Multimodal Level of Service for Urban Streets

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NCHRP 03-70 Panel Member

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National Cooperative Highway Research Program Research Project 03-70, *Multimodal Level of Service Analysis for Urban Streets*

Research Team

- Dowling Associates (Prime)
- George Mason University
- Kittelson & Associates
- Sprinkle Consulting
- The Institute for Transportation Research and Education (North Carolina State University)
- Texas Transportation Institute (Texas A&M University)

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Overview

- Desire to evaluate transportation service from a multimodal perspective
- Non-auto modes often emphasized to achieve community goals such as Smart Growth
- TEA-21 and ISTEA called for mainstreaming transit, pedestrian and bicycle projects into project planning

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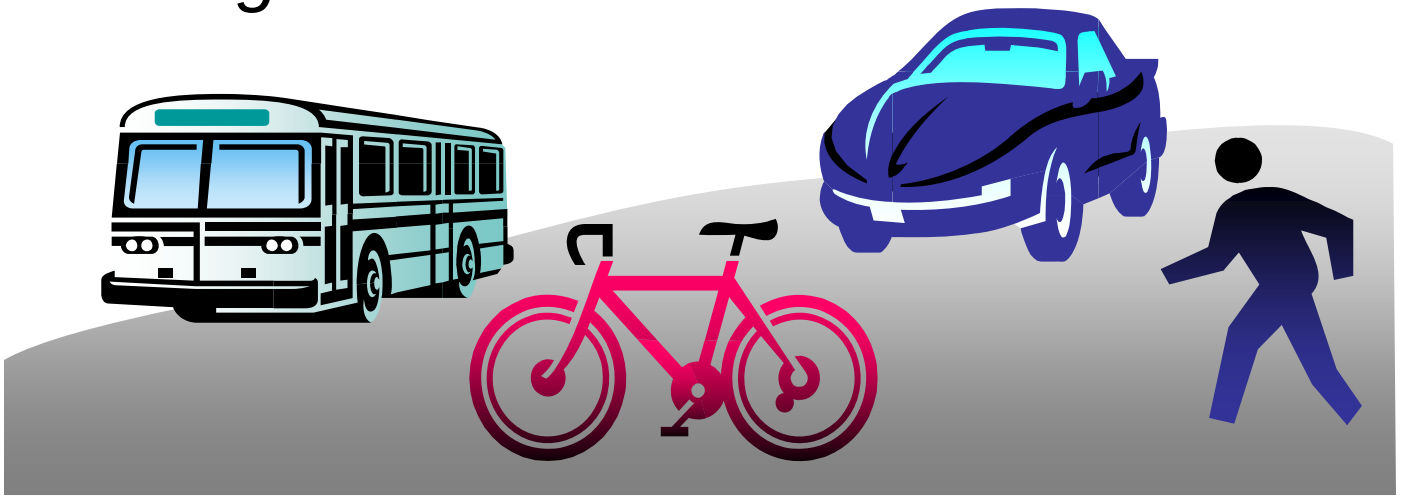
Research Objective

Develop and test framework and enhanced methods for determining levels of service for automobile, transit, bicycle and pedestrian modes on urban streets, with respect to interaction among modes.



LOS from Traveler's Perspective

- HCM claims to predict LOS from traveler's perspective, but little evidence to support claim
- Service measures developed in committee without research of traveler's opinions

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LOS Integration Issues

1. LOS should represent traveler's perspective
2. LOS should be comparable across modes

   LOS C (bike/ped) = LOS C (auto) = LOS C (transit)
3. LOS prediction methods should take into account modal interactions
4. Framework should integrate easily with HCM and TCQSM

