

NEW MULTI-MODAL URBAN STREETS METHODOLOGY: Pedestrian, Bike and Transit Methods

 TRANSPORTATION RESEARCH BOARD



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2

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3

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4

Overview of Webinar Series

- HCM 2010 Overview: Now in four volumes
- New Active Traffic Management chapter
- Changes to the unsignalized intersection methods
- New multimodal urban streets methodology: ped, bike, transit methods
- New signalized intersection methodology
- New multi-modal urban streets methodology: auto mode
- New material on the use of alternative tools: Micro simulation model
- New freeway weaving methodology
- Enhancements to the freeway facilities method
- Enhanced planning methods and application of generalized service volume tables

Presentation Overview

- History and background
- Overview of methods
- Example applications

Webinar Objectives

- Learn how multimodal analyses methods have evolved
- Understand the background behind the 2010 HCM multimodal level of service (MMLOS) methods
- Familiarize users with how to apply the Pedestrian, Bicycle, and Transit MMLOS methods

MULTIMODAL ANALYSIS IN THE HCM: 1950-2000

1950 – 1985 Manuals

- 1950 HCM
 - Streetcars and buses impact vehicle capacity at traffic signals
 - Pedestrian impacts on vehicle capacity addressed indirectly
- 1965 HCM
 - LOS concept introduced
 - Short (11-page) chapter on bus transit
- 1985 HCM
 - Pedestrian and bicycle chapters introduced

2000 Manual

- Expanded pedestrian chapter
 - Service measures: space per pedestrian, average delay, average travel speed
- Expanded bicycle chapter
 - Service measures: average travel speed, average delay, hindrance
- Revised transit chapter
 - Four passenger-oriented service measures: frequency, hours of service, passenger load, reliability

2010 HCM MMLOS METHODS

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Focus Group Findings

- Many jurisdictions don't require multimodal analyses
- Jurisdictions don't find the current HCM capacity-based measures useful
- Most bike and pedestrian facilities don't have capacity issues
 - No need to analyze them using HCM procedures

HCM 2000 Measures Issues

- HCM 2000 focuses on capacity and delay
 - Research suggests these aren't the key factors
 - Auto volumes and other factors are important to service quality



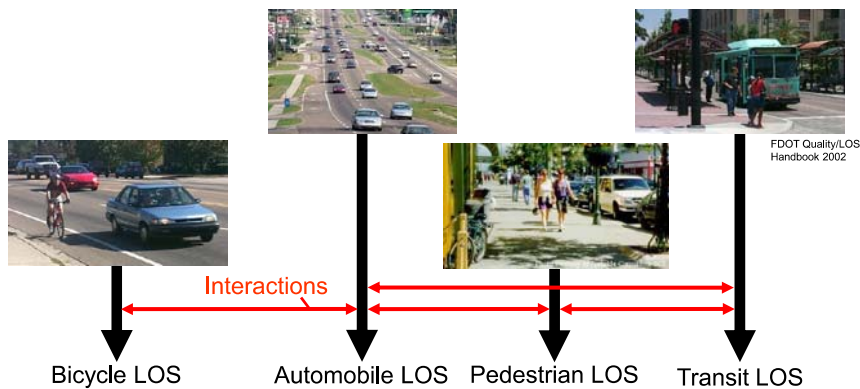
HCM2000: Ped LOS A



HCM2000: Ped LOS D

HCM 2010 Approach

- Multimodal evaluation for urban streets
 - Emphasizes combined evaluation of auto, ped, bike, and transit modes



Quality of Service

- QOS is the perception of how well a facility operates from the traveler's perspective
- Research has quantified traveler perception and developed QOS scores
 - Scores incorporate multiple factors (e.g., traffic volumes, lane widths, etc.)
- Models set LOS thresholds based on survey responses to actual conditions

Quantifying QOS

Model Score	LOS
Score ≤ 2.00	A
2.00 < Score ≤ 2.75	B
2.75 < Score ≤ 3.50	C
3.50 < Score ≤ 4.25	D
4.25 < Score ≤ 5.00	E
Score > 5.00	F

