicyclists and pedestrians.
- Distance between two signalized intersections
  - Roundabout or all-way STOP could also be an end point
- Perception score for bike, ped modes
- Signalized intersection, roundabout, or all-way STOP that terminates a link
- Intersection scores only for ped/bike modes
- Segment = link + downstream intersection
- Perception scores available for all modes
  - Ped & bike scores based on combination of link, intersection, and additional factor
- Facility = 2 or more consecutive segments
- Perception scores available for all modes
  - Length-weighted average of the segment scores
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Pedestrian LOS: Links
Model Factors

- Factors included:
  - Outside travel lane width (+)
  - Bicycle lane/shoulder width (+)
  - Buffer presence (e.g., on-street parking, street trees) (+)
  - Sidewalk presence and width (+)
  - Volume and speed of motor vehicle traffic in outside travel lane (−)

- Pedestrian density considered separately
  - Worse of (density LOS, link LOS score) used in determining overall link LOS
Pedestrian LOS: Links Model Form

\[ I_{p,\text{link}} = 6.0468 + F_v + F_S + F_w \]

- **Ped Link LOS Score**
- **Constant**
- **Vehicle Volume**
- **Vehicle Speed**
- **Cross-Section Factor**

Mid-segment demand flow rate (veh/h)

\[ F_v = 0.0091 \frac{V_m}{4 N_{th}} \]

Number of through lanes in direction of travel

\[ F_S = 4 \left( \frac{S_R}{100} \right)^2 \]

Motorized vehicle running speed (mi/h) [from auto model]

HCM 2010 Overview & Multimodal Level of Service
$$F_w = -1.2276 \ln \left( W_v + 0.5 W_1 + 50 p_{pk} + W_{buf} f_b + W_{aA} f_{sw} \right)$$

- $W_v =$ effective total width of outside through lane, bike lane, and shoulder
- $W_1 =$ effective total width of bike lane and shoulder
- $p_{pk}$ = % occupied on-street parking
- $f_b = 1.00$ (no barrier)
- $f_b = 5.37$ (barrier)
- $f_{sw} = 6.0 - 3W_{aA}$
- $W_{aA} = \min(W_A, 10 \text{ ft})$

HCM 2010 Overview & Multimodal Level of Service
Pedestrian LOS: Signalized Intersections
Pedestrian LOS: Signalized Intersections
Model Factors

- Factors included:
  - Permitted left turn and right-turn-on-red volumes (−)
  - Cross-street motor vehicle volumes and speeds (−)
  - Crossing length (−)
  - Average pedestrian delay (−)
  - Right-turn channelizing island presence (+)
### Pedestrian LOS: Signalized Intersections Model Form

\[ I_{p,int} = 0.5997 + F_w + F_S + F_{delay} + F_v \]

<table>
<thead>
<tr>
<th>Ped Intersection LOS Score</th>
<th>Constant Cross-Section Factor</th>
<th>Speed Factor</th>
<th>Pedestrian Delay Factor</th>
<th>Volum Factor [from auto model]</th>
</tr>
</thead>
</table>

**Pedestrian Delay Factor**

\[ F_w = 0.681 \left( N_d \right)^{0.514} \]

*Number of traffic lanes crossed*

**Speed Factor**

\[ F_S = 0.00013 \quad n_{15,mi} \quad S_{85,mi} \]

*Minor street traffic volume (veh/ln/15 min)*

*Minor street midblock auto speed (mi/h)*

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HCM 2010 Overview & Multimodal Level of Service
Pedestrian LOS: Signalized Intersections

Model Form

\[ F_v = 0.00569 \left( \frac{v_{rtor} + v_{lt,perm}}{4} \right) - N_{rtci,d} \left( 0.0027 \, n_{15,mj} - 0.1946 \right) \]

- **Constant**
- **Conflicting traffic flow over crosswalk (veh/h)**
- **Number of right-turn channelizing islands along crossing**
- **Traffic volume of street being crossed (veh/ln/15 min)**

HCM 2010 Overview & Multimodal Level of Service
Pedestrian LOS: Segments
Model Factors