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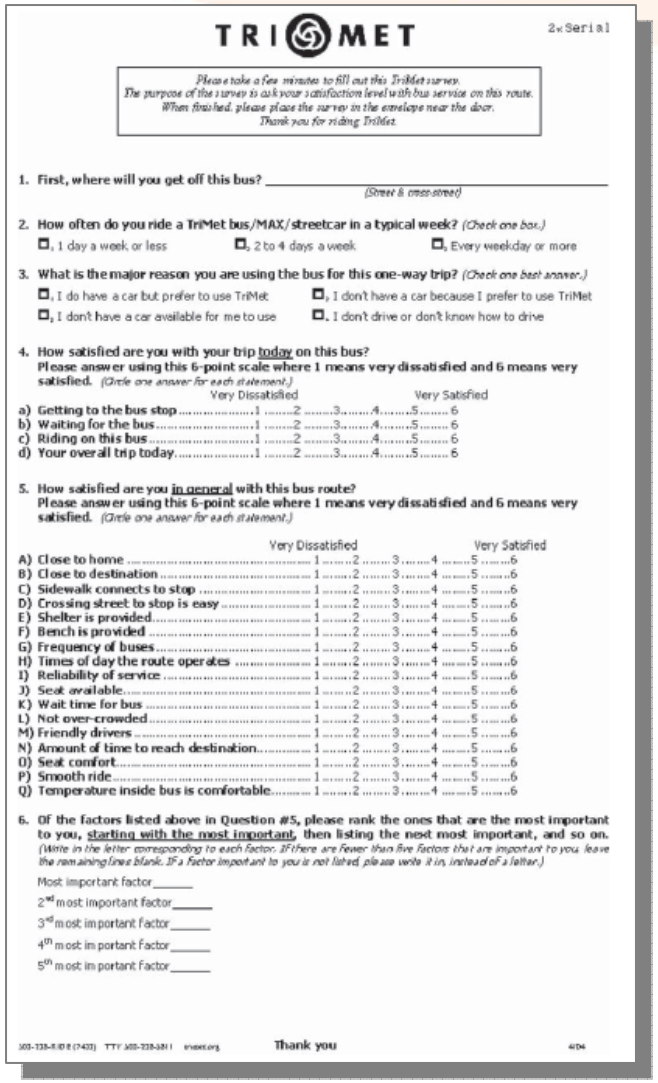
Historical Methods for Measuring Traveler Perception of Satisfaction

- Traveler Intercept Surveys
- Field Laboratory Studies
- Video Laboratory Studies
- NCHRP 3-70 used all of these

Traveler Intercept Surveys

- Directly measure LOS perception
- Mid-trip intercepts
- Large samples possible
- Trip/facility specific → one data point per survey



TRIMET 2xSerial

Please take a few minutes to fill out this TriMet survey.
The purpose of the survey is ask your satisfaction level with bus service on this route.
When finished, please place the survey in the envelope near the door.
Thank you for riding TriMet.

1. **First, where will you get off this bus?** _____
(Street & cross-street)

2. **How often do you ride a TriMet bus/MAX/streetcar in a typical week?** *(Check one box.)*
☐, 1 day a week or less ☐, 2 to 4 days a week ☐, Every weekday or more

3. **What is the major reason you are using the bus for this one-way trip?** *(Check one best answer.)*
☐, I do have a car but prefer to use TriMet ☐, I don't have a car because I prefer to use TriMet
☐, I don't have a car available for me to use ☐, I don't drive or don't know how to drive

4. **How satisfied are you with your trip today on this bus?**
Please answer using this 6-point scale where 1 means very dissatisfied and 6 means very satisfied. *(Circle one answer for each statement.)*

	Very Dissatisfied					Very Satisfied
a) Getting to the bus stop	1	2	3	4	5	6
b) Waiting for the bus	1	2	3	4	5	6
c) Riding on this bus	1	2	3	4	5	6
d) Your overall trip today	1	2	3	4	5	6

5. **How satisfied are you in general with this bus route?**
Please answer using this 6-point scale where 1 means very dissatisfied and 6 means very satisfied. *(Circle one answer for each statement.)*

	Very Dissatisfied					Very Satisfied
A) Close to home	1	2	3	4	5	6
B) Close to destination	1	2	3	4	5	6
C) Sidewalk connects to stop	1	2	3	4	5	6
D) Crossing street to stop is easy	1	2	3	4	5	6
E) Shelter is provided	1	2	3	4	5	6
F) Bench is provided	1	2	3	4	5	6
G) Frequency of buses	1	2	3	4	5	6
H) Times of day the route operates	1	2	3	4	5	6
I) Reliability of service	1	2	3	4	5	6
J) Seat available	1	2	3	4	5	6
K) Wait time for bus	1	2	3	4	5	6
L) Not over-crowded	1	2	3	4	5	6
M) Friendly drivers	1	2	3	4	5	6
N) Amount of time to reach destination	1	2	3	4	5	6
O) Seat comfort	1	2	3	4	5	6
P) Smooth ride	1	2	3	4	5	6
Q) Temperature inside bus is comfortable	1	2	3	4	5	6