HCM 2010 Service Measures

System Element	Chapter	Service Measure Provided			
		Auto	Ped	Bike	Transit
Urban Street Facility	16	✓	✓	✓	✓
Urban Street Segment	17	✓	✓	✓	✓
Signalized Intersection	18	✓	✓	✓	
Two-Way Stop	19	✓	✓		
All-Way Stop	20	✓			
Roundabout	21	✓			
Interchange Ramp Term.	22	✓			
Off-Street Ped-Bike Facility	23		✓	✓	

- Based on traditional service measure

- Based on traveler perception score

MMLOS Defined

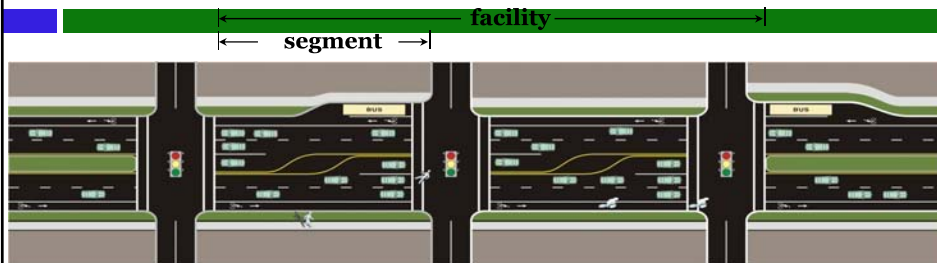
- MMLOS measures the degree to which the urban street design and operations meets the needs of each major mode's users
- Four level of service results for the street:
 - Auto, Transit, Bicycle, Pedestrian
- A combined LOS is not calculated

Main Street Level of Service		
User Type	AM Pk Hr	PM Pk Hr
Auto	C	E
Transit	B	C
Bicycle	D	C
Pedestrian	C	D

Audience Interaction

- The MMLOS measures in the 2010 HCM are:
 - A) Capacity based
 - B) Delay based
 - C) Perception (quality of service) based

MMLOS Applications



- Segments
 - All four modes
- Signalized Intersections
 - Auto, pedestrian, and bicycle modes
- Facility
 - All four modes

Pedestrian LOS Model

*Pedestrian Facility LOS = (0.318*Segment Score + 0.220* Intersection Score + 1.606) * (RCDF)*

- Weights Segment score (0.318) and Intersection score (0.22) differently
- Includes a constant (1.606)
 - LOS score starts in the LOS A range and increases based on the other factors
- RCDF = Roadway Crossing Difficulty Factor
 - Takes into account the difficulty of making a mid-block crossing (if it's allowed)

Audience Interaction

- Facility LOS = Average (Segment LOS, Intersection LOS)
 - True?
 - False?

Pedestrian LOS: Segments



- Factors include:
 - 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 lane (-)
- Pedestrian density considered separately
 - Worse of density LOS and perception LOS determines reported LOS for segment

Pedestrian LOS: Signals



- Factors include:
 - 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 (+)

Bicycle LOS Model

*Bicycle Facility LOS = (0.160*Segment Score + 0.011*e^(Intersection Score) + 0.035 * Driveways and Unsignalized Intersections per Mile + 2.85)*

- Weights Segment score (0.160) and Intersection score (0.011 times the exponent of the score) differently
- Includes a constant (2.85)
 - LOS score starts in the LOS C range and typically increases based on the other factors
- Takes into account the presence of driveways and unsignalized intersection conflicts along the corridor

Audience Interaction

- Unsignalized conflicts (public street intersections and driveways) are taken into account in which Bicycle LOS component?
 - A) Segment LOS
 - B) Intersection LOS
 - C) Facility LOS

Bicycle LOS: Segments



- Factors include:
 - 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 presence and utilization (+/-)

Bicycle LOS: Segments



- Factors include:
 - 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 presence and utilization (+/-)

Bicycle LOS: Signals



- Factors include:
 - Width of outside through lane and bicycle lane (+)
 - Cross-street width (-)
 - Motor vehicle traffic volume in the outside lane (-)