- Factors included:
  - Pedestrian link LOS (+)
  - Pedestrian intersection LOS (+)
  - Street-crossing difficulty (–/+)
    - Delay diverting to signalized crossing
    - Delay crossing street at legal unsignalized location
Pedestrian LOS: Segments
Model Form

\[ I_{p,seg} = F_{cd} \left( 0.318 \ I_{p,link} + 0.220 \ I_{p,int} + 1.606 \right) \]

<table>
<thead>
<tr>
<th>Ped Segment</th>
<th>Ped Link</th>
<th>Ped Intersection</th>
<th>Constant</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOS Score</td>
<td>LOS Score</td>
<td>LOS Score</td>
<td></td>
</tr>
</tbody>
</table>

Minimum of diversion time & unsignalized crossing delay time

\[ F_{cd} = 1.0 + \frac{0.10 \ d_{px} - (0.318 \ I_{p,link} + 0.220 \ I_{p,int} + 1.606)}{7.5} \]
Pedestrian LOS: Facility

- Length-weighted average of segment LOS scores
  - Can mask deficiencies in individual segments
  - Consider also reporting segment LOS score for the worst segment in the facility
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Bicycle LOS: Links
Factors included:

- Volume and speed of traffic in outside travel lane (–)
- Heavy vehicle percentage (–)
- Pavement condition (+)
- Bicycle lane presence (+)
- Bicycle lane, shoulder, and outside lane widths (+)
- On-street parking utilization (–)
Bicycle LOS: Links
Model Form

\[ I_{b,link} = 0.760 + F_v + F_S + F_p + F_w \]

- **Bike Link LOS Score**
- **Constant**
- **Volume Factor**
- **Speed Factor**
- **Pavement Condition Factor**
- **Cross-Section Factor**

**Pavement condition rating (1–5)**

\[ F_p = \frac{7.066}{P_c^2} \]

**Adjusted midblock vehicle flow rate (veh/h)**

\[ F_v = 0.507 \ln \left( \frac{\nu_{ma}}{4 N_{th}} \right) \]

**Number of through lanes in travel direction**

\[ F_S = 0.199 \left[ 1.1199 \ln(S_{Ra} - 20) + 0.8103 \right] \left( 1 + 0.1038 P_{HVa} \right)^2 \]

- **Vehicle running speed (>= 21 mi/h)**
- **Adjusted percent heavy vehicles**

HCM 2010 Overview & Multimodal Level of Service
### Bicycle LOS: Links Model Form

\[ F_w = -0.005 \ W_e^2 \]

**Effective width of outside through lane**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Variable When Condition Is Satisfied</th>
<th>Variable When Condition Is Not Satisfied</th>
</tr>
</thead>
<tbody>
<tr>
<td>( p_{pk} = 0.0 )</td>
<td>( W_t = W_{ol} + W_{bl} + W_{os}^* )</td>
<td>( W_t = W_{ol} + W_{bl} )</td>
</tr>
<tr>
<td>( v_m &gt; 160 \text{ veh/h or street is divided} )</td>
<td>( W_v = W_t )</td>
<td>( W_v = W_t (2 - 0.005 \ v_m) )</td>
</tr>
<tr>
<td>( W_{bl} + W_{os}^* &lt; 4.0 \text{ ft} )</td>
<td>( W_e = W_v - 10 \ p_{pk} \geq 0.0 )</td>
<td>( W_e = W_v + W_{bl} + W_{os}^* - 20 \ p_{pk} \geq 0.0 )</td>
</tr>
</tbody>
</table>

\( W_{os} = \text{width of paved outside shoulder} \)

\( W_{os}^* = \text{adjusted width of paved outside shoulder (same as ped link LOS)} \)
Bicycle LOS: Signalized Intersections
Bicycle LOS: Signalized Intersections
Model Factors

- Factors included:
  - Width of outside through lane and bicycle lane (+)
  - Cross-street width (−)
  - Motor vehicle traffic volume in the outside lane (−)
Bicycle LOS: Signalized Intersections
Model Form

\[ I_{b,\text{int}} = 4.1324 + F_w + F_v \]

- **Bike Intersection LOS Score**
- **Constant**
- **Cross-Section Factor**
- **Vehicle Volume Factor**

\[ F_w = 0.0153 \, W_{cd} - 0.2144 \, W_t \]