6. **Of the factors listed above in Question #5, please rank the ones that are the most important to you, starting with the most important, then listing the next most important, and so on.**
(Write in the letter corresponding to each factor. If there are fewer than five factors that are important to you, leave the remaining lines blank. If a factor important to you is not listed, please write it in, instead of a letter.)

Most important factor_____
2nd most important factor_____
3rd most important factor_____
4th most important factor_____
5th most important factor_____

503-238-RIDE (7433) TTY 503-238-5811 trimet.org **Thank you** 4/04

Field Laboratory Studies

- Recruit test subjects
- Travel over fixed course
- Report LOS perceptions along the way
- Low cost per data point; expensive start-up
- “Real world”
- Liability a concern

Video Laboratory Studies

- Show film clips to recruited subjects
- Initial investment to create clips
- Cost per data point low after initial investment
- Limited ability to capture all factors
- Added expense for calibration to field data

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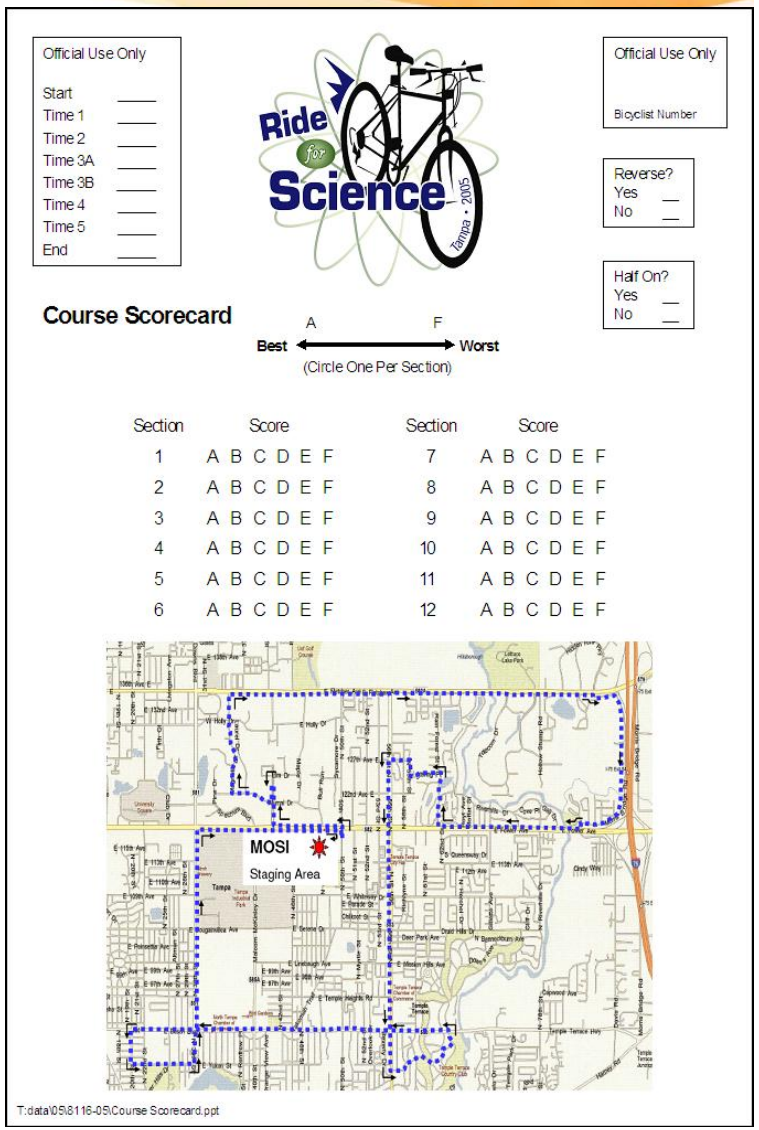
Data Collection