Transit LOS Model

*Transit LOS Score = 6.0 – 1.50 * Transit Wait Ride Score + 0.15 * Ped LOS*

- The WaitRide Score is based on transit headways and a perceived travel time factor
- “Transit” covers buses, streetcars, and street-running light-rail

Audience Interaction

- The Transit LOS model takes into account which of the following experiences:
 - A) Walking to the stop
 - B) Waiting at the stop
 - C) Riding in the transit vehicle
 - D) All of the above

Transit LOS: Segments



- Factors include:
 - Service frequency (+)
 - Average bus speed (+)
 - Bus reliability (+)
 - Average passenger load (-)
 - Shelter, bench presence (+)
 - Pedestrian LOS score for segment (+)

Factors Notes

- Look out for trade-offs across modes
 - On-street parking, signal timing, etc...
- Not all factors can be directly influenced by physical changes to the roadway section
 - Traffic volumes, speeds, and vehicle mix

MMLOS APPLICATIONS

Data Collection

- Much of it is standard for a traffic study
- Additional data:
 - Transit stop amenities
 - RTOR & permitted left-turn volumes
 - Transit performance and occupancy
 - Travel time and # of stops
- Sources:
 - Field measurements
 - Scaled aerials
 - Photos
 - Software outputs
 - Concept plan drawings

Applications

- Existing vs. Build Conditions
 - Build improvements:
 - Widen roadway and add bicycle/pedestrian facilities and on-street parking
 - Signal timing changes
 - Examine improvements to transit service
- One segment with a signalized intersection
- Pedestrian, Bicycle, and Transit Modes
- Segment, Intersection, and Facility Scores

Pedestrian No-Build - Segment

□ Segment characteristics:

- Segment length = 3,640 ft.
- No sidewalk
- Outside travel lane width = 12 ft.
- Shoulder width = 2 ft.
- No buffer or on-street parking
- Peak hour traffic volume in outside lane = 600 vehicles
- Speed limit = 35 mph
- Average vehicle speed = 30 mph

□ Segment LOS = 4.50 (E)

Measure	No-Build	Build
Segment LOS	E	
Intersection LOS		
RCDF		
Facility LOS		

Pedestrian No-Build - Intersection

□ Downstream intersection characteristics:

- RTOR + permitted left-turns = 100 vehicles/hour
- Cross street approach volume = 300 vehicles/hour/lane
- PHF = 0.98
- Cross street speed = 35 MPH
- Cross street section = 5 lanes
- Cycle length = 120 seconds (53% allocated to major street thru)
- Pedestrian walk interval = 7 seconds
- No right-turn channelization islands

□ Intersection LOS = 2.81 (C)

Measure	No-Build	Build
Segment LOS	E	
Intersection LOS	C	
RCDF		
Facility LOS		

Pedestrian No-Build - RCDF

□ Roadway Crossing Difficulty Factor Data:

- Signal spacing = 3,640 feet (segment length)
- Same signal timing data as before
- Mid-block crossing distance = 24 feet
- Same vehicle speed data as before
- Two-way peak hour volume = 1,100 vehicles
- Number of stages to cross = 1

□ RCDF = 1.05

Measure	No-Build	Build
Segment LOS	E	
Intersection LOS	C	
RCDF	1.05	
Facility LOS		

Pedestrian No-Build – Facility

$$\begin{array}{c}
 \text{Segment Score} \quad \text{Intersection Score} \quad \text{RCDF} \\
 \downarrow \quad \quad \quad \downarrow \quad \quad \quad \downarrow \\
 \text{Pedestrian Facility LOS} = (0.318 * 4.50 + 0.220 * 2.81 + 1.606) * (1.05) \\
 = 3.84 (D)
 \end{array}$$

Pedestrian Density LOS = N/A (no sidewalk)

- Therefore use Facility LOS score

Measure	No-Build	Build
Segment LOS	E	
Intersection LOS	C	
RCDF	1.05	
Facility LOS	D	