- **Curb-to-curb cross-street width**
- **Total width of outside lane, bike lane, paved shoulder**

\[ F_v = 0.0066 \, \frac{\nu_{lt} + \nu_{th} + \nu_{rt}}{4 \, N_{th}} \]

- **Motorized traffic volume in travel direction**
- **Number of through lanes in travel direction**

HCM 2010 Overview & Multimodal Level of Service
Bicycle LOS: Segments
Factors included:

- Bicycle link LOS (+)
- Bicycle intersection LOS, if signalized (+)
- Number of access points on right side (–)
  - Includes driveways and unsignalized street intersections
  - Judgment required on how low-volume residential driveways are treated
Bicycle LOS: Segments
Model Form

\[ I_{b,seg} = 0.160 \ I_{b,link} + 0.011 \ F_{bi} \ e^{I_{b,int}} + 0.035 \ \frac{N_{ap,s}}{(L/5280)} + 2.85 \]

Number of access points on right side

Bike Segment LOS Score  Bike Link LOS Score  Indicator Variable  Bike Intersection LOS Score  Segment length (mi)  Constant

\[ F_{bi} = 1 \text{ if signalized} \]
\[ F_{bi} = 0 \text{ if unsignalized} \]
- Length-weighted average of segment LOS scores
  - Can mask deficiencies in individual segments
  - Consider also reporting segment LOS score for the worst segment in the facility
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Transit LOS: Overview

- Only segment and facility LOS models
- Transit facility LOS is a length-weighted average of segment LOS
- “Transit” includes buses, streetcars, and street-running light rail
- Three main model components:
  - Access to transit (pedestrian link LOS)
  - Wait for transit (frequency)
  - Riding transit (perceived travel time rate)
Transit LOS: Segment Model Form

\[ I_{t, \text{seg}} = 6.0 - 1.50 F_h F_{tt} + 0.15 I_{p, \text{link}} \]
Transit LOS: Headway Factor

\[ F_h = 4.00 \, e^{-1.434 \, / (v_s + 0.001)} \]

**Headway factor**

Number of transit vehicles serving segment per hour

HCM 2010 Overview & Multimodal Level of Service
Transit LOS: Perceived Travel Time Components

- **Factors included:**
  - Actual bus travel speed (+)
  - Bus stop amenities (+)
  - Excess wait time due to late bus/train arrival (–)
  - On-board crowding (–)

- **Default value of time data and average passenger trip lengths used to convert actual times into perceived times**
  - For example, the trip seems to take longer when one has to stand
Transit LOS: Perceived Travel Time Factor

\[ F_{tt} = \frac{(e - 1) \ T_{btt} - (e + 1) \ T_{ptt}}{(e - 1) \ T_{ptt} - (e + 1) \ T_{btt}} \]

\( e \) = ridership elasticity with respect to travel time changes, default value = -0.4

\( T_{btt} \) = base travel time rate (4.0 or 6.0 min/mi)

\( T_{ptt} \) = perceived travel time rate
Transit LOS: Perceived Travel Time Rate

Perceived travel time rate (min/mi)

\[ T_{ptt} = \left( a_1 \cdot \frac{60}{S_{Tt,seg}} \right) + \left( 2 T_{ex} \right) - T_{at} \]

- Perceived travel time rate due to stop amenities
- Crowding perception factor
- Actual travel time rate
- Perceived travel time rate due to stop amenities
- Perceived travel time rate due to late arrivals

\[ a_1 = \begin{cases} 
1.00 \\
1 + \frac{(4)(F_i - 0.80)}{4.2} \\
1 + \frac{(4)(F_i - 0.80) + (F_i - 1.00)(6.5 + [(5)(F_i - 1.00)])}{4.2 \times F_i}
\end{cases} \]

Load factor (p/seat) <= 0.80

0.80 < Load factor <= 1.00

Load factor > 1.00
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Case Study
Community Transportation Plan

- First application of MMLOS for Urban Streets
- Pre-2010 HCM
- DC&E – Prime consultant
- “Harri-Oak”
Case Study
Community Transportation Plan