- Collection of travel intercept surveys, field lab studies and video laboratory surveys
- Auto/Bike/Ped video labs – 4 cities
- Transit on-board surveys – 4 cities
- Field laboratory studies – Florida DOT
  - "Walk for Science"
  - "Ride for Science"



Official Use Only

Start ____
Time 1 ____
Time 2 ____
Time 3A ____
Time 3B ____
Time 4 ____
Time 5 ____
End ____

Ride for Science Tampa • 2005

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Bicyclist Number

Reverse?
Yes __
No __

Half On?
Yes __
No __

Course Scorecard

A F
Best ← → Worst
(Circle One Per Section)

Section	Score	Section	Score
1	A B C D E F	7	A B C D E F
2	A B C D E F	8	A B C D E F
3	A B C D E F	9	A B C D E F
4	A B C D E F	10	A B C D E F
5	A B C D E F	11	A B C D E F
6	A B C D E F	12	A B C D E F

T:\data\05\8116-05\Course Scorecard.ppt

Summary of Data Points

Mode	Number of Video Clips (or Bus Routes)	Number of People Surveyed	Number of LOS Responses
Auto	35	145	2449
Bicycle	26	145	1412
Pedestrian	28	145	1450
Transit	14	2678	2678

Nearly 8,000 total data points

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Model Development

- Identification of key variables
- Regression, Cumulative Logistic Regression (maximum likelihood)
- Selection of model types, variables
- Best models to fit data
- Model refinement
  - Adjust to meet agency needs
  - Produce single letter grade LOS
  - Produce LOS A through F

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Auto LOS Model

- Linear regression models examined, but not selected
  - Assumes measured linear change in dependent variable (participant rating → LOS) for change in independent variable
  - Predicts a continuous variable (user satisfaction is discrete)
- Cumulative logistic regression – models discrete variables with hierarchical ordering (e.g. user satisfaction 1 through 6)

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Auto LOS Model

$$\Pr(LOS \leq J) = \frac{1}{1 + \exp(-\alpha_{(J)} - \sum_{k} \beta_k x_k)}$$

Pr(LOS<=J)	= Probability of response of LOS "J" or worse.
α_J	= Alpha, Calibration parameters for LOS.
β_K	= Beta, Calibration parameters for street attributes.
X_K	= Street attributes (k) of the facility. = Stops per mile, Presence of Left turn lanes (0,1)