Pedestrian Build - Segment

- Segment Improvements
 - Add 5 ft. wide sidewalk
 - Widen 2 ft. shoulder to 6 ft. bike lane
 - Add 8 ft. wide on-street parking (assume 70% occupied)
- Segment LOS = 2.29 (B)

Measure	No-Build	Build
Segment LOS	E	B
Intersection LOS	C	
RCDF	1.05	
Facility LOS	D	

Pedestrian Build - Intersection

- Intersection Improvements
 - Restrict RTOR and convert left-turn phasing to protected
 - Previously 100 RTOR + permitted left-turns
- Intersection LOS = 2.66 (B)

Measure	No-Build	Build
Segment LOS	E	B
Intersection LOS	C	B
RCDF	1.05	
Facility LOS	D	

Pedestrian Build - RCDF

- Changes affecting RCDF:
 - Widened cross-section = longer distance to cross mid-block (from 24 feet 36 feet)
- RCDF = 1.20

Measure	No-Build	Build
Segment LOS	E	B
Intersection LOS	C	B
RCDF	1.05	1.20
Facility LOS	D	

Pedestrian Build – Facility

$$\begin{array}{c}
 \text{Segment Score} \quad \text{Intersection Score} \quad \text{RCDF} \\
 \downarrow \quad \quad \quad \downarrow \quad \quad \quad \downarrow \\
 \text{Pedestrian Facility LOS} = (0.318 * 2.29 + 0.220 * 2.66 + 1.606) * (1.20) \\
 = 3.50 \text{ (C)}
 \end{array}$$

Pedestrian Density LOS = A (200 pedestrians per hour)

- Therefore use Facility LOS score

Measure	No-Build	Build
Segment LOS	E	B
Intersection LOS	C	B
RCDF	1.05	1.20
Facility LOS	D	C

Pedestrian LOS Findings

- Score was improved by:
 - Adding facilities:
 - Sidewalks
 - Bike lanes
 - On-street parking
 - Signal changes:
 - RTOR restriction
 - Protected left-turn phasing
- Mid-block crossing difficulty has a significant influence
 - Cross-section additions improved Segment LOS, but increased RCDF

Bicycle No-Build - Segment

- Segment characteristics:
 - Segment length = 3,640 ft.
 - Outside travel lane width = 12 ft.
 - Shoulder width = 2 ft.
 - No on-street parking
 - Peak hour traffic volume in outside lane = 600 vehicles
 - Speed limit = 35 mph
 - Average vehicle speed = 30 mph
 - Pavement Rating = 3.0
- Segment LOS = 4.37 (E)

Measure	No-Build	Build
Segment LOS	E	
Intersection LOS		
Facility LOS		

Bicycle No-Build - Intersection

- Downstream intersection characteristics:
 - Crossing distance = 60 ft.
 - Shoulder and travel lane widths and traffic volume data the same as segment data
- Intersection LOS = 3.08 (C)

Measure	No-Build	Build
Segment LOS	E	
Intersection LOS	C	
Facility LOS		

Bicycle No-Build – Facility

$$\begin{aligned}
 \text{Bicycle Facility LOS} &= (0.160 * \text{Segment Score} + 0.011 * e^{\text{Intersection Score}} + 0.035 * \text{Unsignalized Conflicts/Mile} + 2.85) \\
 &= 5.11 (F)
 \end{aligned}$$

Measure	No-Build	Build
Segment LOS	E	
Intersection LOS	C	
Facility LOS	F	

Bicycle Build - Segment

- Segment improvements:
 - Widen 2 ft. shoulder to 6 ft. bike lane
 - Add 8 ft. wide on-street parking (assume 70% occupied)

- Segment LOS = 1.97 (A)

Measure	No-Build	Build
Segment LOS	E	A
Intersection LOS	C	
Facility LOS	F	

Bicycle Build - Intersection

- Intersection improvements:
 - Same as for segment

- Intersection LOS = 0.51 (A)