- Corridor Characteristics
  - One-way couplet
  - High density residential
  - Commercial nodes
  - Middle school
  - Divided by freeway
  - Former streetcar suburb
  - Public stairways
Case Study
Community Transportation Plan

CBD
Commercial Node
Stairway
Residential
Narrow Sidewalk
Design Alternative 1

- Pedestrian bulb-outs
- Install bike lanes and sharrows
- Change northern couplet to 2-way vehicle operations
- Reduce 5-legged intersection to 4
- Eliminate channelized right turn lanes
Design Alternative 2

- Widen sidewalks
- Install bike lanes and sharrows
- Reduce vehicle lanes (3 to 2)
- Pedestrian bulb-outs
- Bus bulbs and relocation to far side
- Reduce 5-legged intersection to 4
- Eliminate channelized right turn lanes

Source: Design, Community, and Environment

HCM 2010 Overview & Multimodal Level of Service
## MMLOS Results - AM Peak-Hour Southbound

<table>
<thead>
<tr>
<th>Segment &amp; Downstream Signal</th>
<th>Scenario</th>
<th>Transit LOS</th>
<th>Bicycle LOS</th>
<th>Pedestrian LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>From To</td>
<td></td>
<td>LOS Score</td>
<td>LOS Score</td>
<td>Score</td>
</tr>
<tr>
<td>Bayo Vista Ave MacArthur/ Santa Clara</td>
<td>No Project</td>
<td>B 2.74 E 4.39</td>
<td>C 2.77</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alt. 1</td>
<td>C 2.81 E 4.83</td>
<td>C 3.20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alt. 2</td>
<td>B 2.73 E 4.26</td>
<td>B 2.70</td>
<td></td>
</tr>
<tr>
<td>MacArthur/ Santa Clara Pearl St</td>
<td>No Project</td>
<td>C 3.35 D 4.01</td>
<td>C 2.79</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alt. 1</td>
<td>C 3.35 D 4.00</td>
<td>C 2.79</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alt. 2</td>
<td>C 3.35 D 4.01</td>
<td>C 2.81</td>
<td></td>
</tr>
<tr>
<td>Pearl St Westlake School</td>
<td>No Project</td>
<td>C 3.36 D 4.05</td>
<td>C 3.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alt. 1</td>
<td>C 3.36 D 4.00</td>
<td>C 3.02</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alt. 2</td>
<td>C 3.38 D 3.99</td>
<td>C 3.19</td>
<td></td>
</tr>
<tr>
<td>Westlake School 27th/ 24th/ Bay Pl</td>
<td>No Project</td>
<td>C 3.39 F 6.29</td>
<td>C 3.08</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alt. 1</td>
<td>C 3.39 F 5.16</td>
<td>C 3.06</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alt. 2</td>
<td>C 3.38 F 5.05</td>
<td>C 2.98</td>
<td></td>
</tr>
<tr>
<td>27th/ 24th/ Bay Pl Grand Ave</td>
<td>No Project</td>
<td>C 3.33 E 4.89</td>
<td>C 2.79</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alt. 1</td>
<td>C 3.34 E 4.89</td>
<td>C 2.79</td>
<td></td>
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<tr>
<td></td>
<td>Alt. 2</td>
<td>C 3.33 E 4.87</td>
<td>C 2.79</td>
<td></td>
</tr>
<tr>
<td>Facility</td>
<td>No Project</td>
<td>C 3.22 E 4.41</td>
<td>C 2.91</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alt. 1</td>
<td>C 3.23 E 4.40</td>
<td>C 3.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alt. 2</td>
<td>C 3.22 E 4.26</td>
<td>C 2.95</td>
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</tbody>
</table>

*Dowling Associates, Inc., Multi-Modal Level of Service analysis using version 10.3 spreadsheet, March 2009*
Case Study
Community Transportation Plan

- Preferred Alternative
  - Northern couplet to 2-way vehicle operations
  - Reduce vehicle lanes (3 to 2)
  - Install bike lanes and sharrows
  - Widen sidewalks and intersection bulb-outs
  - Bus bulb-outs and relocation to far side

Source: Design, Community, and Environment

HCM 2010 Overview & Multimodal Level of Service
Case Study
Community Transportation Plan