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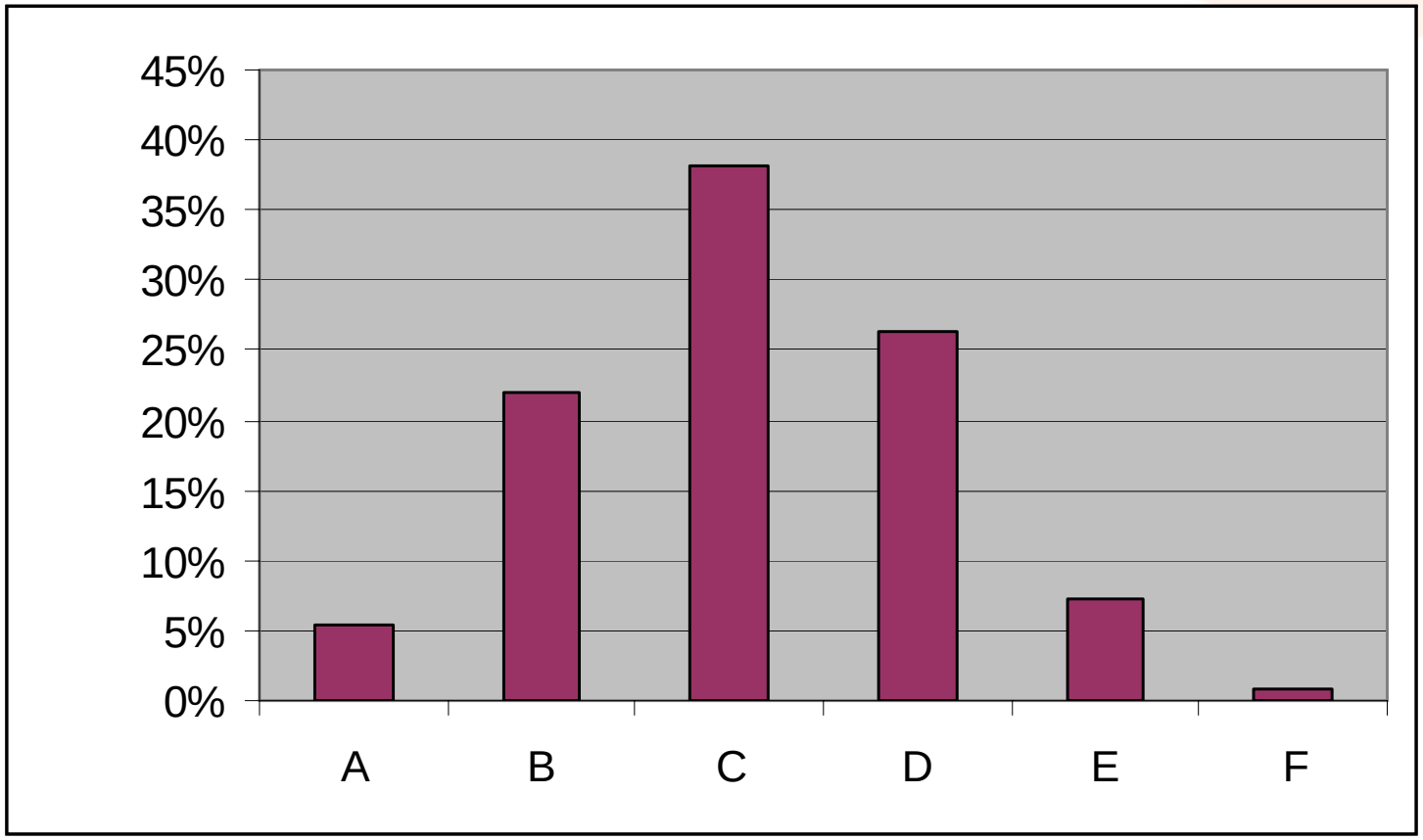
Model Estimates Range of LOS



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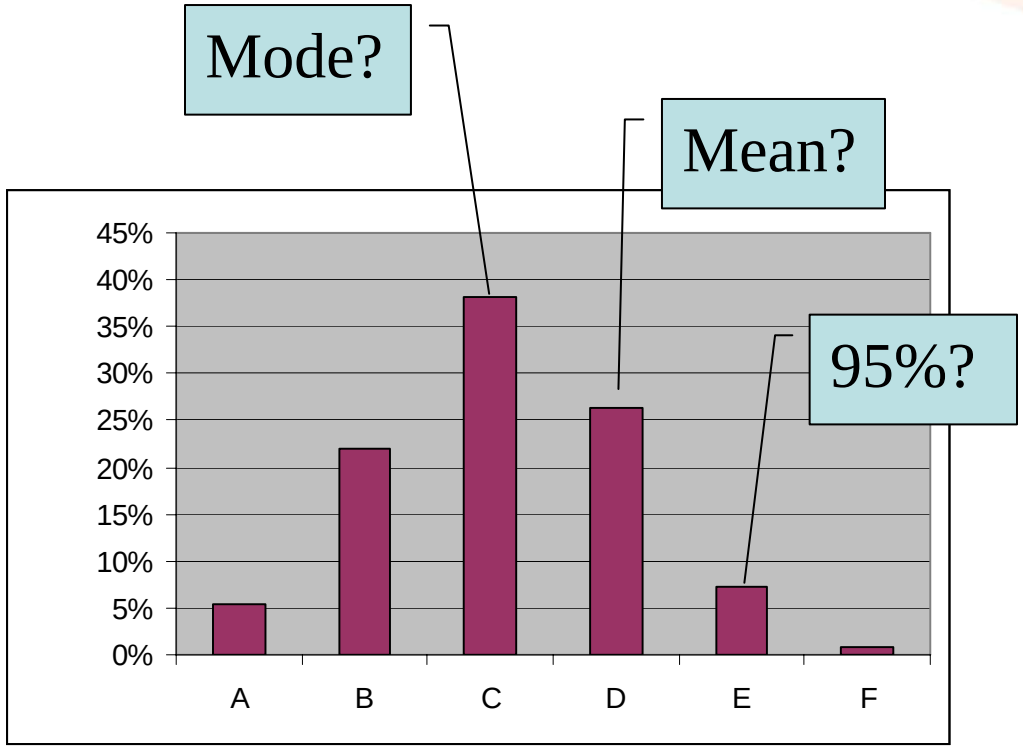
What is LOS of a Distribution?