Measure	No-Build	Build
Segment LOS	E	A
Intersection LOS	C	A
Facility LOS	F	

Bicycle Build – Facility

Segment Score
Intersection Score
Unsignalized Conflicts/Mile

$$\begin{aligned}
 \text{Bicycle Facility LOS} &= (0.160 * 1.97 + 0.011 * e^{(0.51)} + 0.035 * 37.7 + 2.85) \\
 &= 4.50 \text{ (E)}
 \end{aligned}$$

Measure	No-Build	Build
Segment LOS	E	A
Intersection LOS	C	A
Facility LOS	F	E

Bicycle Build – Facility

Add in access management

- Consolidate driveways

Segment Score
Intersection Score
Unsignalized Conflicts/Mile

$$\begin{aligned}
 \text{Bicycle Facility LOS} &= (0.160 * 1.97 + 0.011 * e^{(0.51)} + 0.035 * 8.7 + 2.85) \\
 &= 3.49 \text{ (C)}
 \end{aligned}$$

Measure	No-Build	Build
Segment LOS	E	A
Intersection LOS	C	A
Facility LOS	F	C

Bicycle LOS Findings

- Score was changed by:
 - Adding facilities:
 - Bike lanes
 - On-street parking (+/-)
- Less factors to change to influence score than Pedestrian LOS
- Access management has a significant influence
 - Important to examine Facility LOS

Transit No-Build - WaitRideScore

- Transit characteristics:
 - Service frequency = 2 buses/hour
 - On-time performance = 80%
 - Average passenger load = 50%
 - No benches or shelters
 - Average bus speed = 17 mph
- WaitRideScore = 1.95
- Pedestrian LOS = 3.85 (D)

Measure	No-Build	Build
WaitRideScore	1.95	
Pedestrian LOS	3.85 (D)	
Transit LOS		

Transit No-Build

$$\begin{array}{c}
 \text{WaitRide Score} \quad \text{Pedestrian LOS} \\
 \downarrow \qquad \qquad \downarrow \\
 \text{Transit LOS Score} = 6.0 - 1.50 * 1.95 + 0.15 * 3.85 \\
 = 3.65 (D)
 \end{array}$$

Measure	No-Build	Build
WaitRideScore	1.95	
Pedestrian LOS	3.85 (D)	
Transit LOS	D	

Transit Build - WaitRideScore

- Transit improvement options (WaitRide Score):
 - Service frequency increased from 2 to 4 buses/hour (2.79)
 - Add benches and shelters to both stops (2.02)
 - Improve on-time performance to 95% (2.05)
- Pedestrian LOS = 3.50 (C)

Measure	No-Build	Build
WaitRideScore	1.95	2.79
Pedestrian LOS	3.85 (D)	3.50 (C)
Transit LOS	D	

Transit Build

$$\begin{array}{c} \text{WaitRide Score} \quad \text{Pedestrian LOS} \\ \downarrow \qquad \qquad \downarrow \\ \text{Transit LOS Score} = 6.0 - 1.50 * 2.79 + 0.15 * 3.50 \\ = 2.34 \text{ (B)} \end{array}$$

Measure	No-Build	Build
WaitRideScore	1.95	2.80
Pedestrian LOS	3.85 (D)	3.50 (C)
Transit LOS	D	B

Transit LOS Findings

- Improving service frequency had the most significant impact on the score

Summary

- Measures how well an urban street meets the needs of each major mode's users (QOS)
- Allows for evaluation of trade-offs across modes
- Important to measure Facility LOS to consider all factors
- Not all factors can be improved by projects
- Not all facilities are covered just yet (i.e., roundabouts)
- Always use engineering and local judgment when interpreting score results

Questions?

- Please send your additional questions & comments to...
 - Mark Vandehey (mvandehey@kittelso.com)
 - Paul Ryus (pryus@kittelso.com)
 - Nick Foster (nfoster@kittelso.com)

Thank You

Please provide your feedback. A link to an online evaluation will follow in an e-mail to site registrants. Please distribute this email to participants at your site. The assessment and evaluation will close in one week.

Questions/Comments

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