- Preferred Alternative
  - 5-legged intersection reduced to 4 legs
  - Removal of channelized right turn lanes
  - Shortened signal cycle length
  - Improvement for all modes
  - Signal coordination

Source: Design, Community, and Environment
Benefits of MMLOS

- Outreach
  - Effective communication tool to laypersons
  - Demonstrated serious analysis of all travel modes
- Practitioner viewpoint led to:
  - Refinements to methodology for HCM
  - Sensitivity analysis
  - Software development
Lessons Learned

- Conduct traffic diversion analysis
  - Vehicle volume reduction benefits not quantified
- Estimate vehicle speed
  - Speed reduction benefits not quantified
- Bicyclist LOS
  - Results can exceed score of 6!
  - Difficult to get bikeways above LOS C
  - May need to calibrate to local conditions
Case Study
General Plan

- Adopted 2011
- Dyett and Bhatia – Prime consultant
- How to incorporate MMLOS
### Case Study

#### General Plan

- **Complete Street general policies**
- **Designation of circulation system**
  - Move away from motorist-only perceptions
  - Incorporate more multimodal designations

![Mixed-Use Boulevard (4 lanes)](image)

*Source: Dyett and Bhatia*
Prioritization of different street types by mode

Table 5.2-1 Transportation Facilities Matrix

<table>
<thead>
<tr>
<th>Facility</th>
<th>Transit</th>
<th>Bicycles</th>
<th>Pedestrians</th>
<th>Trucks</th>
<th>Automobiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>State Highway</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auto Arterial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban Arterial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixed Use Boulevard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avenue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

■ = Dominant
□ = Accommodated
○ = Incidental
X = Prohibited

^1 Transit has priority over bicycles on Urban Arterials, where conflicts exist.
• More robust determination of improvements
MMLOS summary of factors for each mode

<table>
<thead>
<tr>
<th>Table 5.2-4</th>
<th>Definition of Multi-modal Level of Service Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LOS</strong></td>
<td><strong>Transit</strong></td>
</tr>
<tr>
<td>(Good walk access to bus stops, frequent service, good bus stop amenities.)</td>
<td>(Few driveway and cross street conflicts, good pavement condition, ample width of outside lane, including parking and bike lanes.)</td>
</tr>
<tr>
<td>A</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>(Poor walk access to bus stops, infrequent service, poor schedule adherence, no bus stop amenities.)</td>
</tr>
<tr>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

Case Study Specific Plan

- Adopted 2011
- Guide to revitalize in a sustainable manner
- MMLOS analysis
  - Existing
  - 2030 No Project
  - 2030 Specific Plan
### MMLOS Analysis

#### AM Peak-Hour

<table>
<thead>
<tr>
<th>Corridor Section</th>
<th>Scenario</th>
<th>Northbound</th>
<th>Southbound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Transit Passenger</td>
<td>Bicyclist</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Score</td>
<td>LOS</td>
</tr>
<tr>
<td>North</td>
<td>Existing</td>
<td>1.67</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>2030 No Project</td>
<td>2.11</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>2030 Specific Plan</td>
<td>2.07</td>
<td>B</td>
</tr>
<tr>
<td>Central</td>
<td>Existing</td>
<td>1.08</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>2030 No Project</td>
<td>1.22</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>2030 Specific Plan</td>
<td>1.20</td>
<td>A</td>
</tr>
<tr>
<td>South</td>
<td>Existing</td>
<td>0.91</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>2030 No Project</td>
<td>1.07</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>2030 Specific Plan</td>
<td>1.04</td>
<td>A</td>
</tr>
</tbody>
</table>

*Legend:
- Worse than existing
- Worse than existing but better than 2030 No Project
- Better than existing

Dowling Associates, Inc., Multi-Modal Level of Service analysis using CompleteStreetsLOS version 2.1.8, November 2010
# Case Study
Specific Plan