$$Auto(LOS) = \sum_{J=1}^{6} Pr(LOS = J) * J_J$$

AutoLOS=Mean(LOS)

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Transit LOS Model

Transit LOS = 6.0 – 1.50 * TransitWaitRideScore + *0.15* * PedLOS

TransitWaitRideScore = F_H * F_{PTTR}

F_h	= Headway factor = (Ridership at current headway)/ (Ridership at 60 min.)
F_{PTTR}	= Perceived travel time factor. = (Ridership at current speed)/ (Ridership at 15 mph.)

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Bicycle LOS Model

Bicycle LOS = a_1(SegLOS) + a_2(IntLOS) + a_3(Conflt) + C

- SegLOS = Segment bicycle LOS
- IntLOS = Intersection bicycle LOS
- Conflt = Driveway conflicts per mile
- C = constant

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Pedestrian LOS Model

Ped LOS = Worse of (Ped Density LOS, Ped Art LOS)

- Ped Density LOS
  - per HCM
- Ped Art LOS
  - Interaction of peds with traffic.

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Pedestrian Art LOS Model

Ped Art LOS = (a_1 SegLOS + a_2 IntLOS + C) x (Midblock)

- SegLOS = Ped segment LOS
- IntLOS = Ped Intersection LOS
- C = constant
- Midblock = midblock crossing factor

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Current HCM Urban Street LOS

- Auto =
  - Speed by arterial class
- Transit =
  - Frequency, speed, reliability
- Bicycle =
  - Speed
- Pedestrian =
  - Speed

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Validity of HCM : NCHRP 3-70

Mode	HCM	NCHRP 3-70
Auto	17%	43%
Transit	21%	50%
Bicycle	35%	50%
Pedestrian	18%	64%

Percent LOS matches with mean lab/field results.

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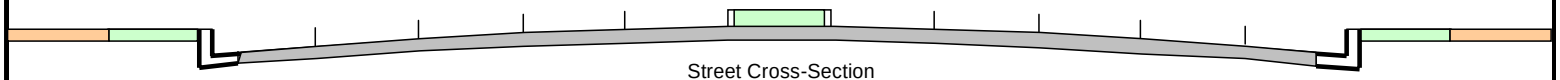
Computational Engine

NCHRP 3-70 Multimodal LOS

			Range Check
ADT	5,000	(>=0 vpd)	OK
% HV	5%	(0-100%)	OK
Buses/hr	4	(>=0 bph)	OK
Peds/hr	60	(>=0 pph)	OK

Mode	LOS	LOS #	v/c
Auto	C	2.76	0.3558
Transit	C	2.87	
Bicycle	E	4.02	
Pedestrian	C	2.69	

ROW 34 ft



Street Cross-Section

Sidewalk	Buffer	Parking	Bike Ln	Trav. Lane	Trav. Lane	Trav. Lane	Median	Trav. Lane	Trav. Lane	Trav. Lane	Bike Ln	Parking	Buffer	Sidewalk	Range Checks
5	0	0	0	12	0	0	0	0	0	12	0	0	0	5	OK

(all entries in feet, enter zero for non-existant lanes)

Street :

Limits:

Key: Data Entry

Draft, for internal evaluation only

Spreadsheet by: R. Dowling, Dowling Associates, Inc., July 5, 2007, Updated 02/12/08.

Key Parameters			
Signal Spacing:	1,320	(200-10,560 ft.)	OK
Progression Quality:	3	(1=poor, 6=excellent)	OK
Speed Limit	25	(15-70 mph)	OK
Bus Stops w. Shelter:	50%	(0-100%)	OK
Pavement Quality:	3	(1=poor, 5=excellent)	OK

Additional Parameters

Auto LOS Inputs	
Peaking Factor (k)	0.09
Directional Factor (d)	0.55
Peak Hr. Fac. (PHF)	0.92
Adj. Sat Flow (vphgl)	1800
Through g/c	0.42
Cycle Length (sec)	100

Pedestrian LOS Inputs	
% Parking Occ.	0%
Barrier (Yes/No)	Yes
RTOR+Perm LT (vph)	50
X-Street Vol. (vph)	1500
X-Street Speed (mph)	35
X-Street Lanes (#)	5
Right Turn Islands (#)	2
X-Street Walk g/c	0.10

Transit LOS Inputs	
% On Time	85%
% Stops w. Benches	50%
Load Factor (p/seat)	1.00
CBD (Yes/No)	Yes
Bus Stops/segment	1
Delay/Bus Stop (sec)	20

Bicycle LOS Inputs	
Unsig Conflicts/Mile	10

Auto LOS – Which Model?

Recommended Model

- Independent Variables
  - Stops per Mile
  - Presence of Left Turn Lanes
- Better fit to data
- Stops per mile better predictor of user satisfaction (than average travel speed)
- Is not speed-based – usefulness to planners?

Alternative Model

- Independent Variables
  - Average Travel Speed
  - Presence of Median
- Uses speed/time/delay – more useful to planners, elected officials, etc.
- More accurate than HCM
- Not as accurate as recommended model

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New 2010 Highway Capacity Manual

- NCHRP 3-70, *Multimodal Level of Service Analysis for Urban Streets*
- NCHRP 3-79, *Measuring and Predicting the Performance of Automobile Traffic on Urban Streets*

New Urban Street Chapters

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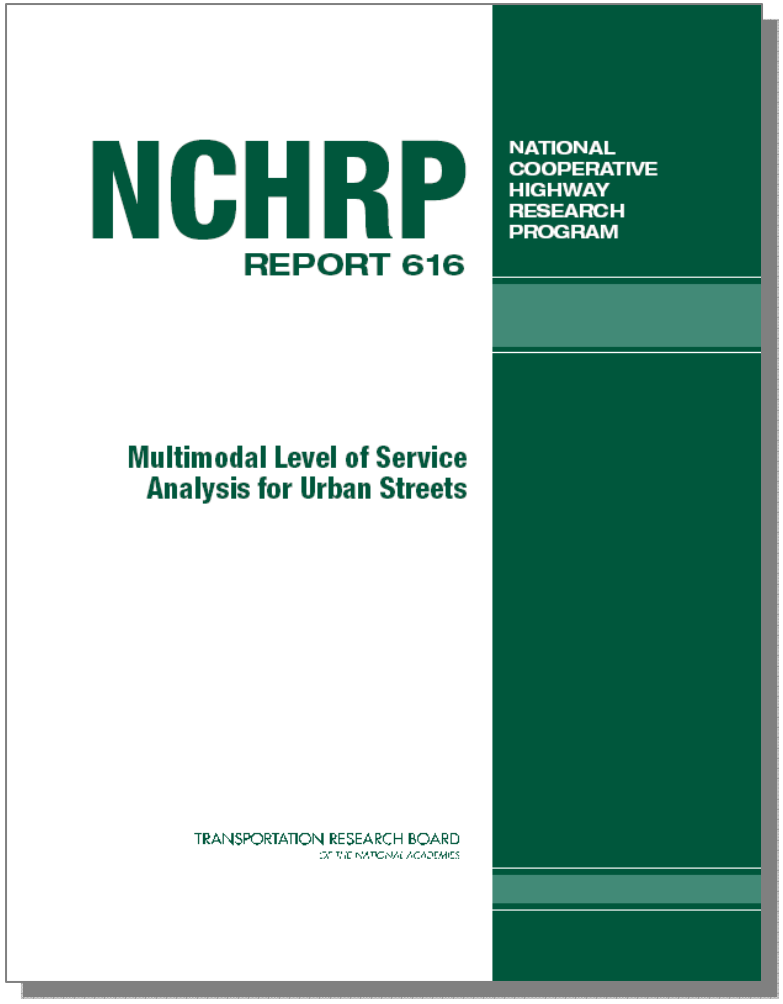
Final Report



http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_616.pdf

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