## MMLOS Analysis

### PM Peak-Hour

<table>
<thead>
<tr>
<th>Corridor Section</th>
<th>Scenario</th>
<th>Northbound</th>
<th>Southbound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transit Passenger</td>
<td>Bicyclist</td>
<td>Pedestrian</td>
</tr>
<tr>
<td></td>
<td>Score</td>
<td>LOS</td>
<td>Score</td>
</tr>
<tr>
<td>North</td>
<td>Existing</td>
<td>1.71</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>2030 No Project</td>
<td>1.79</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>2030 Specific Plan</td>
<td>1.76</td>
<td>A</td>
</tr>
<tr>
<td>Central</td>
<td>Existing</td>
<td>1.10</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>2030 No Project</td>
<td>1.14</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>2030 Specific Plan</td>
<td>1.12</td>
<td>A</td>
</tr>
<tr>
<td>South</td>
<td>Existing</td>
<td>0.95</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>2030 No Project</td>
<td>0.99</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>2030 Specific Plan</td>
<td>0.96</td>
<td>A</td>
</tr>
</tbody>
</table>

*Dowling Associates, Inc., Multi-Modal Level of Service analysis using CompleteStreetsLOS version 2.1.8, November 2010*

### Legend

- **Worse than existing**
- **Worse than existing but better than 2030 No Project**
- **Better than existing**
Benefits of MMLOS

- Provided baseline LOS for all travel modes
  - Reasonableness of LOS standards
- Tested MMLOS for Specific Plan scenario
- Multimodal roadway designations
  - Provides guidelines for improvements
  - Informs mitigation requirements
  - Provides an analysis tool
Lessons Learned

- MMLOS works well analyzing fixed right-of-way
  - How to allocate space
  - Quantifies trade-offs between modes
- Developing policy standards
  - Establish baseline
  - Conduct sketch what-if scenarios
- May lead to prioritizing specific modes on streets
Overview

- What’s New for HCM 2010?
- Brief history of HCM multimodal analysis
- Development of the HCM methodology
  - Pedestrian LOS model
  - Bicycle LOS model
  - Transit LOS model
- Complete Streets and General Plan Case Studies
- Traffic Impact and Sensitivity Case Studies
- Q&A
Traffic Impact and Sensitivity Case Studies

- Worked with the City of Pasadena to analyze multimodal impacts of two projects
  1. Road Diet Evaluation
  2. Development Impact Analysis
When implementing a road diet, many concerns arise including:

- How will the lane reduction affect the auto mode?
- Will transit operations be affected?
- How much will the bicycle mode improve as a result of adding bike lanes?
- Will there be any benefit to pedestrians?

Orange Grove Blvd. was analyzed using multimodal LOS to address these concerns.
Traffic Impact and Sensitivity Case Studies

Road Diet Evaluation

HCM 2010 Overview & Multimodal Level of Service

11,200 ADT
1.6 Miles
Traffic Impact and Sensitivity Case Studies
Road Diet Evaluation

Existing Cross Section

Proposed Cross Section

HCM 2010 Overview & Multimodal Level of Service
Issues with Current Cross Section

- No facilities for bicyclists
- Light traffic volumes for a large right-of-way (ROW) roadway
- Higher speeds and wider crossing width which detract from a neighborhood feel
Traffic Impact and Sensitivity Case Studies

Road Diet Evaluation
Traffic Impact and Sensitivity Case Studies

Road Diet Evaluation
Traffic Impact and Sensitivity Case Studies

Road Diet Evaluation

HCM 2010 Overview & Multimodal Level of Service
Traffic Impact and Sensitivity Case Studies

Road Diet Evaluation

The Result:

- Analysis showed that the road diet will result in minor changes to the transit and auto mode.
- The pedestrian and bicycle modes will improve between 9% and 20% if the road diet is implemented on this corridor.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Existing Score (LOS)</th>
<th>Road Diet Score (LOS)</th>
<th>Difference</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto</td>
<td>2.33 (B)</td>
<td>2.57 (B)</td>
<td>0.24</td>
<td>10.3%</td>
</tr>
<tr>
<td>Transit</td>
<td>3.23 (C)</td>
<td>3.19 (C)</td>
<td>-0.04</td>
<td>-1.2%</td>
</tr>
<tr>
<td>Bicycle</td>
<td>3.44 (C)</td>
<td>2.73 (B)</td>
<td>-0.71</td>
<td>-20.6%</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>2.89 (C)</td>
<td>2.63 (B)</td>
<td>-0.26</td>
<td>-9.0%</td>
</tr>
</tbody>
</table>

EB

<table>
<thead>
<tr>
<th>Mode</th>
<th>Existing Score (LOS)</th>
<th>Road Diet Score (LOS)</th>
<th>Difference</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto</td>
<td>2.32 (B)</td>
<td>2.45 (B)</td>
<td>0.13</td>
<td>5.6%</td>
</tr>
<tr>
<td>Transit</td>
<td>3.09 (C)</td>
<td>3.05 (C)</td>
<td>-0.04</td>
<td>-1.3%</td>
</tr>
<tr>
<td>Bicycle</td>
<td>3.33 (C)</td>
<td>2.66 (B)</td>
<td>-0.67</td>
<td>-20.1%</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>2.84 (C)</td>
<td>2.58 (B)</td>
<td>-0.26</td>
<td>-9.2%</td>
</tr>
</tbody>
</table>

W
Traffic Impact and Sensitivity Case Studies

Road Diet Evaluation

- **Transit**
  - Auto speed decreased (-)
  - Pedestrian LOS improved (+)

- **Bicycle**
  - Slower auto speeds (+)
  - Fewer through lanes for same volume (-)
  - Exclusive bike lane (+)

- **Pedestrian**
  - More vehicles in lane nearest pedestrians (-)
  - Increased space between auto and ped (+)
  - Slower auto speeds (+)
Development Impact Analysis
Impact studies generally only consider auto

Pasadena finding it difficult to mitigate certain areas

How might MMLOS provide another tool

A recent development project was selected to test multimodal LOS
Traffic Impact and Sensitivity Case Studies

Development Impact Analysis

Project consisted of:

- 156 room hotel
- 38,000 ft² of dining
- 14,000 ft² retail
- 103,000 ft² office
- 8,000 ft² of bank

Generated 4,900 daily trips

- 289 trips in the AM peak hour
- 488 trips in the PM peak hour
Traffic Impact and Sensitivity Case Studies

Development Impact Analysis
### Facility Level Results for Colorado Blvd.

<table>
<thead>
<tr>
<th>Direction</th>
<th>Mode</th>
<th>AM Peak</th>
<th></th>
<th></th>
<th>PM Peak</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Existing</td>
<td>2015</td>
<td>2015 + Proj</td>
<td>Existing</td>
<td>2015</td>
</tr>
<tr>
<td>Eastbound</td>
<td>Auto</td>
<td>2.97 (C)</td>
<td>2.99 (C)</td>
<td>2.99 (C)</td>
<td>3.04 (C)</td>
<td>3.08 (C)</td>
</tr>
<tr>
<td></td>
<td>Transit</td>
<td>1.29 (A)</td>
<td>1.32 (A)</td>
<td>1.32 (A)</td>
<td>1.36 (A)</td>
<td>1.43 (A)</td>
</tr>
<tr>
<td></td>
<td>Pedestrian</td>
<td>2.46 (B)</td>
<td>2.52 (B)</td>
<td>2.54 (B)</td>
<td><strong>2.65 (B)</strong></td>
<td><strong>2.77 (C)</strong></td>
</tr>
<tr>
<td></td>
<td>Bicycle</td>
<td>3.39 (C)</td>
<td>3.42 (C)</td>
<td>3.42 (C)</td>
<td>3.47 (C)</td>
<td>3.50 (C)</td>
</tr>
<tr>
<td></td>
<td>Overall</td>
<td>2.53 (B)</td>
<td>2.56 (B)</td>
<td>2.57 (B)</td>
<td>2.63 (B)</td>
<td>2.70 (B)</td>
</tr>
<tr>
<td>Westbound</td>
<td>Auto</td>
<td>3.02 (C)</td>
<td>3.05 (C)</td>
<td>3.05 (C)</td>
<td>3.02 (C)</td>
<td>3.06 (C)</td>
</tr>
<tr>
<td></td>
<td>Transit</td>
<td>1.26 (A)</td>
<td>1.32 (A)</td>
<td>1.33 (A)</td>
<td>1.47 (A)</td>
<td>1.54 (A)</td>
</tr>
<tr>
<td></td>
<td>Pedestrian</td>
<td>2.58 (B)</td>
<td>2.67 (B)</td>
<td>2.68 (B)</td>
<td><strong>2.61 (B)</strong></td>
<td><strong>2.71 (B)</strong></td>
</tr>
<tr>
<td></td>
<td>Bicycle</td>
<td>3.29 (C)</td>
<td>3.32 (C)</td>
<td>3.32 (C)</td>
<td><strong>3.30 (C)</strong></td>
<td><strong>3.33 (C)</strong></td>
</tr>
<tr>
<td></td>
<td>Overall</td>
<td>2.54 (B)</td>
<td>2.59 (B)</td>
<td>2.60 (B)</td>
<td>2.60 (B)</td>
<td>2.66 (B)</td>
</tr>
</tbody>
</table>
Link results for Colorado Blvd.

<table>
<thead>
<tr>
<th>Segment</th>
<th>Mode</th>
<th>Direction</th>
<th>Existing</th>
<th>2015</th>
<th>2015 + Proj</th>
<th>Diff.</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Auto</td>
<td>EB</td>
<td>2.88 (C)</td>
<td>2.90 (C)</td>
<td>2.91 (C)</td>
<td>0.01</td>
<td>0.3%</td>
</tr>
<tr>
<td></td>
<td>Transit</td>
<td>WB</td>
<td>1.54 (A)</td>
<td>1.61 (A)</td>
<td>1.61 (A)</td>
<td>0.00</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>Pedestrian</td>
<td>EB</td>
<td>1.80 (A)</td>
<td>2.16 (B)</td>
<td>2.21 (B)</td>
<td>0.05</td>
<td>2.3%</td>
</tr>
<tr>
<td>El Molino Ave to Oak Knoll Ave</td>
<td>Bicycle</td>
<td>EB</td>
<td>2.98 (C)</td>
<td>3.10 (C)</td>
<td>3.12 (C)</td>
<td>0.02</td>
<td>0.6%</td>
</tr>
<tr>
<td></td>
<td>Auto</td>
<td>EB</td>
<td>3.10 (C)</td>
<td>3.17 (C)</td>
<td>3.19 (C)</td>
<td>0.02</td>
<td>0.6%</td>
</tr>
<tr>
<td></td>
<td>Transit</td>
<td>EB</td>
<td>1.44 (A)</td>
<td>1.53 (A)</td>
<td>1.54 (A)</td>
<td>0.01</td>
<td>0.7%</td>
</tr>
<tr>
<td></td>
<td>Pedestrian</td>
<td>EB</td>
<td>1.83 (A)</td>
<td>2.19 (B)</td>
<td>2.24 (B)</td>
<td>0.05</td>
<td>2.3%</td>
</tr>
<tr>
<td></td>
<td>Bicycle</td>
<td>EB</td>
<td>2.68 (B)</td>
<td>2.80 (C)</td>
<td>2.81 (C)</td>
<td>0.01</td>
<td>0.4%</td>
</tr>
</tbody>
</table>
Traffic Impact and Sensitivity Case Studies

Development Impact Analysis

- **Transit**
  - Minimal effect, transit speed slightly slower (-)
  - Pedestrian LOS slightly worse (-)

- **Bicycle**
  - Slower auto speeds (+)
  - Increased volume (-)

- **Pedestrian**
  - More vehicles in lane nearest pedestrians (-)
  - Slower auto speeds (+)

- **All impacts minor, volume has only small effect on LOS for non-auto modes**
Lessons Learned:

- Multimodal LOS not very sensitive to volume changes
- Methodology much better at quantitatively showing impacts to all four modes resulting from physical attributes such as:
  - Cross section changes (Pedestrians/Bikes)
  - Trees or other buffers (Pedestrians)
  - Pavement condition (Bikes)
Overview

- What’s New for HCM 2010?
- Brief history of HCM multimodal analysis
- Development of the HCM methodology
  - Pedestrian LOS model
  - Bicycle LOS model
  - Transit LOS model
- Complete Streets and General Plan Case Studies
- Traffic Impact and Sensitivity Case Studies
- Q&A
Questions/Comments

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